Special Report 930
January 1994

Central Oregon Agricultural Research Center Annual Report, 1993

Agricultural Experiment Station
Oregon State University

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Cover photo: weather station, Madras site

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*Central Oregon Agricultural Research Center
in cooperation with
Crook and Jefferson Counties*

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UPDATE, 1993

CENTRAL OREGON AGRICULTURAL RESEARCH CENTER

Fred Crowe and Alan Mitchell

Beginning with this year's update, we have divided our reports into two classes: Complete reports and updates of research in progress. In most cases, a short update should result in a more complete, full length report in a subsequent year.

Our audience is diverse. First local and regional growers are interested in how our research might be of use in their operations at this time. A broader public is also generally interested in agricultural research. Scientists elsewhere in the state, country, and world are interested in agricultural research elsewhere, and express interest in these reports which frequently appear here before appearing in the formal scientific literature. Furthermore, these annual reports provide an historical account of research activity over the years, and may be referenced by many people including future researchers and growers curious to what has been tried years ago. Finally, a number of people find our annual weather summary of primary interest. We are pleased to serve all audiences.

Powell Butte Weather Station -- a new compliment to the station at Madras

For serveral years we have had an automated weather station at the Madras office site of the Central Oregon Agricultural Research Center. We are pleased to announce the establishment of a new station at the Powell Butte research farm. With both stations in operation, central Oregon will be well served. These weather stations will span most of the range between the shorter growing season (Powell Butte) to the longer growing season (Madras) of the region. As with many such weather stations in the Pacific Northwest, both of ours are in cooperation with the United States Bureau of Reclamation, which manages the data, and the Bonneville Power Administration, which provided the hardware. The new Powell Butte weather station has an even more complex inter-relationship, which largely came together through the energy and action of Mylen Bohle and Alan Mitchell on this staff, working with the managers of the various irrigation districts.

Five central Oregon irrigation districts agreed to pay for the operation and maintenance of the new AgriMet weather station recently installed at COARC Powell Butte. This latest station was installed September 21, 1993. It is one of 41 stations in the northwest providing accurate water information to irrigators during the growing season.

The Ochoco, Central Oregon, Arnold, Tumalo, and Swalley irrigation districts agreed to sponsor the AgriMet weather station for a minimum of three years at a cost of about $1,230 per year. Central Electric Cooperative and Bonneville Power Administration, support the AgriMet station located at the COARC Madras field, which has been in operation since 1988.

AgriMet is the Northwest's cooperative agricultural network. The system automatically tracks weather conditions using satellite telemetry and computer link-up, and generates daily crop water use information for irrigators throughout the region. The AgriMet weather stations collect the information and transmit it to a geo-stationary satellite. Once the information is transmitted, a land-based satellite receiver in Boise, Idaho, collects the data. It is then channeled into the Bureau of Reclamation's computer network, processed, and placed in a database where it can be retrieved by irrigation managers by way of computer link.

Daily crop water information from AgriMet has been available through telephone recorded messages in Madras, Culver, Prineville, and Redmond. Central Electric Cooperative has sponsored this service for the past few years. In addition to crop water use data, the system provides, temperature, precipitation, wind speed, wind direction, soil temperature, humidity, and solar radiation measurements for use by agricultural scientists or the general public. One example of the way this information may be used is for insect emergence models, which predict the life cycles of pest and beneficial insects that occur on crops in the region.

Station Staff in 1993

State-supported staff:

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

Dr. Alan Mitchell, Assistant Professor of Crop & 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 on potatoes)

Dale Coats, Research Assistant

Pat Foltz, Bio-Science Research Superintendent

Sylvia McCallum, Bio-Science Research Technician

Peter Tomseth, Bio-Science Research Technician

Joan Starkel, Office Coordinator

Other staff, supported on grant funds:

Neysa Farris, Research Assistant

Joy Light, Research Assistant

Karen Stevenson, Undergraduate Research Assistant

Thi Bich Quan Chau, Student Technician

Truc Chau, Student Technician

Heather Clowers, Student Technician

Margie Durette, Student Technician

Emily Ray, Student Technician

Jennifer Samsel, Student Technician

Kyle Turner, Student Technician

Jerod Williams, Student Technician

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Madras, Oregon
1993 Water Year
(source AgriMet)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
AIR TEMP. (°F)												
AVE. MAX. TEMP.	64	47	37	31	34	50	57	71	71	73	79	78
AVE. MIN. TEMP.	40	32	23	18	21	33	36	44	46	47	49	44
MEAN TEMP.	51	39	30	24	27	42	47	58	59	60	64	61
AIR TEMPERATURE (No. of Days)												
MAX. 90° OR ABOVE	0	0	0	0	0	0	0	0	0	0	2	3
MAX. 32° OR BELOW	0	1	7	16	11	0	0	0	0	0	0	0
MIN. 32° OR BELOW	3	14	28	29	24	12	5	0	0	0	0	3
MIN. 0° OR BELOW	0	0	0	0	1	0	0	0	0	0	0	0
GROUND TEMP. (°F at 4")												
AVE. MAXIMUM	55	44	37	37	37	44	49	57	60	60	63	58
AVE. MINIMUM	50	42	36	36	36	41	46	54	58	58	60	55
GROUND TEMP. (°F at 8")												
AVE. MAXIMUM	55	45	38	37	37	42	48	56	60	60	63	58
AVE. MINIMUM	53	44	38	37	37	41	46	54	58	59	61	57
PRECIPITATION (inches)												
MONTHLY TOTAL	1.76	0.87	1.19	1.35	0.77	1.64	1.01	2.14	1.02	0.65	0.82	0.01
EVAPOTRANSPIRATION (inches)												
AVE. PER DAY	0.11	0.04	0.03	0.02	0.04	0.07	0.13	0.20	0.23	0.24	0.25	0.22
WINDAGE (miles)												
AVE. PER DAY	100	105	133	104	91	109	155	142	132	145	134	113
SOLAR RADIATION (langleys)												
AVE. PER DAY	247	145	97	109	93	228	371	485	565	554	515	418
HUMIDITY (percent relative humidity)												
AVE. PER DAY	70	82	81	80	80	78	67	64	62	63	59	53

GROWING SEASON	**Last Date Before July 15**	**First Date After July 15**	**Total Number of Days Between Temp. Min.**
AIR TEMP . MIN.			
32° or below	Apr. 27	Sep. 21	146
28° or below	Apr. 12	n/a	n/a
24° or below	Mar. 2	n/a	n/a

[1]EVALUATION OF PEPPERMINT FIELD PERFORMANCE FROM PLANTS REGENERATED FROM MERISTEM TIP CULTURE

Frederick J. Crowe
Central Oregon Agricultural Research Center
Madras, Oregon

Abstract

'Black Mitchum' peppermint, commercially meristem tip cultured (M) and then propagated by rooted stem cutting was compared to the same variety (of the original mother stock to M plants) propagated by rooted stem cutting (Non-M). Rooted cuttings of each type were placed into a randomized, complete block experimental design field trial in 1992. In 1993, M plants initially were more vigorous through the first half of the season. Main stems were 15 percent taller and more consistently upright throughout the season. Total above-ground plant dry weight was 17-40 percent greater in M plants compared to Non-M plants. The superior total dry weight advantage for M plants was stem weight. Non-M plants had a greater number of branches and total leaves, greater total leaf weight, and less stem weight than M plants. Though stem thicknesses were similar for both M and Non-M plants, the leaf-to-stem ratio was much greater for Non-M plants than for M plants. This likely explains the earlier and more extensive lodging of Non-M plants through July, in contrast to M plants which remained upright until just prior to harvest in mid-August. For three harvest dates in August, oil yield from plots with Non-M plants was 16-55 percent greater compared to plots with M plants. Oil composition was similar between treatments, except for total heads, which was higher for Non-M than for M plants. These results are discussed with respect to management practices that might improve performance of M plants while taking advantage of the vigor shown following meristem tip culturing.

Introduction

Meristem tip culture of plant materials was introduced in the 1960s. It is a process where a growing point of a plant is extracted prior to development of the conductive tissues, and a new plant is then regenerated (3). With this process, genetic identity is retained but vascular pathogens, such as viruses and certain bacteria and fungi that move quickly through vascular tissues, can be eliminated (7). [Vascular tissues are those which allow long-distance transport of water and nutrients around the plant.] Meristem tip culture has proven most beneficial for development of pathogen-free planting materials for vegetatively-propagated crops (bulbs, cloves, tubers, corms, crowns, rootstock, etc.) where vascular pathogens commonly are retained in the planting material from generation to generation. In most cases, when vascular pathogens are so eliminated, plant materials respond by growing without disease symptoms and/or with greater vigor. If increased vigor occurs following meristem tip culture, a vascular pathogen present in the stock that the meristem tip cultured plants were derived, even when clear disease symptoms were not apparent.

[1]This investigation was supported by research grants from The Oregon Mint Commission

This research project was developed in response to observations that 'Black Mitchum' peppermint, commercially meristem tip cultured in Montana, was growing more vigorously when field planted in Montana compared to other Montata plantings. A review of the scientific literature indicated peppermint and other mint species had been repeatedly meristem tip cultured and regenerated in various laboratories around the world, following standard practices for inducing roots and shoots in culture (1,4,5). None of these reports indicated a growth enhancement following this procedure, although not all reports included field planting of the regenerated material. None of these reports were from laboratories from agricultural centers in North America, nor were standard commercial North American varieties used.

Materials and Methods

Rooted cuttings of 'Black Mitchum' peppermint derived from commercially meristem-tip cultured (M plants, specific procedures undefined) were received from Starkle Farms, Inc., Ronan, MT. Similarly, rooted cuttings from non-meristem tip cultured plants (Non-M plants) were obtained from Plant Technology, Inc, Albany OR. Both materials arrived as boxed cuttings on June 30, 1992. Stem length of rooted cuttings of M plants were 8-12 inches above roots, with 1-3 side branches. Stem length of Non-M plants was 4-6 inches above roots, with no side branching. Root masses of M rooted cuttings were 2-3 times the volume of Non-M plants. Leaves on M plants were larger than those on Non-M plants.

In discussion with the two propagators, it was clear that greenhouse handling of each of the two was somewhat different, and that M plants had been held longer since cuttings were taken than had Non-M plants. On this basis of differential handling, it was anticipated that initial growth in the field following planting would likely be different for the two sources, and that the initial effect of meristem tip culturing could not be distinguished from effects of handling practices.

Planting was on July 1, 1993. Just prior to planting, rooted cutting of M plants were trimmed to 6 inches, and roots were trimmed to match root length of Non-M plants. Non-M rooted cuttings were planted without trimming. Opened furrows were 4-inches deep. Plants were placed in the furrows and immediately covered, with 2 inches left above the soil line. In each of 25-ft x 25-ft square plots, 250 rooted cuttings were planted one per foot into ten 25-ft opened furrows spaced 2 ft apart. Four plots of each treatment (M and Non-M) were arranged in a randomized, complete block experimental design. Plots were separated by 6-ft unplanted alleys. Plots were immediately irrigated with solid set irrigation, and regularly irrigated and fertilized equally as per commercial practices through the course of the study. Plots were hand-weeded through the early fall of 1993, when a half-rate of "Sinbar" herbicide was applied. Beginning in 1993, all weed control, fertility and irrigation was as per standard commercial practice for the peppermint in central Oregon. No insect or mite control was required in either 1992 or 1993.

Plots were harvested with a 40-inch wide plot forage harvester, and sub samples were collected for oil distillation in research stills located at the Central Oregon Agricultural Research Center. Oil was distilled within 10 days of harvest from hay which had been air-dried from about 10 pounds of fresh hay. Distillation was in small research stills, with exit temperature of condensate held between 110-120°F and as close to commercial procedures as could be followed (2). Oven-dry weight of harvested hay was calculated based on the total fresh harvested weight. Other data were collected as indicated below. Data were analyzed by analysis of variance.

Results

Results from 1992: Mid-day temperatures immediately following planting were near 100° F during the two weeks following planting. All stems and foliage left above ground desiccated. New top growth appeared later in July, and stands were evaluated in early August. Stands were about 95 percent for all plots. Growth continued into October, 1992. Initial growth was slightly more vigorous on M plants in July and early August, but growth was determined to be equal after about mid-August. Rhizomes developed in late August and September in all plots. Plots were not harvested in 1992.

Results from 1993: Early spring prostrate growth was similar for mint in all plots. Beginning in mid-May, growth began to appear taller and more vigorous in plots with M plants. Beginning in early June, various types of data were collected to compare mint growth and performance in plots. For plant height, branching, leaf dry weight, stem dry weight, and stem thickness, forty plants were selected at random throughout plots, excluding a one-foot perimeter where plant growth was unrepresentative of growth internal to the plot. Estimates of lodging were taken by visual rating of the entire plot, again excluding a perimeter one foot. Harvest was as described above. Fresh weight of hay collected from 40-inch x 25-ft strips was taken. Sub-samples were collected for dry weight and oil measurements.

Results are expressed in a series of Tables 1-6. M plants were consistently more vigorous. This is reflected by a 15 percent height advantage (Table 1), greater total dry weight through the growing season (Table 4) and 17-40 percent greater total dry weight at harvest (Table 5). However, this vigor was not channeled into plant components which resulted in improved commercial importance. Non-M plants, although shorter (Table 1), branched more extensively and developed more leaves (Tables 2 and 4). Non-M plants were of equal stem thickness (Table 3), but because more of the weight of Non-M plants was in leaves rather than stem (Table 4), Non-M plants lodged earlier and more extensively than M plants (Table 3). At harvest M plants had predominantly older leaves, many of which fell off due to delayed harvest.

Because there was much more of the plant as leaves in Non-M plants than found for M plants, oil yields favored Non-M plants (Table 5).

Oil composition was determined by Wm. Leman, Inc. Components evaluated included total heads, total menthol, menthofuran, and esters. For both M and Non-M treatments, the relative composition of each component changed with each harvest date. This difference with respect to harvest date was statistically significant at the 1 percent level for each component. Considering all plots for harvest dates of August 9, 12 and 16, total heads averaged 10.5, 8.3 and 9.3 percent; total menthol averaged 50.4, 55.2 and 52.7

percent; menthofuran averaged 3.2, 4.0 and 6.9 percent; and esters averaged 6.6, 8.0, and 7.7 percent respectively. The only component which was statistically different between M and Non-M treatments was total heads (Table 6), with the M treatment consistently less than the Non-M treatment for each harvest date.

With each delay in harvest date, M plants visually appeared to suffer greater drought stress than Non-plants. At the third harvest date, all plants in all plots were drought stressed, but M plants more so, which likely relates to the enhanced leaf drop in plots with M plants.

Discussion

The relatively poor performance (20-50 percent less oil yield combined with 20-40 percent greater hay weights to handle) of meristem tip cultured plants in this trial in 1993 apparently also was reported to have been experienced in commercial plantings in Montana, Washington, and other states, where growers have planted this material in anticipation of improved performance. Two caveats must be kept in mind: first, one year's performance may not reflect long-term performance. Second and more importantly, the growth differences might be manageable. For example, rolling the mint in July to induce branching and secondary growth might result in greatly improved performance. Or perhaps clipping the primary stems might similarly induce side branching. Perhaps the increased vigor could lead to a double cutting system which may not result in poor vigor the following year, which frequently results when non-meristem tip-cultured mint is double cut.

Enhanced growth of plants which had been meristem tissue-cultured suggests either that (a) some unknown vascular pathogen may have been eliminated, or (b) that a genetic change may have occurred in the meristem process. Several cursory efforts to detect a viral particle in Non-M 'Black Mitchum' plants using an electron microscope so far have been negative (T. Allen, Oregon State University, and William Grey, Montana State University, personal communication). However, virologist (D. Mayhew, California State Dept. Agr., Sacramento, personal communication) has indicated visualization using transmission electron microscopy of a long ,flexuous rod, closteroirus-like particles in a sample of Oregon-grown mint. When thin-sectioned, a large accumulation of virus-like particles were observed in the vascular tissue. Preliminary efforts to transmit a virus mechanically or by grafting were not successful. No further efforts are in progress at this time.

The likelihood of a genetic change seems small, but remains possible. Apparently, natural selections of Japanese mint (*Mentha arvensis*) may vary in ploidy, which affects growth, yield and oil composition (6). If meristem tip-culturing is done in a normal manner, usually such chromosomal changes will not occur. The extent that wild or cultivated peppermints may vary in this respect is undetermined.

Conclusions

It is recommended that verification studies be conducted to determine if a vascular pathogen is present in most or some field-grown peppermint. Verification of such a pathogen or pathogens, and the types, would help direct future meristem tip-culture efforts, verification would also shape any organized program to develop pathogen-free materials on an industry-wide basis, and would assist efforts to investigate field epidemiology of any such pathogens. Should systemic pathogens not be found, it may be prudent to conduct a cytogenetic analysis of meristemmed tissue to determine if major chromosomal translocations or even ploidy changes may have occurred. These analyses could proceed sequentially or together.

It is not clear that mint, which is freed of a vascular pathogen, will remain pathogen free. Many other such pathogen-free plant materials become re-infected via insect or other vectors, or mechanically during routine handling (7).

Our plots will be maintained for several years to evaluate long-term comparative performance, of meristemmed and non-meristemmed mint, and to determine if the plots retain the vigor over time (should some vascular pathogen become reintroduced into the planting). The plots are suitably sized, such that a single management practice (e.g. rolling) could be introduced for further comparisons.

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TABLES

Table 1. Height (cm) of main stems in 'Black Mitchum' peppermint either meristem tip cultured (M) or not meristem tip-cultured (Non-M), located in a replicated field trial at the Central Oregon Agricultural Research Center, Madras OR, 1993. [Means of 40 plants selected at random from each of 4 randomized and replicated plots].

Treatment	June 8, 1993	July 12, 1993
Meristem	56.9	84.5
Non-meristem	49.2	73.4
Significance Level	4%	1%

Table 2. Number of branches and total leaves of 'Black Mitchum' peppermint either meristem tip cultured (M) or not meristem tip-cultured (Non-M), located in a replicated field trial at the Central Oregon Agricultural Research Center, Madras OR, 1993. [Means of 40 plants selected at random from each of 4 randomized and replicated plots].

Treatments	Number of Branches per Main Stem on July 12, 1993	Total Number of Leaves on Main Stem and Attached Branches on July 12, 1993
Meristem	26.1	21.2
Non-meristem	32.8	26.1
Significance Level	10%	5%

Table 3. Stem thickness (cm) and percentage stems which had lodged of 'Black Mitchum' peppermint either meristem tip cultured (M) or not meristem tip-cultured (Non-M), located in a replicated field trial at the Central Oregon Agricultural Research Center, Madras OR, 1993. [Thickness values are means of 40 plants selected at random from each of 4 randomized and replicated plots, lodging is an estimated visual rating for entire plots].

Treatment	Main Stem Thickness on July 23, 1993	Percentage Lodging on July 26, 1993
Meristem	1.27	50
Non-meristem	1.24	98
Significance Level	Not Sig	<1%

Table 4. Dry weight (gm) of foliage and stems of 'Black Mitchum' peppermint either meristem tip cultured (M) or not meristem tip-cultured (Non-M), located in a replicated field trial at the Central Oregon Agricultural Research Center, Madras OR, 1993. [Total oven dry weight of 40 plants selected at random from each of 4 randomized and replicated plots]

Treatment	Dry Wt Leaves (L), July 28, 1993	Dry Wt Stems (S),July 28, 1993	Dry Wt L+S, July 28, 1993	L/S Dry Wt Ratio, July 28, 1993
Meristem	62.7	86.9	149.5	0.726
Non-meristem	68.2	73.5	141.7	0.924
Significance Level	Not Sig	Not Sig	Not Sig	<1%

Table 5. Oil yield and dry weight yields of 'Black Mitchum' peppermint either meristem tip cultured (M) or not meristem tip-cultured (Non-M), located in a replicated field trial at the Central Oregon Agricultural Research Center, Madras OR, 1993. [Derived from 25 ft x 40 in harvested strip, and distillation from approx. 10-lb subsample of fresh hay.]

OIL YIELD, LBS/AC	Harvest 1, Aug 9, 1993	Harvest 2, Aug12, 1993	Harvest 3, Aug 16, 1993	Average All Harvests
Meristem	57.7	57.8	39.9	51.8
Non-meristem	71.6	67.2	61.8	66.8
Significance Level	1%	1%	1%	1%

DRY WEIGHT YIELD, LBS/AC	Harvest 1	Harvest 2	Harvest 3	Average All Harvests
Meristem	9812	7815	5899	7841
Non-meristem	7579	6671	4199	6149
Significance Level	Not Sig	Not Sig	Not Sig	Not Sig

[Note: There was additionally a statistically significant harvest date effect ($P \leq 0.01$): dry weight dropped with later harvest date, due to increased loss of leaves

OIL/DRY WT RATIO	Harvest 1	Harvest 2	Harvest 3	Average All Harvests
Meristem	0.60	0.77	0.67	0.68
Non-meristem	0.96	1.06	1.54	1.19
Significance Level	5%	5%	5%	5%

[Note: There was a statistically significant harvest date x treatment interaction ($P \leq 0.05$): The oil to dry weight ratio increased more in non-meristemmed mint than meristemmed mint. Meristemmed mint was observed to lose leaves disproportionately to meristemmed mint.]

Table 6. Oil compositional character "total heads" (%) from 'Black Mitchum' peppermint either meristem tip cultured (M) or not meristem tip-cultured (Non-M), located in a replicated field trial at the Central Oregon Agricultural Research Center, Madras OR, 1993. [Oil analyzed by Wm. Leman, Inc.]

TOTAL HEADS	Harvest 1, Aug 9, 1993	Harvest 2, Aug 12, 1993	Harvest 3, Aug 16, 1993	Average All Harvests
Meristem	10.3	8.1	8.8	9.1
Non-meristem	10.7	8.6	9.4	9.6
Significance Level	5%	5%	5%	5%

[Note: Differences among harvest dates were statistically significant at the 1% level.]

PEPPERMINT RELAY INTERCROPPING WITH RYE

Alan R. Mitchell
Central Oregon Agricultural Research Center
Madras, Oregon

Abstract

A field of established peppermint (*Mentha piperita*, L) was planted with rye (*Secale cereale*, L.) after harvest to test the peppermint's ability to perform with winter competition in an arid climate. In early spring the peppermint was taller and its leaves larger within the rye canopy than outside. Rye was removed in two of the treatments in late spring by cutting the peppermint and rye at ground level and at 12 inches. In the non-removed treatment, the rye lodged shortly thereafter, probably the result of bird activity. Yield was greatest for the ground-level treatment although there were no significant differences between any of the treatments and a no-rye control. Rye cut at the 12-inch level produced significantly lower dry matter yields. The similar yield of the rye-intercropped peppermint suggests that relay intercropping could be utilized to reduce weeds and to reduce winter nitrate leaching by removing excess nitrogen in the fall. Intercropping may also have implications for insect control and irrigation requirements.

Introduction

Peppermint is a perennial crop grown primarily for oil, which is used in flavoring. As with other high-value crops, peppermint growers use high inputs of agricultural chemicals. Peppermint responds well to nitrogen fertilizer (Clark and Menary, 1980) and growers typically use more nitrogen than removed by the crop. Herbicides are used throughout the year, but especially in the late winter and spring when the peppermint has not produced enough growth to effectively compete with the weeds. The herbicide terbacil (Sinbar, DuPont) has been commonly used as a soil residual herbicide and applied in large amounts during the first years of peppermint rotation, which is generally five to six years.

Relay intercropping is defined as growing two or more crops simultaneously during part of the life cycle of each (Andrews and Kassam, 1976). Peppermint relay intercropping has not been studied as far as we know. Spring mulching with rye has been attempted in the Midwest, where single rows of rye (*Secale cereale*) spaced six to ten ft apart, have been used to prevent wind erosion in the spring (Walt Stevensen, personal communication). These rows are either chopped out later, or left to decay during the summer.

Intercropping would require new growth from the peppermint rhizomes in late spring after removal of the winter crop. Such late spring growth would be similar to that required in the wetter climate of western Oregon, where peppermint is propane flamed in April to control rust pathogens, and the plant must begin its growth from the rhizomes a second time.

The objective of this study was to test the feasibility of relay intercropping peppermint with a cool season crop. If feasible, the practice may have additional benefits of reduced chemical inputs and removal of excess nitrate in the soil. Our goal was to test the peppermint growth under intercropping. Testing which crop species perform better would naturally follow. Rye was used as the second crop because of its cold tolerance and its moderate resistance to terbacil. The treatments consisted of three methods of rye removal in the late spring and a no-rye control plot. The treatments were cutting the rye above the height of the peppermint ("mint level"), cutting all the rye and peppermint ("ground level"), and not cutting the rye ("not cut").

Materials and Methods

The experiment was conducted at the Central Oregon Agricultural Research Center near Madras, Oregon on second-year peppermint (cv. 'Murray'). The peppermint had been planted in March, 1991, and shallow tillage was performed to enhance stand by spreading rhizomes in February, 1992.

The trial was a randomized complete block design replicated three times. Plots were 10 ft by 30 ft with a 10 ft border between blocks. Rye was planted on August 13, 1992 following harvest on July 27. The rye was broadcast by hand on to the plots, then a rotary corrugator was used to throw an approximately 0.5 inch soil mulch on top of the seed. The plots were irrigated the following day. After emergence, some burning of the seedlings was observed, a likely effect of the terbacil and warm temperatures. Reseeding by hand was only partially successful; hence, the plant stand was only half of a full-density grain crop.

A mixture of urea and ammonium sulphate (40-0-0-6) was applied at the rate of 240 lb/ac on April 12, 1993 and 400 lb/ac on June 14, 1993. The total nitrogen applied was 256 lb/ac, the university recommendation. Terbacil had been applied at the rate of 1.5 lb/ac in 1991 and 1.5 lb/ac in April, 1992. In 1993, terbacil was applied to the control plots at a rate of 1.5 pint/ac, but not to the rye plot, which received 1.5 pt/ac of bromoxynil (Buctril, Rhone-Poulenc) on April 12 to control grasses and broadleaf weeds. Thereafter, the plots were hand-weeded.

Precipitation was 14.5 inches, or 183 percent of normal, for the water year to June 1993. Temperatures were also cooler. Rye-removal treatments occurred on June 4, which was later than anticipated, but wet soil conditions due to rain prevented an earlier removal. Plots were cut with a small sickle mower. The mint-level and ground-level treatments were cut approximately 12 and 3 inches above the ground, respectively.

Peppermint was harvested on August 12. Yield was taken as the weight of a swath measuring 40 inches wide by 25 ft long, from which an approximately 10-lb subsample was reserved for oil yield analysis. Sacked peppermint was immediately dried in the open air and stored indoors until distillation at a small-scale research distillery. Oil quality analysis was performed with a gas chromatograph by Essex Laboratories, Salem, OR.

Results

General Observations

From March until June the peppermint growing with the rye was observed to be taller with larger, greener leaves than the control peppermint (Figure 1). At the time of rye removal, June 4, the peppermint within the rye was 12 inches tall, compared to six inches on the control plots. The larger plants within the rye canopy may have been due to a number of factors including frost and wind protection. Because spring in central Oregon is characterized by windy days and cold nights, with the last frost normally occurring in late May, any frost protection would improve growth. Windbreaks have been observed to reduce frost (Kaminski, 1968) and the rye canopy acted as a windbreak for peppermint plants. Increased growth with windbreaks have been observed on other crops where sheltered plants have higher turgidity (Rosenberg, 1966) and greater stomatal aperture (Rosenberg et al., 1967).

Throughout the spring, the rye plots had fewer weeds than the control, which can be attributed to both increased competition and the allelopathic properties of rye (Barnes and Putnam, 1986). Allelopathy is the repression of plants due to toxic chemicals from nearby crops and their residues.

Figure 1. Peppermint growing beneath the rye canopy, Madras, OR, May 13, 1993.

A view of the peppermint following rye removal is shown in Fig. 2. Note that the no-cut rye stood over 3.5 ft tall.

After rye removal, there was no major infestation of weeds, and the peppermint quickly grew to full canopy. There was no rye regrowth from tillers in any of the plots. The rye in the no-cut plot fell over by late June due to either wind or bird activity or a combination thereof. At harvest, there was no rye visible in the plots.

Figure 2. Height of peppermint at time of rye removal, Madras, OR, June 4, 1993.

<u>Yield</u>

There was a significant difference ($\alpha=0.05$) in the peppermint dry matter yield, with the mint-level treatment (2169 lb/ac) yielding less than the other three treatments (Figure 3): ground-level (4022 lb/ac), no cut (5674 lb/ac) and the control (5190 lb/ac). There was no significant difference in the oil yield. The different yield results for the oil and dry-matter may appear to be an anomaly; however, the discrepancy was due to the higher oil concentration of the ground-level treatment because it had no rye stems in the harvested peppermint. The ground-level treatment also had less stem mass because the stems growth started anew in June. Indeed, the yield of the ground-level peppermint treatment emphasizes the earlier finding of Hollingsworth (1981) that oil is to be found primarily in the peppermint leaves, and that only the summer leaves are retained by the plant. The ground-level treatment resulted in plants which were equal in retained leaves, but had less stem mass.

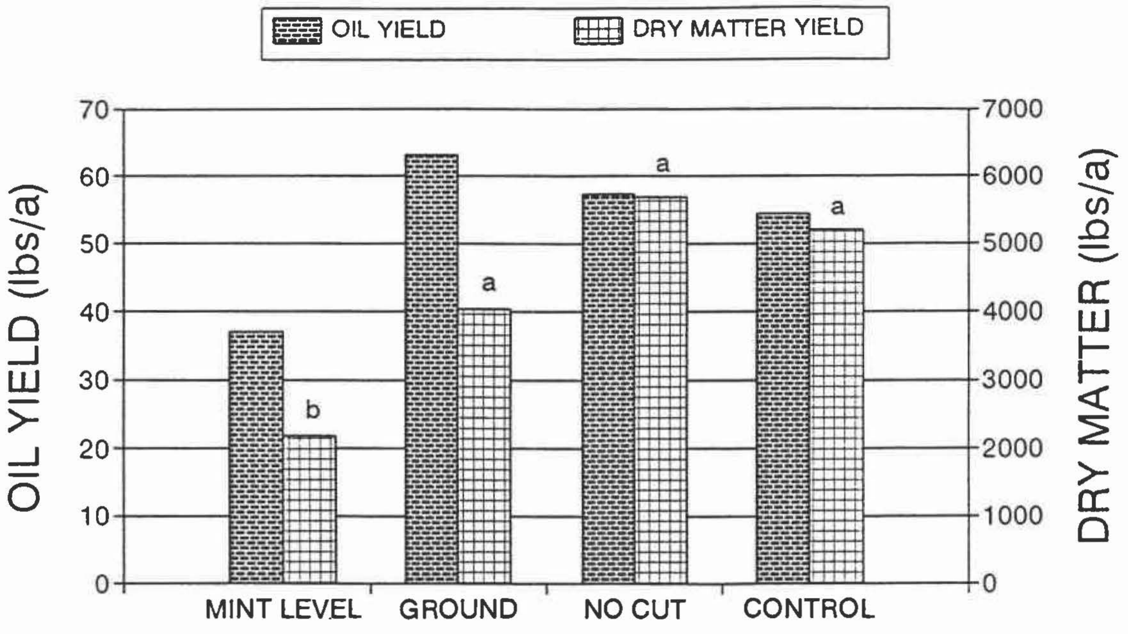

Figure 3. Oil and dry matter yield for the mint intercropping experiment, Madras, OR, 1993. Dry matter yields labelled with the same letter are not significantly different at the 0.05 level by Duncan's multiple range test. Oil yield was not significantly different.

Oil constituent analyses was conducted to test whether rye affected the quality in any way. The results were not available at the time of this report.

Conclusions

The favorable peppermint yield results under relay intercropping with rye are encouraging for production. Excess nitrate in the soil that is susceptible to leaching during winter months could be utilized by fall cover crops as has been demonstrated in other locales (Wagger and Mengel, 1988). In addition, it may be possible to relay intercrop with a grain that would produce a marketable hay crop.

There is the possibility that pests could be better controlled to reduce the reliance on chemical pesticides. Suppression of weeds may result from plant competition, or if the winter crop has allelopathic characteristics (Liebman and Janke, 1990). Control of the two-spotted spider mite by natural predators is encouraged by humid conditions that may occur in the microscale within a crop canopy bounded by taller grains. Biological control of parasitic nematodes with cover crops is an area of intense research in other crops that may also be adaptable to peppermint.

Future research should concentrate on other plant species that may meet some of the objectives listed above. Also, long term effects should be studied because it is not known whether the peppermint can consistently perform under yearly intercropping.

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SURVIVAL OF VERTICILLIUM DAHLIAE IN PEPPERMINT STEMS AS AFFECTED BY PROPANE FLAMING AT VARIOUS GROUND SPEEDS

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Abstract

Research by C. E. Horner, Oregon State University plant pathologist during the 1960s in the Willamette Valley, indicated that post-harvest propane flaming of peppermint could assist in the control of verticillium wilt. An internal stem temperature of 60 °F was necessary, but could be achieved by flaming at 2.5 to 3 mph at 30 psi, 10-12 inches above the ground. The objective of this project in central Oregon was to reinvestigate optimal tractor speed. Due to an inadequate number of plants tagged for symptoms of verticillium, there were no statistical differences between speeds from 2 to 5 mph (at 0.5 mph increments) and untreated plots. However, the trend indicates that percent control decreased with increase in tractor speed, and that speeds above 2.5 mph may not provide adequate control of verticillium wilt.

Introduction

During the 1960s Oregon State University plant pathologist, C. E. Horner conducted research in the Willamette Valley on post-harvest propane flaming as a method of controlling verticillium wilt in peppermint. He reported that an internal stem temperature of 60°F was necessary to kill 85-100 percent of *Verticillium dahliae* in infected stems. The propane flaming recommendation to achieve this temperature was 2.5 to 3 mph at 30 psi, 10-12 inches above the ground.

An informal evaluation conducted in central Oregon by Fred Crowe and Mark Hagman raised the possibility that similar control could be achieved at ground speeds up to 5 mph. As flaming speeds increase, the cost of flaming decreases, providing an incentive for growers to identify the highest speed that will still provide adequate control of verticillium wilt. The objective of this research was to revisit the subject of flaming speed in an effort to identify, under central Oregon conditions, the optimal speed for flaming when considering cost effectiveness and desire for a high level of wilt control.

Methods and Materials

The trial was established with H & T Farms on a 5-year old field of Redefined Murry Mitchum peppermint, near Culver, OR. The eight treatments included speeds from 2 to 5 mph at 0.5 mph increments, and an untreated check. The 30 x 30 ft plots were replicated 3 times in a randomized complete block design. Ten plants per plot, exhibiting symptoms of verticillium wilt, were tagged with Stake Chaser brush type flags. Three-inch stem samples were taken from each flagged plant on August 23 prior to swathing on August 24. Unfortunately, during the swathing process an average of half the flags got caught in the swather and were removed, with some plots having as low as two tagged plants remaining. This reduced the number of plants identifiable for comparison of presence of *V. dahliae* prior to and after flaming. Plots were flamed on August 31 with a Rears 30 ft flamer operating at 40 psi. Post-flaming samples from flagged plants were taken on September 1. Sets of paired samples from some flagged plants were identified as either vertical or horizontal to determine if stem position affected flaming effectiveness.

Stem sections were stored temporarily under refrigeration, then surface disinfected with 5 percent household bleach in water. Ten one-millimeter high sub-sections per stem were placed onto sterile plain agar in Petri plates in the laboratory. Stem sub sections and surrounding agar were visually screened for fungal structures characteristic of *V. dahliae* after one to two weeks. Any stem sub-section with presence of *V. dahliae* was sufficient for the stem to be labelled as infected with the pathogen.

Results and Discussion

Table 1 provides a summary of percent kill of *V. dahliae*, based on companion stems from the same plant from which *V. dahliae* was isolated prior to flaming. The decreased number of samples per plot, due to flag removal by the swather, and pre-samples that appeared to have verticillium symptoms that tested negative, reduces confidence in the results. Decreased number of samples also influenced the statistical analysis, and although the trend is for the percent control of verticillium to decline as tractor speed increases, there are no statistically significant differences ($P \leq 0.05$) between treatments. However, the data suggest that speeds above 2.5 mph may not give adequate kill and there may be a 10 percent drop in kill with every 0.5 mph increase in speed. No differences were detected in presence of *V. dahliae* between vertical stems and those lying horizontal on the ground.

A second year study, perhaps focused on the 2 to 3.5 mph range, is needed to refine the data and increase confidence in the results. Nevertheless, these data support C. E. Horner's original reports and do not support usage of higher ground speeds.

Table 1. Percent kill of *Verticillium dahliae* in stems by flaming with speeds from 2 mph to 5 mph, at 40 psi, near Culver, OR, 1993.

Treatments	Reduction of *V. dahliae* in infected stems
(tractor speed)	(percent)
2 mph	94
2.5 mph	90
3 mph	77
3.5 mph	44
4 mph	59
4.5 mph	58
5 mph	44
Untreated	42

Differences between treatments are non-significant ($P \leq 0.05$).

[1]PEPPERMINT PERFORMANCE AND WILT INCIDENCE, AS INFLUENCED BY SELECTED CULTURAL PRACTICES AND INOCULUM DENSITY OF *VERTICILLIUM DAHLIAE* [YEAR 4]

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Abstract

Large (10ft x 80ft), previously-fumigated field plots (main plots) were uniformly infested in December of 1989 with 0, 0.01, 0.1, 1.0 or 5.0 microsclerotia (MS) of the fungus *Verticillium dahliae* per gram of soil, followed by planting of wilt- and nematode-free 'Todd's peppermint in the spring of 1990. Beginning after harvest in 1990, plots were split. Split plots were either propane flamed after harvest but not tilled at any time; or rototilled in the early spring of 1991 but not flamed. These treatments have been reapplied annually in the fall-spring of 1991-92, and 1992-93. Data is primarily presented for growth and harvest in 1993, but these are compared with data from 1990, 1991, and 1992.

In 1993, percentage ground cover in late spring was about 85 percent for all plots initially infested at 1.0 MS/g soil or less, both tilled and non-tilled split plots, a distinct reduction for tilled split plots compared to previous years. The most pronounced stand depression (to less than 60 percent) occurred in the most highly infested tilled split plots. Stand density in untilled split plots initially highly infested remained below 60 percent as in 1992. In 1993, verticillium wilt symptoms once again were highly associated with initial infestation levels of *V. dahliae*, and tilled but non flamed split plots had 5-20 times as many apparent symptomatic plants than did flamed and non tilled split plots. In 1993, oil yields averaged slightly less than 60 pounds/acre across all treatments compared to 60-80 pounds for various treatments in 1991 and 1992. However, all treatments averaged over 31 pounds per 267 ft^2 harvested split plot area in 1993 compared to just above a 25 pound average for all treatments in 1991 and 1992. Thus, in 1993 there was substantially more growth channeled into upper plant parts, but less into oil production. In 1991 and 1992, oil and dry weights were higher for flamed split plots at higher initial infestations and higher for tilled split plots at lower infestations. In contrast, for 1993 there were no differences between tilled and flamed treatments for any initial infestation levels. Clearly, however, in 1993 peppermint yielded more poorly at the highest level of initial infestation (averaging only 43.6 pounds of oil per acre and only 20 pounds of dry hay per 267 ft^2), than at other initial infestation levels. In 1993, the accumulated past and current manifestations of verticillium wilt (winter damage, in-season plant death, and other influences) resulted in roughly 27 percent and 43 percent decrease in oil and dry weight yields, respectively, at the highest level

[1]This investigation was supported by research grants from the Oregon Mint Commission and The Mint Industry Research Council

of initial infestation, but little or no yield losses from lower levels of initial infestations.

Several mint oil components varied in concentration with tilled or non-tilled treatments, likely related to slight maturity differences in plant growth with these two treatments. There were additional effects of initial infestation levels of *V. dahliae* on compositional differences, which were most pronounced at the highest initial infestation level.

In 1992 and 1993 no microsclerotia were recovered from numerous soil samples from throughout the field trial, suggesting that the population had dropped to well below 0.5-1.0 MS/g soil.

Introduction

This long introduction to a presentation of four years' research results also provides a general overview of the central Oregon and national mint industry with respect to its primary disease, verticillium wilt. Verticillium wilt disease of peppermint is defined here as the interaction of the crop plant (*Mentha piperita*), the pathogen (*Verticillium dahliae*) and the environment. The environment may influence the responsiveness of the crop plant to attack by the pathogen, the ability of the pathogen to grow into or within the plant, or the aggressiveness of this growth. The overall objective of the verticillium wilt management program is to investigate how this disease (thus, this interaction) responds to various management inputs currently or potentially available for commercial farmers. With proper management, production and quality of current and future mint crops in the same field and in a region might be optimized.

Peppermint (*Mentha piperita*) and spearmint (*M. cardiaca* and *M. spicata*) are perennial crops. In established fields, plants spread by means of rhizomes and stolons. A new crop of rhizomes and stolons grow under short photoperiod each year in the late summer and fall from the previous rhizomes and stolons. New rhizomes and stolons produce some roots and stems in the fall, but new roots and stems are primarily produced on these structures during the next spring and summer until flowering. Where winter is mild, both the new underground rhizomes and new above ground stolons may survive, but in colder regions winter survival is primarily as rhizomes. It may be rare for old rhizomes to survive the winter, continue to function and contribute to crop production, although this may occur with *M. cardiaca* in some fields (C.E. Horner, Oregon State University, personal communication).

The primary crop product from these plants is oil formed in glands on the leaves and flower parts, and to a lesser extent on stems. Mint oils are used for flavor and odor, although in earlier times they also were used as preservatives. There are no established industrial uses. The oils are a complex mixture of related terpene-derived chemicals, which change in relative proportion through the season. Optimal oil quality is achieved during the early flowering period at mid- to late summer (6,26,38). At that time, mint is swathed, allowed to dry for a day, then chopped into large enclosed trailers that are delivered to large stills. Steam is passed through the hay in the trailers, and the oil is condensed and stored in large drums. Steam heating of the hay during distillation kills any *V. dahliae* in the hay (M. Lacy, Michigan State University, personal communication). The mint hay then is reutilized as a soil supplement or as animal feed, or is otherwise discarded. Late summer and fall (post-harvest) management of the crop is required for development of rhizomes with sufficient carbohydrate storage to survive winter stresses and for vigorous spring growth (C.E. Horner, Oregon State University, personal communication).

Most mint is distilled initially on the farm. This oil is sold to companies which re-distill and develop blends from various fields and regions to the component composition specifications of end users such as toothpaste, chewing gum and candy manufacturers. Oil composition is of primary concern to the oil buyers and end users. Oil buyers normally contract prices with farmers in advance of production, within certain composition standards. Farmers attempt to maximize oil volume while staying within the contracted compositional standards.

The United States currently produces nearly 100 percent of the world market of mint oils. Because of inferior oil quality, mint is not grown much south of the 42° Latitude in the Northern Hemisphere, and length of growing season limits commercial production much north of the 48° Latitude. Northern and Eastern Europe, Russia, and Asia have suitable land for production, but currently there is no effective competition, to the United States from these regions. In the Southern Hemisphere, there is little agricultural land within suitable latitudes, although a small amount of commercial production occurs in New Zealand and southern Australia.

As indicated above, the North American mint industry primarily is restricted to a band of farmland across the northern tier of the UnitedStates. For peppermint, at least 156 components contribute to the quality of peppermint oil, few which are dominant components. Each geographical region tends to produce a certain compositional character (flavor, odor, taste, color, etc), but each field and each part of each field tends to be somewhat different, and these vary from year to year. Thus, each 500-lb. barrel of mint oil (which may represent from 4-20 acres of fresh mint hay) is separately analyzed by gas chromatography, and is individually blended as needed.

Table 1 lists acres in production, average production per acre, and typical values per pound of peppermint oil produced from each United States regions of production and for several recent years.

For spearmint oils, both Scotch spearmint (*M. cardiaca*) and native spearmint (*M. spicata*) both are produced commercially. Both are grown on fewer acres than peppermint, and have tended to follow peppermint distribution because of similar climatic and soil requirements, industry and grower production expertise, and capital investments in distillation systems. Because spearmint oil is less complex (76 components, dominated by only one or two of these components), cheaper manufactured grades of spearmint oil are more competitive with the natural oil industry than is the case with peppermint oil. For the same reasons, spearmint oils are not distinctive for each region as are peppermint oils, thus their production is focused in areas of highest heat units and yields and lowest production costs, such as the Yakima Valley of Washington, the Columbia Basin of Washington and Oregon, and parts of Idaho. Finally, when manufactured spearmint became highly competitive, federal marketing orders were created to preserve the natural spearmint oil industry. Thus, the creation of spearmint allotments tended to keep production located where it was at that time.

Peppermint and Scotch spearmint are highly susceptible to *V. dahliae*, whereas native spearmint is highly resistant. This project proposal is specifically oriented to verticillium wilt of peppermint, much of this project would be applicable to Scotch spearmint, because of its sensitivity to verticillium wilt.

Prior to wilt development, mint stands were commanly left in production for an indefinite period. Stands of 20 years or more still exist in a few fields. However, once wilt spreads within a field, plants die, mint stands thin, and the planting becomes unproductive, a condition described as "wilting out". The specialized strain or strains of *Verticillium dahliae* which incite verticillium wilt of peppermint and Scotch spearmint now exist in most fields in most mint-producing regions of the United States. Because of limitations on suitable climate and soils, the mint industry no longer has the option of easily relocating to "wilt-free" areas of North America to maintain reliable production.

Limitations on agronomically suitable acreage for mint production has forced United States growers increasingly to replant peppermint into soils which (based on experience) are badly "wilted-out" -- that is soils presumably with high populations of the mint strain that persist from previous disease episodes. With increasing frequency, growers are disappointed to find the second or third planting of peppermint developing severe wilt within the first, second, or third harvest year. This situation has occurred in the past in previous mint producing regions. Gradual intensification of wilt forced such a pattern of mint decline until mint production was discontinued in New England near the turn of the century. After relocation of the industry to the mid-West early in the 1900, many acres were discontinued in Michigan by the late 1940s (26,28). Mint was introduced into Oregon and Washington and in the 1940s and 1950s, and more recently into Idaho, Montana, and parts of Canada. Current intensification of verticillium wilt in western North America, and continued elimination of acreage in the upper Mid-western United States, may represent the third cycle of production decline.

With little suitable verticillium-infested acreage left in North America, combined with increasing attempts to produce quality oil in China and Eastern Europe, the United States mint industry is under pressure to maintain production in verticillium-infested regions in spite of infestation with the wilt fungus.

With wilt infestation widespread in the western United States, current peppermint stands are kept on average about 6-7 years. Stands of 20 years or more still exist, but are few. On average, about one-sixth to one-seventh of the peppermint acreage is replanted each year. Most commercial fields are planted using stems, stolons, and rhizomes dug from either other commercial fields, or from fields grown specifically as sources of rootstock. Collectively, these stems, stolons, and rhizomes are known as "roots", and roughly one acre of dug "roots" will plant about seven commercial acres. Thus, about one acre in 40 (or 2.5 percent) is used as rootstock. [Also, peppermint from a similar small proportion of acres is harvested for dried foliage (e.g. tea leaves).] One of the main ways in which *V. dahiae* is transported among fields is via infected and infested rootstock, including the soil that is necessarily dug and carried along with rhizomes during this process. Nematodes, some insects, and weeds (and possibly viruses, although this is uncertain) are also spread in this manner. The short supply of high quality uninfected rootstock available for planting is a major problem in the mint industry.

V. dahiae survives in soil as melanized, multicelled clusters of cells termed microsclerotia, thought to be somewhat resistant to desiccation and predation. Roots are the part of the plant initially infected from nearby germinating microsclerotia. Most root infections involve only a few surface roots cells, and do not become systemic. Occasionally, root infections become systemic. Hyphae of *V. dahiae* enter the xylem and the fungus grows upward via hyphal growth and by production of conidial spores which move with the transpiration stream. The pathogen becomes established in the upper plant parts prior to symptom development. Symptoms usually are associated with various plant growth stresses, especially moisture and heat stress. Stems and foliage may be stunted, leaves may turn yellow or red then die, and stems die. Oil yield is directly affected by loss of foliage on dead stems, although nearby plants may compensate by increased foliage production (6,28). Preliminary evidence indicates that post-harvest vigor may be reduced and that winter damage may result on rhizomes infected during the summer and fall (9,10,11). Microsclerotia eventually form abundantly in diseased stems above the soil line. It is less clear whether sclerotia form abundantly on diseased rhizomes and stolons. Presumably, few if any sclerotia form in and on roots.

The central Oregon region encompasses Jefferson, Crook, and Deschutes Counties. Nevertheless, research information from this station is applicable for peppermint and spearmint growers throughout much of the inter mountain region of the northwestern United States and western Canada. Peppermint oil ranks between tenth and fifteenth on the list of agricultural commodities for Oregon; in 1990 it was twelfth (30). Combined with a smaller production of spearmint oil (30) and undocumented sales of mint leaves for tea and rhizomes as rootstock, this ranking likely would be elevated by a few positions each year. As shown in Table 1, Oregon produces about half of the national peppermint oil, and central Oregon produces just under half of the state production. In central Oregon, peppermint comprises roughly one fifth of off-farm sales for crops in this region, and (together with grass seed production) is one of the two dominant crops in central Oregon. Prices for central Oregon oil tend to be higher than other regions (Table 1). This is due to a consistently highly desirable oil composition for this region. On the other hand, production costs in central Oregon are higher than in some other regions, and verticillium wilt is widely distributed on the few acres available in the region. When oil prices decline, the acreage in central Oregon tends to decline more than in some other regions where costs of production are lower and where there may still be more verticillium-free acres available. When oil prices increase, the acreage of peppermint in central Oregon may exceed 25,000 acres.

Peppermint began to be generally produced in central Oregon in the early 1960s, and verticillium wilt appeared in the same decade. At the present time, essentially all fields have had at least one mint crop, and many are in their second or third planting cycle for this crop. As has been the case for every new production area, in the early years, the very vigorous but very wilt-susceptible variety 'Black Mitchum' was planted. Stands were kept for many years and were allowed to wilt badly prior to removal. As in most areas where wilt has become established, 'Black Mitchum' now is rarely grown in central Oregon due to its extreme susceptibility to *V. dahiae*. It has been replaced by two somewhat more wilt-tolerant varieties. ['Black Mitchum' is the commercial variety originally introduced into the Unites States in 1883 from England where it already had a long history. In the U.S. 'Black Mitchum' supplanted earlier European garden varieties which had been grown since the 1600's. It is a natural hybrid, and produces few true seed when bred. When these few seed germinate, the oil composition has proven unsatisfactory for the oil industry (28). 'Todds' and 'Murray' were developed in the 1970's as gamma-radiated clones from 'Black Mitchum', and their oil composition is essentially the same as that of 'Black Mitchum'. These new varieties have somewhat higher tolerance to verticillium wilt, but somewhat lower vigor (17,18,19,38).] Unfortunately, as infested fields in central Oregon have been replanted with peppermint, recurrence of wilt often has been unacceptably severe even on these newer varieties. Instead of maintaining vigorous stands for 6-8 years, extensive stand decline and poor yields may occur in year one, two, or three. A similar pattern of wilt has occurred or is occurring in other mint-producing regions. It will not be too many years before most land suitable for peppermint in Idaho, Montana and in smaller inter mountain regions through the northwestern states that will also have widespread wilt infestations.

Verticillium wilt is a dominant and widespread problem in mint production, but *V. dahliae* certainly is not the only commercially-limiting pest problem. Lesion nematode species (*Pratylenchus penetrans* and/or *P. neglectus*), spider mites, several insects with soil phases in their life cycles, and numerous weeds are other common and widespread pests. Regionally, other important diseases include mint rust, phoma stem blight and others, but these rarely are limiting in central Oregon, nor are they necessarily chronic problems in any region. As with most minor crops, available pesticides are few, and fewer yet are being registered. Distillation of mint oil tends to concentrate some pesticides, further eliminating some promising products. Soil fumigants in some cases have temporarily reduced verticillium wilt during the first year or two of perreniating peppermint crops (16,17), but this has not been effective or economical for common usage. Other soil chemical treatments are largely ineffective. For these reasons, methods to manage or control verticillium wilt must be integrated into overall pest and crop management programs.

In central Oregon, the primary management response to intensification of wilt in fields used for peppermint production is to shorten stand lifetimes, rotating mint with other high valued crops, together with the use of the less susceptible varieties 'Todds' and 'Murray'. Except where stands deteriorate rapidly (1-4 years), rotation has allowed continued mint production in infested soils. In the Willamette Valley, rotations usually can be a little longer, as plants seem to be under somewhat less stress. Further, in the Willamette Valley post-harvest propane flaming combined with no tillage or reduced tillage during the stand lifetime was shown to prevent intensification of verticillium wilt, presumably by greatly reducing inoculum production in stems and incorporation into the soil (15,27). In the Midwest, tillage is absolutely necessary to prevent winter kill. Even in the Willamette Valley of Oregon, with fewer insecticides to control soil insects and fewer herbicides to control weeds, there is pressure to resume periodic tillage for control of complexes of insect pests and weeds. Should tillage become necessary for these reasons, thus may eliminate or reduce the impact of propane flaming on verticillium wilt.

Propane flaming without tillage initially was not accepted as a common practice in central Oregon because the dominant tillage component was believed to be necessary to prevent winter desiccation of shallow rhizomes, at least in some years. Rhizomes are covered to approximately 10 cm by the various tillage methods used. Fall plowing plus spring harrow (with a spring tooth harrow) was the common practice perhaps 15 years ago. This provided for good burial of roots (control of winter damage), filling in of blank areas, and good spring weed control of winter annual broadleaf and grass weeds. With the availability of more herbicides and increasing concern that tillage in general exacerbates vert wilt, double or single fall disking, quickly followed by a cultipacker or roller or something similar to pack and seal has become most common. This provides less weed control, with greater dependence on herbicides. There is some movement of roots into bare areas, and some burial of roots a little deeper than without disking. There is a perception (a hope?) that disking may not move sclerotia around as much as plowing, but this has not been verified. Sometimes, there is some rotary hoe activity in central Oregon, particularly when weeds get worse, but there is very little shallow plowing. In recent years, spring tillage may be somewhat favored over fall tillage in the Prineville/Powell Butte area.

From variable performance of mint and disease across soil types within fields, and from anecdotal evidence relating to other crop management factors (fertility, irrigation, time of tillage, handling of rootstock, etc) it may be concluded that the many factors influencing plant stress may aggravate or ameliorate wilt incidence. These stress-related factors should be distinguished from factors that reduce inoculum potential in the soil (i.e. either soil populations, or the activity of these soil populations). Without investigation under controlled conditions, these two classes of factors are not easily distinguished.

Mint was widely planted in central Oregon in the 1960s as one of the few high value crops available. As wilt developed and intensified, most of these fields were allowed to "wilt out" before the crops were removed. The worst fields have only been replanted beginning in the mid-1980s and more recently. Unfortunately, many of these fields have experienced or are experiencing early unacceptable wilt levels on these replantings. Situations intermediate to this scenario exist, also.

Many of the perceptions of peppermint wilt progression over time, and the responses to the disease, depend on assumptions of the population dynamics of *V. dahliae* microsclerotia below the soil. For example, the risk for early and intense disease losses is thought to be related to high populations of microsclerotia on previous mint crops, especially when previous stands were allowed to "wilt out" too extensively before being removed. Similarly, certain crop rotations are thought to worsen or lessen subsequent disease incidence by influencing the number of microsclerotia in the soil. However, few population dynamics have been investigated in mint to confirm these perceptions.

For crops such as cotton, tomato and potato, systemic infections do not develop (immune wilt response) yet they still may have their root cortices colonized. However, these coritical infections do not lead to formation of microsclerotia, which survive from year to year (4). Similarly, V. *dahliae* does not successfully colonize plant debris in the soil (4).

On the other hand, for many crops, crop rotation has not proven effective due to the fact that microsclerotia can persist many years (23). Data for population shifts over time are not generally available. Perhaps microsclerotial numbers regularly decline, but severe disease thresholds still are exceeded. Furthermore, *V. dahliae* may systemically infect and successfully reproduce microsclerotia on numerous plants which may not manifest a disease response such as wilt (13,21,22). The pattern that seems to emerge is one in which soil populations of microsclerotia of *V. dahliae* may decline or increase with both host and non-host cropping systems, but which rarely decline sufficiently for disease control unless plants are totally excluded for many years, or unless very specific rotations involving non-host crops are grown for some period of years. Again, however, little specific data exists documenting the dynamics of such postulated patterns for verticillium wilt of any crop. C.E. Horner, USDA and Oregon State University (retired, personal communication) has recommended production of peppermint in short rotations (to prevent rapid, high buildup of inoculum) followed by strict rotations of corn and certain other non-host crops and soil fumigation can provide a sustainable peppermint production system in spite of the presence of some verticillium wilt. To make this system work, he believes that the soil must not be too highly infested to start with, but there are no population dynamic analyses to support this explanation.

Huisman and co-workers (13,21,22) have described much of the detail of infection of roots of cotton and tomatoes by *V. dahliae* and other fungi. The number of root infections which become systemic within the plant is quite small in proportion of the total number of root infections; several hundred or more root colonies may form per centimeter of root length. Most such root infections only involve a few root surface cells. In general, the number of root infections is proportional to the inoculum density, and this is true of numerous soil fungi including many saprophytes and some pathogens (13,21,22). As summarized by Huisman (21) for both his own work and related work of others: "...*V.*

dahliae is primarily a colonizer of the rhizoplane and/or root cortex and is adapted to a wide host range. Almost all plants thus far examined (57 out of 63 species), including both dicotyledenous and monocotyledonous plants, were colonized. The colonization rate of roots is surprisingly uniform. Whether a plant is susceptible or immune to systemic invasion appears unrelated to the ability of the fungus to colonize the root cortex. The principal difference between wilt susceptible and immune plants would appear to be the ability by the pathogen to systematically invade the vascular system of the former. However, systemic invasion is of profound significance in the buildup of populations in the soil..", as this is where large number of microsclerotia are produced. No differences in initial root colonization were found among cotton cultivars varying widely in resistance to wilt (21,22).

Although root infections may be proportional to inoculum density, it does not automatically follow that this is true for systemic infections. However, Ashworth and Huisman did report that various cotton (1) and tomato (2) cultivars varying in resistance to wilt showed distinct inoculum density vs. disease relationships in the field. Similarly, the number of systemic, symptomatic infections in the field has been related to the number of propagules of the pathogen in the soil for pistachios and olives (L. Ashworth, personal communication), and potatoes (8).

Lacy and Horner (25) reported (1-yr microplot data) that peppermint responded adversely to increased inoculum density, however, their ranges of infestation were much higher than typically found in the field. Preliminary data from an earlier phase of this project proposal, from a long term experiment using large field plots, supports this concept (9,10,11), but lowered the biologically meaningful range of infestation well below that tested by Lacy and Horner.

Various soil factors may affect the relationship between inoculum density and disease. Inoculum potential may be reduced by either reducing inoculum density (the number of soil propagules per unit of soil), or by lowering the effectiveness of propagules.

Microsclerotia of *V. dahliae*, normally held dormant by various soil organisms (3,34) germinate in soil in response to nutrients leaking from plant roots (34). In cotton, Ashworth et al reported that copper in soil also might influence this fungistasis (3). Cappaert et al. (8) found that early season root infections were those primarily involved in later season potato early dying, and that early season moisture greatly affected the incidence of potato early dying. High early irrigation levels led to higher late season disease, and low early season irrigation resulted in little late season disease. In a follow-up analysis of this effect, Gaudreault (12) found that high soil moisture levels lowered the number of early root infections by *V. dahliae* on potato, but elevated the total number of infections which became systemic. Perhaps this was caused by orienting these infections near the undifferentiated tissues of root tips in roots, that were very slow growing due to the excessive moisture. Gerik and Huisman (13), have shown (along with others cited in their paper) that *V. dahliae* never penetrates matured vascular tissue behind root tips, but must infect the vascular system in the region of early differentiation near to root tips.

Others have shown that factors that slow or impede root growth seem to exacerbate wilt infections (2), so a common mechanism may be any condition that slows root growth enough to allow for microsclerotia to germinate and infect prior to rapid root elongation, differentiation, and vascular maturity.

Based on studies on other plants, the number of microsclerotia formed in superficial root infections (i.e. the ones that do not become systemic) may not much affect inoculum densities (13,21,22). On the other hand, large upward shifts in microsclerotial populations arise from the large numbers of microsclerotia forming in above ground stems, that eventually find their way into the soil (1,13,20,33). Flaming of stems after harvest is beneficial because, flaming kills most of the fungus in stems. "Eventually", however, is not a well-defined period -- it could take a year or two or more for sclerotia bound in stems to become free in soil as stems decay and soil is tilled or mixed by animals in the soil. Huisman and Ashworth (23) working with cotton and Davis and Huisman (Univ. Idaho and Univ. Calif., respectively, personal communication) working with *V. dahliae* on potatoes, found that increases in soil populations usually lagged disease incidence by a year or two, until stems broke down and released microsclerotia and the soil was tilled. Further, J. Davis (Univ. Idaho, personal communication) has observed an increase in potato early dying prior to his ability to recover increasing microsclerotia from soil during the stem decay processes -- an observation similar to ours above for mint. In 1991, sample cores could have missed these clumps of microsclerotia forming from stems infected in 1990. On this basis, our lower-than-expected microsclerotial recovery might primarily represent residual inoculum, free in the soil. It is not known just when sclerotia form in stems, or under what conditions they form after stem death.

Clearly, the verticillium wilt problem with peppermint is related to extreme susceptibility of available varieties, in addition the vegetatively propagated nature of the crop that allows easy disease transferal among fields. Peppermint (*Mentha piperita*) and spearmint (*M. cardiaca*) are both highly susceptible to *V. dahliae*, whereas native spearmint (*M. spicata*) is highly resistant. The 'Black Mitchum' variety of peppermint is the original variety introduced into the United States in the 1600s. Attempts to improve upon this variety have proven difficult. Peppermint is a hexaploid (probably a hybrid between *Mentha aquatica* and *M. spicata*) from which it is difficult to get seed (28). When crosses are successfully made within peppermint (perhaps one germinable seed per million ovules), the offspring are unstable and oil composition rarely is acceptable by industry standards. Consequently, no new lines ever have been generated by true breeding. Two new varieties ('Todds' and 'Murray') were developed and introduced to the industry in the 1970s. These were produced by mutation breeding with gamma radiation, which has at least maintained the oil compositional characteristics of 'Black Mitchum'. These and other selections produced in this manner occasionally have increased tolerance to verticillium wilt, but also have reduced vigor (17,18,19,37). Attempts to improve the resistance of spearmint have not been any more successful than for peppermint.

The usage of 'Todds' and 'Murray' varieties of peppermint, along with reductions in length of stands are left in the ground, are the basis of "second generation" mint production in wilt infested regions. Even these varieties "wilt out" under intense disease pressure in many fields, so private breeding efforts still are maintained by the mint industry. Recently, there have been efforts toward development of somaclonal variation and other "biotechnologically oriented" ways of manipulating mint to produce wilt resistant varieties of acceptable oil composition (M. Lacy, Michigan State University, personal communication). Currently, however, there is no standardized testing of any selections produced by any means, and the principal investigator may participate in development of such standards and in screening of selections.

With such a narrow genetic base in the host plant, strains of varying pathogenicity in *V. dahliae* have not been distinguished. Strains that incite typical symptoms on peppermint are referred to as "mint strains" and those that do not are considered non-pathogenic (28). One exception is that strains pathogenic to potato (potato early dying disease) may elicit a mild leaf symptom on peppermint, which does not progress into typical wilt. New techniques for comparison of strains have been used for large collections of strains of *V. dahliae* (35), but the mint strains have not yet been tested in this manner.

With respect to pathogenicity of *V. dahliae*, it is possible that enough genetic variation actually exists among commercial and non-commercial mint selections and varieties, and among other mint species, that several strains might be distinguished. This could be useful should it be shown, for example, that pathogenicities among strains vary among region, with crop rotations, with nematode interaction, etc.

Data reported below are for four years from a field trial located in central Oregon to investigate mint performance as affected by: (a) a range of soil infestation levels by *V. Dahliae*, and (b) either post-harvest propane flaming without any soil tillage or soil tillage without any post-harvest propane flaming.

Materials and Methods

Todd's Mitchum peppermint roots were obtained from commercial, field-grown rootstock, excluded from certification only because the source field was within 5 miles of known infested fields. No *V. dahliae* was found in this rootstock, and no nematodes were found in either soil from the rootstock field or from the rootstock. Roots were planted in February, 1990, in soil fumigated in 1988 with 400 lb/ac Methyl Bromide + Chloropicrin (54/46 percent). The test site had never been in mint, but had been in potatoes several times. Using soil assays described below, a low level of "potato" strain of *V. dahliae* was found in the plot area prior to fumigation, but not after.

Inoculum (microsclerotia) of *V. dahliae* pathogenic to mint was grown in the laboratory during 1989 on cellophane agar, then dispersed in a blender, mixed with sand, and air-dried. Three months prior to planting, main plots 10 x 80 ft were infested with 0, 0.01, 0.1, 1.0 and 5.0 microsclerotia (MS)/gram (g) soil and to a depth of 6inches in various plots. Main plots were arranged in a randomized strip block experimental design with five replications. Grass borders had been established in 1989, and a rigorous program of equipment sterilization, solid set irrigation and field usage patterns was followed after fumigation to limit cross-contamination among test plots.

Mites were treated once in each of 1990, 1991, and 1993 (Comite), but a high predatory mite population suppressed two-spotted mites in 1992 and at other times such that no miticide was needed. Sinbar was used in each year. In addition, plots were weeded by hand, and Buctril was applied after harvest in 1991 and 1992 for groundsel control. Rates and timing of application of all products was as per recommended practices in the area. In 1990, all plots received 100 lbs/ac N in early April and 150 lbs/ac N in early May. In 1991, 1992, and 1993 plots received 80 lbs/ac N in April, 120 lbs/ac N in late May, and 75 lbs/ac N in late June. Mint was irrigated as per typical local farmer practices -- drought stress was not allowed to develop at any time of any year.

Within the trial area above, duplicate sets of split plots within main plots were created for management under either flame/no plow or no flame/plow management systems (16,27). In each year, half of the plots were flamed within 1 week after harvest, and irrigation was resumed. The other split plots were tilled to a depth of 6 inches in early spring (last week of February or first week of March).

As an estimate of stand density, percentage ground cover was determined on first-year mint on August 20, 1990, excluding both bare ground and dead top growth. In 1991, 1992 and 1993 ground cover was determined earlier (June) because mint growth was more abundant. Ground cover was again determined in the fall of each year, after harvest. In each year, fresh hay was harvested with a 40 in wide forage swather along the 80-ft plot length (267 ft^2). Fresh hay was weighed and sub samples were taken for dry weight and oil yield determination. Hay from the remainder of the plots was swathed and removed immediately following harvest of data strips. Mint was harvested on August 27 in 1990, on August 23 in 1991, on August 1 in 1992, and on August 18 in 1993. Differences in maturity associated with tillage or non-tillage were observed in 1991, and in 1992 this was noted again and is discussed below. Oil was distilled at the OSU-Corvallis research still in 1990-92 and at the OSU-COARC research still in 1993, either from fresh hay within a few days of harvest, or later from dry hay. Distillation procedures were as per Hughes (20), with distillate emerging from condensers between 110-120° F. Oil composition was determined by gas chromatography from oil samples provided to the A.M. Todd Co., Kalamazoo MI.

Mint growth is such that identity of discrete plants is difficult, but it was assumed that plants with symptoms appearing at least 8 inches from other plants with symptoms resulted from discrete infections. There was no attempt to distinguish symptoms arising from fresh root infections from *V. dahliae* residing in the soil, from infections that may have carried over the winter in infected but surviving rhizomes. Wilt incidence was evaluated weekly to every two weeks once symptoms appeared. Wire-based flags were placed near each fresh symptomatic plant, at least 8 inches distant from other symptomatic plants.

Percentage ground cover, wilt incidence, fresh hay weight, dry hay weight, oil yield, and selected other measurements collected from plots were analyzed by analysis of variance.

Soil samples were taken with a 1-inch core sampling tube to 6-inch soil depth. For each of two duplicate sub samples, 20 cores were composited. In some cases repeated samples were taken. Soil was air dried for 4-6 weeks to eliminate spores and mycelium of *V. dahliae* but not the resistant microsclerotia (1,7,29). After grinding of soil, 50-g samples were blended for 30 seconds in 200 mls water containing 2 g Calgon and 2 ml Tergitol to disperse soil particles. Soil was then wet-sieved through 120- and 400-mesh screens and the residue surface sterilized briefly (5 sec) twice between rinses. Residue was allowed to settle and the volume was adjusted to 50 ml with water. The sample was then stirred, and 20, 1-ml aliquots were spread across 20 petri plates containing a selective growth medium (7,24,29). Plates were incubated at room temperature for 2 or more weeks before observing for colonies of *V. dahliae*. Alternatively, a separate analysis was conducted with an Anderson Air Sampler, in which microsclerotia are recovered from smaller soil volumes, pulverized and passed through an air system for direct and uniform deposition on plates containing selective growth medium.

Results and Discussion

Crop stresses, 1992-1993: The trial area was well irrigated and should not have been stressed in the fall-winter of 1992-93. The winter of 1992-93 was of average temperature, with substantial snow cover, and also should not have resulted in crop stress. Spring rains were abundant and precluded moisture stress during this period, including soon after spring tillage. The spring was cool and damp, retarding early mint development. The summer was without excessive heat. These spring and summer influences may have retarded mint development and resulted in lower oil yields, even though hay dry weights were high. Verticillium wilt results from the interaction of vascular plugging incited by the fungus, combined with transpiration demand. Transpiration demand and wilt are exacerbated during hot weather. Nevertheless, wilt symptoms appeared somewhat early compared to other years, and appeared on mint regrowth after harvest as the heat persisted into late summer. Spider mites built up near to harvest but were controlled without apparent adverse plant response. As in 1992, pin nematodes (*Paratylenchus*) were found to be abundant in soil samples. Numbers per quartt of soil ranged as high as 100,000 pin nematodes. There was no relationship of numbers of pin nematodes with treatments. It is undetermined whether pin nematodes created additional crop stress. Except for weediness as discussed below, no other growth stresses were noted.

Ground Cover: Stand density, as determined by the plot surface area, green with late spring/early summer mint growth (expressed as percentage ground cover), is shown for 1990 through 1993 in Figure 1. Percentage ground cover was above 96 percent for all initial verticillium infestation levels in the late spring of 1990. After the first season of mint growth and verticillium wilt activity, the first round of split plot treatments, and a near-record cold winter of 1990-91 on an open field, percentage ground cover in the spring of 1991 remained above 95 percent where split plots were spring tilled, but dropped to about 80 percent for all initial verticillium infestations of 1.0 MS/g soil or lower. These differences were statistically significant ($P<0.05$). Most dramatic, percentage ground cover at the initial 5.0 MS/g soil infestation dropped to below 30 percent, clearly implicating an interaction between high levels of verticillium infestation and winter injury (5).

In 1992, stand differences remained as for 1991, but slightly recovered for all non-tilled split plots -- 85 percent for plots initially infested with 1.0 MS/g soil or less, and near 60 percent for the highest rate of initial infestation. These stand differences were statistically significant ($P<0.05$).

In 1993, ground cover for both tilled and non-tilled plots was about 85 percent for initial verticillium infestations of 1.0 MS/g soil or lower. Ground cover for both tilled and non-tilled plots at the highest rate of initial infestation averaged just below 60 percent. Thus, in 1993, there was a statistically significant ($P<0.05$) and distinct drop in stand density for all tilled plots compared to previous years, with the most pronounced depression occurring in tilled plots in the most highly infested plots. The reasons for this are not understood, but may be due to additional interactions between crop management, *V. dahliae* and crop growth.

Weeds: Winter annual broadleaf weeds, especially Groundsel *(Senecio vulgaris)*, were again abundant in all untilled split plots in the spring of 1993, and through the season. Tillage in late February or early March largely eliminated these weeds for several months in tilled split plots.. By summer, these weeds spread back into tilled split plots, requiring control efforts in all plots. Concerning grassy weeds, Rat Tail Fescue *(Vulpia myosuroides)* was abundant in untilled split plots in the fall of 1992 and the spring of 1993. Possibly, the trial area was irrigated too abundantly in 1992, flushing any residual Sinbar from the relatively sandy soil at the Powell Butte farm, and allowing the Rat Tail Fescue *(Vulpia myosuroides)* to establish. Additionally, because of the very wet spring, Sinbar was applied late, delaying the herbicidal effect on this grass until early summer. Peppermint growth was retarded in some plots due to grass competition, but seemed to recover and appear normal by harvest. Harvest data may reflect some of this effect, but this is unclear.

Growth & Development: In 1991 and 1992, it was noticed that tilled plots were slightly delayed in growth and development compared to untilled plots. Presumably, tilled plants needed to re-establish a root system whereas untilled plants were not delayed. Such growth and developmental differences likely account for some quality differences at harvest, but data from each year do not indicate any clear effect on yield components. However, the experiment was not designed in a manner to measure such effects. Growth and development were quantified and reported earlier for 1992 (9), and 1993 growth was quite similar to 1992, except for the effect of grassy weeds as indicated above.

Wilt incidence: Verticillium wilt incidence for 1990-93 is shown in Figure 2. Verticillium wilt symptoms once again were highly associated with initial infestation levels of *V.*

dahliae. Tilled but non flamed split plots had 5-20 times as many apparent symptomatic plants than did flamed and non tilled split plots, statistically significant ($P<0.05$). There was not a dramatic increase between years with respect to the total number of symptomatic plants in tilled split plots as there had been in the previous two seasons. Nor was the number of symptomatic plants per unit spring ground cover much different in 1993 than in 1992. This suggests that more damage resulted in 1993 from the undetermined spring x management interaction discussed above than from in-season plant death.

The "Horner" model (15,27) for verticillium wilt incidence changes associated with tilling and flaming seem to partially, but not totally, hold for the data from this trial. From the beginning, there has been a difference in the amount of in-season wilt in tilled vs. flamed split plots. This difference has widened slightly, but not as substantially as the Horner model would suggest. This is further discussed with the results of soil assay recoveries of microsclerotia in the next section.

Plot integrity: It would shorten the useful lifetime of this field trial if wilt intensifie in initially non infested plots. During 1991 and 1992, a slight amount of wilt symptoms appeared in initially non infested plots, presumably from cross-contamination. Rodents and deer have browsed in the plots, worms and insects have been found in the soil profile. In spite of strict measures to prevent movement with machinery and personnel, these may have transported some inoculum among plots. To date, there has very little gopher activity in the plots, although these exist elsewhere on our field. No net increase in the apparent contamination occurred in 1993; if relatively little disease continues to occur in these plots, we believe that this study can continue for several more years.

Harvest yields: Harvest yield was determined by several different measures. Fresh hay weight was measured from the 40-inchs x 80 ft harvested strip (267 ft^2) along the plot centers. Percentage moisture was determined from sub samples of fresh hay, which were then dried. Dry weights were calculated from fresh weights and percentage moisture and were highly correlated (>95%) with the directly measured fresh weights. Fresh hay weights are not shown, but dry weight means for each treatment are shown graphically in Figure 3 for all four years. Oil was distilled from sub samples of fresh hay from each plot (or this sample was dried for later distillation), ranging from 8-11 pounds of fresh hay per plot. Oil yield on a per acre basis was calculated using fresh weights and oil recovered from sub samples. Mean oil yield for each treatment is expressed graphically in Figure 4 for all four years.

Plant harvest performance was measured as dry weight per harvested strips through split plots, and oil per acre distilled from hay samples from each split plot. In 1993, oil yields averaged slightly less than 60 pounds/acre across all treatments compared to 60-80 pounds for various treatments in 1991 and 1992. However, all treatments averaged over 31 pounds per 267 ft^2 harvested split plot area in 1993 compared to just above a 25 pound average for all treatments in 1991 and 1992. Thus, in 1993 there was substantially more growth channeled into upper plant parts, but less into oil production. This seems to verify commercial growers experience for the region. In 1991 and 1992, oil and dry weights consistently were statistically significantly higher ($P<0.05$) for flamed split plots at higher initial infestations and higher for tilled split plots at lower infestations.

In contrast, for 1993 there were no statistically significant differences ($P<0.05$) between tilled and flamed treatments for any initial infestation levels. Clearly, however, in 1993 peppermint yielded more poorly ($P<0.5$) at the highest level of initial infestation (averaging only 43.6 pounds of oil per acre and only 20 pounds of dry hay per 267 ft^2), than at other initial infestation levels (which averaged more than 60 pounds of oil per acre and about 35 pounds of dry hay per 267 ft2 split plot harvested area). In 1993, the accumulated past and current manifestations of verticillium wilt (winter damage, in-season plant death, and other influences) resulted in roughly 27 percent and 43 percent decrease in oil and dry weight yields, respectively, at the highest level of initial infestation, but little or no yield losses from lower levels of initial infestations.

Oil composition: Over 30 oil components were evaluated, and most data are not presented here. Relative composition of selected components is shown in Figure 5. As in 1992 (9,10), several mint oil components varied in concentration with tilled or non-tilled treatments, likely related to slight maturity differences in plant growth with these two treatments. Again as in 1992, there were additional effects of initial infestation levels of *V. dahliae* on compositional differences. Data in Figure 5 are included for esters, menthofuran, and menthofuran. All data is statistically significant ($P<0.05$). Data and statistical significance were most pronounced at the highest initial infestation level, likely associated with plant stresses induced by *V. dahliae*.

Block effects ans interactions: Statistically significant block effects and interactions ($P<0.05$) occurred in some years for several measured parameters. These occurred with plant height vs. initial verticillium infestation vs. blocks, wilt incidence vs. blocks, and all yield measurements vs. initial verticillium infestation vs. blocks. In general, mint height and yield were greatest on the east end of the field where soil was deepest (12-18 inches), but diminished toward the west, where soil was shallower (8-12 inches) and where soil stayed wetter after irrigation or precipitation. Wilt incidence was highest on the east, and diminished toward the west. These generalizations were true for both non infested plots and for all infested plots up through the initial 1.0 MS/g soil infestation rate. Interactions occurred with the exceptionally highly infested plots (initially 5.0 MS/g of soil). In these plots, the direction of the block effects described above frequently were reversed. Plots on the east end were watered sufficiently to avoid drought stresses, such that plots toward the west were at times over-watered. We offer no specific explanation for these effects at this time, but these may be worthy of study in themselves if they might reveal clues to optimum management for both mint performance and wilt control.

Recovery of MS from infested plots: Measurements of MS/g soil at the inception of the trial were near to calculated infested amounts. By 1991, soil assays indicated the soil population of survival structures of *V. dahliae* had dropped from 5 or more MS/g soil to around 1.5 MS/g soil in the initially most highly infested plots , both in tilled+non flamed and flamed+non tilled split plots. In 1992 and 1993 no microsclerotia were recovered from numerous soil samples from throughout the field trial, suggesting that the population had dropped to well below 0.5-1.0 MS/g soil, the limit of the soil assay for individual soil samples. No microsclerotia were found in 1992 or 1993 even where the initial infestation was near 5.0 MS/g soil just a few years earlier.

For verticillium wilt diseases of several crops, the number of microsclerotia formed in superficial root infections (i.e. the ones that do not become systemic) seemingly only maintain or slightly shift initial inoculum densities (21,22). On the other hand, large upward shifts in microsclerotia populations arise from the large numbers of microsclerotia which form in above ground stems and eventually find their way into the soil (1,21,22,25). Flaming of stems after harvest, is beneficial because flaming kills the *V. dahliae* abundantly produced in stems. "Eventually," however, is not a well-defined period, but there is evidence that microsclerotia appear dispersed from stems into soil somewhere between 1-2 years (1,21,22,25, and J. Davis, University of Idaho, personal communication). Presumably, in our trial there has been plenty of time for appearance of sclerotia formed in stems during 1990, 1991, and 1992, but none have been seen.

Recovery efficiency may be poor for some soils, perhaps including the soil from our trial, but there are no known completed and reported studies of recovery efficiencies of microsclerotia of *V. dahliae*. Microsclerotia recoveries can vary seasonally, with mid-summer recoveries 2-4 times early spring and late fall levels (24). We have taken some care to measure our populations at mid-season when they are thought to be highest. The actual number of microsclerotia soil may not be so highly variable. Measured seasonal variability might have much to do with the ability of microsclerotia to germinate on selective media at different times of the year, perhaps due to the seasonal dynamics of other soil biological factors. Investigation of recovery efficiency has been proposed as part of this continuing project, but was not funded.

It is may be possible that very low soil populations of *V. dahliae* microsclerotia can result in the disease patterns seen above. Why then does so much disease seem to result from postulated but unmeasurable levels in later years compared to 1990 and perhaps 1991? Conceivably, the lab grown inoculum has a lower level of activity than naturally-produced inoculum. An alternate hypothesis is that inoculum of *V. dahliae* has largely disappeared from the trial area during the course of the experiment. This would indicate that nearly all disease would carry over within rhizomes infected during the first year or two, and regularly re-infected each season. C.E. Horner, (personal communication), has described peppermint as regenerating a new set of rhizomes each fall, with subsequent death of old rhizomes each winter and spring. Very little spring growth results from rhizomes which produced the stems for the previous crop. Wilt symptoms continue to appear on re growth after harvest in August, up until fall dormancy, so clearly some infected rhizomes over winter to contribute to disease the next year. [Recall the enhanced winter kill in plots initially most heavily infested. These also were the plots with the greatest fall carryover of infected rhizomes.]

But why would soil-residing inoculum all but have disappeared and failed to be replaced by ongoing disease? Three possibilities are: (1) Soil in the Powell Butte area, and specifically on the COARC research farm at Powell Butte may be suppressive to *V. dahliae*. Soil suppressivness is a descriptive term which describes the failure of a soil pathogen to thrive in certain soil, and usually is related to the antagonism of other organisms. This is a well known phenomenon, but is not reported widely for verticillium wilt diseases. We know of no reports from field soils which describe the total failure of *V. dahliae* microsclerotia to survive, although such reports may exist. Interestingly, there is relatively little wilt in the greater Powell Butte area, even though mint has been produced there for many years. (2) *V. dahliae* may not form many microsclerotia on stems of the 'Todds' variety used in the trial. This seems unlikely given the close relationship of 'Todds' with 'Black Mitchum', a variety on which that microsclerotia may form abundantly (15,25,27,28). (3) Perhaps delaying spring tillage allowed other organisms to displace (consume?) any microsclerotia that may have formed in the stems the previous fall in non flamed split plots, together with natural attrition and lack of replacement in flamed and untilled plots. Combinations of mechanisms of these and other mechanisms could be occurring.

We finally decided against the possibility that poor or inconsistent technique or peculiar soil effects were interfering with soil assays. Over several years, we sent parts of several soil samples to several other laboratories that regularly assay soil for *V. dahliae*, then measured similar recoveries. Occasional elevated recoveries in our lab have been attributed to the presence of ephemeral conidia, suggesting that certain soil samples were assayed too quickly for conidia to have died off. To determine whether conidia are present we re-assay soil at a later date. No recovery of *V. dahliae* resulted upon re-assay. Of course, if these occasional conidial recoveries were real, then the conidia themselves must have come from somewhere. Presumably, they may have come from sporulation from microsclerotia in soil, but they also may have come from roots and rhizomes picked up in the soil sample tubes.

General discussion: Huisman (21,22) has described much of the detail of infection of roots by *V. dahliae* and other fungi. With other crops and non-crop species, the number of root infections becoming systemic within the plant is quite small in proportion to the total number of root infections. Several hundred or more root colonies may form per centimeter of root length. Most such root infections only involve a few root surface cells. In general, the number of root infections is proportional to the inoculum density, and is true of numerous soil fungi including many saprophytes and some pathogens (10). As summarized by Huisman (22) for both his own work and related work of others:

"...*V. dahliae* is primarily a colonizer of the rhizoplane and/or root cortex and is adapted to a wide host range. Almost all plants thus far examined (57 out of 63 species), including both dicotyledenous and monocotyledonous plants, were colonized. The colonization rate of roots is surprisingly uniform. Whether a plant is susceptible or immune to systemic invasion appears unrelated to the ability of the fungus to colonize the root cortex. The principal difference between wilt susceptible and immune plants would appear to be the ability by the pathogen to systematically invade the vascular system of the former. However, systemic invasion is of profound significance in the buildup of populations in the soil..", as this is where large number of microsclerotia are produced.

No differences in initial root colonization were found among cotton cultivars varying widely in resistance to wilt (21,22). In spite of our uncertainty of the changes in population of microsclerotia in our plots soils, we suspect this summary describes the situation with root infection of peppermint.

Although root infections may be proportional to inoculum density, it is not necessarily true for systemic infections. Ashworth and Huisman (1) reported that various cotton cultivars varying in resistance to wilt showed distinct inoculum density vs. disease relationships in the field. Similarly, the number of systemic, symptomatic infections in the field has been related to the number of propagules of the pathogen in the soil for pistachios, olives, and tomatoes (L. Ashworth, personal communication), and potatoes (M. Powelson, personal communication). With respect to the initial amount of microsclerotia of *V. dahliae* which we put into the soil in this trial, our data certainly verifies these other reports.

With respect to oil yield, in 1991 and 1992 the superior performance of flamed vs. tilled mint at the higher initial levels of infestation seems to fit with prior mint production concepts. These differences were not suspected based on visual observation; based on ground cover data and weediness, the flamed plots appeared distinctly inferior during the season even though the mint in flamed plots tended to grow a little earlier than in tilled plots. As the mint compensated for gaps, however, the appearance of plots became more uniform. In 1992, yield differences between flamed+non tilled and tilled+non flamed treatments were not present. The reasons for this are yet unclear as discussed above, but suggest that the "Horner" model for flaming without tillage may need to be modified in some situations, perhaps based on variety, region, or timing of these operations.

In 1990 and 1991, superior mint performance at an intermediate level of the range of infestation was measured and reported (this data is not reiterated here). This was not expected, but could indicate that there can at times be a beneficial biological relationship between certain inoculum densities of the fungus and the plant, below which this beneficial effect is absent, and above which the relationship becomes pathogenic. In 1992, there was no evidence of enhanced performance associated with low to intermediate *V. dahliae* infestation levels. In 1993, there was again elevated mint performance at initially intermediate infestation ranges (Figures 1, 3 and 4). We are aware of only one previous journal report of a beneficial effect of *V. dahliae*, on tomato (5). [Note in citation 2 that the name of the pathogen is labeled *V. albo-atrum*, which was the name used for *V. dahliae* at that time. *V. albo-atrum* still is used for a closely related pathogen.] Rooted mint cuttings inoculated with potato strains of *V. dahliae* seemed to grow taller than non inoculated cuttings, whereas the mint strain incited wilt as expected. (9) In our field trials, no potato strain was present, and the isolates used to infest the trials all were confirmed pathogenic to mint. All isolates of *V. dahliae* recovered from mint during the trial has been pathogenic when inoculated back into mint. Thus, in our field trial it seems as if the pathogenic strain of *V. dahliae* may be conferring a growth advantage at low levels of infestation, but a pathogenic effect at higher levels. What this means for commercial production is not clear, and it may not occur in all fields and for all improved varieties, and is almost certainly not true for 'Black Mitchum'.

Block and interaction effects reported here may offer leads toward other management tools for verticillium wilt of mint. For example, Cappaert et al. (8) found irrigation management during early and mid-season to be an effective toll for suppressing *V. dahliae* and in reducing incidence of potato early dying disease.

Conclusions [1990-1993]

1. Verticillium can interact with cold temperatures to lower winter hardiness of peppermint. [A similar phenomenon was reported for *Pratylenchus* nematodes for peppermint in the same winter (33).]

2. Mint (at least the 'Todds' variety used in our field trial) can greatly compensate for poor stands due to verticillium. Whether the mint in our highest rate of infestation has '"wilted out" is subject to interpretation.

3. Weeds are encouraged and weed control is exacerbated with poor stands and lack of tillage. Verticillium wilt itself (or other causes of stand thinning) exacerbate weed problems.

4. The number of plants which die following development of wilt symptoms in the field during the growing season increased with increasing initial numbers of MS in the soil.

5. The "Horner" model for management of wilt, and explaining how wilt of peppermint increases or decreases under certain management practices, may require some modification in parts of central Oregon, or with modern semi wilt tolerant, or under certain practices modified from the original methods.

6. Much of the wilt which occurs in one year carries over as infections internal to over wintering rhizomes, without the need for re-infection from the soil. This concept seems to apply in the above trial, and was expressed by Nelson in 1950 (28). These observations certainly fit with the concept that much wilt is carried internal infection inside rootstock, irrespective of whether the soil clinging to the rootstock is infested with microsclerotia.

7. Inoculum may not have increased in our trial in a manner substantial enough to account for serious wilt problems on a subsequent mint crop. This may not be a justified statement, however, if the wilt levels observed may occur from sub assayable levels. It is intended that mint will eventually be removed from these plots, that the plot integrity will be retained during some rotation crop sequence, and that the plots will be replanted so that future mint performance can be related to current mint performance and soil infestation levels of *V. dahliae*.

8. Low levels of the mint strain *V. dahliae* and possibly the presence of non pathogenic strains of *V. dahliae* may confer some slight growth advantage to peppermint. This observation needs confirmation, clearly is not true for higher infestations, and may not be manageable phenomenon if true.

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Table 1. Acreage, yield, and unit value of peppermint oil produced in the United States for various recent years. (Source : A. M. Todd Co.)

Product Region [1]	Midwest (IA,MI,WI)	Willamete Valley, OR	Central Or & LaGrande, OR [2]	Columbia Basin (OR&WA) Yakima Valley, WA	Montana	Idaho	Nevada & Utah	Total
Acres in 3 yrs.								
1991	34.5	26.9	21.2	19.6	4.5	18.0	4.2	128.9
1992	38.0	27.0	19.4	17.7	5.0	16.7	7.2	131.0
1993	29.5	24.5	17.4	17.9	5.9	15.8	8.3	119.3
Production(pounds of oil per acre)for 5 yrs,1988-1992 [3]								
Average	33.3	77.5	55	89.2	61.1	72.8	67.2	
Range	15-48	30-120	30-100	70-140	30-100	60-110	50-105	
Value per pound of oil for 2 years [4]								
1988	13-55	13-25	14-28	12-24	* [5]	11-20	11-20	
1992	9-10	11	14-16	10-11	12	10-11	10-11	

1. Production regions are classified by distilled oil composition

2. LaGrande averages approximately 10% of this class

3. These 5 years represent the typical range of yields, including years of both high and low production

4. Most oil production is contracted, whereas a smaller fraction is sold on the open market

5. Montana was not producing peppermint in 1988

TABLE 2. Acreage of spearmint in the U.S. in 1991 (Source: A.M Todd Co.).

spearmint species	acreage (thousands)		
	1991	1992	1993
Scotch spearmint (*M. cardiaca*)	31.3	33.2	28.6
Native spearmint (*M. spicata*)	46.0	48.7	41.0

Table 1. Microsclerotia/GM soil infested and recovered since inception of a field trial at the Powell Butte field of the Central Oregon Agricultural Research Center, 1989-1993.

	Microsclerotia/GM soil									
1989 infestation (Nov) calculated amount	0		0.01		0.1		1.0		5.0	
1990 recovered (June) prior to till & flame trts	***[a]		***		***		0.6 (0.6)[b]		7.1 (3.4)	
1990-91 plots split	flame	till	flame	till	flame	till	flame	till	flame	till
1991 recovered (July)	***	***	***	***	0[c]	0	0.5 (0.3)	1.1 (0.4)	1.6 (0.3)	1.4 (1.1)
1992 recovered (June)	0	0	0	0	0	0	0	0	0	0
(July)	0	0	0	0	0	0	0	0	0	0
(Aug)	0	0	0	0	0	0	0	0	0	0
1993 recovered (June)	0	0	0	0	0	0	0	0	0	0
(July)	0	0	0	0	0	0	0	0	0	0
(Aug)	0	0	0	0	0	0	0	0	0	0

a. Indicates recovery was not attempted.
b. Microsclerotia were recovered from each of two duplicate 20-core x 6-inch deep soil samples taken from each plot and averaged together.
Values shown are means of 5 replications (standard deviations are in parentheses).
c. Zeros indicate no sclerotia were recovered from soil in any of 5 replications. Lower limit of each duplicate samples (each replication) is approximately 0.5 microsclerotia/gm soil.

FIGURE 1. Stand density data for the verticillium infestation x cultural practices peppermint field trial at the Powell Butte farm of Central Oregon Agricultural Research Center, Oregon State University, 1990-1993. Stand density is expressed as the percentage ground cover by peppermint plants after green up in the spring (early summer for 1990). Data shown are means of 5 replications of main plots (verticillium infestation) or split plots (flaming+no tillage and tillage+no flaming treatments). MS/g soil indicates the number of microsclerotia of *Verticillium dahliae* per gram soil with which plots were initially infested. Means shown were statistically significant ($P<0.05$) for infestation levels for each year, and where means are shown for tillage and flaming treatments, these also were statistically significantly different ($P<0.05$). In 1992, there was a statistically significant infestation level x cultural practice interaction ($P<0.05$). The winter of 1990-91 was extremely cold, without snow cover, which resulted in stand loss where split plots were not tilled, especially at the highest rate of infestation of *V. dahliae*. Presumably, stand densities were high in tilled split plots due to redistribution of surviving rhizomes. Between 1991-93, stands partially recovered in the split plots initially infested with 5.0 MS/g soil and which were not tilled. In 1993, stands were very similar for both tilled and untilled split plots, so the means for these treatments are not separated here. Stand in tilled plots was reduced to the same level as untilled plots in previous years, although an explanation for this response is uncertain, it does not seem to involve the winter effects of 1992-93. Further, the tilled split plots at the highest rate of initial infestation showed the greatest decline in 1993.

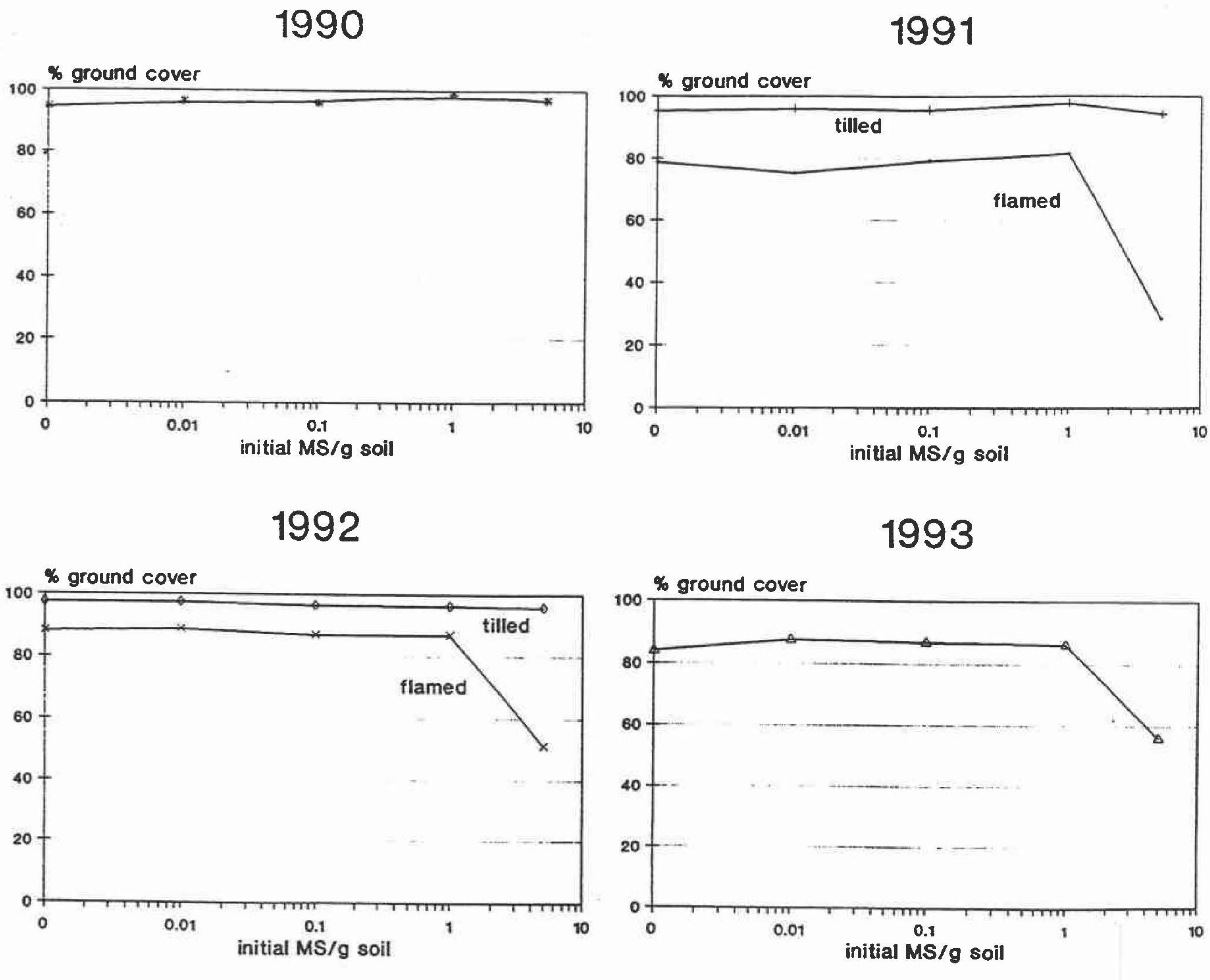


FIGURE 2. Verticillium wilt incidence for the verticillium infestation x cultural practices peppermint field trial at the Powell Butte farm of Central Oregon Agricultural Research Center, Oregon State University, 1990-1993. Wilt incidence was rated as the cumulative number of discrete symptomatic plants which appeared within plots during the season prior to harvest. Data shown are means of 5 replications of main plots (verticillium infestation) or split plots (flaming+no tillage and tillage+no flaming treatments). MS/g soil indicates the number of microsclerotia of *Verticillium dahliae* per gram soil with which plots were initially infested. Means shown were statistically significant ($P<0.05$) for infestation levels for each year, and where means are shown for tillage and flaming treatments, these also were statistically significantly different ($P<0.05$). In 1992, where wilt ratings exceeded 500 per 10-ft x 80-ft split plot for some replications, discrete ratings could no longer be distinguished, and the rating was left at 500. Thus, for the tilled split plot initially infested with 5.0 MS/g soil, the mean shown is an under-representation of the actual wilt incidence. In 1993, wilt rating for all split plots initially infested with 5.0 MS/g soil were left un rated, so no mean is shown.

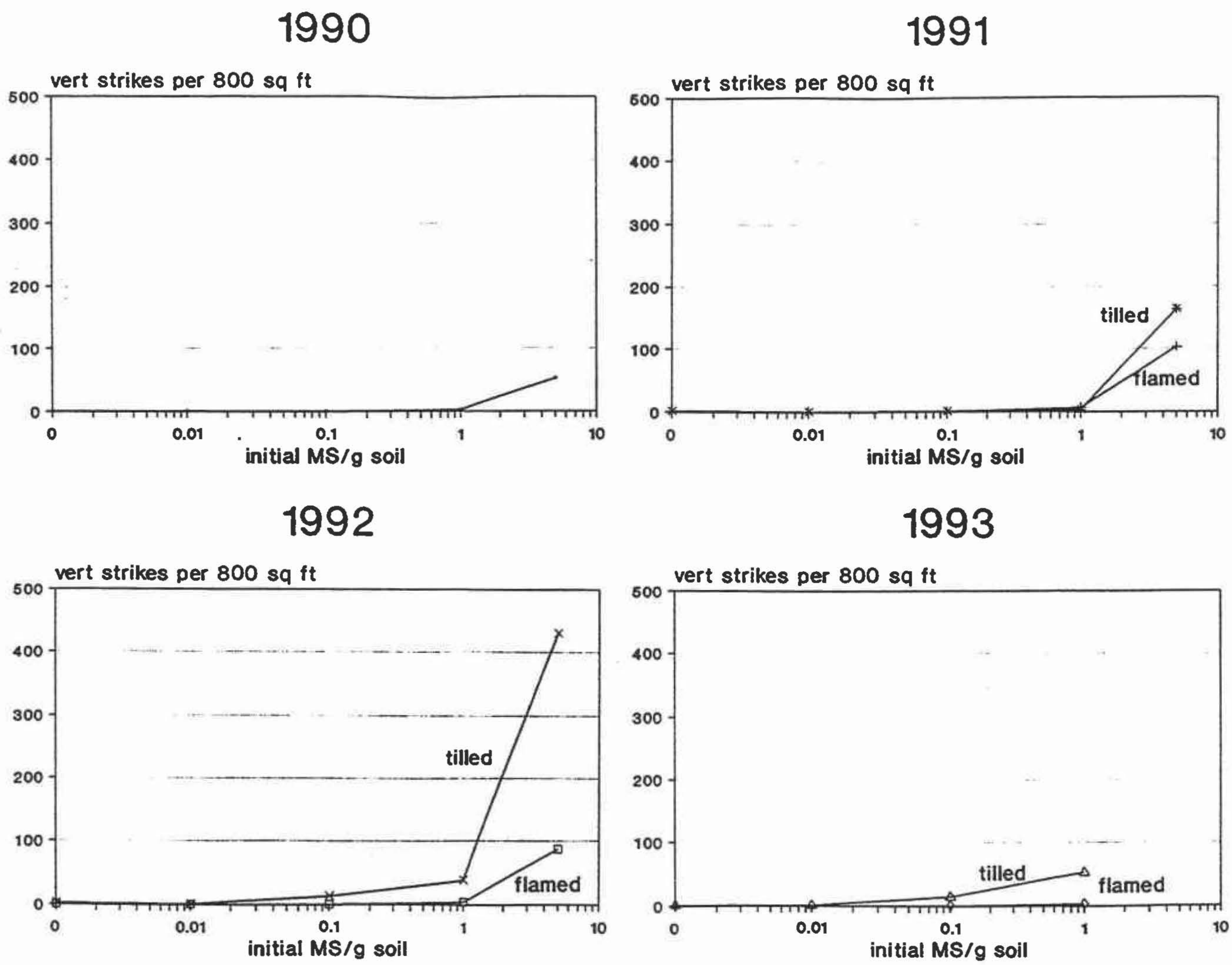


FIGURE 3. Dry weight data (lbs dry hay harvested from 267 ft^2 through the center of split plots) for the verticillium infestation x cultural practices peppermint field trial at the Powell Butte farm of Central Oregon Agricultural Research Center, Oregon State University, 1990-1993. Data shown are means of 5 replications of main plots (verticillium infestation) or split plots (flaming+no tillage and tillage+no flaming treatments). MS/g soil indicates the number of microsclerotia of *Verticillium dahliae* per gram soil initially with which plots were initially infested. Means shown were statistically significant ($P<0.05$) for infestation levels for each year, and where means are shown for tillage and flaming treatments, these also were statistically significantly different ($P<0.05$). In 1991 and in 1992, there was a statistically significant infestation level x cultural practice interaction ($P<0.05$).

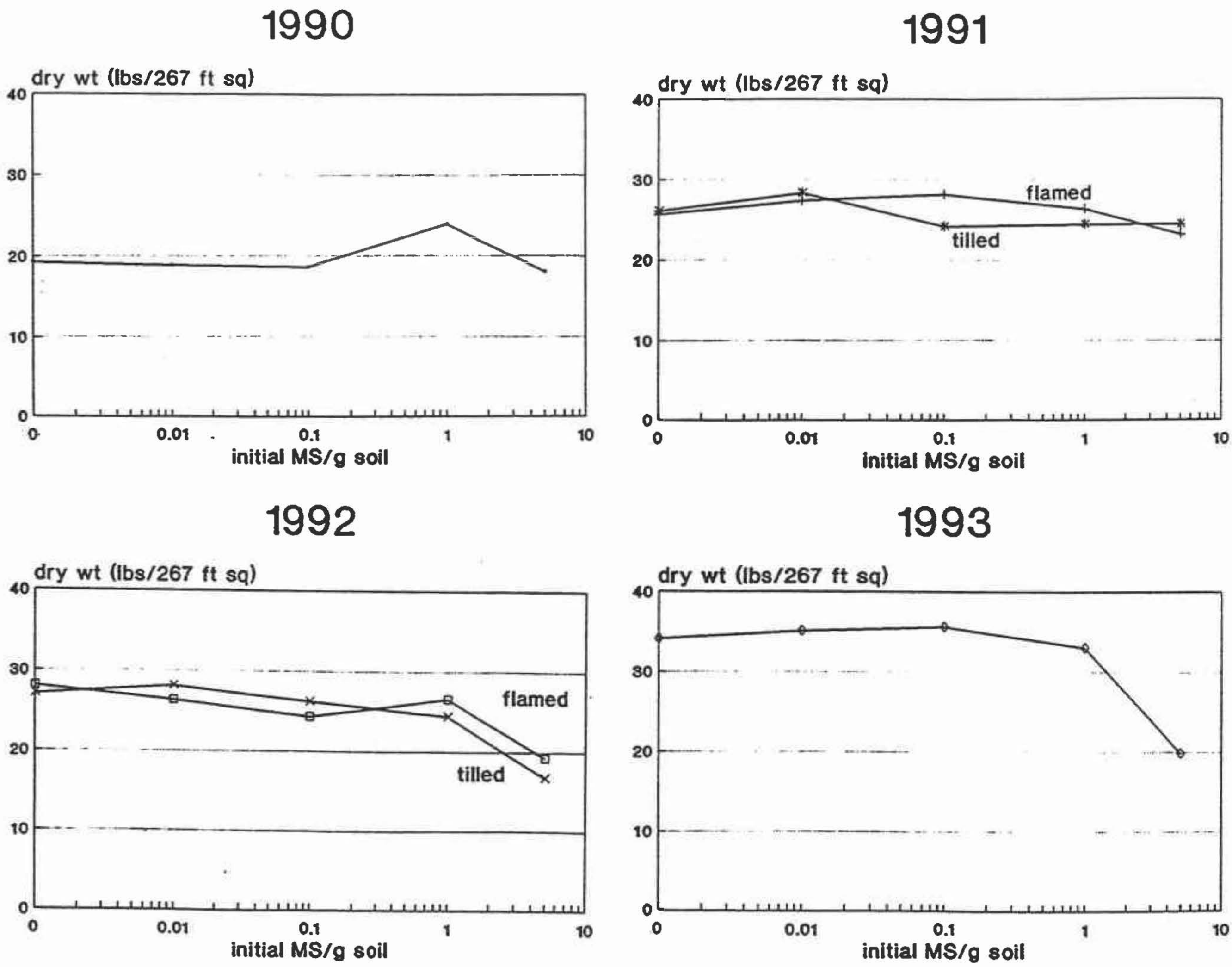


FIGURE 4. Oil yield (lbs/acre) for the verticillium infestation x cultural practices peppermint field trial at the Powell Butte farm of Central Oregon Agricultural Research Center, Oregon State University, 1990-1993. Data shown are means of 5 replications of either main plots (verticillium infestation) or split plots (flaming+no tillage and tillage+no flaming treatments). MS/g soil indicates the number of microsclerotia of *Verticillium dahliae* per gram soil with which plots were initially infested. Means shown were statistically significant ($P<0.05$) for infestation levels for each year, and where means are shown for tillage and flaming treatments, these also were statistically significantly different ($P<0.05$). In 1992, there was a statistically significant infestation level x cultural practice interaction ($P<0.05$).

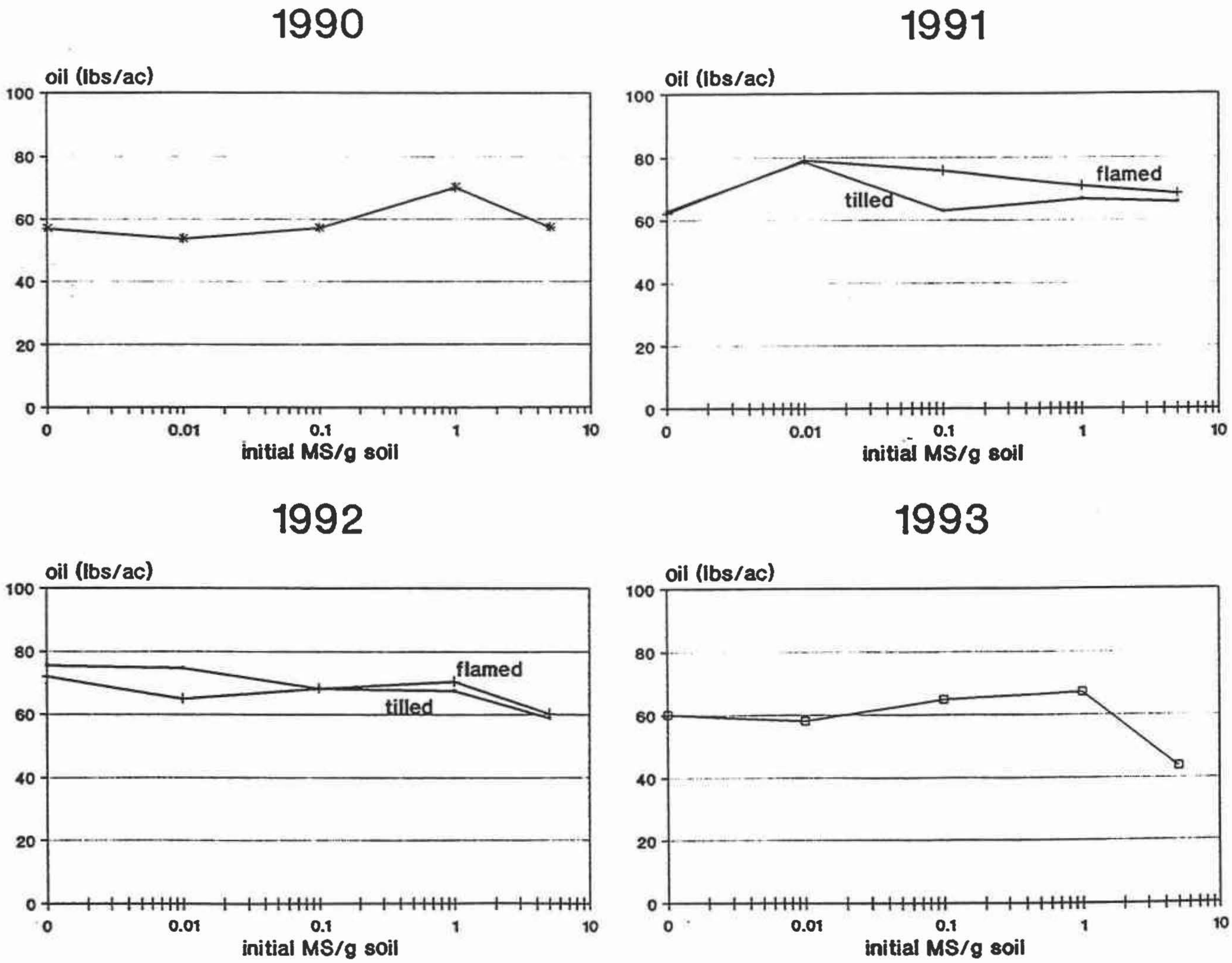
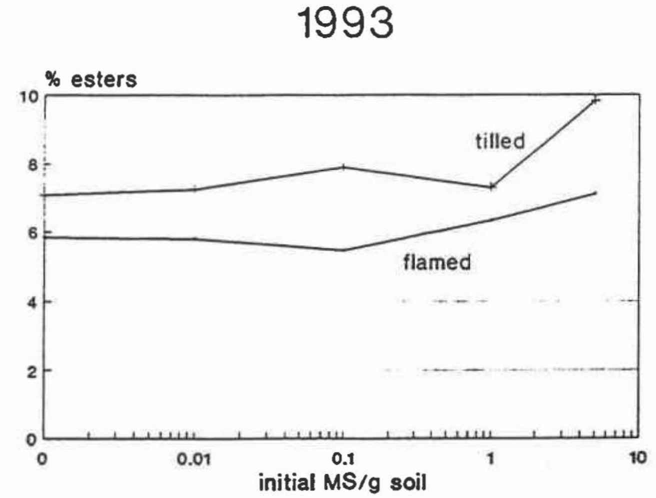
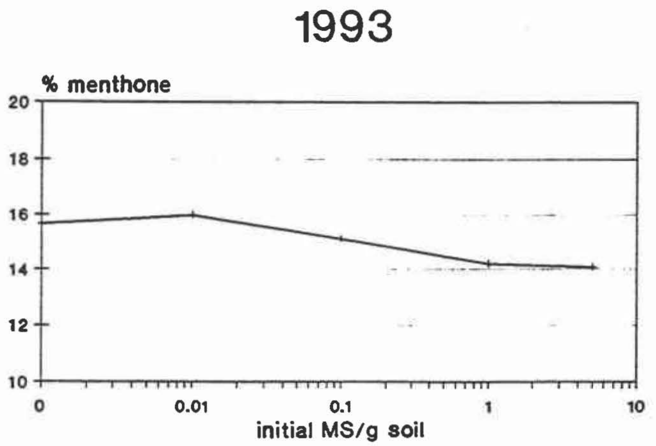
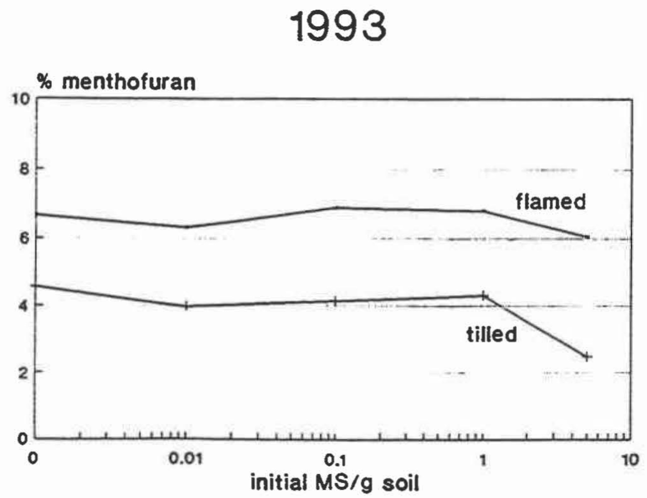


FIGURE 5. Oil composition data for the verticillium infestation x cultural practices peppermint field trial at the Powell Butte farm of Central Oregon Agricultural Research Center, Oregon State University, 1990-1993. Data only for 1993 for percentage Esters, Menthone, and Menthofuran are presented here. Data shown are means of 5 replications of main plots (verticillium infestation) or split plots (flaming+no tillage and tillage+no flaming treatments). MS/g soil indicates the number of microsclerotia of *Verticillium dahliae* per gram soil with which plots were initially infested. Means shown were statistically significant (P<0.05) for infestation levels for each year, and where means are shown for tillage and flaming treatments, these also were statistically significantly different (P<0.05).







IRRIGATION AND NITROGEN FERTILITY OF PEPPERMINT IN CENTRAL OREGON, I. YIELD AND OIL QUALITY*

Alan R. Mitchell, Neysa A. Farris, Fred J. Crowe

Abstract

This report summarizes two years of an experiment to test the effects of irrigation and nitrogen (N) fertility on peppermint at the Central Oregon Agricultural Research Center in Madras, OR. In 1992 and 1993, the dry matter and oil yields were greatly affected by irrigation level and N-fertilizer level. Both oil concentration and oil quality were influenced by irrigation level, but not by N rate.

Introduction

It is conceivable that the optimal irrigation management of peppermint may include water stress to produce more oil yield. Many peppermint growers in the Northwest believe that a certain amount of water stress may improve peppermint oil yields (Weber, 1978). Loomis (1976) proposed a stress management theory to increase leaf retention. However, other scientists have found that peppermint produces optimum yield at highest levels of irrigation (Clark and Menary, 1980). Preliminary results of peppermint irrigation studies at Purdue University suggest that full irrigation is the optimal management practice (Simon and Joly, 1989). Scientists have also found that reducing irrigation early in the season did not seem to stress the peppermint plant (Clark and Menary, 1980).

With growing concern over environmental pollution, including agricultural contributions of nitrogen (N) in the form of nitrate to groundwater, it is imperative to know the N rates for optimum economic yield, as well as N rates for minimal groundwater contamination. The present N-fertilization practice for central Oregon is to apply a total of 250-300 lb/ac of N to a peppermint crop divided into several applications. Although peppermint yields best under high N fertilization, the fact that multiple applications are practiced suggests that much of the N is lost. Only 150 lb/ac of N is accounted for by the above-ground plant (Hee, 1974). The remaining 100-150 lb/ac may be lost below the root zone due to excessive irrigation. The process of nitrification transforms fertilizer N to nitrate, a very soluble N form which is then susceptible to being carried below the root zone by excess applied water.

Fertilizers that release nitrate slowly have the promise of reducing nitrate leaching. Supplemental additions of N in the irrigation water have been found to increase oil yield under some situations (Heuttig, 1969). This is now a common practice among growers. The yield response to summer applied N may result from applying N as the plant requires it. This suggests that N may be washed out of the root zone by rainfall or excess irrigation. If

*This study was supported by the Oregon Mint Commision , Oregon Department of Environmental Quality and Exxon Chemical of Canada.

excess irrigation is responsible for N loss, then the use of a slowly soluble N fertilizer should increase the amount of N available to the plant.

To answer the questions of slow-release N fertilizer requires knowledge of the quantity of water and N fertilizer that is required for optimal oil yield. Tested together, we will be able to look at the irrigation and nitrogen interaction. The first report will disclose the yield effects, while the second report will cover nitrate leaching.

Objectives

The objectives of the experiment were to investigate management practices of irrigation, nitrogen fertilizer rates, split applications, and slow-release fertilizer.

Materials and Methods

Experimental Design

The research was carried out at the Central Oregon Agricultural Research Center (COARC) in Madras, Oregon on second-year peppermint, variety 'Murray'. The peppermint was planted in March 1991, and tilled to enhance stand in February 1992. A line-source sprinkler system was set up to control applied water to the experimental plot. The line-source system is a low cost method for applying water at different rates to different sectors of the plot (Hanks et al., 1976). The trial was replicated eight times, and nitrogen treatments were super-imposed on the irrigation treatment in a split block (or strip plot) design. Plots were 25 X 8 ft with the longest side parallel to the sprinkler line.

In 1993, the experiment was truncated to four replications, and another single-year experiment was established on a nearby uniform stand of peppermint to avoid the residual effects of nitrogen fertilizer from the previous years. The original experiment will be called the multi-year experiment since it will have the same the fertility and irrigation practices over several years. The single-year experiment was designed in the same fashion, except that it had smaller plot measuring 9 X 8 ft, and an additional N0 treatment of no nitrogen fertilizer. In February 1993, two of the four replications of the multi-year experiment were tilled to enhance stand density.

In 1992, irrigation water was applied at five rates based on water loss from the 4th irrigation level, with I5 receiving full irrigation and the others the following amounts: I4 = 83 percent of I5, I3 = 67 percent, I2 = 52 percent, and I1 = 50 percent. In 1993, the I4 level was irrigated according to depletion reported by the Bureau of Reclamation's AgriMet weather system until mid-June, when soil water content indicated that following that irrigation scheme may result in excess water applied. Thereafter, water was applied according to depletion.

In both years, irrigation occurred twice weekly during June and July. Catch cans were used to monitor the amounts of applied water. In 1992, soil water content was measured with Watermark sensors five days per week and with the neutron probe twice weekly. Sensors were buried at three depths: 2 to 4 inches, 6 to 8 inches, and 20 to 22 inches. Ten sets of sensors were applied in two replications of the five irrigation levels. Neutron meter access tubes were installed in each of five irrigation levels of 12 N treatments. The meter measured soil water content in 6-inch increments, with the total depth varying from 2 to 7 ft , depending on the strength of the hardpan layer at the 2-ft depth.

In 1993, three sets of 48 sensors were attached to a datalogger as described by Light et al. (1993). Sensors were buried the same depths as above with the addition of sensors buried horizontally 0.5 inches below the soil surface. In 1993, the neutron measurement were taken every other week.

Fertility Treatments

The N fertility treatments were applied to the peppermint irrigation experiment. Treatment fertilizers were applied in the spring with additional differential rates were applied in summer (Table 1). For spring application, nitrogen was applied as urea (46-0-0) with a 3-ft wide fertilizer spreader which was calibrated to the listed rates. In 1992, aqueous urea-ammonia solution (32-0-0) was applied with a hand-held sprayer during summer irrigations to simulated irrigation-applied fertilizer. In the October 1992, 50 lb/ac of N was applied to all the plots of both the single and multi-year experiments. In 1993, the supplemental fertilizer was applied as urea. Soil N measurements were taken in March, throughout the summer, and after fall growth.

The 1992 harvest was on July 29, approximately 10 days earlier that usual. In 1993, the single-year experiment was harvested on August 10. The multi-year experiment was harvested according to maturity level: I1 and I2 of the non-tilled section were harvested on August 9, treatments I3, I4,and I5 were harvested on August 12, and the tilled blocks were harvested August 16.

Table 1. Fertilizer trial rates, Madras, OR, 1991-1993.

Fertilizer plot	Spring	Summer	Total
	--------------- lb/ac	------------------	
N0*	0	0	0
N1	50	0	50
N2	150	0	150
N3	250	0	250
N4	250	100**	350
N5 PCU***	250	0	250
N6	150	100**	250

* treatment exists only in single year experiment and in an extra PCAPS plot
** split application of 50 lb/ac each
*** polymer-coated urea

Subsamples of the plot were 40 inches wide by 25 ft long, which produced enough peppermint forage to distill in burlap sacks. Due to time and cost considerations, only three replications of the nitrogen experiment and three replications of the irrigation experiment were used for peppermint oil analysis. Sacked peppermint was quickly dried in the open air, and stored indoors until distillation. In 1992, there was a delay in peppermint oil distilling until November due to lack of availability of the USDA facility in Corvallis, OR. In 1993, the oil was distilled at a small-scale research distillery at COARC. The 1992 oil quality analysis was performed by A.M. Todd, Kalamazoo, Michigan and the 1993 analysis by Wm. Lehman Inc., Bremen, Indiana.

Results

The 1992 yield data for irrigation effects across all N treatments (Table 2) shows that the highest yield was achieved with the maximum irrigation rate (I5). In 1993, irrigation was managed so that I5 would have excess water, resulting in I4 having the maximum yield for both the single and multi-year experiments. In answer to the question of whether water stress may increase yield: the 1992 data produced no evidence that it does, and the 1993 data indicated that excess irrigation may have reduced yield by lowering the oil concentration. In 1993, the I4 treatment had the highest yields in both the single-year and multi-year experiments, but the mean tests did not indicate a significant difference in dry matter yield between the I3, I4, and I5 treatments.

Table 2. Irrigation level effects on peppermint dry matter yield, oil yield, and concentration for 1992 and 1993 and the 1993 single year experiment, Madras, OR. Column means followed by a common letter are not significantly different at the $\alpha=0.05$ level.

Irrigation Level	Ratio	Dry Matter Yield 1992	Dry Matter Yield multi 1993	Dry Matter Yield single 1993	Oil Yield 1992	Oil Yield multi 1993	Oil Yield single 1993	Oil/Dry Matter 1992	Oil/Dry Matter multi 1993	Oil/Dry Matter single 1993
	-percent-	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	lb/ac	percent	percent	percent
I1	50	793 a	5012 a	1975 a	24.2 a	34.5 a	21.5 a	3.05	0.69	1.09
I2	52	1098 b	4538 a	3039 a	28.9 a	41.6 a	27.5 a	2.63	0.92	0.91
I3	67	1362 bc	6796 b	5280 b	31.8 a	64.7 b	37.8 ab	2.34	0.95	0.72
I4	83	2055 d	6638 b	4954 b	30.1 a	69.2 b	61.8 c	1.47	1.04	1.24
I5	100	2446 e	6744 b	5671 b	46.2 b	60.6 b	55.9 bc	1.90	0.90	0.99

Table 3. Impact of Irrigation Level on Peppermint Oil Quality, Madras, OR, 1992.

Constituents	Signif.	Change	Irrigation Level I1	I2	I3	I4	I5
			%				
MENTHOL	*	-	40.95	40.12	39.23	39.54	39.77
MENTHONE	**	+	13.94	16.12	18.45	20.57	20.84
HEADS	**	-	13.34	12.68	12.37	11.63	11.04
CINEOLE	**	-	6.78	6.50	6.37	6.02	5.78
ESTER	**	-	7.02	5.77	5.18	4.74	4.38
MENTHOFURAN	**	?	2.64	3.76	3.77	3.10	3.45
NEOMENTHOL	**	-	4.38	4.02	3.70	3.53	3.39
D-ISOMENTHONE	**	+	2.60	2.69	2.78	2.89	2.80
GERMANCRENE-D	**	+	2.19	2.22	2.34	2.42	2.62
B-CARYOPHYLLENE	**	-	3.07	2.79	2.68	2.54	2.46
BETA PINENE	*	-	1.95	1.88	1.87	1.79	1.72
LIMONENE	**	-	2.20	2.13	1.97	1.70	1.56
ALPHA PINENE	*	-	0.95	0.91	0.92	0.88	0.84
PULEGONE	*	?	0.84	1.14	1.04	0.82	0.83
B-BOURBONENE	**	-	0.85	0.75	0.66	0.60	0.59
3-OCTANOL	**	+	0.18	0.19	0.20	0.24	0.26
MYRCENE	**	-	0.28	0.28	0.28	0.26	0.25
PARA CYMENE	**	-	0.21	0.18	0.12	0.14	0.10
			MEAN				
SABINENE HYDRATE	NS		2.18				
PIPERTONE	NS		0.42				
GAMMA TERPINENE	NS		0.25				
TERPINOL	NS		0.23				
ALPHA TERPINENE	NS		0.13				

* significant at the 5%, ** at the 1% level, NS not significantly different.
\+ or - is the increase/decrease in concentration with increasing irrigation.

Figure 1 shows how oil and dry-matter yield were influenced by irrigation level. The treatments I3, I4, and I5 were not significantly different, yet there appearred to be a decrease in oil content for I5, which resulted from a decrease in oil concentration for that treatment. Possible explanations of the lower concentration (Table 2) are a greater stem biomass induce by high irrigation and/or the oil gland damage by sprinkler irrigation (Croteau, 1977).

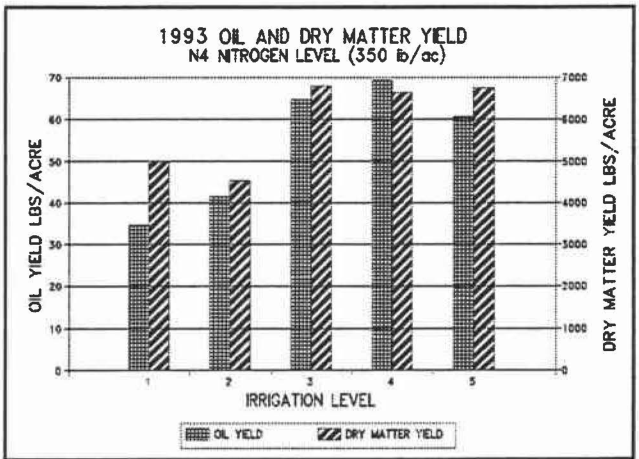


Figure 1. Irrigation effects on oil and dry matter yields for 350 lb/ac treatment for the 1993 single-year experiment, Madras, OR.

In 1992, the irrigation-rate yield data (Table 2) showed that the highest yield was achieved with the maximum irrigation rate (I5). Dry matter yield was better differentiated between treatments than oil yield. This can be explained by the increase in oil/dry matter concentration. Such an increase in concentration is usually associated with maturity (Bullis et al., 1948; White et al., 1987), which may have been induced by water stress. However, the concentration effects differed by the year. In 1992, the concentration increased with stress (lower irrigation), but in 1993 the concentration was highest at the optimal irrigation level, I4 (Table 2). This was true for both the single and multi-year experiments. This effect is also illustrated in Figure 3, which compares dry matter with oil yield for 1993 yield data. Differences in weather during the two years may account for this discrepancy between years, with 1992 being warmer than normal, and 1993 cooler than normal with more precipitation. Hence, the overall concentrations were lower throughout the region in 1993 probably due to more stem growth and lesser heat units. The stress-induced maturity-concentration effect of 1992 was not seen in 1993 because of differential harvest dates, or the lack of maturity difference due to cooler weather.

Oil Quality

In 1992, the irrigation variable affected 17 out of 23 oil constituents (Table 3), including the principal components of menthol, menthone, esters, and menthofuran. In 1993, three of the four constituents tested were signifantly affected by irrigation level with menthofuran being the exception. In its influence on oil quality constituents, water stress appeared to be related to maturity. During the period up to 50 percent bloom, the oil may increase in menthol, esters, and menthofuran (Bullis et al., 1948; White et al., 1987). These same constituents increase with irrigation level (Table 3 and Figure 2). The ester content was the most sensitive parameter of irrigation stress or maturity. Menthofuran was significantly affected by irrigation level in 1992, but not in 1993, and in both years it is hard to interpret because it did not vary uniformly (Figure 2). Neither the substantial water stress imposed on I1 nor the nitrogen fertility treatments made oil quality undesirable.

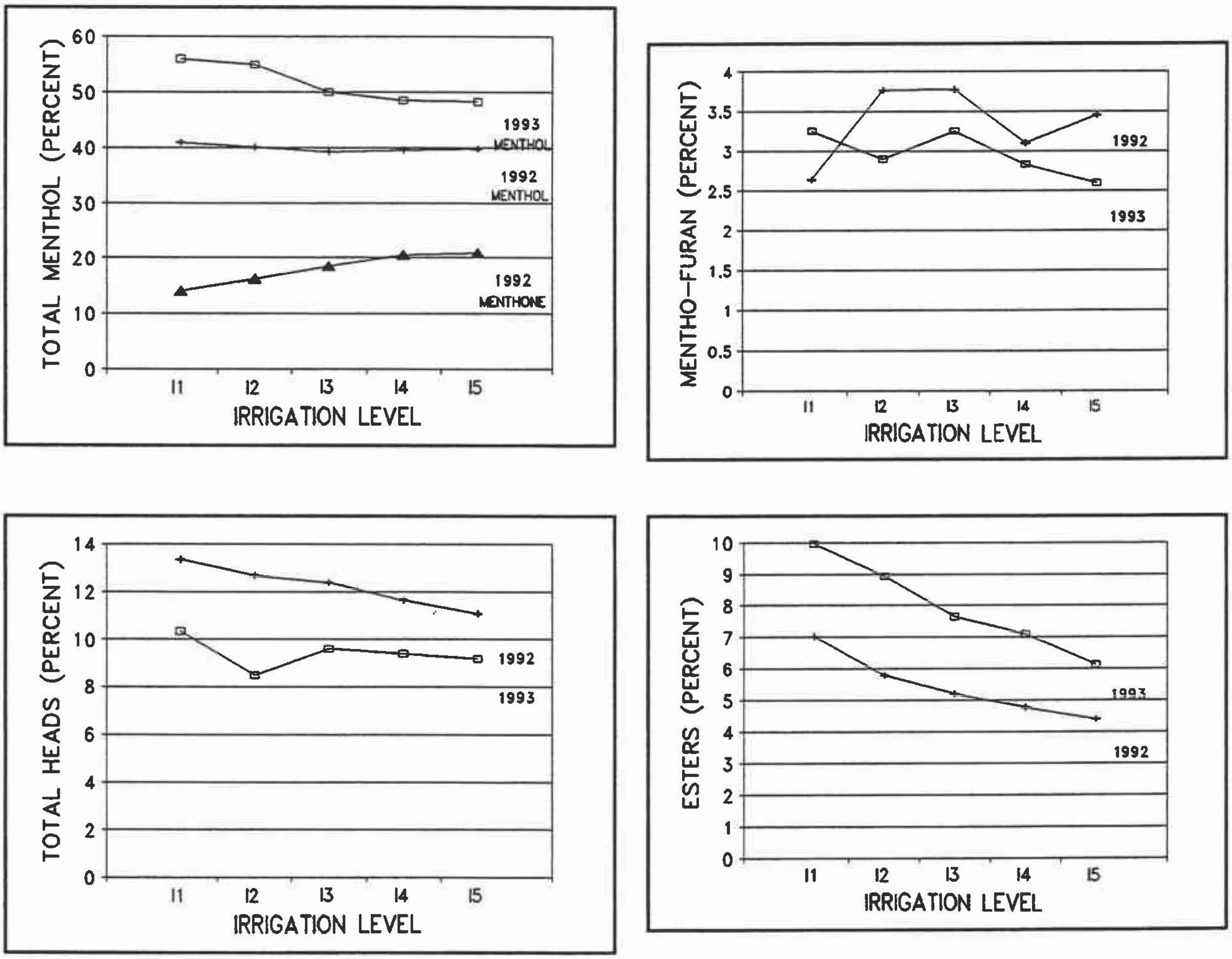


Figure 2. Peppermint oil constituents menthol, menthone, menthofuran, total heads, and esters as influenced by irrigation treatments for 1992 and 1993, Madras, OR.

Nitrate Fertility and Irrigation Interactions

Dry matter yield data are shown in Figures 3, 4, and 5 for all irrigation and nitrogen treatments over both years. In 1992, the supplemental summer nitrate application treatments (N4 and N6) were the top yielding treatments for I5, which was the optimal irrigation treatment that year (Figure 3 and 4). In 1993, the N3 (250 lb/ac) treatment yielded better than the higher rates for most irrigation levels including excess irrigation (I5). But as Figure 6 shows, the polymer-coated urea (N5) and the split application treatment (N4) yielded better than the single application (N3) for the high irrigation rate only. This is attributable to leaching that occurred under high irrigation, which made the slow-release and split-applied methods favorable for plant growth. In the absence of leaching, a single spring application was sufficient.

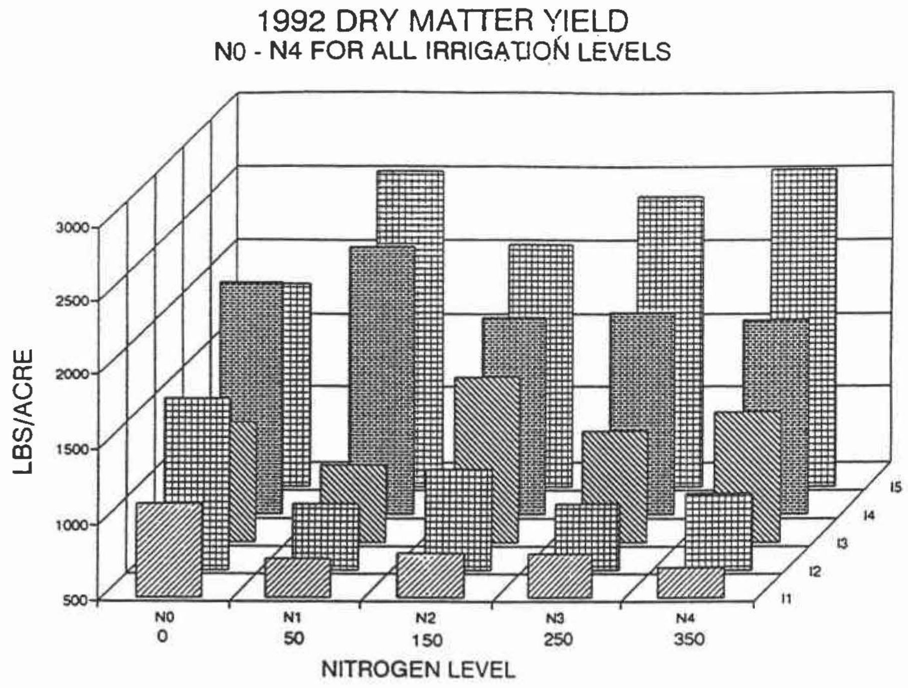


Figure 3. Peppermint dry-matter yield for nitrogen fertilizer rates, Madras, OR, 1992.

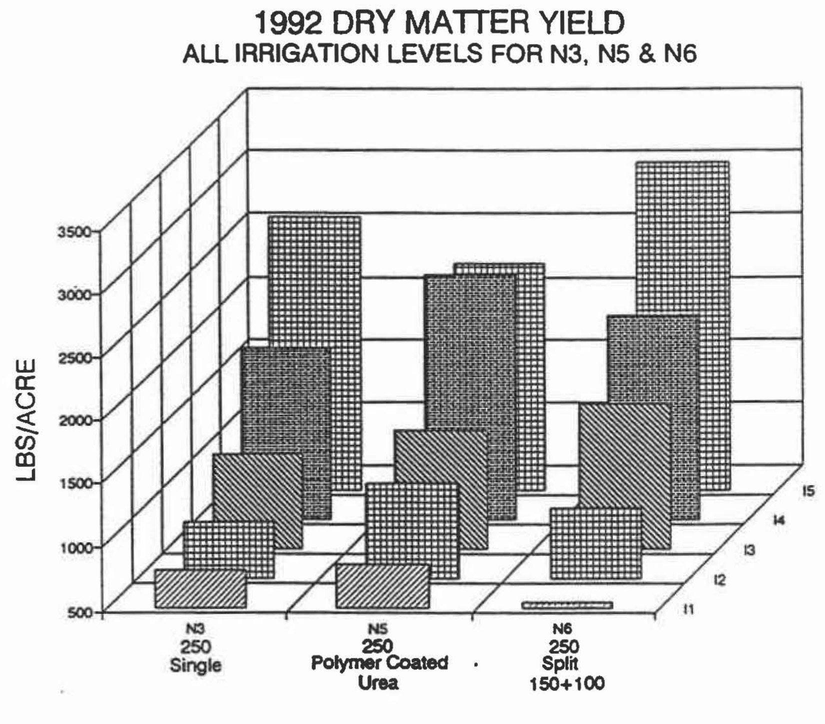


Figure 4. Peppermint dry-matter yield for nitrogen applied in a single spring application, as polymer-coated urea, and as a split-application, Madras, OR, 1992.

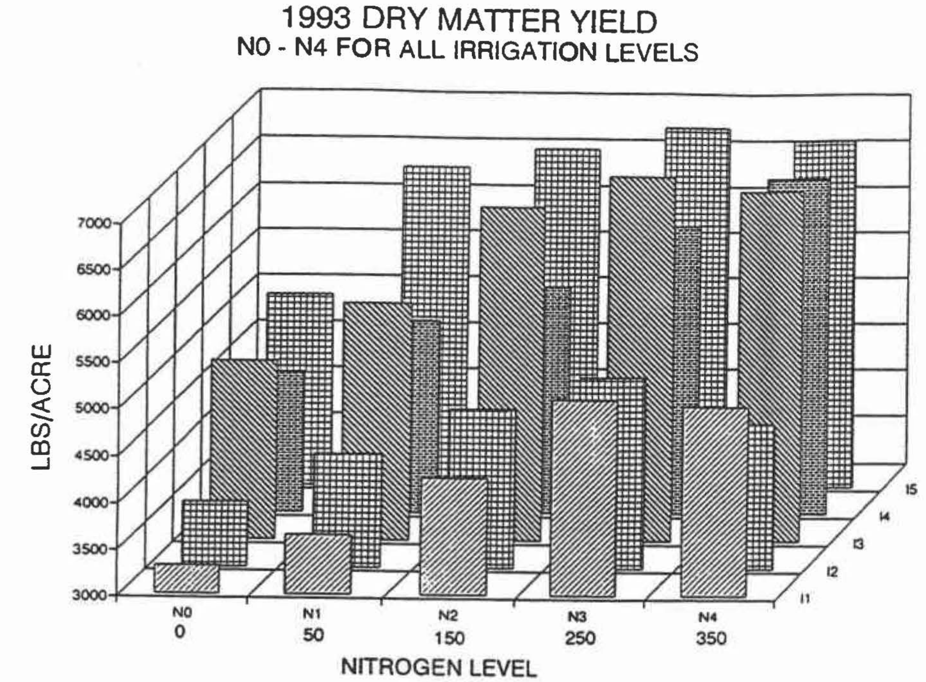


Figure 5. Peppermint dry-matter yield for nitrogen fertilizer rates, Madras, OR, 1993.

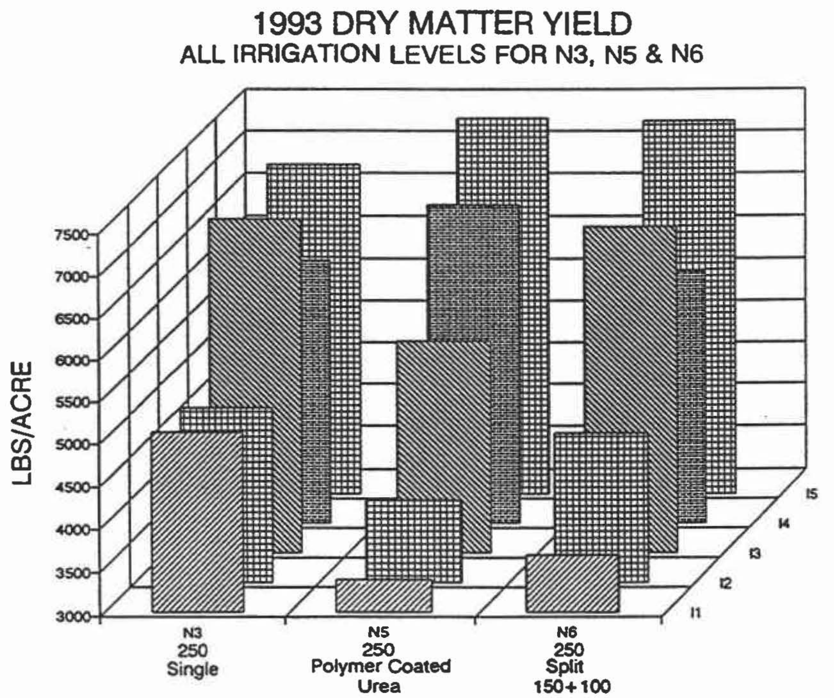


Figure 6. Peppermint dry-matter yield for nitrogen applied in a single spring application, as polymer-coated urea, and as a split-application, Madras, OR, 1993.

At low irrigation levels, low rates of N performed better than their counterparts due to a probable salinity effect of the fertilizer that can depress yield. Dow et al. (1981) showed that peppermint is salt sensitive at soil salinities of 2 mmhos/cm, which may have occurred in areas of the root zone after the fertilizer was applied. At the highest irrigation level, the polymer-coated urea treatment (N5) yielded slightly less than the 250-lb/ac control (N3), but it also had less N applied (225 lb/ac). At lower irrigation levels, N5 yielded more than all but the lowest N treatment. This supports our field observations that the polymer-coated urea avoided a salinity effect that cause mild necrosis in some leaf margins for the high N treatments in early June.

Soil Nitrogen Dynamics of Slow-release Fertilizer

Periodic soil sampling of the top 12 inches showed the amount of N in the soil before, during, and after the 1992 growing season. Comparison of the soil inorganic N for treatments N5 (Figure 7) and N3 (Figure 8) showed the polymer-coated urea delayed the release of N to the soil. Initially, in March 1992, the N5 had more residual soil N, but then N5 showed lower N until July 22. After July 22, the N5 treatment had more soil N than N3. Unfortunately, harvest occurred July 29, so the crop had little time to take advantage of the higher soil N of the polymer-coated urea. In comparison to N1 (50 lb/ac), the N5 treatment showed more soil N for all dates except June 17 (Figure 9). The August 11 samples showed a higher concentration for the N5 soil. (Total N is reported instead of nitrate, because our soil consistently tested over 90 percent nitrate in total inorganic N.)

Following harvest, some polymer-coated urea was observed still in pellet form. Sampling of the surface layer (0 to 0.5 inches) of the soil in August (Figure 10) showed over 50 lb/ac of N in that layer. Figure 10 also shows a 200 lb/ac drop in soil N during the post-harvest period from August to November. These 200 lb/ac may have been assimilated by the plant, or leached below the root zone. Total N appeared to move downward for the N5 under high irrigation, I5, where the N at the 12 to 24-inch layer increased in time, while N in the 0 to 12-inch layer decreased over the same period. This is typical for other N treatments as well.

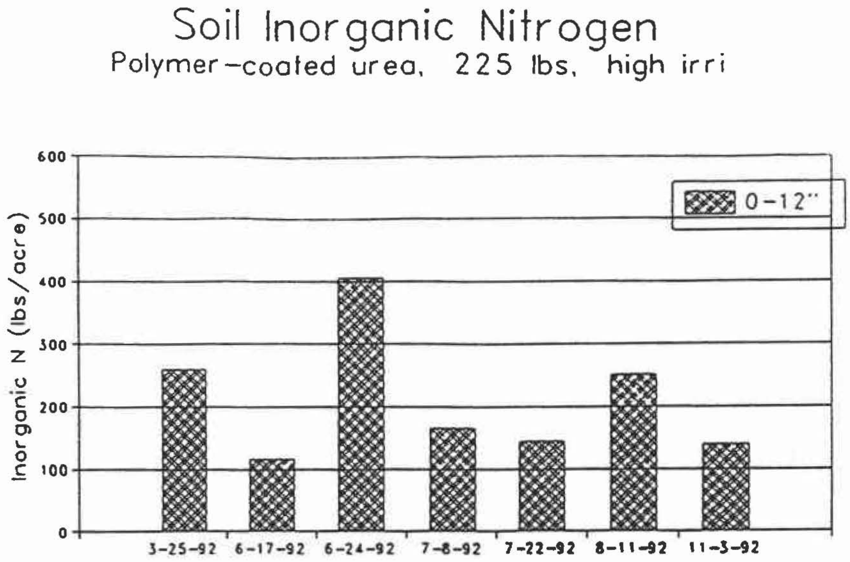


Figure 7. Soil inorganic N in top foot under 250 lb/ac polymer-coated urea, Madras, OR, 1992. Harvest occurred on July 29, 1992.

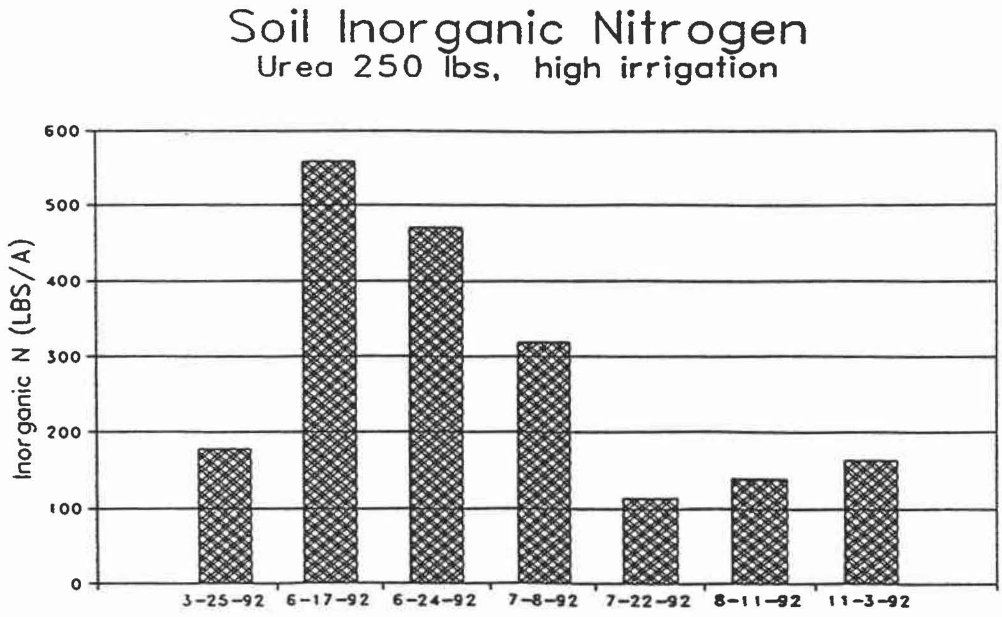


Figure 8. Soil inorganic N in top foot under 250 lb/ac N as urea, Madras, OR, 1992.

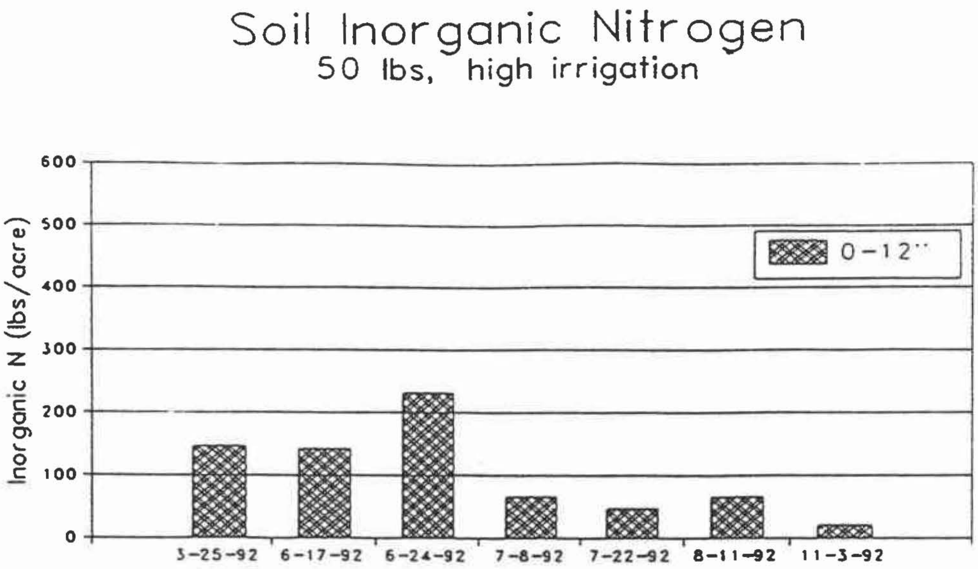


Figure 9. Soil inorganic N in top foot for 50 lb/ac treatment, Madras, OR, 1992.

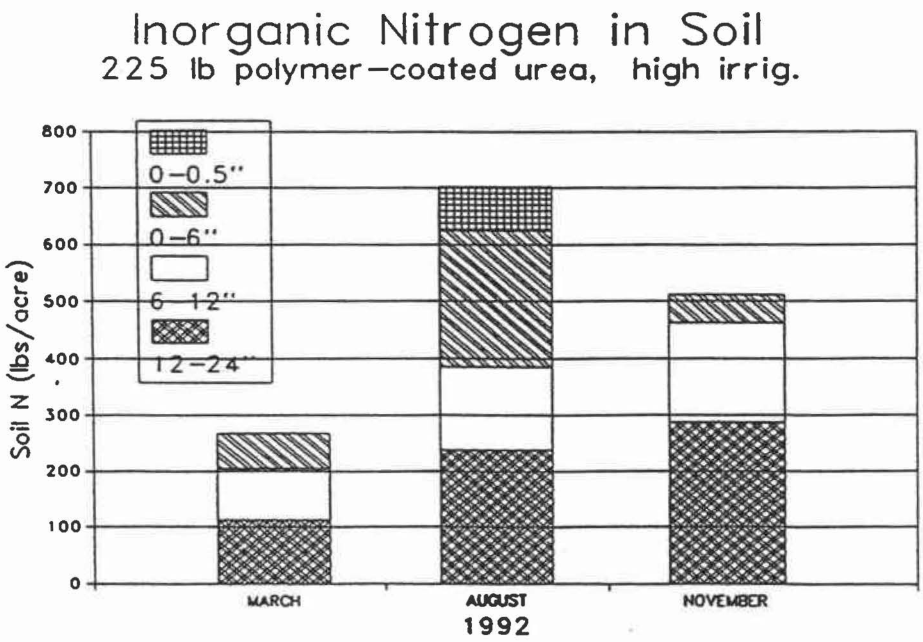


Figure 10. Soil inorganic N for entire profile of polymer-coated urea, Madras, OR, 1992.

To summarize: within the constraints of our experiment (equal irrigation intervals and variable amounts) there is no evidence that stress can improve oil yield, but excess irrigation may reduce it. Two years of data show that optimal irrigation with minimal leaching appears to be the best irrigation strategy for oil production.

Two years of data indicate that split-application of fertilizer and slow-release nitrogen forms only have the potential to increase yield when excess irrigation promotes nitrate leaching. Under low irrigation conditions, high N rates can cause salinity stress. Under high irrigation rates, high N applied as split applications may be needed to achieve maximum yield.

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IRRIGATION AND NITROGEN FERTILITY OF PEPPERMINT IN CENTRAL OREGON, II. NITRATE LEACHING*

Alan R. Mitchell, Neysa A. Farris, Fred J. Crowe

Abstract

The irrigation by nitrogen fertilizer study provided an opportunity to study nitrate leaching under different inputs of both. Passive capillary samplers below the root zone indicated that there was no leaching of water or nitrate during the summer and fall of 1992, but leaching occurred during the winter precipitation period in 1993. Soil profile nitrate concentrations were measured to determine the loss of nitrate for each treatment.

Introduction

Nitrate is a potential contaminant of groundwater at levels above 10 mg/l nitrogen (N). Non-point source nitrate originates in animal manures and commercial fertilizers, especially for high-valued crops where nitrogen is abundantly applied and the root zone is shallow. The fundamental question is how much nitrogen is required to produce optimum yields of peppermint, and how much nitrate is lost below the root zone.

With growing concern over environmental pollution, including agricultural contributions of N in the form of nitrate to groundwater, it is imperative to know the N rates for optimum economic yield, as well as N rates for minimal groundwater contamination. The present N-fertilization practice for central Oregon is to apply a total of 250-300 lb/ac of N to a peppermint crop divided into several applications. Although peppermint yields best under high N fertilization, the fact that multiple applications are practiced suggests that much of the N is lost. Only 150 lb/ac of N is accounted for by the above-ground plant (Hee, 1974). The remaining 100-150 lb/ac may be lost below the root zone due to excessive irrigation. The process of nitrification transforms fertilizer N to nitrate, a very soluble N form which is then susceptible to being carried below the root zone by excess applied water.

Tested together, irrigation and nitrogen factors will provide data on the amount of N lost below the root zone. The loss of N due to leaching beyond the root zone is a water management as well as a fertilizer management problem. These two studies are being conducted together in order to study the interactions of irrigation and N.

Objectives

The objective was to investigate management practices for their effect on nitrate leaching

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*This study was supported by the Oregon Mint Commision, Oregon Department of Environmental Quality and Exxon Chemical of Canada.

beyond the root zone.

Materials and Methods

Leaching of Nitrate

Passive capillary samplers (PCAPS) were designed and built by Dr. John Selker, OSU Dept. of Bioresource Engineering, based on the design of Boll et al. (1992). Twelve PCAPS were installed in the peppermint plots on April 23, 1992. The samplers (12.8 inches by 34.1 inches at the top by 20 inches deep) were buried with the top placed at the interface between the soil and the hard pan, which was 24 to 29 inches deep. The PCAPS were placed in the I3, I4, and I5 levels of nitrogen plots N0, N2, N5, and N6 as shown in Figure 1. (For information on the irrigation and nitrogen treatments, see pages 54 and 55 of the previous report, "I.Yield and Oil Quality".)

As shown in Figure 2, the PCAPS, or wick lysimeters, were designed to collect the water that passes through the root zone into the vadose zone, the unsaturated soil that exists between the root zone and the ground water table. Wicks on the top face of a PCAPS extend to three collection jars located 18 inches below the top. This design provides for water collection with a small negative tension, or without requiring soil saturation, usually an unnatural condition in the arid zones. Water was collected from four small tubes connected to the three jars and to the overflow, and the tubes were extended to a manifold at the edge of the field 50 ft away. A vacuum pump was used to collect the leachate that was later analyzed for ingorganic N.

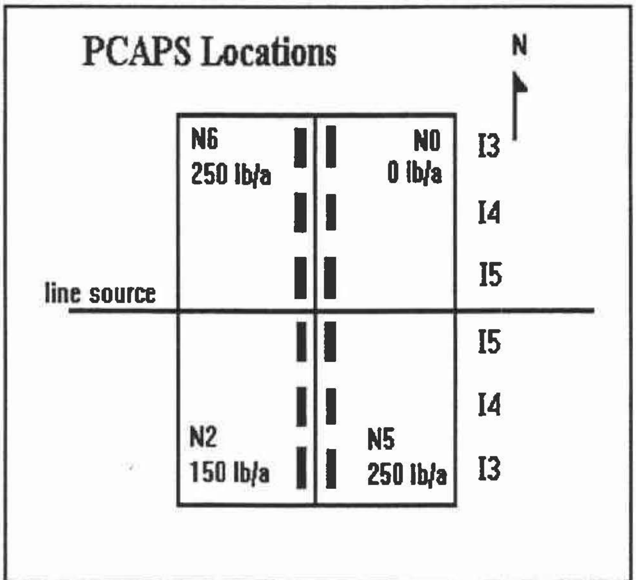


Figure 2. Diagram of PCAPS locations within the line-source sprinkler experiment established April, 1992 at Madras, OR.

Figure 2. Passive capillary sampler installed in April 1992 at Madras, OR.

Soil sampling for nitrate and ammonia determination was conducted in the first and second replication. Soil cores were taken to a depth of 5 ft with a hand core sampler for the top 2 ft, and a hydraulic core sampler for the remaining 3 ft. The soil was extracted with 2 N KCl then analyzed for inorganic N (Wescan Model 360, Alltech Assoc. Inc., Deerfield, IL).

Results

Leaching of Nitrate--PCAPS

Throughout 1992, the PCAPS samplers did not intercept any water during the growing season. The neutron probe and Watermark data showed water contents were not at saturation near the PCAPS, which corroborated our conclusion of no leaching.

In March 1993, leachate was obtained from the PCAPS. High winter precipitation likely contributed to the leaching. A weather station within 1,000 ft of the site measured 7.11 inches of precipitation from October 1992 to March 19, 1993, the date of our first PCAPS sample. No readings were taken during that winter period due to snow accumulation. Because the samples sat in the PCAPS the entire winter, we do not know the time that leaching occurred. Also, many of the PCAPS collection bottles were full, which may have underestimated the leachate depth. It is also important to keep in mind that the peppermint was replanted over the PCAPS in May 1992, and that during the season, the plants were not at full cover.

The nitrogen concentration (nitrate plus ammonia), leachate depth, and total nitrogen loss of the PCAPS solutions are shown on the following pages in Figures 3, 4, and 5, respectively. These graphs are designed to show the PCAPS data with irrigation level constant in the vertical direction, and N level constant in the horizontal direction. Increasing levels of irrigation and N are downward and to the right.

The nitrogen concentration of the leachate (Figure 3) ranged from a low of 20 mg/l to a high over 300 mg/l, an order of magnitude difference. The USEPA drinking water standard is 10 mg/l. In general, N6 (250 lb/ac) had the highest concentration and N2 (150 lb/ac) the lowest. The N0 treatment was fertilized at a 250 lb/ac rate during establishment in 1991 and the medium rate may be a result thereof. The highest irrigation level, I5, consistently had the highest concentration.

Concentration must be considered with the total leachate. In Figure 4 the March leachate is colored in black. Although all plots (supposedly) received the same precipitation, the March leachate was highly variable. During the summer of 1993 the PCAPS showed some leaching in the I5 irrigation treatment, but relatively little in the I4 and I3 irrigation levels. As mentioned previously, the 1993 irrigation was managed to be in excess for the I5 treatment. These results showed that little, if any, nitrate was lost during the growing season under well managed irrigation. Thus the leaching of nitrate occurs primarily during the winter months, December to March, when central Oregon receives over half its precipitation.

Figure 3. Nitrogen concentration (nitrate plus ammonium) of PCAPS leachate, Madras, OR, 1993.

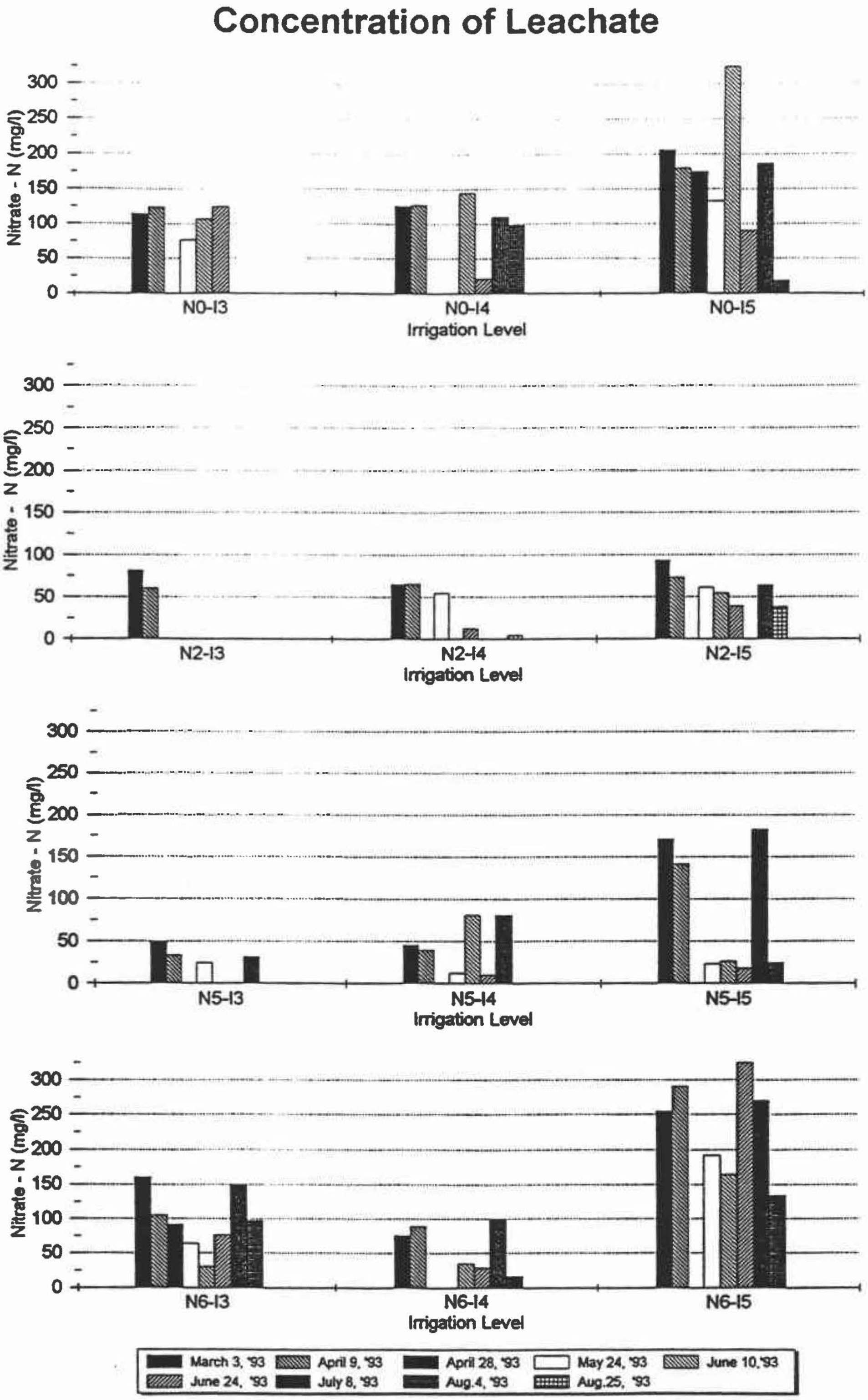


Figure 4. Quantity of PCAPS leachate, Madras, OR, 1993.

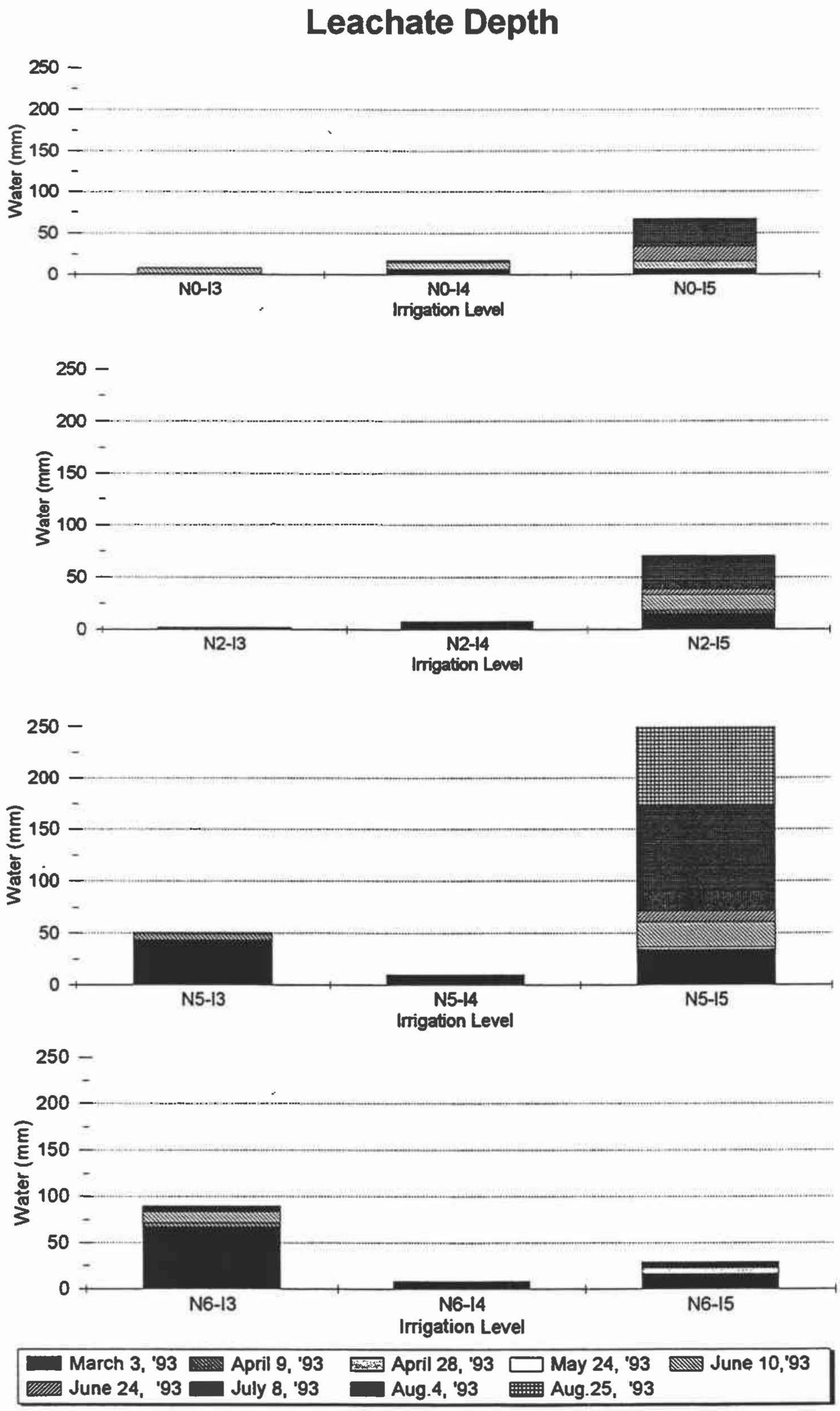
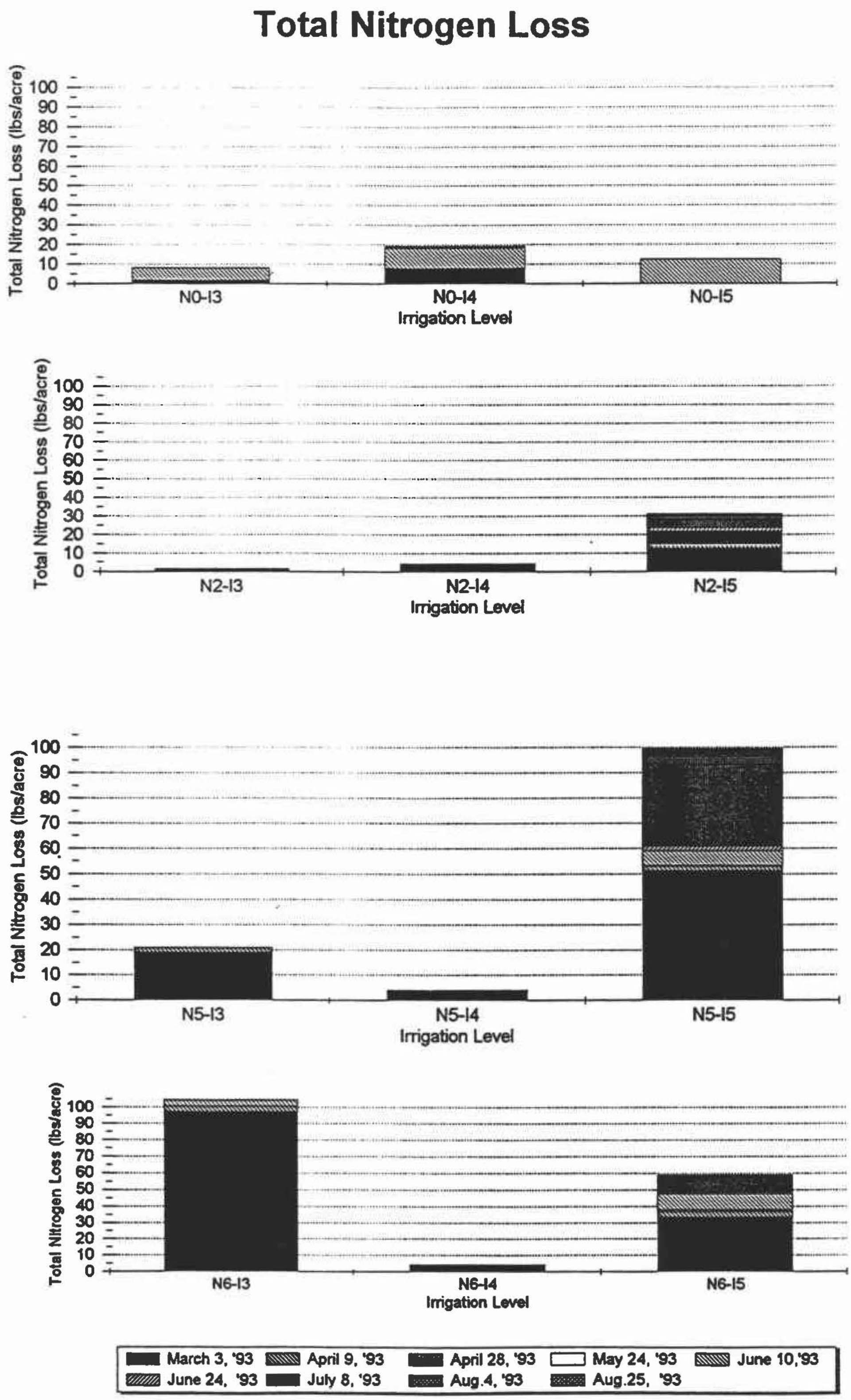


Figure 5. Total nitrogen loss from soil monitored by PCAPS samplers, Madras, OR, 1993.



Total nitrogen loss is shown in Figure 5. Expected trends prevailed with more N loss under high fertilizer and higher irrigation level. However, for the high fertility treatments, the I4 irrigation level was much lower than the I3 and I4 levels. The N6-I3 PCAPS sampler was much higher than the rest with the equivalent of an 100 lb/ac N loss.

Nitrate Leaching--Soil Samples

Soil samples taken in winter of 1991, prior to initiation of the project, and in the fall of 1991 indicated that nitrogen had increased at the 5-ft depth below the root zone (Mitchell, 1991) The data showed that the initial 10-mg/l soil N level had increased to 20 to 40 mg/l. The nitrate peak at the 5-ft depth indicated to us, at that time, that nitrate leaching had occurred to a depth of 5 ft, although sampling contamination may have been at fault.

More recently, soil samples taken in March 1993 in the plots near the PCAPS show soil inorganic nitrogen at levels near 25 mg/l (Figures 6 and 7). In order to compare with the PCAPS samples, one must divide the level by the soil water content, or approximately 0.30 g water/ g soil. The result is approximately 85 mg/l N in solution, which compares well with the PCAPS concentrations (Figure 3).

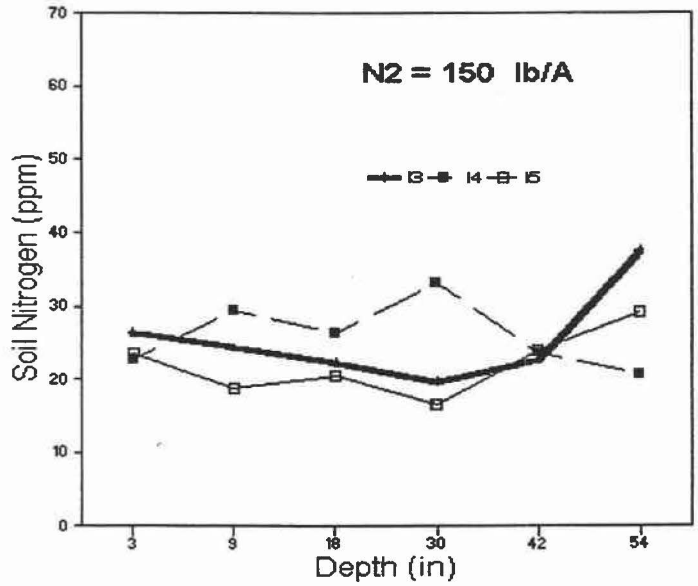


Figure 6. Soil inorganic nitrogen for the N2 treatment sampled March 1993, Madras, OR.

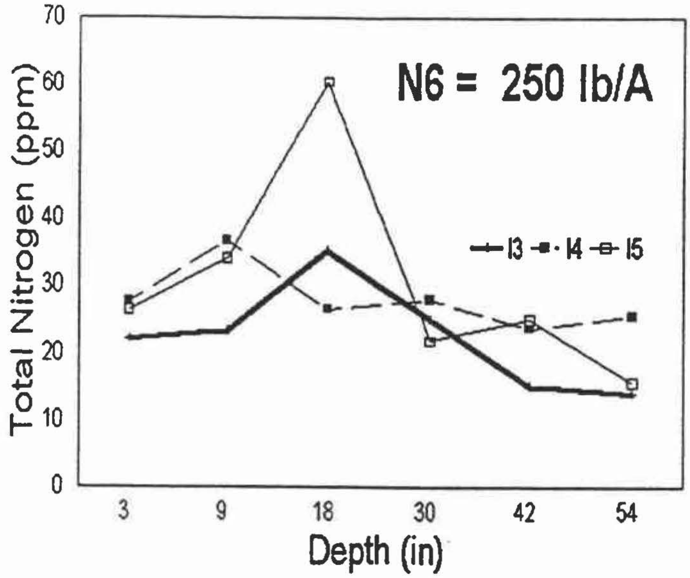


Figure 7. Soil inorganic nitrogen for the N6 treatment sampled March 1993, Madras, OR.

The other noticeable information in the soil data is effect of the irrigation level on nitrate content. For treatment N6 (Figure 7), the highest irrigation level I5 showed a sharp N peak at 18 inches, which is the B horizon. Other than that, there appears to be no consistent irrigation effect on nitrate concentration. One explanation may be that differential irrigation was applied only in spring and summer, while like amounts were applied in the fall and, of course, during winter precipitation.

Summary

Passive capillary samplers (PCAPS) were installed at the bottom of the root zone, and indicated that water and nitrate leach during the winter and under high irrigation. Nitrate concentrations in the soil water below the root zone were found to be greater than the drinking water standard.

Although there is much soil data still to be analyzed, the PCAPS data indicated that winter leaching can occur on all treatments, but that summer leaching was miminal for this soil/crop system unless excess irrigation was applied. For 1993, the total nitrogen lost was highly variable between 5 and 100 lb/ac/yr.

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POST-HARVEST PEPPERMINT MANAGEMENT TO ALLEVIEATE DROUGHT

Alan R. Mitchell

Abstract

Peppermint was treated with flaming and mulching operations after harvest to test regrowth and the subsequent yield under drought conditions. Treatments included mulching, mulching with grass straw, mulching with peppermint hay residue, flaming, and a control with nothing done as a post harvest measure. Different levels of irrigation were applied in the fall to each replication to give indication of water stress effect. Cultural treatment had no discernable effect on the following year's yield or oil quality. There was a slight block effect suggesting that increasing irrigation in the fall improved oil yield in the subsequent year. More research is needed to document the effect of fall irrigation on subsequent yield, and to measure the plant components that are most affected by fall regrowth.

Introduction

During the recent drought years in central Oregon (1986 to 1992), farmers were forced to manage crops with limited irrigation water. After peppermint harvest in August, many farmers were left with little irrigation water and faced a decision of when to apply their limited irrigation water to promote peppermint regrowth. One option was to delay the plant growth by non-irrigation or other cultural means in order to reduce crop water use until the arrival of cooler fall temperatures and possible fall rains.

The objective of our field study was to test post-harvest management practices for mint survival. These practices were meant to conserve soil water and were imposed under an irrigation variable. Propane flaming was a treatment that would delay crop growth by eliminating all above ground plants. Throwing a layer of soil, grass straw, or peppermint residue (hay), would also delay the above-soil growth of the plants, reduce soil evaporation, and thereby conserve soil water.

Materials and Methods

The experiment was conducted at the Central Oregon Agricultural Research Center near Madras, Oregon on second-year peppermint (*Mentha piperita*, 'Murray'). The peppermint had been planted in March, 1991, and shallow tillage was performed to enhance stand by spreading rhizomes in February, 1992.

Cultural treatments were established on August 13, 1992 following harvest on July 27. Treatments were flaming, soil mulching, grass-straw mulching, peppermint-hay mulching, and a control with no post harvest measures taken. Plots were 30 x 30 ft with a 10 ft border between blocks. Soil mulching was accomplished with a rotary corrugator that threw approximately 0.5-inches of soil on the surface. The grass straw was applied at a rate of 2.2 ton/ac and the soil mulch was applied afterward to keep the grass in place during wind events. The peppermint residue was applied at a rate of 30 ton/ac of moist hay and then mulched. The flaming was done with a research propane flamer at a ground speed of 2 mph.

The irrigation variable was applied with sprinkler lines located in the middle of each replicate, or block. During the period from August 14 to mid October, 1992, the three replicates were irrigated either weekly, monthly, or once in October. In 1993, all treatments were irrigated at the same non-stressed level. While this experimental design was not statistically sound by not allowing a valid tests for irrigation rate, lack of resources prevented a sound and detailed study. Essentially the experiment was only one replicate of a strip-plot design with the factors of irrigation level and cultural practice.

A mixture of urea and ammonium sulphate (40-0-0-6) was applied at the rate of 240 lb/ac on April 12, 1993 and 400 lb/ac on June 14, 1993. The total nitrogen applied was 256 lb/ac, the university recommendation. Terbacil (Sinbar, DuPont) had been applied at the rate of 1.5 lb/ac in 1991 and 1.5 lb/ac in April, 1992. In 1993, terbacil was applied to the control plots at a rate of 1.5 pint/ac, but not to the rye plot, which received 1.5 pt/ac of bromoxynil (Buctril, Rhone-Poulenc) on April 12, 1993 to control grasses and broadleaf weeds. Thereafter, the plots were hand-weeded.

Peppermint was harvested on August 12, 1993. Yield was determined from a swath measuring 40 inches wide x 25 ft long, from which a subsample (approximately 10 lb) was reserved for oil yield analysis. Sacked peppermint was immediately dried in the open air and stored indoors until distillation at a small scale research distillery on location.

Results

Stand regrowth

Notes and photographs were taken weekly on the regrowth. In the fall, the high irrigation treatment had more visible regrowth than the lower irrigation treatments. A wet winter resulted in similar spring regrowth for all treatments. Precipitation was 14.5 inches, or 183 percent of normal, for the water year from October 1992 to June 1993, and the temperatures were cooler. Grass seedlings emerged in the straw plots in March, but the herbicide effectively controlled them by late April.

Yield

As mentioned previously, lack of replication of the irrigation level limits us to speaking of generalities. However, an analysis of variance was performed using irrigation level as replication. There was no effect of cultural treatment, and the average yield was 4417 lb/a dry matter and 61.0 lb/a oil. For oil yield, there was a block (irrigation) effect at the α=0.10 level, with yields of 72.4, 60.0, and 50.5 lb/a for the high, medium, and low irrigation levels, respectively. These trends would indicate that post-harvest irrigation management affects yield in the subsequent year.

Analysis of variance was performed on four oil quality parameters: total heads, total menthol, menthofuran, and esters. No significant difference was found between treatments for any of the parameters. For total menthol, there was a block (irrigation) effect at the $\alpha=0.10$ level with values of 51.1, 50.3, and 52.1 percent menthol.

Conclusions

Cultural treatment had no discernable effect on the following year's yield or oil quality. Future research should concentrate on irrigation management after harvest. Also, other post-harvest stresses may also influence yield in the subsequent year. Presumably, this is due to greater growth of the underground rhizomes during the fall, which has a long lasting effect on growth and yield.

At this time, no further research is planned on the cultural treatments. Future research should concentrate on the post-harvest irrigation management and its effect on plant growth.

SURGE FLOW AND ALTERNATING FURROW IRRIGATION OF PEPPERMINT TO CONSERVE WATER[1]

Alan R. Mitchell and Karen Stevenson

Abstract

Surge flow and alternating furrow irrigation methods were compared against continuous flow for water saving and crop yield on a field of second-year peppermint (*Mentha piperita, L.*) in a Madras loam soil. Surge flow irrigation creates a series of on and off cycles of water flow. Alternating furrow consists of irrigating every-other furrow during every-other irrigation so that all furrows are irrigated over the course of two irrigations. Continuous flow will irrigate all rows each time. Measurements were taken of furrow advance, runoff, finishing time, and soil water tension. Oil and dry matter yields were not significantly different among methods. The results indicate surge flow and alternating furrow irrigation methods are beneficial for saving water without significant yield loss.

Introduction

The surge flow concept in surface irrigation was first introduced at Utah State University by Stringham and Keller (1979). By definition, surge flow is the intermittent application of water to irrigation pathways, creating a series of on and off periods of constant or variable duration. In other words, irrigation water is turned on and off in cycles that allow the soil to drain the standing water. The desired effect is to reduce the infiltration of water into the soil at the top end of the field. Research has been done in Utah, Colorado, and Washington with water savings on sandy and silt loams. Miller and Shock (1993) compared surge irrigation with conventional continuous flow on an onion field in Ontario, Oregon. They reported a decrease in runoff on surge flow from 50 percent on continuous to 29 percent on the surge flow, resulting in a slight yield loss of 90 cwt/ac, only 15 cwt/ac below the area's average. Available nitrogen was also monitored. Surge flow irrigation resulted in a loss of 186 lb N/ac less than continuous flow.

The reduction in infiltration rate is the phenomenon that makes surge flow irrigation desirable, and it is caused by at least four physical processes (Stringham et al., 1988). First, *consolidation due to soil particle migration and reorientation* during the off cycle results in a less permeable soil near the surface (Samani et al., 1985). During draining, the sand will settle out of the water first, then the silt and clay particles will settle on top. The small particles that settle out later will clog the pores that conduct water, thus reducing the infiltration rate. Also, the density of these smaller particles is greater, reducing the pores' size.

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[1]This study was supported by the Oregon Department of Environmental Quality.

Second, *air entrapment* reduces the infiltration during water reapplication (Linden and Dixon, 1975). During the off cycle, air enters the top of the soil after the water recedes. The bulk of the soil water is below the surface with air above it. As water is re-applied, the air becomes trapped between the water applied and the water below in the soil. The trapped air increases in pressure, and it is this pressure working against the entering water that reduces the infiltration rate.

Third, the *redistribution of water* slows the hydraulic gradient, the force that drives water flow. Infiltration is caused by both gravity (the weight of water pushing it downward) and soil suction (the ability of dry soil to wick water). During the off cycle, the water in the soil continues to be redistributed by these forces even though there is no water at the surface. When another irrigation cycle occurs, the soil gradient forces of gravity and suction are distributed over greater lengths, decreasing the infiltration rate.

Fourth, *channel smoothing* results from the off cycles, as the furrow channels become more streamlined throughout the irrigation season. The smoothing is caused by the particle migration mentioned above. The flatter, wider channels lower the water level in the furrow which reduces infiltration into the sides of the bed and moves the water faster down the furrow.

Surge flow irrigation has not yet been tested for soils and field conditions in central Oregon. The objective of this study was to increase irrigation efficiency without yield loss. The study compared surge flow, continuous flow, and alternating furrow irrigation practices. Alternating-furrow irrigation was included as a treatment because it previously showed water savings and an increased dry matter yield compared to continuous (Mitchell et al., 1993a).

Materials and Methods

The experiment was conducted in a field of 3.21 acres, with 2.0 acres of peppermint surrounded by a border crop of spring wheat. The soil was Madras loam (fine-loamy, mixed, mesic, Xerolic Durargid). The field had a slope of 2.0 percent with a 560-ft irrigation run.

On April 12, 1993, the second-year peppermint was fertilized with 250 lb/ac of fertilizer (40-0-0-6) which was a mixture of urea and ammonium sulfate. On July 23, 1993 a second application of 150 lb/ac of fertilizer (40-0-0-6) was applied. The furrows were dug using a rotary corrugator, which covered the bed with a mulch and buried the fertilizer. The furrows were 4.5 inches deep and 30 inches apart.

The peppermint was harvested on August 17, 1993 with a forage harvester. Five fresh weight samples were taken from a 12.5 ft X 3.33 ft area at five distances along the irrigation runs, 100, 200, 300, 400, and 500 ft. The samples were distilled at COARC.

The experiment was a random block design with four replications (Figure 1). Each treatment was 12.5 ft wide consisting of five furrows. The field was irrigated using a gated pipe system with water flowing through a flow meter and a pressure reduction tank. Two lengths of gated pipe were set up to accommodate the surge flow method. One pipe was set to deliver water to two of the four surge flow replications and the other pipe was set for the other two replications. Both pipe were set for the continuous flow and alternating furrow replications. The gates were calibrated and monitored to deliver 5 gallons of water per minute using a stop watch and a 5-liter pitcher. A flow meter determined the total flow in the entire system.

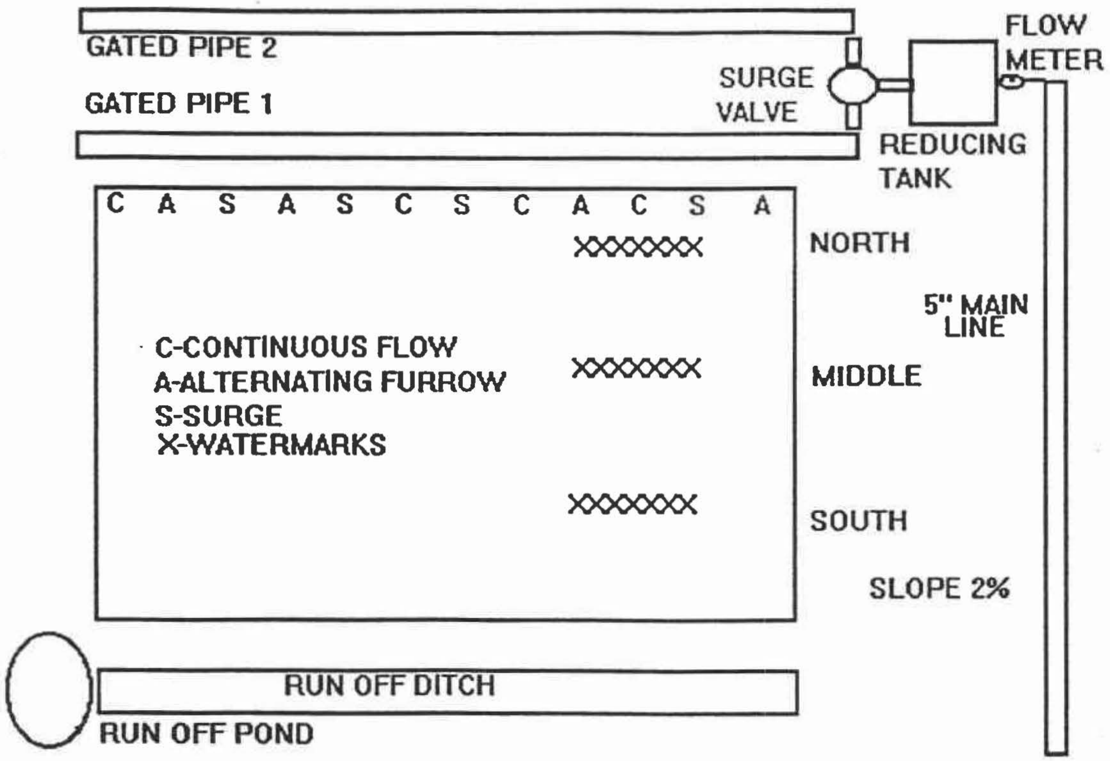

Figure 1. Design of furrow irrigation experiment, Madras, OR, 1993.

The Waterman LVC-5 6-inch Surge Flow Valve was used to control the surge flow irrigation (Waterman Industries, Inc. P.O. Box 458, Exeter, CA 93221). The control panel may be programmed with seven programs. Three are preset for specific furrow run lengths and four are designed with a specific number of surge cycles. In this experiment, program 5 was set according to the time required to advance 1/5 of the furrow run or at 100 ft. The rest of the surge flows were automatically calculated by the program using initial surge flow cycles. Each surge flow cycle's duration increased as follows: for a 30-minute first surge flow the cycles lasted 30, 46, 58, 66, and 74 minutes. After the first five cycles were completed the program automatically ran several "finishing" cycles with reduced cycle times. The finishing cycles were to minimize runoff. The water was shut off when all treatments were soaked across the bed.

The first furrow irrigation occurred on July 1. At this time the stand was approximately 9 inches tall and not at full canopy. Subsequent furrow irrigations occurred on July 7,13, 27, August 3, 6, and 11. During the last two irrigations, all gates were open on the alternating furrows because of the long irrigation time that this treatment required.

Furrow Advance and Runoff

Furrow advance readings were taken every hour from each row during the irrigation periods to determine how much water was needed to advance to a designated point. When the row finished, runoff measurements were taken. Runoff measurements were taken each hour for continuous flow and alternating furrow irrigation methods. For the surge treatment, runoff measurements were taken every half hour due to the variation in the surge flow runoff during the on/off cycles. All five rows from plot were channeled with a plastic pipe into a runoff ditch. The readings were taken with a stop watch and a bucket, using a 1,000-ml graduated cylinder for accurate volume measurement. The flow rate data was integrated over time to calculate the amount of runoff in acre in/acre.

Granular Matrix Sensors

Granular matrix sensors (GMS) were placed in each of the three treatments at the south, middle and north sections of the field (Irrometer Co., P.O. Box 2423, Riverside, Ca, 92516.) The north and south locations had four GMS per treatment, one each at 16, 8, and 4 inches deep and an extra surface GMS laying horizontal just below the soil surface. The middle location had six GMS per treatment, one each at 16 and 8 inches and at the surface, and three GMS at the 4-inch level. The additional GMS at the 4-inch depth were needed to schedule irrigations, as this is the depth most sensitive to peppermint crop water need. (Mitchell, et al. 1993b). Readings were taken daily at 7:30 a.m.

Results

Furrow Advance

The furrow advance rates are compared in Figure 2 for the July 7 irrigation. The continuous flow treatment took 11,000 gallons of water reach the end of the field while the surge flow took 4,300 gallons. The furrow-advance volume was less for the surge flow compared to the continuous flow, but was similar for the last 140 ft of the field. The alternating furrow had a fast advance comparable to the surge irrigation, but then slowed down. This may have been be caused by additional infiltration into adjacent rows which reduced the water volume in the furrow. The continuous flow advanced to the end of the field in the least amount of time, but used the greatest amount of water.

Irrigation

Irrigation components are given in Table 1 for all seven irrigations. The surge flow and alternating- furrow treatment required only 50 and 42 percent of the water applied to continuous flow treatment, respectively. Surge flow and alternating furrow runoff was about 36 and 30 percent of the continuous flow (Figure 3.) Surge and alternating-furrow also received less net irrigation: 6.33 in and 7.9 in compared to 11.28 in for the continuous treatment. Alternating furrow had the least runoff, but took the longest time to finish (Figure 4.) This was because, during stream advance, all five rows absorbed water from the two or three rows being irrigated.

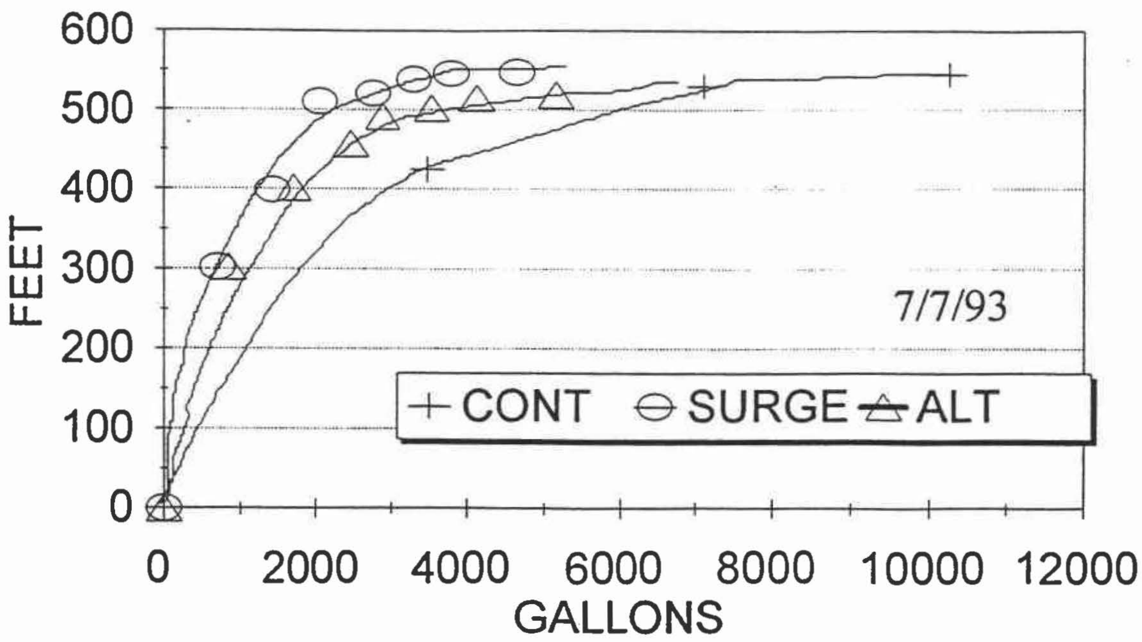

Figure 2. Furrow advance by volume, July 7 irrigation data, Madras, OR, 1993.

Table 1. Irrigation components of surge, alternating furrow study, Madras, OR, 1993.

	SURGE			CONTROL			ALTERNATING FURROW		
	APPLIED	RUNOFF	NET	APPLIED	RUNOFF	NET	APPLIED	RUNOFF	NET
DATE		acre in/acre			acre in/acre			acre in/acre	
07/01/93	1.59	0.15	1.43	3.17	0.44	2.73	1.27	0.05	1.22
07/07/93	1.09	0.27	0.82	2.17	0.62	1.55	1.20	0.09	1.12
07/13/93	0.83	0.23	0.60	1.65	0.74	0.91	0.60	0.13	0.46
07/27/93	1.51	0.20	1.31	3.02	0.89	2.13	1.81	0.12	1.70
08/03/93	1.33	0.24	1.09	2.66	0.81	1.85	1.06	0.09	0.97
08/06/93	0.73	0.27	0.46	1.47	0.28	1.19	1.47	0.38	1.08
08/11/93	0.98	0.37	0.61	1.97	1.05	0.92	1.97	0.61	1.36
TOTAL	8.06	1.73	6.33	16.12	4.83	11.28	9.38	1.48	7.90
% RUNOFF		21.50%			30.00%			15.75%	
% OF CONTROL	50.00%	35.83%	56.07%	100.00%	100.00%	100.00%	58.21%	30.56%	70.06%

Yield

There were no significant differences in dry matter yield between irrigation treatments, with an overall average and standard deviation of 3494 $\pm$ 619 lb/ac. There was also no effect from position in the field, differing from last year's results where peppermint yielded best near the top end of the field.

The oil yield was not significantly different at the $\alpha=0.05$ level, but differed at the $\alpha=0.10$ level, with the alternating-furrow treatment yielding 58.6 lb/ac compared to 52.9 lb/ac for both the surge and the continuous. The higher yield may have been helped by the final two irrigations being continuous-flow every furrow.

Also, maturity may have effected the oil yield. The entire field was harvested on the same day, and it is possible that the higher oil concentration (oil/dry matter) may have been due to a more mature plant.

Granular Matrix Sensors

The 4-inch depth GMS readings in the surge flow replication showed more stress than continuous flow and alternating furrow (Fig. 5), but the yields showed no evidence of stress. The effects of soil particle migration and reorientation may have slowed down the infiltration process. The irrigation duration could have been too short for an adequate amount of water to be absorbed. Since the yields showed no significant difference, this implies that peppermint can survive stress under these conditions to 100 kPa at 4 in and still produce an acceptable oil yield.

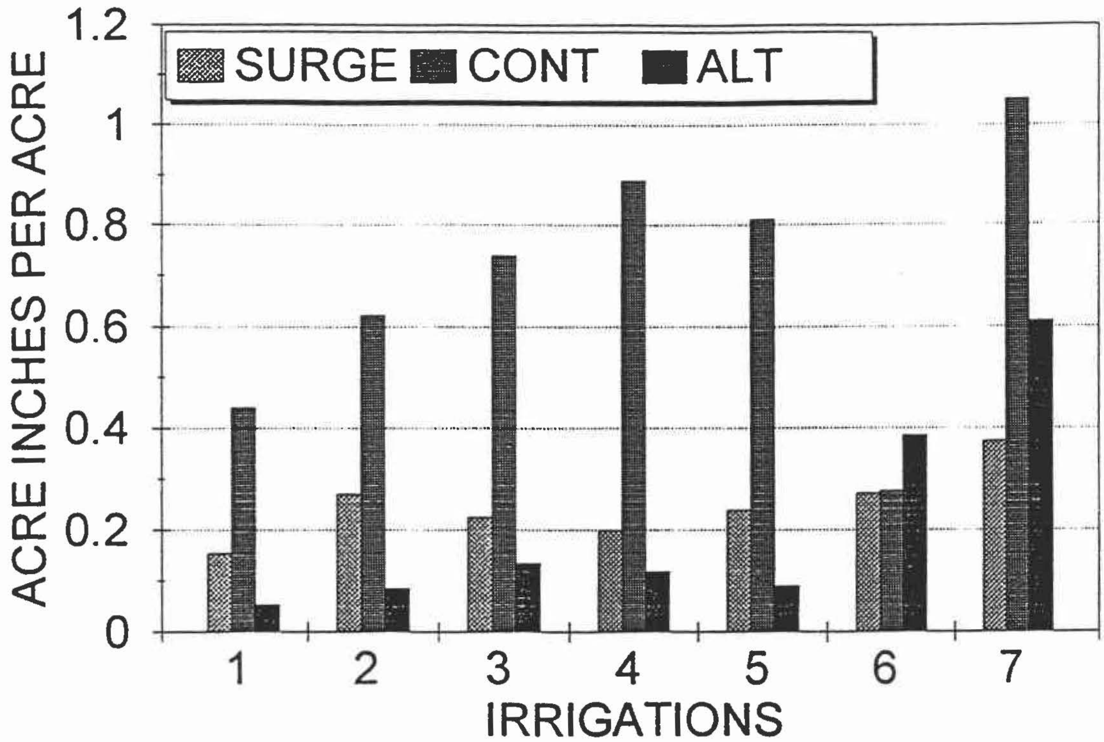

Figure 3. Runoff for all seven irrigations, Madras, OR, 1993.

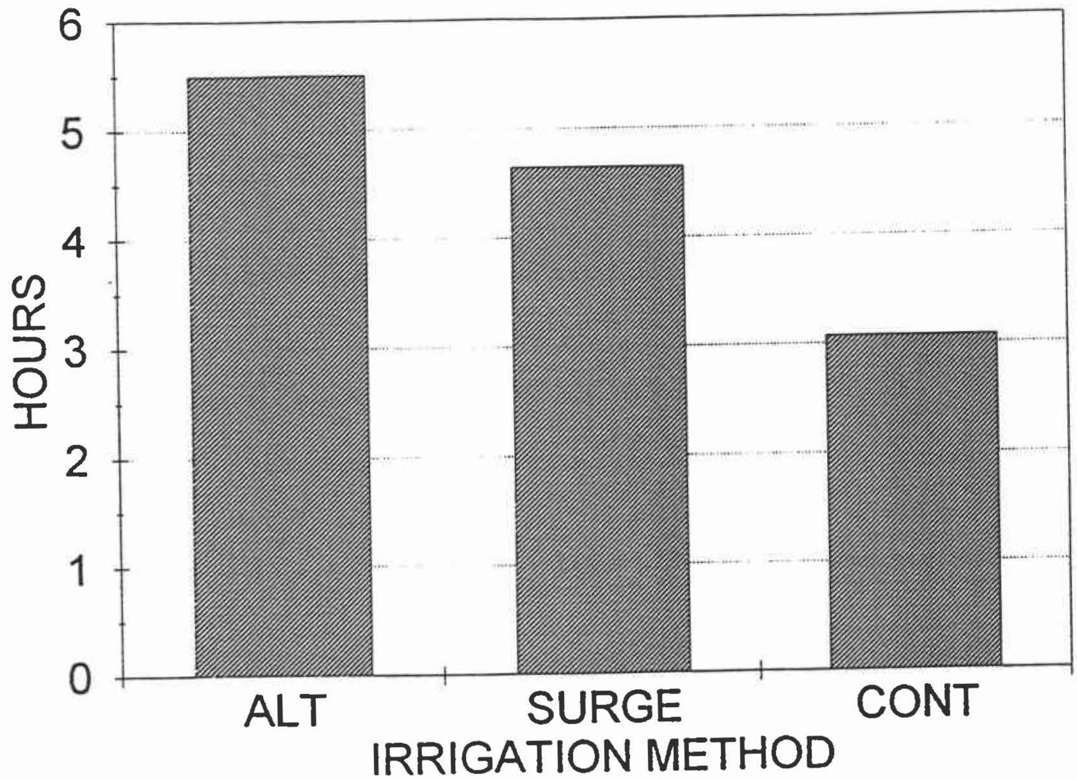

Figure 4. Average time to advance 560 ft of furrow, August 3 irrigation data, Madras, OR, 1993.

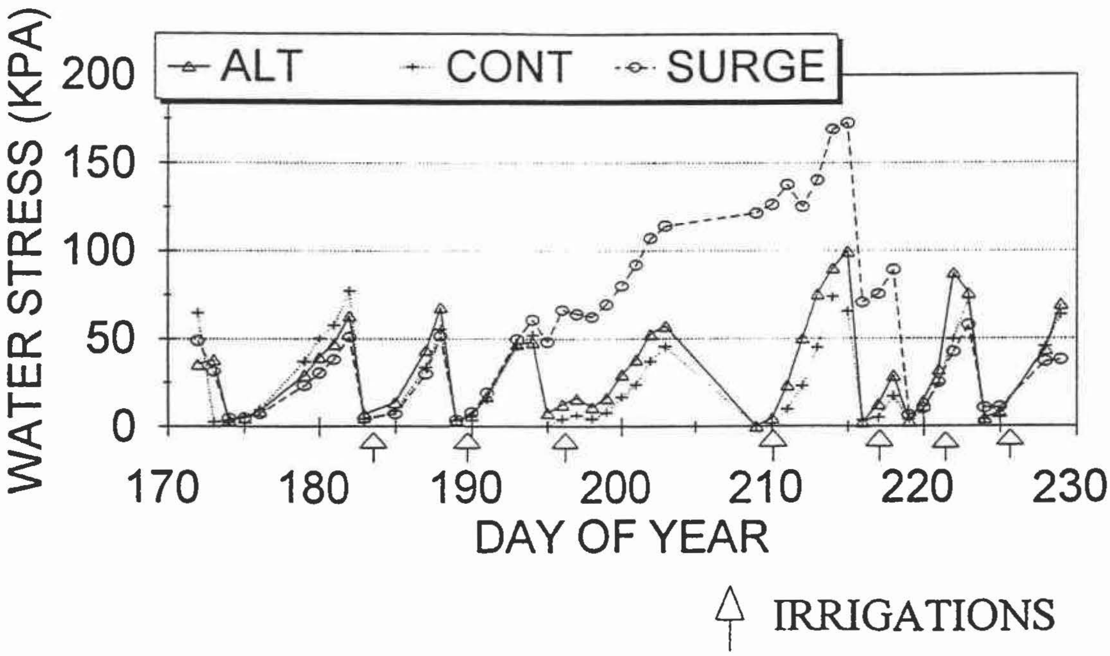

Figure 5. Soil tension at the four inch depth throughout the season, Madras, OR, 1993.

Conclusions

Surge flow irrigation proved to be a beneficial method of irrigation for peppermint. Surge flow saved water and reduced runoff with maintaining yields comparable with continuous flow. The alternating furrow also saved water without yield loss, but it takes longer to complete the irrigation and requires more labor for changing the gates each irrigation. Surge flow irrigation requires a minimal amount of labor since the valve controls the surge flows. However the initial cost of the valve and controller must be considered. The controller is movable and can work on several valves if they are operating at different times. When water is scarce, surge flow irrigation is an opportunity to conserve water.

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PHEROMONE TRAPPING MINT ROOT BORER, CENTRAL OREGON

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Abstract

Twenty-five pheromone traps attractive to male mint root borer moths were placed in 17 fields throughout central Oregon on June 3, 1993. Traps were monitored weekly from June 14 to September 23. Trap counts peaked during the weeks ending August 2 and August 9, with the last moths collected on September 6. Borer numbers in all fields were very low compared to other Northwest mint production areas. Climatic variation from year to year appears to influence population peaks, with little difference due to geographic and climatic variability within central Oregon.

Introduction

The mint root borer is a common pest in many mint production areas of the Pacific Northwest. Although not historically reported in central Oregon, the borer was documented at the Lower Bridge, Deschutes County, area during the 1991 season. Pheromone traps, which emit a scent that attracts the male moths, were used during the 1992 season to determine the extent of the borers' distribution in central Oregon. In addition to Lower Bridge, their presence was documented at Powell Butte, Prineville,and Lone Pine in Crook County, and the Culver-Metolius area in Jefferson County. Although no borers were found in traps on the Agency Plains and at Gateway, their presence throughout all areas of central Oregon was suspected. Moth numbers in all traps were relatively low compared to other mint production areas. It is believed that the mint root borer has been in central Oregon at low levels for an extended period, rather than the area experiencing a recent outbreak.

The objective of the 1993 project was to determine if the timing of emergence differs with climatic variability in central Oregon. Twenty-five traps were placed in 17 fields located at Lower Bridge, Prineville, Lone Pine, Culver, Agency Plains, and Little Agency Plains.

Methods and Materials

Twenty-five pheromone traps were placed in 17 fields throughout central Oregon on June 3. Six traps were located at Lower Bridge, five near Prineville, two at Lone Pine, six in the Culver area, four on Agency Plains, and two on Little Agency Plains. Traps were checked on a weekly basis from June 14 to September 13, when the last traps were removed from fields.

Results and Discussion

Individual and regional trap results are provided in Table 1, with a summary by date of total numbers trapped in Figure 1. Numbers of individuals trapped are considered low for all fields, including the one on Agency Plains and at Lower Bridge that each had several times the number found in other fields. The overall peak in population for 1993 was during the weeks ending August 2 and August 9, with the last moths collected on September 6. This compares to a peak during the week ending July 23 in 1992. A later peak would be expected for the 1993 season due to cool spring and summer weather. The only variability in regional peaks was on Agency Plains, which appeared to peak the week ending August 2, a week earlier than the other areas. It appears that overall climatic conditions affect borer development, with one possible difference in peaks within geographic and climatic areas of central Oregon.

There does not appear to be an obvious explanation for the dip in trap counts for the week ending July 12 or the precipitous decline on August 16. Weather data and pesticide applications do not appear to be the cause.

Research being conducted in the Willamette Valley has failed to find a correlation between moth counts in pheromone traps and larval numbers in the field. Pheromone trapping is an indicator of the presence of mint root borer, but field sampling is necessary to determine if treatable levels are present.

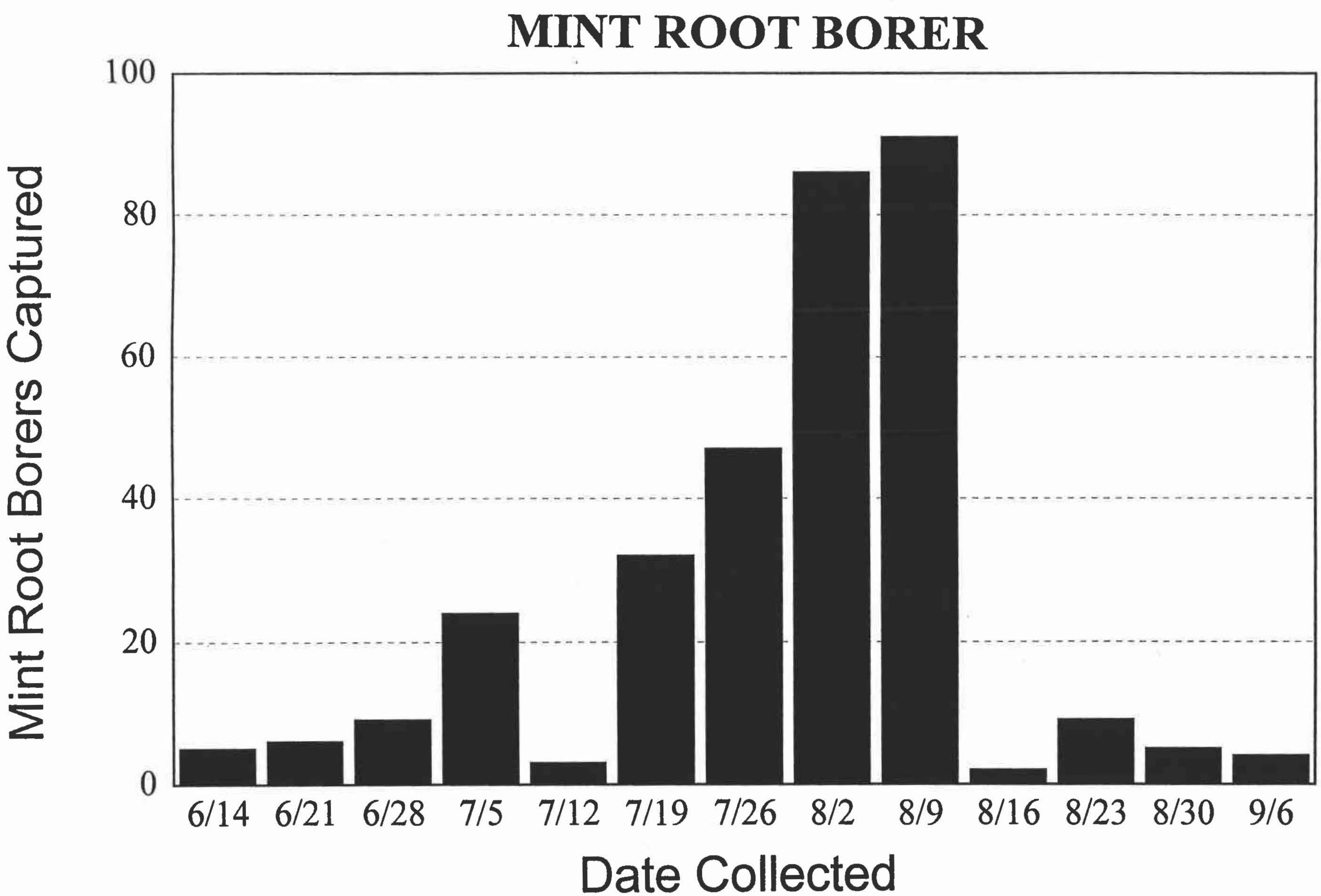
Table 1. Summary of individual male mint root borer moths captured in pheromone traps in central Oregon, 1993.

Location	Trap	June 14	June 21	June 28	July 5	July 12	July 19	July 26	Aug 2	Aug 9	Aug 16	Aug 23	Aug 30	Sep 6	Sep 13	Total
Lower Bridge	Total	4	0	2	5	2	-	20	25	51	0	5	-	1	0	115
	1 a	0	0	0	0	0	-	1	6	10	0	2	-	0	0	19
	1 b	0	0	0	0	0	-	1	0	2	0	2	-	0	0	5
	2 a	0	0	1	2	0	-	2	1	4	0	1	-	0	0	11
	2 b	0	0	0	0	0	-	1	0	3	0	0	-	0	0	4
	3 a	2	0	1	2	1	-	4	7	15	0	0	-	0	0	32
	3 b	2	0	0	1	1	-	11	11	17	0	0	-	1	0	44
Prineville / Lone Pine	Total	0	0	1	5	0	4	8	5	10	0	0	0	0	0	33
	4	0	0	0	0	0	0	0	0	0	0	0	0	R	-	0
	5	0	0	0	0	0	0	0	0	1	0	0	0	0	R	1
	6	0	0	1	4	0	2	5	2	0	0	0	0	0	R	14
	7 a	0	0	0	0	0	0	1	0	3	0	0	0	R	-	4
	7 b	0	0	0	0	0	0	1	0	2	0	0	0	0	0	3
	8 a	0	0	0	0	0	0	0	0	0	0	0	0	0	R	0
	8 b	0	0	0	1	0	2	1	3	4	0	0	0	0	R	11
Culver	Total	0	0	1	5	1	5	1	4	11	2	0	0	0	0	30
	9	0	0	0	2	0	2	0	0	0	0	0	0	R	-	4
	10	0	0	0	0	1	0	0	1	1	0	0	0	R	-	3
	11 a	0	0	0	0	0	0	0	2	3	1	0	0	0	R	6
	11 b	0	0	1	1	0	1	0	1	3	0	0	0	R	-	7
	12	0	0	0	2	0	2	0	0	2	1	0	0	R	-	7
	13	0	0	0	0	0	0	1	0	2	0	0	0	R	-	3
Agency / Little Agency Plains	Total	1	6	5	9	0	23	18	52	19	0	9	5	3	0	145
	14 a	0	1	0	0	0	0	0	0	3	0	0	0	0	0	4
	14 b	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
	15 a	0	3	3	3	0	12	5	18	6	0	4	0	0	0	54
	15 b	1	2	0	6	0	11	12	33	10	0	0	5	3	0	83
	16	0	0	0	0	0	0	1	1	0	R	-	-	-	-	2
	17	0	0	0	0	0	0	0	0	0	0	R	-	-	-	0
Central Oregon	**Total**	**5**	**6**	**9**	**24**	**3**	**32**	**47**	**86**	**91**	**2**	**9**	**5**	**4**	**0**	**323**

- indicates no data for that location and date

R indicates removal of trap from field the preceeding date

Figure 1. Summary by date of pheromone trapping of mint root borer in central Oregon, 1993.



SURFACE IRRIGATION EVALUATIONS UNDER CONVENTIONAL GATED PIPE IRRIGATION AND SURGE IRRIGATION[1]

Robert Schattin, Neysa A. Farris, Alan R. Mitchell

Abstract

On-farm field evaluations of conventional surface irrigation systems, and a surge irrigation system were performed by the Soil Conservation Service (SCS) and Oregon State University. The seven completed evaluations may be used to generalize the potential deep percolation resulting from surface irrigation as moderate (i.e. 2 inches per irrigation), although deep percolation may represent a substantial portion of overall water application (i.e. 30 to 50 percent). Some significant data measurement problems, particularly related to quantifying runoff, can make a greater reliance on this data difficult. The surge system evaluation presented a good opportunity to explore, on a commercial farm, this technology for the first time in Jefferson County.

Introduction

The objective was to evaluate on-farm conventional surface irrigation systems. These evaluations sought to quantify the extent of deep percolation from surface irrigation systems. A knowledge of deep percolation is important to quantify the potential leaching of nutrients into the vadose zone. Furthermore, a field evaluation of surface irrigation systems is important when determining proper surface irrigation design procedures.

Another objective was to evaluate improved surface irrigation systems technology, specifically surge-controlled surface irrigation systems. The principles of surge irrigation are described in another report on page 79. Two solar-powered Waterman Surge Irrigation control valves were evaluated for runoff, and irrigation efficiencies. This documentation of improved efficiencies may well lead to reduced deep percolation and subsequent agricultural loading of the vadose zone. Additionally, the SCS investigated Agricultural Research Service (ARS) design procedures for cablegation for on-farm use in Jefferson County.

Methods

Individual landowners, Mr. Don Boyle and Mr. Gary Harris, allowed data collection on their surface irrigated systems. The procedure used to evaluate deep percolation consisted of on-farm measurement of soil moisture before and after, total water applied, and runoff. Deep percolation was calculated as the unmeasured portion of the equation.

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[1]This study was a cooperative effort of the USDA Soil Conservation Service, Oregon State University, and the Jefferson County Soil and Water Conservation District. It was supported by Oregon Department of Environmental Quality.

In general, the soil moisture measurement before and after irrigation was the highest quality data. Direct gravimetric soil sampling was used to evaluate the percent by weight, and a bulk density value of 1.25 Mg/m^3 was used to obtain percent by volume. This estimated bulk density corresponded well with SCS research values, and a modification of the estimated bulk density does not appreciably effect the subsequent computations.

Data collection of soil samples was very time consuming. An equally accurate result may have been obtained with fewer soil samples. Total soil moisture estimated in inches before and after is a function of the estimated root zone depth of the crop. For the purpose of this evaluation this was assumed to be 18 inches for garlic (Mr. Harris's field), and 24 inches for peppermint (Mr. Boyle's field). The assumption of a deeper root zone depth generally leads to less deep percolation calculated.

Direct gate measurements were made using a bucket and stopwatch. In general, a sampling of five to ten gates was made and multiplied by the total number of gates to calculate the amount of water being applied to a field. The computed water delivered to each row was in the 5.75 gal/min to 7.0 gal/min range. This corresponded well with typical system design values. Also the total gal/min serving a field was spot checked with the amount of water the landowner thought they were receiving and this check corresponded well. On some occasions the water delivered to an existing pipeline was estimated as the same as on the previous set for that field.

Runoff measurements were first tried using a cumulative flow meter placed at the end of the field. Shortly into trials these flow meters were found to plug up and proved unreliable. The Jefferson County Soil and Water Conservation District (SWCD) and SCS are pursuing design options to get full value out of these meters. A second limitation of the cumulative flow meters is the variability of head that they are subjected to. The initial runoff flows provided very little head and hence need a smaller meter. Subsequent runoff produced greater heads, corresponding flows, and the need for larger meters.

Runoff measurements were subsequently made using a V-notch corrugated weir. Several samples were taken at each measurement time and an average runoff per row multiplied by the number of rows showing runoff was used to calculate total runoff. These measurements were made periodically throughout the evaluations, and an average end area method was used to linearly interpolate between measurement points.

A general limitation to the runoff measurements was that they were not made after irrigation was discontinued. As a result, the attached summary table may tend to show less runoff than actually occurred, and a somewhat high computation of deep percolation. We decided to present the data as received with this note.

Overall direct gate measurements and runoff measurements were significantly complicated by dealing with an on-farm system. Lack of communication between landowners and data collectors sometimes resulted in missed measurements and/or unknown times of beginning and ending irrigation. To the extent possible, we have tried to screen the data provided based on reasonableness and with a thought to it's application. The data collectors and the irrigators who participated are to be commended for their efforts.

Surge Irrigation

Mr. Boyle agreed to allow data collection on his fields. Two sets were monitored under gated pipe irrigation systems controlled with solar powered surge valves. Different pre-programmed settings were tried throughout the season. A conventional gated pipe system was evaluated, directly adjacent to the surge sets, that had the same row spacing and length

Data collection methodology was the same as reported above. Many of the same problems, particularly related to runoff collection, were repeated during the surge systems analysis.

SCS performed an in-depth investigation of using ARS cablegation procedures on Mr. Dean Brooks' property. The conclusion was that the existing system of gated pipe irrigation did not readily lend itself to modification to cablegation. The cable plug is not designed to run through a gated pipe but rather an adjacent mainline. After analysis of Mr. Brooks' situation this retrofit to cablegation was not deemed cost effective. The SCS continues to look for an appropriate cablegation system candidate in Jefferson County and will pursue the use of local ASCS cost share dollars for its installation.

Results

Table 1 presents the data obtained during the conventional surface gated pipe irrigation evaluations. Some evaluations were not included in this summary because data omissions made final calculation impossible. A complete set of data and calculations is available for review at the SCS Bend Area Office.

The most conclusive statement, with respect to data quality, is that on several occasions the two irrigators began irrigation with relatively high available water contents. Also the irrigations were fairly uniform in their gross depths of application and were in line with average design values for Madras soils and approximately 50 to 60 percent efficiency. From recent laboratory data furnished by the Soil Survey Party Leader for the Upper Deschutes River Soil Survey, the estimated water content at field capacity of a Madras Loam is 31 percent by volume. From the data it is evident that this value was often exceeded following an irrigation. Soil moisture values greater than 31 percent may indicate a saturated soil held up by a relatively impervious layer underlying the shallow soils in the area. Hence, the relatively saturated soils may negatively affect crop production in addition to the implications of early watering on deep percolation and irrigation inefficiency.

A reasonable generalization is that the irrigation efficiencies were in the range of 30 to 45 percent without tail water recovery. A 10 to 20 percent increase in irrigation efficiency is expected with the installation of tail water recover systems. These values would further increase if a deeper rooting depth was assumed. Caution is required when extrapolating the limited test results to a larger area.

An estimate of deep percolation in the range of one to three inches per irrigation is reasonable. For the majority of the crops irrigated in Jefferson County this would approach four irrigations per season, or approximately eight inches of deep percolation. It is noted that this estimate of deep percolation is in the context of a natural precipitation zone of nine inches annually.

No correlation between length of run and irrigation efficiency is evident. This may be in part related to the moderately deep Madras Loam, which is estimated at 24 inches and is underlain by basalt. SCS computational procedures, based on uniformly deep soil, would estimate much higher deep percolation for the lengths of run analyzed.

<u>Surge Irrigation</u>

Table 2 presents the data obtained during the surge irrigation evaluation. Some evaluations were not included in this summary because data omissions made final calculation impossible. A complete set of data and calculations is available for review at the SCS Bend Area Office.

Efficiencies were shown to improve under the surge irrigation systems. Irrigation efficiencies in the range of 50 to 60 percent are reasonable to expect using the surge systems. Many more set times are possible than the ones tried. SCS will continue working with Mr. Boyle on improved surge valve use.

Again, the irrigations began with relatively wet soils. Due to the complexity of measuring runoff data by row, no estimates were made to indicate the relative amount of system inefficiencies allocated to deep percolation or runoff.

There is a clear difference between expected runoff under conventional (continuous) or surge systems. Actually, some of the highest rates of runoff were found under the surge systems. This is indicative of improper operation, as the main aim of the surge systems is to reduce runoff. The movement of water to the end of the row occurs much more quickly under the repetitive levels as shown on the graph. However if an individual surge level is on too long this can lead to excessive runoff. From the data we conclude that secondary surges on Mr. Boyle's fields should not exceed two hours. Often these surge times exceeded four hours.

Additional surge system data, would be useful to quantify the exact time that runoff begins. With one exception, no data during the initial two hours of surge were obtained. This information could be used to better design the surge durations.

The runoff data under surge irrigation will be used to refine the design of surge duration next year as the SCS continues to work with Mr. Boyle.

Conclusion

The seven evaluations do not provide adequately sufficient data to be applicable to Jefferson County as a whole. The evaluations may be used to generalize the potential deep percolation resulting from surface irrigation as moderate (i.e. 2 inches per irrigation), although deep percolation may represent a substantial portion of overall water application (i.e. 30 to 50 percent). Some significant data measurement problems, particularly related to quantifying runoff, make a greater reliance on this data difficult. Also the limited number of evaluations performed must be considered when reviewing this data. For the irrigations evaluated, irrigation water management may be the single most effective irrigation system improvement. For the evaluations, the lowest initial soil moisture resulted in irrigation efficiency approaching 75 percent and was often in the 90 percent range.

The solar-powered surge irrigation valves improved overall irrigation efficiencies compared to the results obtained under conventional gated pipe irrigation systems. The measurements of runoff were insufficient to allocate system inefficiencies to either deep percolation or runoff. This runoff data indicates the surge durations may have been too long. The data collectors encountered many of the same runoff measurement problems reported earlier, although these were further complicated by the fact that many more periods, the on and off surges, existed during an irrigation. Since some superior irrigation efficiencies were obtained with the surge valve it is warranted to continue their evaluation in Jefferson County, with particular attention paid to the surge cycle time. At this time a wholesale recommendation to adopt surge irrigation technology in Jefferson County can not be made.

Recommendations

The on-farm evaluation of surface irrigation systems in Jefferson County represented a real challenge to the SCS and OSU team. A great deal was learned relative to flow measurement, coordination with landowners, the need for detailed soil sampling, and measurement of flows on-farm. It is recommended that SCS and the SWCD continue to monitor, on a regular basis, at least two irrigators per year to fully develop the skill to monitor real on-farm situations.

A shortcoming of this past year's evaluation was the limited time and money spent. Improvements, particularly related to flow measurement, would likely mean some trial structural measures. Additionally, the time required to fully monitor a 24 hour irrigation set (and be out there every hour) is significant. To be most useful, future evaluations need to focus more carefully on the time and equipment needed.

The most obvious focus for future SCS program activity may be irrigation scheduling, followed by tailwater recovery systems, and then followed by system conversion, e.g. shortening of run lengths.

Table 1. Field efficiency test for conventional surface, gated pipe irrigation systems, Madras, OR 1993.

FIELD	Acres	Length of Run Ft.	Soil	Crop
Harris - S2	7.21	1086	Madras Loam	bluegrass
Harris - S4	3.85	617	"	garlic
Boyle - Cont.	3.53	1280	"	peppermint

IRRIGATIONS

H-S2-I1	Harris Set 2 Irrig.	B-CO-I1	Boyle Continuous Irrig. #1
H-S2-I2	Harris Set 2 Irrig.	B-CO-I2	Boyle Continuous Irrig. #2
H-S4-I1	Harris Set 4 Irrig.	B-CO-I5	Boyle Continuous Irrig. #5
H-S4-I2	Harris Set 4 Irrig.		

Event	Gross Appl. --in--	Water Content* before ----percent----	after	Crop depleted --in--	Field efficiency** -percent-	Runoff (est.)*** --in--	Deep Percolation --in--
H-S2-I1	5.3	27.3	35.3	1.4	27-37	1.5	2.3
H-S2-I2	2.7	27.3	32.6	0.9	35-39	0.8	1.0
H-S4-I1	4.2	22.4	32.1	1.7	42-50	1.6	0.8
H-S4-I2	3.1	28.3	30.3	1.1	35-99	2.2	0.0
B-CO-I1	4.8	30.1	32.7	0.6	13-17	1.2	2.9
B-CO-I2	3.8	22.5	26.0	0.8	21-29	1.0	2.1
B-CO-I5	4.1	33.1	33.0	0.0	0-0	0.7	3.4

* From recent laboratory data of the Upper Deschutes River Soil Survey (not yet published) the Madras loam volummetric water content at field capacity is 31 percent.
** Field efficiency - the first value is efficiency assuming no collection of tail water, the second value assumes efficiency assuming 100 percent tail water recovery.
*** Some data collection discrepancies were found in the above sampling. Refer to the complete report before using this data.

Table 2. Field efficiency test for the surge irrigation system, Madras, OR, 1993.

FIELD	Acres	Run Length Ft.	Soil	Crop
Boyle - Continuous	3.53	1280	Madras Loam	Peppermint
Boyle - North Surge	7.1	1280	Madras Loam	"
Boyle - South Surge	7.1	1280	Madras Loam	"

Field-irrigation

BO-NS-I1	Boyle North Surge Irrigation #1
BO-NS-I2	Boyle North Surge Irrigation #2
BO-NS-I5	Boyle North Surge Irrigation #5
BO-SS-I1	Boyle South Surge Irrigation #1

Event	Gross Appl.	Water Content* before	Water Content* after	Crop depleted	Field efficiency**	Runoff (est.)***	Deep Percolation
	--in--	----percent----		--in--	-percent-	--in--	--in--
BO-NS-I1	1.7	28.80	33.70	1.2	68.0	----	----
BO-NS-I2	2.1	22.94	27.38	1.1	50.4	----	----
BO-NS-I5	2.3	31.28	35.57	0.9	38.0	----	----
BO-SS-I1	3.4	23.45	31.39	1.4	42.0	----	----

* From recent laboratory data of the Upper Deschutes River Soil Survey (not yet published) the Madras loam volummetric water content at field capacity is 31 percent.
** Some data collection discrepancies were found in the above sampling. Refer to the complete report before using this data.
***Insufficient data was collected during surge trials to accurately allocate system inefficiency due to runoff or deep percolation components.

DEVELOPMENT OF CONTROL PROGRAM FOR *CLAVICEPS PURPUREA* IN KENTUCKY BLUEGRASS SEED PRODUCTION

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Abstract

Ergot, an important flower-infecting pathogen affecting grass production, is particularly damaging to Kentucky bluegrass. To determine control measures without the use of field burning, three fungicides in combination with, and without, a surfactant were evaluated on two 'Coventry' Kentucky bluegrass fields located at Trail Crossing and Powell Butte. One hundred panicle samples were collected prior to harvest. Ergot infestation was substantially higher at Powell Butte, which had been infested with sclerotia during the winter and spring. All treatments significantly reduced the total number of sclerotia per plot compared to an untreated check. Of the several materials used, Punch provided the greatest control. Double applications of Tilt and Folicur at the high rate provided greater protection than single applications, or double applications at the low rates. This was true whether the second application was a fungicide or the wetting agent, Penaturf. Evaluation of percent panicles with sclerotia and average sclerotia per panicle provided similar results to total sclerotia per plot.

Introduction

Ergot, caused by the fungus, *Claviceps purpurea*, is an important flower-infecting pathogen in grass seed production regions of the Pacific Northwest. The pathogen produces an elongated, black sclerotia that replaces seeds in infected florets and causes a reduction in yield. These sclerotia are the primary means of survival and source of inoculum. In the spring, during flowering, spores from the sclerotia infect the grass flower and produce secondary spores, which causes exudate (honeydew) and makes harvest difficult. These secondary spores can be spread by water, wind and insects prior to sclerotia formation.

As one of the grass species grown for seed in Oregon, Kentucky bluegrass is particularly affected by ergot. Surveys conducted in central Oregon, where Kentucky bluegrass is the dominant variety being grown, indicate strong regional variation of ergot, with high levels in the Culver and Metolius area, contrasting to low incidence on the Agency Plains, north of Madras.

Because there are no fungicides registered for ergot, the only method of controlling the disease has been through open field burning. This practice has partially suppressed the disease in the past, as indicated by research conducted by John Hardison, plant pathologist at

Oregon State University. In spite of burning, ergot remains a major pest. Recently, pressure to decrease burning may leave grass seed producers with no effective tools to control ergot.

Methods and Materials

Research was conducted on two first-year 'Coventry' Kentucky bluegrass fields in central Oregon. One was with a grower cooperator in the Trail Crossing area and the other was at the Central Oregon Agricultural Research Center, Powell Butte site. The Powell Butte location was inoculated with ergot sclerotia during the winter and spring to insure a high inoculum level prior to application. Three fungicides, flusilazole (Punch, Dupont), propiconazole (Tilt, Ciba Geigy), and tebuconazole (Folicur, Mobay), in combination with, and without, Penaturf surfactant were applied to 10 x 20 ft plots replicated four times in a randomized complete block design. Materials were applied with a CO_2 pressurized boom sprayer. Following local standard procedure for fungicide application to grass seed, one pint/100 gal of LI 700 penetrant and 1 pint/ac of 17 percent oil were applied in combination with all fungicides, except one of two 7 oz ai/ac Punch treatments. Applications were made at Trail Crossing on June 7 and June 19, and treatments at the Powell Butte site were made on June 10 and June 19. The double surfactant treatment at Trail Crossing consisted of LI 700 at 4 pt/100 gal and 17 percent oil at 1 pt/ac, rather than Penaturf at 87 oz/ac as used at Powell Butte.

One hundred panicle samples were collected from each plot at Trail Crossing on July 6 and at Powell Butte on July 9. Samples were evaluated for percent of panicles with sclerotia, average sclerotia per panicle, and total sclerotia per plot. As of this reporting, evaluation of seed weight per plot, weight per 1,000 seed, and percent germination has not been completed.

Results and Discussion

A summary of the results for the Trail Crossing location is provided in Table 1, and data for the Powell Butte site is shown in Table 2. Disease levels at Powell Butte, where the trial was inoculated with sclerotia, were much more severe than at Trail Crossing. There were statistically significant differences between treatments for all variables evaluated.

All treatments significantly reduced the total number of sclerotia per plot when compared to the untreated check. Punch provided the best ergot control, with exception of the treatment without the LI 700 and 17 percent oil. Double treatments of all three materials at the higher rate out-performed single treatments of the same rate or double application at half the rate. This was true whether the second application was a fungicide or the wetting agent, Penaturf. Effectiveness of the double treatment of Penaturf at Powell Butte, or the LI 700 and 17 percent oil treatment at Trail Crossing, was well below that of the double fungicide treatments at the higher rates. Results for percent panicles with sclerotia and sclerotia per panicle were similar to total sclerotia per plot.

These same treatments were evaluated during 1992 at the Trail Crossing location. There were low levels of ergot throughout the area, and no statistical difference was discernable between treatments. However, the trend was for double fungicide treatments at the high rates to provide the greatest crop protection. It also appears from the 1992 data that Penaturf may have reduced seed weight, while the single Punch application without the surfactant Silwet-77 produced the highest weight. Germination tests from the 1992 study indicate that double applications of Folicur significantly reduced seed germination, while there were no significant differences between the untreated plots and those treated with Tilt, Punch and Penaturf. If seed weight or germination is adversely influenced in 1993, this may place limitations on the use of certain products or application methodologies.

Table 1. Evaluation of fungicide treatments for ergot control on 'Coventry' Kentucky bluegrass in the Trail Crossing area of central Oregon, 1993.

Fungicide Treatments	Rate of application June 7	June 19	Panicles with sclerotia	Sclerotia per panicle	Sclerotia per plot
	----oz ai/a----		percent		100 panicles
Punch 25EC	7[1]		1.8 ab[2]	0.8 a	3.3 ab
Punch 25EC	14		0.3 a	0.3 a	0.3 a
Punch 25EC	7		0.5 ab	0.5 a	1.0 a
Punch 25EC, Punch 25EC	7	7	0 a	0 a	0 a
Punch 25EC, Penaturf	7	78	0 a	0 a	0 a
Folicur 3.6F	3.6		1.0 ab	0.6 a	1.3 a
Folicur 3.6F, Folicur 3.6F	1.8	1.8	2.5 ab	2.2 a	8.8 b
Folicur 3.6F, Folicur 3.6F	3.6	3.6	1.3 ab	0.6 a	1.5 a
Folicur 3.6F, Penaturf	3.6	87	0.5 ab	0.5 a	0.5 a
Tilt 3.6E	3.3		2.5 ab	1.2 a	4.0 ab
Tilt 3.6E, Tilt 3.6E	1.7	1.7	1.3 ab	1.8 a	3.5 ab
Tilt 3.6E, Tilt 3.6E	3.3	3.3	0.5 ab	0.5 a	0.5 a
Tilt 3.6E, Penaturf	3.3	87	0.5 ab	1.3 a	1.3 a
Penaturf, Penaturf	87	87	2.5 ab	1.3 a	4.3 ab
Untreated	---	---	3.5 b	5.3 b	16.5 c

[1] Fungicide treatment without LI 700 penetrant and 17 percent oil.

[2] Means in column followed by the same letter are not statistically different by Duncan's Multiple Range test at $P \leq 0.05$.

Table 2. Evaluation of fungicide treatments for ergot control on 'Coventry' Kentucky bluegrass at the COARC Powell Butte location in central Oregon, 1993.

Fungicide Treatments	Rate of application June 10	Rate of application June 19	Panicles with sclerotia	Sclerotia per panicle	Sclerotia per plot
	----oz ai/a----		percent		100 panicles
Punch 25EC	7[1]		41 def[2]	2.1 abc	121 abcde
Punch 25EC	14		8 a	1.2 a	12 a
Punch 25EC	7		22 ab	1.7 ab	51 ab
Punch 25EC, Punch 25EC	7	7	17 ab	1.7 ab	31 a
Punch 25EC, Penaturf	7	78	15 ab	1.3 a	24 a
Folicur 3.6F	3.6		45 def	2.9 bcd	184 bcde
Folicur 3.6F, Folicur 3.6F	1.8	1.8	57 fg	3.2 cd	224 de
Folicur 3.6F, Folicur 3.6F	3.6	3.6	30 bcd	2.2 abc	78 abcd
Folicur 3.6F, Penaturf	3.6	87	24 abc	1.8 abc	52 ab
Tilt 3.6E	3.3		45 def	3.2 cd	212 cde
Tilt 3.6E, Tilt 3.6E	1.7	1.7	50 ef	3.1 bcd	191 bcde
Tilt 3.6E, Tilt 3.6E	3.3	3.3	31 bcde	2.4 abc	97 abcde
Tilt 3.6E, Penaturf	3.3	87	32 bcde	1.9 abc	73 abc
Penaturf, Penaturf	87	87	56 fg	3.9 d	244 e
Untreated	---	---	70 g	4.0 d	466 f

[1] Fungicide treatment without LI 700 penetrant and 17 percent oil.

[2] Means in column followed by the same letter are not statistically different by Duncan's Multiple Range test at $P \leq 0.05$.

EVALUATION OF POST-HARVEST RESIDUE REMOVAL EQUIPMENT ON KENTUCKY BLUEGRASS GROWN FOR SEED IN CENTRAL OREGON

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Abstract

In 1991 a study was initiated to evaluate post-harvest residue removal equipment on Kentucky bluegrass (*Poa pratensis L.*). This study started with two grower's fields, planted either with aggressive or non-aggressive variety types. Each year two more fields were added for a total of six fields at the climax of the trial. Data presented is for the 1992 harvest of two fields (aggressive and non-aggressive), and 1993 harvest of four fields (two aggressive and two non-aggressive). The trial will run until harvest of 1997.

Baling after combining is the common practice in central Oregon, therefore all treatments were in addition to baling. Averaged over all testing sites, seed yield and fertile tiller number were highest with open-field burning. Seed yield and fertile tiller number were intermediate when residue was removed with a vacuum-sweep plus propane treatment, vacuum-sweep treatment alone or with the wheel rake. Flail-only and bale-only treatments resulted in the lowest seed yields and fertile tiller numbers. Overall second year seed yields were comparable to third year seed yields with non-aggressive varieties slightly out-yielding aggressive varieties. Thousand seed weight and seed germination percentages were comparable among all treatments.

Introduction

The intermountain region of Idaho, Washington and Oregon are stable suppliers of high quality Kentucky bluegrass (*Poa pratensis L.*) seed. The cool winter climate and hot dry summers favor Kentucky bluegrass seed production. Since the 1950s the industry has increased from a few acres of the cultivar 'Marion' to production of over 100,000 acres and over 100 cultivars. This intermountain region has produced a stable supply of over 60 million pounds annually, which makes this region the primary producer for the world.

In the early development of Kentucky bluegrass seed production, growers became aware of the importance of post-harvest residue removal. Open-field burning was adopted as the standard practice for post-harvest residue removal and primarily for the suppression or elimination of diseases (Hardison 1976). Hardison in 1980 reviewed the history of field burning on perennial grass seed production, which started in the early 1950s for Kentucky bluegrass, primarily for control of Ergot and Silvertop disease. Burning also has partial control of Stripe smut , Flag smut, Rusts, Powdery mildew, Leaf rust and other leaf diseases on Kentucky bluegrass according to Hardison 1980.

Post-harvest open-field burning has been responsible for maintenance of yield and high quality seed production in the Pacific Northwest. However, increased concern for air quality has pressured growers to find alternative ways of removing debris after harvest. Pumphrey in 1965 demonstrated that seed yields of Kentucky bluegrass were highest where residue was removed prior to the initiation of fall regrowth. Complete residue removal by mechanical means or by burning showed the highest seed yields, and statistically there were no differences between the two methods. He also showed that the more complete the residue removal, the better the chance for increased yields at the following seed harvest. Canode and Law (1977) concurred with these findings. Their data showed that open-field burning of residue may maintain the productivity of the stand for several years longer than mechanical removal, and that thatching, mulching, gapping or increasing the row spacing did not appear to be economically acceptable alternatives. Gapping was accomplished by tilling across rows every other 30 cm to give an appearance of blocks of grass rather than rows. Canode and Law further reported that alternate year burning with straw removal in the year of non-burning, and high levels of continuous mechanical residue removal gave increased yields compared to straw removal alone. However, seed yields under these management strategies were less than under annual burning alone. In earlier studies by Evans and Canode in 1971, and Canode in 1972, the use of cultivating, gapping and mechanical removal was investigated. Cultivating seemed to remove productive tillers from the outer edge of the row, while the centers of the row become unproductive in older stands. The results indicated that Kentucky bluegrass can be grown in wider rows to give the same results as cultivating. Gapping reduced seed yield in the second year stands and increased seed yield in the third. Gapping in the establishment year significantly increased production in the fourth crop, where residue was removed mechanically. Mechanical removal of residue resulted in higher seed yields than did burning of the residue in the second and third year seed crop. Burning gave higher seed yields in the fourth and fifth crops.

Chilcote and Youngberg in 1975 reported on non-burning techniques of post-harvest residue removal. They used a hay rake treatment, a so-called "close cut" treatment by using a rotary mower followed by a street sweeper and a flail-chop treatment. The close-cut treatment removed the most residue. The flail chop was intermediate and the hay rake removed the least residue. In all instances raking and flail-chop removal of residue were found to be inferior to open burn. However, seed yield reduction as a result of these mechanical removal techniques was very dependent on grass seed species. Orchardgrass, for example, was able to maintain seed yield under a mechanical removal program, whereas fine fescue and Kentucky bluegrass were very sensitive and showed considerable yield reduction after just one year of non-burning.

With new technology in equipment available, this study's objectives was to: 1) demonstrate different mechanical residue management practices; 2) determine crop growth and development of Kentucky bluegrass with reduced smoke impact management treatments; and 3) compare the mechanical treatments to open-field burning for seed yield and seed quality.

Materials and Methods

Two on-farm sites were established in 1991 in central Oregon to evaluate the full compliment of the latest technology for mechanical post-harvest residue removal on Kentucky bluegrass seed production. Additionally two more fields were added in 1992 and in 1993 (for a total of six fields) for a comparison over time.

Because the primary focus for the study was to evaluate the most advanced technology in post-harvest residue equipment, we needed to identify what extent of residue removal was desired. The most common practice of open field burning leaves the field absent of any non-combustible debris and also eliminates debris around the crown of the plant. This cleansing of the soil surface allows maximum light penetration as well as allowing maximum efficiency for pesticide applications. Mechanical residue removal can be accomplished by using various methods. Each method varies in the amount and efficiency of soil cleansing. New equipment used for the study included a Wheel Rake, which has stiff tines to scratch the residue, thatch and remove debris from around the crowns, and a redesigned Grass Vac, both developed by Rear's Manufacturing in Eugene, Oregon. The Grass Vac machine enabled us to clip and vacuum remove the stubble to a 1 inch height. With the Wheel Rake, the bulk of the residue is windrowed, which is baled or otherwise disposed of. Other equipment utilized included a flail mower and a propane flamer with conventional nozzle spacing at 40 psi. Propane flaming after vacuum sweep or wheel rake results in relatively little smoke.

Commercial grass seed fields in central Oregon normally have a large portion of the crop residue removed as baled straw, followed by open-burning of stubble, propane burning or both. Thus, this "field treatment" was compared with several alternative methods of stubble management. Treatments included (1) field treatment; (2) bale-only (no subsequent stubble management); (3) flail chop (flailing all the stubble back on the ground); (4) rake (Wheel Rake); (5) rake plus propane (6) vacuum sweep (mechanical removal of stubble after baling with a Grass Vac); and (7) vacuum sweep plus propane. The treatment plot size was 100 x 22 ft.

Data were collected for vegetative tiller development, fertile tiller development, seed yield, and seed quality. All other management practices such as fertilizing, irrigating, and pest control were done as the normal grower practices for the individual fields. Harvest was completed with the use of conventional equipment and sub-samples were collected to obtain a percent clean out. Seed was cleaned and 1,000 seed weight and germination percents were determined.

Results and Discussion

Significant differences in seed yield resulted from the various management treatments. Seed yields are reported as pounds per acre of clean seed. Figure 1 and 3 shows seed yields and fertile tiller number for aggressive variety types in 1993. Figure 2 and 4 shows seed yields and fertile tiller number for non-aggressive variety types in 1993. Figure 5 shows seed yields and fertile tiller numbers for non-aggressive variety types in 1992. Figure 6 shows seed yields and fertile tiller numbers for aggressive variety types in 1992. The highest yields consistently were produced where the residue was removed completely either by mechanical means or by burning. Bale-only treatment resulted in the least seed yield as well as the lowest number of fertile tillers. Differences in seed yield by variety type were observed in our study. In 1992 the aggressive variety showed a significant need for a more complete residue removal. However, in 1993 the aggressive variety did not need complete residue removal. The winter of 1992 was dryer than the winter of 1993, which may have effected the need for completeness of residue removal.

Tiller development: The general trend of fertile tiller numbers was the same as the trend for seed yield (figures 1-6). Fall and spring vegetative tiller development showed no differences among treatments, with the exception that plants in the bale-only treatment had fewer tillers.

Seed quality: Seed quality was determined by observing germination percentage and by measuring 1,000 seed weight. Seed quality was not affected by different residue management treatments (data not shown).

Our results support general grower experiences with respect to open-field burning vs bale-only treatment. The bale only treatments showed etiolated regrowth in the fall, which is in agreement with Canode and Law (1975, 1977) as well as Ensign, et al. (1983), who conducted a study with shading of Kentucky bluegrass. They concluded that seed yield from plants shaded at 62 percent for 150 days did not differ from plants where the residue was only baled off. Field burning encouraged higher fertile tiller numbers and yield. This increase was true for the older stands, but was even more pronounced on younger stands.

In general, mechanical removal performed much better in our studies compared to bale-only treatment. However, compared to open-field burning, removal of residue with vacuum-sweep or vacuum-sweep followed by propane flaming were not quite as reliable. It is likely that mechanical means of straw removal will elevate the cost of production over the cost of open-field burning, both by requiring additional equipment purchase and usage and by depressing yield. For non-aggressive varieties, these mechanical means of residue removal may prove adequate. The rake plus propane treatment showed good promise in the first year of use as a cheaper more efficient mechanical stubble removal technique.

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Figure 1. Rugby Kentucky Bluegrass
Siegenhagen Farm, 1993
Third Harvest

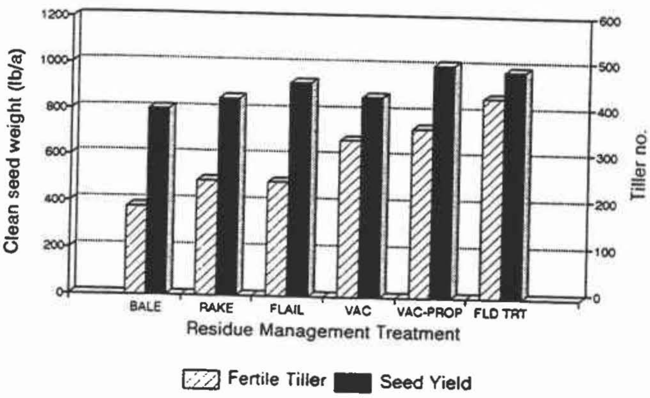


Figure 2. Abbey Kentucky Bluegrass
Siegenhagen Farm, 1993
Third harvest

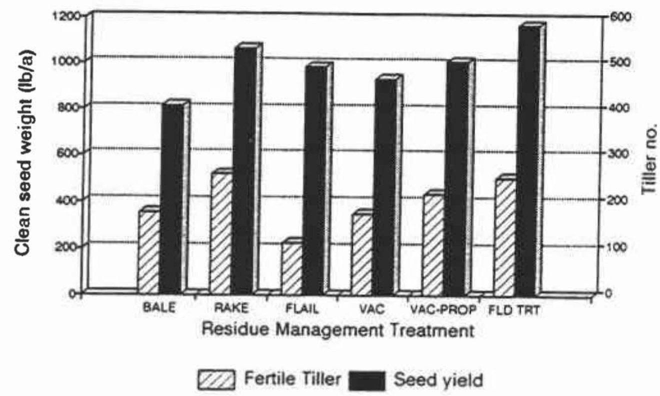


Figure 3. Rugby Kentucky Bluegrass
Brad Klann Farm, 1993
Second harvest

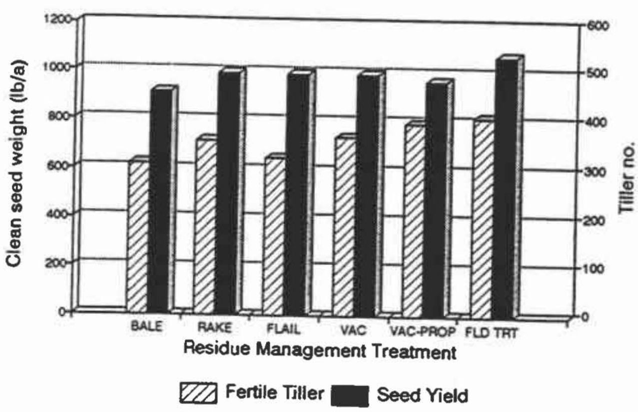


Figure 4. Merit Kentucky Bluegrass
Brad Klann Farm, 1993
Second harvest

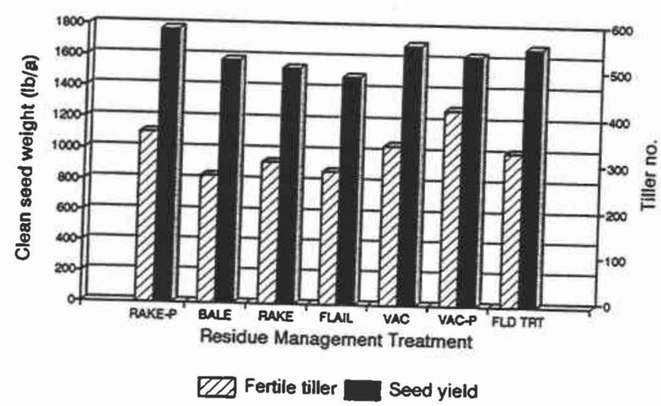


Figure 5. Abbey Kentucky Bluegrass
Siegenhagen Farm, 1992
Second harvest

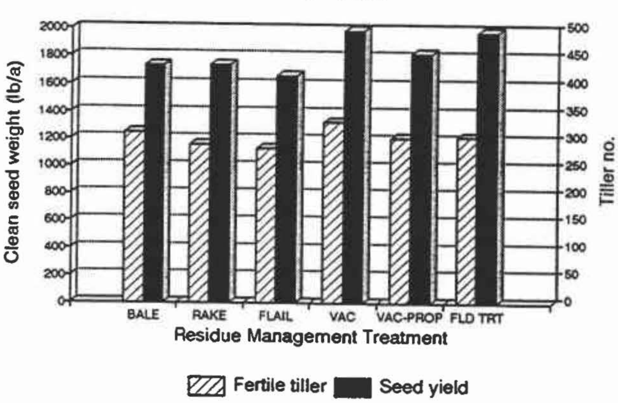
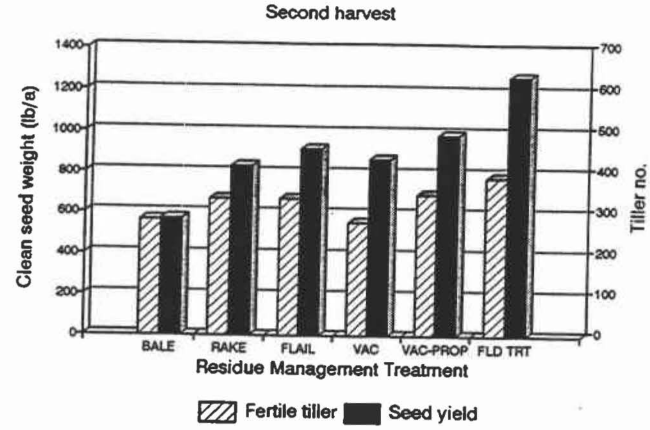


Figure 6. Rugby Kentucky Bluegrass
Siegenhagen Farm, 1992
Second harvest



HERBICIDE EFFICACY TRIALS ON SEED ONIONS, 1993

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Ed Clark, Northwest Chemical
Brett Dunn, Round Butte Seed
Kurt Farris, Round Butte Seed
Rod Kitterman, Gowan

Abstract

Herbicide trials were conducted on seed onions at three locations in central Oregon to evaluated Prefar alone, Prefar in combination with Dacthal, and a late application of Buctril at 8 oz/ac. Prefar was applied post-emergence at 4, 6 and 8 qt/ac to a fall, seed-planted field of onions on March 29, and pre-emergence to spring planted bulbs on April 23 . Prefar, in combination with Dacthal at 5 lb/ac, was applied pre-emergence to a seed-planted field on July 8. This was followed by an application of Buctril at 8 oz/ac on August 13. No phytotoxicity was observed at any of the locations. The weed spectrum at only one location included redroot pigweed and lambsquarter, weeds listed on the Prefar and Dacthal labels. Significant control of these two species was provided by Prefar at all three rates. Dacthal provided good control of lambsquarter, moderate control of redroot pigweed, and appeared to have some activity against puncturevine. Prefar and Dacthal were not effective against the remaining weed spectrum. Buctril at 8 oz/ac produced slight foliar burn, but did not control 4- to 6-inch high groundsel.

Introduction

Acreage of onions grown for seed continues to increase in central Oregon. Pesticide registration for vegetable seed crops, including onions, is very limited and registered materials can provide inadequate control. In response to the industry's continued search for efficacious materials with potential for registration, several herbicide trials were conducted on seed onions during the 1993 season. The objectives were to evaluate efficacy and potential phytotoxicity of Prefar alone, and in combination with Dacthal and Buctril, against the weed complex found in central Oregon seed onion fields.

Methods and Materials

Prefar at 4, 6 and 10 qt/ac was applied post-emergence on March 29 to a fall, seed-planted field farmed by Jim Carlson. The same treatments were applied pre-emergence on April 23 to a field of Loy Peterson's planted from bulbs, and applied pre-emergence on July 8 to an H & T field planted from seed. At the H & T location, Dacthal at 5 lb/ac was applied immediately following Prefar applications to one half of each plot, including untreated plots. This was followed by 8 oz/ac of Buctril applied August 13 to half the area treated with Dacthal. Depending on location, materials were applied to 9 x 20 ft or 9 x 16 ft plots with a CO_2 pressurized boom sprayer at 40 psi at a carrier rate of 20 gal/ac. Plots were replicated three times in a randomized complete block design. Following application at the Carlson location there was ample precipitation to incorporate the Prefar. Plots at the Peterson and H & T locations were sprinkler irrigated following initial applications.

Informal visual evaluations for phytotoxicity were made several times at each of the three locations following herbicide applications. Formal evaluations of efficacy were made on May 7 at Carlson's, on July 14 at Peterson's and on July 28 at H & T's field. The weed complex at the Carlson location was primarily groundsel, vetch and mustard. There were scattered 6- to 8-inch high groundsel, with large a number of plants less than 3 inches high. The primary weeds at the Peterson location were groundsel, hairy nightshade and common mallow. Evaluation of the nightshade was divided into plants that were flowering and smaller vegetative plants. The weed complex at the H & T location included groundsel, redroot pigweed, hairy nightshade, lambsquarter, puncture vine, carrot volunteers and watergrass.

Of the weed complex observed at these three central Oregon locations, only lambsquarter and redroot pigweed are listed on the Prefar label, and those only for the southwest corner of the United States. The Dacthal label lists lambsquarter as susceptible, and redroot pigweed as moderately susceptible.

Results and Discussion

No phytotoxicity from any of the materials was observed at the three locations. As shown in Table 1, there were no statistically significant differences between the three rates of Prefar and the untreated plots at the Carlson location. From visual observation, variability in weed density appeared to be correlated with changes in stand density through the plots rather than treatments applied. Results of the Peterson location, shown in Table 2, indicate a statistical difference on mallow between the untreated plots and plots treated with Prefar at 10 qt/ac. There were also differences between Prefar at 6 qt/ac and the untreated plots for all weeds in the uncultivated area in the row. Whether control of all weeds within the row is indeed significant may be questionable, since Prefar at 10 qt/ac was not significantly different from the untreated plots. None of the weeds evaluated at either location are listed on the Prefar label.

There were statistically significant differences between all rates of Prefar and untreated plots for redroot pigweed and lambsquarter at the H & T location. Dacthal alone applied to half the untreated plots also appears to provide good control of lambsquarter and modertcontrol of redroot pigweed. In addition, Dacthal appears to be active against puncture vine. Results against hairy nightshade are inconclusive due to the small number of plants present. Neither Prefar nor Dacthal provided observable control against groundsel, watergrass or carrot volunteers. Although total pigweed and lambsquarter numbers were low, activity against these species is consistent with label information for both products.

Buctril applied at 8 oz/ac later in the season resulted in some foliar burn, but did not provide control of groundsel at the 4- to 6-inch stage.

Table 1. Efficacy of Prefar applied post-emergence to seed onions at the Carlson location, Culver, OR on March 29, 1993.

Treatments	Groundsel Small	Groundsel Large	Vetch	Mustard	In Row
	----------------rating scale from 1 to 3 ----------------				
Prefar 4 qts	2.0	1.0	0.7	0.3	1.6
Prefar 6 qts	2.0	0.3	0.3	0	1.6
Prefar 10 qts	2.0	0.7	0.3	0.7	1.6
Untreated	2.0	1.0	0.3	0	1.6

Key: 1 = few, 3 = many

Table 2. Efficacy of Prefar applied pre-emergence to seed onion bulbs at the Peterson location, Madras, OR on April 23, 1993.

Treatments	Groundsel	Nightshade Vegetative	Nightshade Flowering	Mallow	In Row
	---------------------- percent control----------------------				
Prefar 4 qts	33 a	50	17	43 ab	13 ab
Prefar 6 qts	60 a	30	33	27 ab	23 a
Prefar 10 qts	33 a	27	20	47 a	13 ab
Untreated	0 b	0	0	0 b	0 b

Percent control were statistically different with Duncan's Multiple Range test at P≤ 0.01

Table 3. Efficacy of July 8, 1993 pre-emergence applications of Prefar, with Dacthal treated sub-plots, in seed onions at the H & T location, Culver OR.

Treatments	Redroot Pigweed	Lambs-quarter	Carrot	Puncture Vine	Hairy Nightshade	Watergrass
	number of plants per plot					
Prefar 4 qts	0 b	0 b	2.3	0.3	0	0.7
+ Dacthal 5 #	0.7	0	4.7	0	0	0.3
Prefar 6 qts	0 b	0 b	2.0	1.0	0	0
+ Dacthal 5#	0	0	4.0	0	0	0.3
Prefar 10 qts	0 b	0 b	5.3	0.3	0.3	0.7
+ Dacthal 5#	0	0	5.7	0	0	0.3
Untreated	4.7 a	3.0 a	2.3	0.7	0.3	0.3
+ Dacthal 5#	1.0	0	1.7	0	0.3	0.7

Percent control were statistically different with Duncan's Multiple Range test at P≤ 0.01

PHOTORESPIRATION INHIBITION OF CENTRAL OREGON PEPPERMINT

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Fred Crowe, COARC Superintendent
Sherode Powers, Grower Cooperator
Dan Phillips, A. M. Todd

Abstract

Nonomura reported increased growth on several crops in Arizona when methanol was applied foliar. Plant response was reported to increase as rate of application increased to the point of toxicity. On central Oregon peppermint methanol was applied from 25 percent at 20 gal/ac to 75 percent at 40 gal/ac with 1 g/liter urea and 0.05 g/liter Triton. Additional treatments included 1 g/liter urea and 0.05 g/liter Triton alone, glycine with 1 g/liter phosphate, and an untreated check. No phytotoxicity was observed, and there was no increase in plant height, wet hay weight per 100 ft^2, or oil quantity.

Introduction

Research by Nonomura and Bensen at Scripps Institute indicates that small amounts of methanol added to algae cultural medium resulted in 100 percent increase in dry weight yields over a 10-day period. It is believed that application of methanol allows C-3 plants, which include algae, to utilize the more efficient C-4 metabolism pathway.

Nonomura recently reported increased growth when methanol is applied foliar to several crops in Arizona (Proc. Natl. Acad. Sci. USA, Vol. 89, pp. 9794-9798. October, 1992). Plant response increased as rate of application increased to the point of toxicity. The greatest response was seen when methanol was applied during full sun, with no response observed when plants were shaded or during the winter months. Plant response to glycine applied with phosphate was similar to methanol.

In response to this research, a project was initiated in central Oregon during the 1993 season to evaluate the response of peppermint to methanol and glycine applications.

Methods and Materials

Field plots were established with a peppermint grower-cooperator in the Lower Bridge area. Treatments included methanol with 1 g/liter urea and 0.05 g/liter Triton, 1 g/liter urea and 0.05 g/liter Triton alone, 1 percent (1 g/liter) glycine with 1 g/liter phosphate, and an untreated check. The 9 x 32 ft plots were replicated three times in a randomized complete block design. Applications were initiated on June 8, with biweekly applications on June 19 and July 6, and weekly applications on July 13, July 21, July 28, and August 4. Methanol was applied at 25 percent for the first two applications. Based on a lack of phytotoxicity at lower rates, the percentage was increase to 50 percent for the third and forth application dates, and 75 percent for the three remaining applications. Materials were applied with a CO_2 pressurized boom sprayer at 40 psi and 20 gal/ac for the first four applications, and 40 gal/ac for the last three applications.

Informal visual evaluation of the plots were made on each application date. On August 6 plant height was averaged from measurements in four quadrants of each plot. Yield was evaluated by cutting a 100 square feet (5 x 20 ft) sample from the center of each plot and determining wet weight using a hanging scale. Oil yield was determined from 10-pound hay samples distilled at the COARC research stills.

Results and Discussion

No phytotoxicity was observed for any of the treatment or rates of methanol on any of the application dates. As shown in Table 1, there were no statistically significant differences ($P \leq 0.05$) between height, weight, or oil quantity for any of the treatments.

Table 1. Treatment results for photorespiration inhibition trial on peppermint conducted in central Oregon during the 1993 growing season.

Treatments	Height	Weight	Oil
	(in.)	(lbs.)	(mL)
Untreated	23.3	56.4	10.5
Minimal	22.1	48.8	10.4
Methanol	24.0	59.2	9.8
Glycine	23.8	50.8	8.5

Differences between treatments are non-significant ($P \leq 0.05$).

PERFORMANCE OF KENTUCKY BLUEGRASS SEED TREATED WITH METHANOL

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Abstract

Foliar-applied methanol was purported to enhance growth and yield for C3 crop plants in Arizona, possibly by inhibition of photorespiration. In central Oregon, Kentucky bluegrass in plots treated in the spring of 1993 with methanol or glycine showed a statistically significant ($P<0.05$) reduction in vegetative growth, and a trend for reduced vegetative tillers and seed yield when compared to plants in untreated plots. These results support the hypothesis that methanol may actively alter physiological processes, but suggest an opposite effect than that reported from Arizona.

Introduction

In 1992, Nonamura and Benson (1,4,5,6) reported that foliar-applied methanol increased crop production of C_3 plants. Under high light intensity, methanol may have reduced photorespiration, increasing the efficiency of carbon utilization. In the Arizona desert in the summer, methanol in aqueous solution increased crop yield (2,3,4,6). Phytotoxicity was reported between about 15 and 50 percent methanol, depending on plant species; optimal effects were seen for concentrations just below phytotoxic levels (6). Plants appeared to require less water as maturity was shortened (6).

As one of a series of investigations to determine if growth and yield responses might be gained in central Oregon from methanol treatment, we made application to Kentucky bluegrass (*Poa pratensis*) grown for seed production. This species of C_3 plant grows optimally during cool temperatures during the fall and spring. Floral induction of vegetative tillers to fertile tillers occurs in the fall. Following winter dormancy (with periodic growth during warmer winter days), tillers mature in the spring, anthesis occurs around the first week of June, seed matures during June, and seed may be harvested during early July. It is uncertain how much effect on crop yield and quality that inhibition of photorespiration might have after anthesis.

The primary factor reported to favor responses to methanol was high light (1,2,3,4,5,6), presumably total daily flux, which is a combination of daylength and solar intensity. Lack of general plant responses to methanol in Arizona in the winter were attributed to less light flux, rather than to reduced temperature (6). Lower limits for effective light intensity were not defined, but the response was seen in the summer rather than in the winter in Arizona (6). Central Oregon encompasses an arid, high altitude (2,500-4,000 ft) area, and daylengths for much of the growing season are longer than Arizona daylengths (Figure 1). At the spring equinox (March 20, 1993) the daylengths in central Oregon begin to exceed those in Arizona. This period would extend through the fall equinox (September 23, 1993). Thus, pending variation due to cloudiness, total light flux normally would be as high or higher through much of the growing season in central Oregon vs Arizona. However, for many plant species, plant growth during much of the season in central Oregon may be inhibited by cooler temperatures; the relationship between temperature and light flux with respect to methanol-induced growth responses is not known. Further, minutes of daylight as shown in Figure 1 do not directly translate into light flux, as light flux is moderated by cloudiness and perhaps other factors. Typically, for central Oregon, cloudiness is not extensive during the growing season.

Specifically, then, with respect to Kentucky bluegrass, for much of its early growth in the fall, late winter, and early spring, total light flux for Kentucky bluegrass might not be as great as in Arizona, and perhaps not great enough for a response to methanol application. But for growth in the late spring and early summer, total light flux for Kentucky bluegrass would be higher than in Arizona, so methanol application might have significant opportunity to elicit plant responses.

There may two different opportunities for treatment of Kentucky bluegrass: fall and spring. In 1993, we treated only through the spring, on a field which until then had been handled in a commercial manner.

Materials and Methods

No toxicity determinations were made on Kentucky bluegrass. The concentration of methanol was held at 25 percent, as recommended by A. Nonamura as a non-toxic but effective concentration for most crops. Methanol was applied in three replications in a randomized complete block design. Plots were 9 ft wide x 32 ft long. Materials were applied using a CO_2-powered backpack sprayer. Spray was applied at 40 lb/in^2, 20 gal/ac. The spray boom was held at 18 inches high, and six Teejet 8002VS were spaced at 18 inches along a 9 ft boom.

Treatments were as listed in Table 1. A glycine plus phosphate treatment was included upon the recommendation of A. Nonamura, as a potential alternative to methanol. As methanol was purported to increase plant growth, a minimal nitrogen solution as urea was included to supply needed supplemental nitrogen for such additional growth. This required that a second experimental control treatment (MEM) be added to the list of treatments. Triton X100 was included as a spreader-sticker wetting agent.

Table 1. Treatments used in the Kentucky bluegrass methanol trial located at the Central Oregon Agricultural Research Center, Madras, OR, 1993.

Treatment	Materials used
Untreated	none
MEM	1 g/l urea and 0.05 g/l Triton X100
Methanol + MEM	25% methanol + MEM
Glycine	1% glycine + 0.1% phosphate + 0.05 g/l Triton x100

The variety of Kentucky bluegrass was 'Adelphi', and management was as per standard commercial practice for the region with respect to fertility, irrigation, weed control, etc. Treatments were applied on May 11, May 26, June 8 (late anthesis) and June 24 (during seed maturity). On July 7, all vegetation above 1 inch was removed from 2 ft^2 of each plot. Total weight and numbers of fertile tillers were counted. Uncleaned and cleaned seed weight for each sample was determined by standard seed separation methods.

Results

Weather in the spring of 1993 was much cloudier and cooler than normal. These data are not summarized here, but likely accounted for less light flux than normal for this period. The extent to which this may have influenced plant responses is not clear, but could be significant based on Arizona reports (6).

Foliage height differences during May and June were only scanned visually; no measurements were taken, but no differences were noted visually. Also, there was no obvious difference in timing of anthesis, or in crop maturity as the season progressed.

Means of data for total dry weight, fertile tiller number, combined seed weight, and cleaned seed weight are shown in Table 2. Statistically significant differences were found only for total dry weight, although means for fertile tiller number and seed weights follow the same trends. For all parameters, however, higher mean values were found for Kentucky bluegrass in the experimental controls (untreated and MEM treated plots) compared to methanol and glycine treatments.

Table 2. Performance data for methanol-treated Kentucky bluegrass at the Central Oregon Agricultural Research Center, 1993

Treatment	Total Sample Dry Weight (g)	Fertile Tiller No.	Uncleaned Seed Weight (g)	Clean Seed Weight (g)
Untreated	874 A	567	215	21.8
MEM	821 AB	429	198	18.2
Methanol	713 B	470	181	18.2
Glycine	675 B	371	164	11.8

For Total Sample Dry Weight, numbers followed by different letters were significantly different ($P<0.05$) for both the F-Test and Duncan's Multiple Range Test. No significant differences ($P<0.05$) were found among treatments for fertile tillers or seed weights.

Discussion

The extent to which increased cloudiness in the spring of 1993 may have affected the results above is uncertain, but there were fewer sunny hours in 1993 than in normal seasons. Additionally, the spring was cooler than normal, which extended the season by one to two weeks, but with no net effect on bluegrass yields for the region.

These data support the conclusion that methanol and glycine influenced plant growth and yield, but the data are not as clear or strong as is needed to support strong statistical statements. Whether more replications would have resulted in greater statistical separation among treatments is a question that may be pursued in future trials.

Total sample dry weight was higher for Kentucky bluegrass in untreated and MEM treated plots than in methanol and glycine treated plots. Similarly, there was a trend for higher seed yield in the experimental control treatments. These responses, if verified, are the opposite of those anticipated based on reports from Arizona (1,2,3,4,5,6), where foliar-applied methanol increased plant growth and yields compared to untreated plants. Nevertheless, there at least was the suggestion of plant responses in our data. Any responses are noteworthy, and suggest that such treatments might serve as management or research tools in some manner. It may well be worthwhile to further investigate the response of Kentucky bluegrass in central Oregon to foliar-applied methanol, both for fall and spring application.

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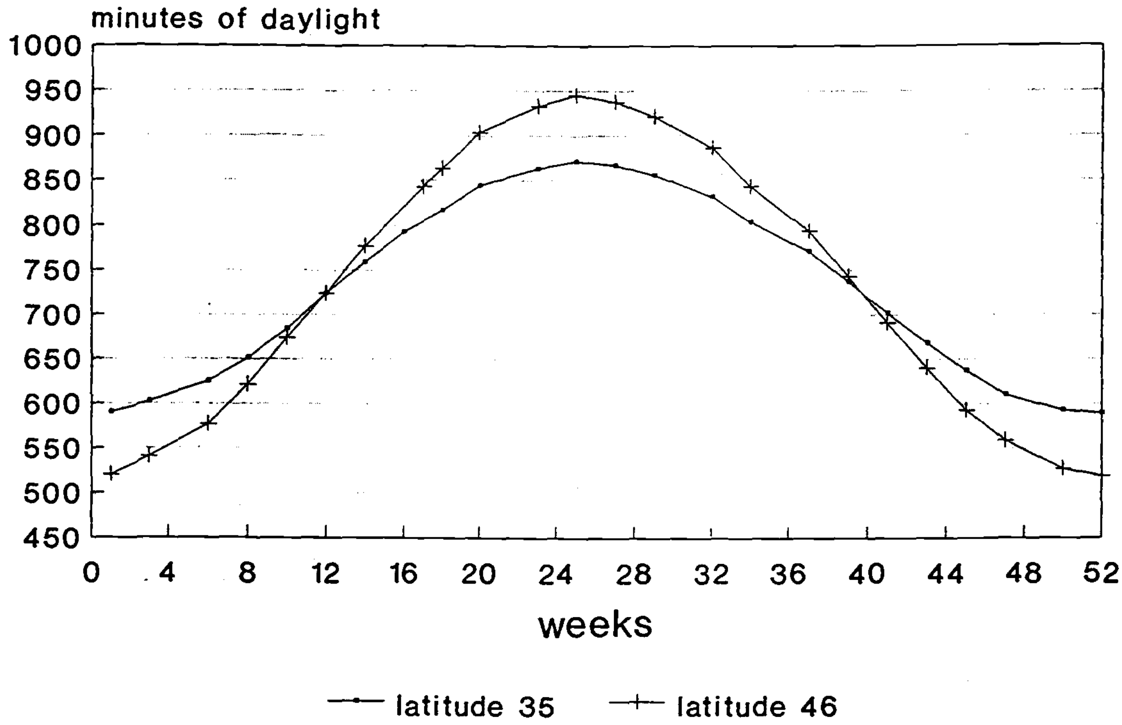
Figure 1. Minutes of daylight calculated for Central Oregon (latitude 46) and for northern Arizona (latitude 35) for 1993, based on data from the U.S. Naval Observatory (7). For Kentucky bluegrass, anthesis in central Oregon occurs at about week 23 in typical years, and occurred in week 25 in 1993 due to extended cloudy, cool spring weather in 1993.



PLANT PERFORMANCE AND WATER USE OF METHANOL TREATED PEPPERMINT

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Abstract

Methanol applied to the foliage has been reported to reduce water use of C_3 crops. A field experiment on peppermint measured plant performance and soil water depletion for methanol and an untreated control. No differences were found in dry matter yield, oil yield, plant height, leaf weight, or water use. Preliminary phytotoxicity studies showed no toxicity or necrosis at concentrations up to 99 percent methanol.

Introduction

Last fall 1992, Drs. Arthur M. Nonomura and A.A. Benson announced the results of field trials that claimed that foliar-applied methanol can increase crop production of C_3 plants (Benson and Nonomura, 1992; Nonomura and Benson, 1992a, b, c). Methanol, commonly called wood alcohol, can reportedly reduce the photorespiration of C_3 plants, which occurs under high light intensity, making them as efficient as C_4 plants. In Arizona, methanol in aqueous solution was found to increase crop yield of plants under high light intensity, although species and cultivars of plants differed in their response. Also, phytotoxicity was reported between about 15 and 50 percent methanol, depending on the plant species. For this reason, methanol concentrations were reduced for sub-phytotoxic levels for field applications.

Methanol responses have been associated with high light intensities. Peppermint growth in central Oregon that contributes to oil yield primarily occurs in June, July, and early August. During these months, total daylight hours exceed those in Arizona, which suggests that peppermint might respond well to methanol.

According to Dr. Nonomura, treated plants appeared to require less water both during the growing period and near harvest because the plants matured sooner (Nonomura and Benson, 1992c; Mauney, 1993; L. A. Times, 1992). The potential for water conservation is important in drought-stricken areas, such as central Oregon. Water use for irrigation is increasingly debated throughout the West. If methanol does in fact reduce water requirements, then this may be a partial solution to increasing the water-use efficiency of crops.

We conducted exploratory research on the water conservation potential of methanol, using potatoes and peppermint, in addition to monitoring plant growth and yield. These crops should have a potential for yield increases because they exhibit wilting in the field during hot summer days (Nonomura, personal communication.) Both crops are important to the agricultural economy of central Oregon. The objective of the experiments was to compare crop water use under methanol-treated and non-treated plots. Only the peppermint results are available at this time and will be reported.

Materials and Methods

Two preliminary studies on methanol toxicity took place in May. In the first, eight treatments of methanol concentrations in water in regular 10 percent intervals from 0 to 70 percent were applied to three replications in a randomized block design. A hand-held spray bottle was used to apply methanol solution to ten 1-ft^2 plots. Application rate was 20 gal/ac. The second trial two weeks later was done in the same manner, with the additional concentrations of 80, 90, and 99 percent methanol, and to 4-ft^2 plots. At the time of application, it was sunny and warm (approximately 70° F).

The water-use measurements were part of two larger studies. Methanol was applied in three replications in a randomized complete block design. The plots measured 9 x 30 ft. The initial methanol application rate was 20 gal/ac of solution that included a nutrient minimal enhancement media of 1 g/l urea, 1 g/l Triton, a surfactant. As experimental control comparisons, other treatments included totally untreated plots, and plots treated with a minimal enhancement media (MEM) consisting of 1 g/l and 0.05 g/l Triton X100. A glycine-phosphate treatment, as shown in Table 1, also was included as an alternative to methanol. Peppermint plots were sprayed on June 24, July 8, 23, and 29, and August 5. Because of the lack phytotoxicity and lack of discernable difference in plant growth, the last two applications were increased to 40 gal/ac of 75 percent methanol solution. Harvest was August 9 and 10-lb samples were distilled at a research distillery on location. Oil quality was tested by A.M. Todd, Kalamazoo, MI.

Due to cost, not all methanol treatments had the crop water use tested. Crop water use was tested for the treatments designated in Table 1.

Table 1. Treatments of methanol trial test for crop water use, Madras, OR, 1993.

Treatment	Spray mixtures applied at rate of 20 gal/ac
untreated	none
MEM*	1 g/l urea and 0.05 g/l Triton X100
methanol+MEM*	25% methanol + 1 g/l urea and 0.05 g/l Triton X100**
glycine	1% glycine + 0.1% phosphate + 0.05 g/l Triton X100

* Water use tested for these treatments
** Percentage of methanol upped to 75% and rate of application increased to 40 gal/ac, beginning July 8, 1993.

Crop water use was measured with a series of granular matrix sensors (GMS) that were buried at several soil depths and multiplexed to an automated datalogger as shown in Figure 1 for peppermint. The change in soil water content was integrated for the soil depths to arrive at crop water use for the period between irrigations, assuming deep percolation was negligible. All methanol treatments were sprinkler irrigated at the same rates. The GMS were previously calibrated for soil tension (Eldridge et al. 1993) and for soil water content for the Madras loam (fine-loamy, mixed, mesic, Xerollic Durargid) on which the study took place.

Plant height was measured on July 29, 1993. Leaf mass was measured on August 9, 1993 for 40 plants per replication. Peppermint was harvested on August 9, 1993. Yield was determined from a swath measuring 40 inches wide x 25 ft. long, from which a subsample (approximately 10 lb) was reserved for oil yield analysis. Sacked peppermint was immediately dried in the open air and stored indoors until distillation in a small scale research distillery on location.

Results

No leaf toxicity or necrosis was observed in either preliminary toxicity trial, even at concentrations above 90 percent. As far as we know, this is the first such result for methanol-treated crops. One explanation may lie in the nature of the peppermint plant that consists of up to 2 percent alcohol. Such plants may possess mechanisms that resist alcohols such as methanol. It is possible that methanol failed to be taken into the cells of the peppermint leaves.

Plant height measurements showed no significant difference between the four treatments ($P \leq 0.05$). The overall average was 64.4 ± 4.1 cm. Leaf mass measurements taken at harvest also showed no significant differences between treatments.

There were no yield differences for the methanol treatments for peppermint. Average peppermint dry matter yield was $4{,}855 \pm 600$ lb/ac and oil yield was 53.7 ± 3.1 lb/ac. Oil quality constituents menthol, menthofuran, esters, and total head were all found to be unaffected by methanol treatment.

Water use of peppermint was not influenced by methanol treatment as tested by ANOVA. The daily change in profile water content is shown in Figure 2 for the average of both treatments. The treatment values match each other very well, which demonstrates that the GMS method of measuring water gave consistent results. The average ET from June 9 to harvest on August 12 was 5.0 mm/day for the methanol treatment and 5.1 mm/day for the control. These ET values compared favorably with neutron-meter data from an adjacent field that showed an average of 5.0 mm/day for the same period.

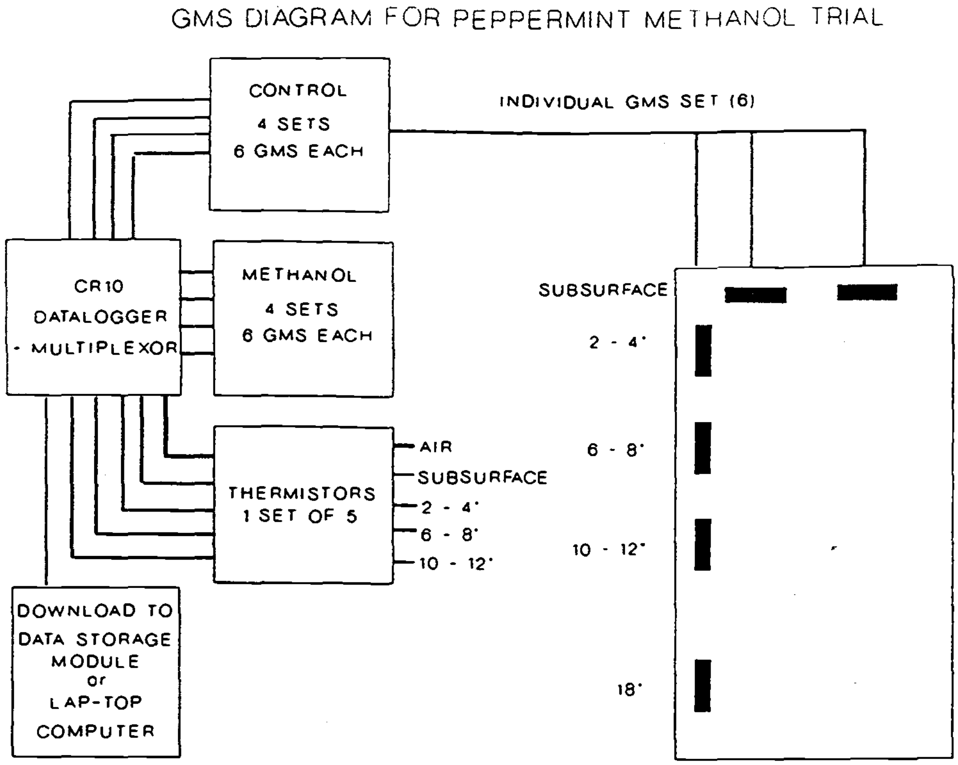

Figure 1. Design of GMS data collection for peppermint methanol trial, Madras, OR, 1993.

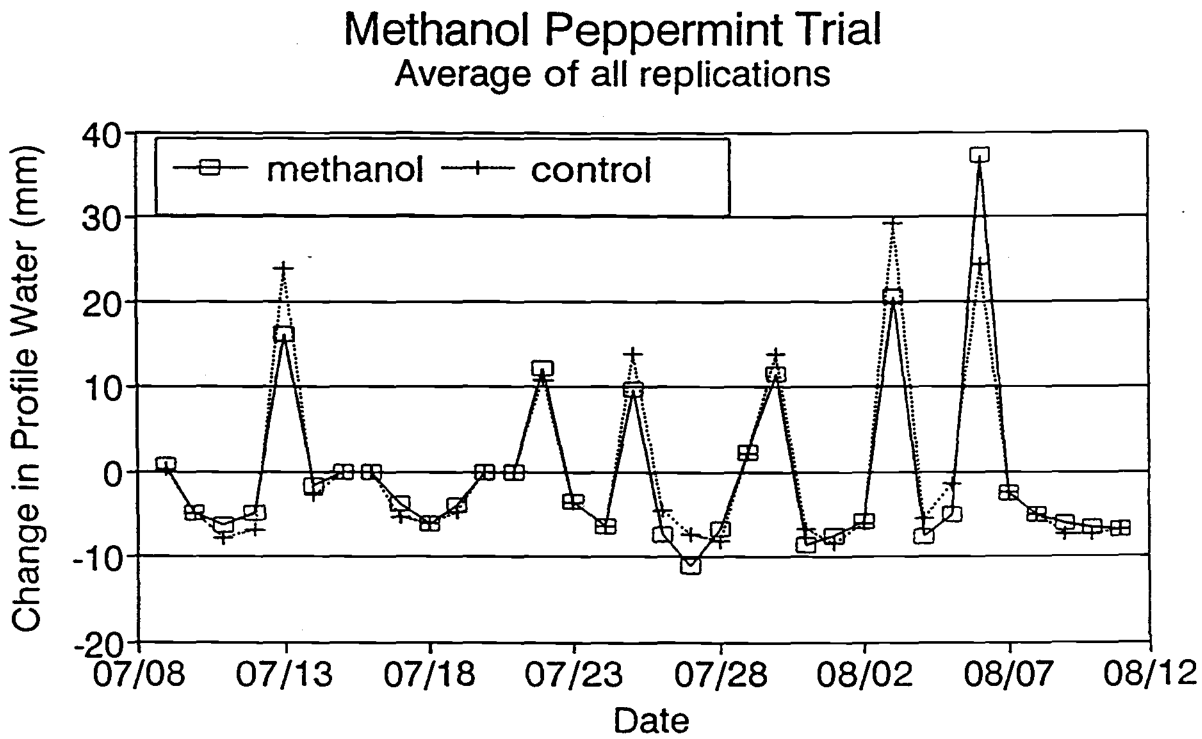

Figure 2. Daily water use by methol-treated peppermint compared to the untreated control, Madras, OR, 1993. Positive values are irrigation while negative are soil water depletion.

Conclusion

Water use of methanol-treated peppermint did not differ from the untreated control. This was probably the result of the inefficacy of the methanol in increasing plant growth or yield under our conditions. Peppermint showed no sign of toxicity to methanol, unlike other plants. The GMS method of measuring change in profile water gave consistent results, but no differences were observed under the methanol treatment. It is unknown at this time whether lack of response was due to lower temperatures than reported for trials conducted in Arizona, somewhat cloudy conditions early in this trial, or due to other reasons.

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IRRIGATED SPRING FORAGE BARLEY AND OAT VARIETIES TESTED FOR GRAIN PRODUCTION DEMONSTRATION

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Abstract

Thirteen varieties of forage barley and six varieties of forage oat were planted at Madras, Oregon for seed increase and to obtain some initial agronomic data on each cultivar under irrigated conditions.

Introduction

Forage cereals offer producers another cropping option in short water years or short feed years. Cereal species and varieties have a wide range of acceptability in terms of forage yield and other agronomic characteristics needed when planted under irrigated conditions.

Materials and Methods

The 13 barley and six oat varieties were planted on April 23, 1991 with a cone type experimental drill with eight-inch row spacing. Only a single plot for each variety, 5 x 20 ft was planted, and was not fertilized because of high residual nitrate nitrogen level. The first irrigation was May 2 and last irrigation was July 27. A Hege plot combine was used to harvest a 5 x 15 ft on August 23. Yield, test weight, height, and lodging were the data obtained for the demonstration trial.

Yield, test weight, height, and lodging data were collected. Data are reported on an air dry moisture basis.

Results

The results for yield, test weight, height, and lodging for the different forage cereal varieties are presented in Table 1. This data represents one year of data and a single replication. The primary objective of the trial was to increase seed for a replicated forage trial the following year. This information is of limited use for grain yield of each of these varieties.

Belford was the top yielding barley at 5,745 lb/ac, followed by Haybet and Whitford at 4,895 and 4,585 lb/ac, respectively. Test weights were high for some of the barley cultivars as they are of the hull-less type. Montezuma was the top yielder, followed by Sierra and then Swan. Park had the highest test weight of the oat varieties. Lodging was a problem for all the varieties except for Westford barley.

Table 1. Yield, test weight, height, and lodging data for a single replication of thirteen barley and six oat varieties planted in 1991 at COARC, Madras, OR.

Specie Variety		Yield lb/a	Test Wt. lb/bu	Height in	Lodging %
Barley					
Faust	(AHL)	2916	57.7	40	95
Belford	(H)	5745	43.6	40	75
Common	(A)	3003	45.0	39	100
Westford	(A)	3067	42.9	42	5
Eureka	(AHL)	3094	58.2	41	85
Russian	(HL)	2627	55.8	38	100
Haybet	(2RA)	4895	48.3	35	90
Nepal	(HL)	2119	55.6	40	70
"Weimer"	(A)	3624	43.4	42	90
Meloy	(H)	3403	44.5	36	90
Alberta	(A)	2107	41.3	35	85
Whitford		4585	45.6	42	50
Exp. Line	(A)	4051	40.9	37	95
Oat					
Park		3133	40.0	46	45
Montezuma		4126	36.1	40	70
Kanota		2931	35.8	47	80
Sierra		3915	35.0	46	40
Texas Red		2560	34.8	47	90
Swan		3601	37.5	43	75

A=awnless, HL=hull-less, H=hooded, 2R=two row

PLANTING METHOD, WEED CONTROL AND SEEDING RATE EFFECTS ON TWIN SOFT WHITE SPRING WHEAT

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Abstract

A planting method x weed control x seeding rate trial with Twin soft white spring wheat was established at COARC Powell Butte site in Oregon. The objective was to test if higher seeding rates with different methods of planting could decrease the need for applying herbicides. Grain yield, test weight, height, lodging, and grain N uptake were all significantly higher with the drill method of planting compared to broadcast and rotovate. Yield was not affected in any way by either weed control or seeding rate. Higher seeding rates with no weed control tended to increase percent protein.

Introduction

Lower input, sustainable agriculture and use of less chemical pesticides is the focus of many producers as society becomes more concerned about our environment and the food we eat. If less pesticides were used without a decrease in production, the farmer would obtain a profit. The consumer perceives that this is safer, knowing that less pesticides are being applied to the food they eat with less potential damage to the environment. This trial was set out to determine if seeding rate or planting method would have any effect upon weed control and thus yield and quality of soft white spring wheat. If producers could obtain excellent weed control by increasing seeding rate and/or narrowing the space between wheat plants, the wheat would out-compete the weeds without the application of expensive herbicides.

Materials and Methods

Twin soft white spring wheat was planted on April 13, 1990 at the COARC Powell Butte site. The design was a three factor factorial in a randomized block with four replications. The three factors were seeding rates, planting method, and weed control. The seeding rates were 30, 45, and 60 seeds/ft^2 (97, 145, and 194 lb/ac respectively). Planting was done with an eight inch row spacing cone type experimental drill or broadcasting the seed by hand and rotovating. Weed control was practiced on half of the plots with an application of 2 pints of Bronate on June 5. The weed control plots were also hand weeded on June 13. The plots were fertilized with 80 lb N/ac (239 lb of ammonium nitrate material) and 60 lb S/ac (400 lb of gypsum material). The first irrigation was on May 5 and the last irrigation occurred on August 4. The planted plots, 5 x 20 feet and 5 x 15 feet, were harvested with a Hege plot combine on September 6, 1990.

Yield, test weight, protein, height, lodging, and grain N uptake data were collected. The percent protein was predicted with near infrared reflectance spectrometry (NIRS) by the OSU Crop and Soil Science Dept. All data are presented on an air dry moisture basis.

Results and Discussion

Yield, test weight, height, and grain N uptake were all positively affected by the method of planting (Table 1). Yield, test weight, height, lodging, and grain N uptake were increased by 21.8 bu/ac, 0.3 lb/bu, 2 inches and 22 pounds by drilling compared to broadcasting and rotovating. There was no advantage to higher seeding rates or in weed control, on yield, height, and grain N uptake. There was no advantage from a yield standpoint to applying herbicide. Test weight was increased by using chemical weed control (55.6 vs 55.3, P=.03).

Table 1. Planting method effect on the yield, test weight, protein, height, lodging, and grain N uptake on Twin soft white spring wheat planted in 1990 at COARC, Powell Butte, Oregon.

Planting Method	Yield bu/a	Test Weight lb/bu	Protein %	Height in	Lodging %	Grain N Uptake lb/a
Drilled	83.7	55.6	10.6	39	14	93.3
Broadcast	61.9	55.3	10.9	37	4	71.3
Prob.	.001	.011	NS	.009	.093	.001
CV%	13.2	0.9	7.4	5.1	219.7	15.5

Protein and lodging were affected by a seeding rate and weed control interaction (Table 2). For the 60 seeds/ft^2 seeding rate without weed control, percent protein was significantly lower than the 45 and 30 seeds/ft^2 seeding rate without weed control. However, the high seeding rate with weed control gave a significantly higher percent protein than treatment without weed control. There was a trend for lower lodging with the no weed control plots with increasing seeding rates whereas the weed control plots reacted inversely. It appears that the plants in the higher seeding rate plots were more uniformly distributed and helped hold each other up. There seemed to be a trend for higher protein with greater lodging. The CV's for lodging were very high and reveal a lot of variability in the treatment plots.

Table 3 contains all the treatment means as well as the statistics for the trial.

Table 2. Weed control (W.C.) x seeding rate (S.R.) effect on the percent protein and percent lodging of Twin soft white wheat planted in 1990 at COARC, Powell Butte, OR.

Treatment W.C.	S.R.	Protein %	Lodging %
+	30	10.8	4
+	45	10.4	0
+	60	11.0	16
-	30	11.2	22
-	45	10.9	10
-	60	10.2	1
Prob.		.048	.050
PLSD .10		0.7	16.3
PLSD .05		0.8	19.6
CV%		7.4	219.7

Table 3. Planting method x weed control x seeding rate effects on the yield, test weight, protein, height, lodging and grain N uptake on Twin soft white spring wheat planted in 1990 at COARC, Powell Butte, Oregon.

Treatment PMWCSR	Yield bu/ac	Test Wt. lb/bu	Protein %	Height in	Lodging %	Grain N Uptake lb/ac
D + 30	88.6	56.0	10.7	39.3	6	99.7
D + 45	83.5	55.9	10.0	39.0	0	87.7
D + 60	83.4	55.8	10.8	39.5	19	94.1
D + 30	77.3	55.1	11.0	38.5	34	89.7
D + 45	87.4	55.4	10.8	40.3	21	98.6
D + 60	81.9	55.7	10.4	37.5	1	89.9
B - 30	58.7	55.4	11.0	36.8	1	68.5
B - 45	58.3	55.3	10.8	37.8	0	66.2
B - 60	65.9	55.4	11.2	37.8	13	78.3
B - 30	60.5	55.1	11.5	37.3	10	73.5
B - 45	63.9	55.4	11.0	37.0	0	74.1
B - 60	64.1	55.0	10.0	38.3	0	67.4
Mean	72.8	55.5	10.7	38.3	9	82.3
Prob.						
R	NS	NS	.052	.026	.009	.018
SM	.001	.011	NS	.009	.093	.001
WC	NS	.030	NS	NS	NS	NS
SMxWC	NS	NS	NS	NS	NS	NS
SR	NS	NS	NS	NS	NS	NS
SMxSR	NS	NS	NS	NS	NS	NS
WCxSRNS	NS	.048	NS	.050		NS
SMxWCxSR	NS	NS	NS	NS	NS	NS
CV%	13.2	0.9	7.4	5.1	219.7	15.5

P.M. = planting method, D = drill, B = broadcast and rotovate; W.C. = weed control, + with, - without; S.R. = seeding rate lb/a; R= reps

THE EFFECT OF NITROGEN FERTILIZER RATES ON TWIN SOFT WHITE SPRING WHEAT

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Abstract

Twin soft white spring wheat was planted at the COARC Powell Butte site to determine the effect of nitrogen fertilizer on certain agronomic and quality aspects. The nitrogen fertilizer significantly increased yield, percent protein, height, protein yield and grain N uptake. Test weight and lodging was not significantly affected though there was a trend increase.

Introduction

Soft white wheat is more marketable with lower protein. The export market is demanding more and more a specific protein content of the wheat that is purchased. This trial was set up to look at different rates of nitrogen fertilizer effects on Twin soft white spring yield and quality in the central Oregon area.

Materials and Methods

Twin soft white spring wheat was planted on April 13, 1990 at the rate of 30 seeds/ft^2 (97 lb/ac) with a cone type experimental drill (six 8-inch rows) into plots 5 x 20 feet. The experimental design was randomized block with four replications. The trial was fertilized with 80 lbs/ac N (239 pounds of ammonium nitrate material per acre) and 60 lbs/ac sulfur (400 pounds of gypsum material). The first irrigation occurred on May 5 and the last irrigation occurred on August 4. The plots were sprayed with 2 pints of Bronate on June 5. The plots were harvested with a Hege plot combine on September 6, 1990.

Yield, test weight, percent protein, height, lodging, and grain N uptake were determined. The protein percentage was predicted with near infrared reflectance spectrometry (NIRS) at the Oregon State University Crop and Soil Science Department. The data are presented on an "air dry" moisture basis.

Results and Discussion

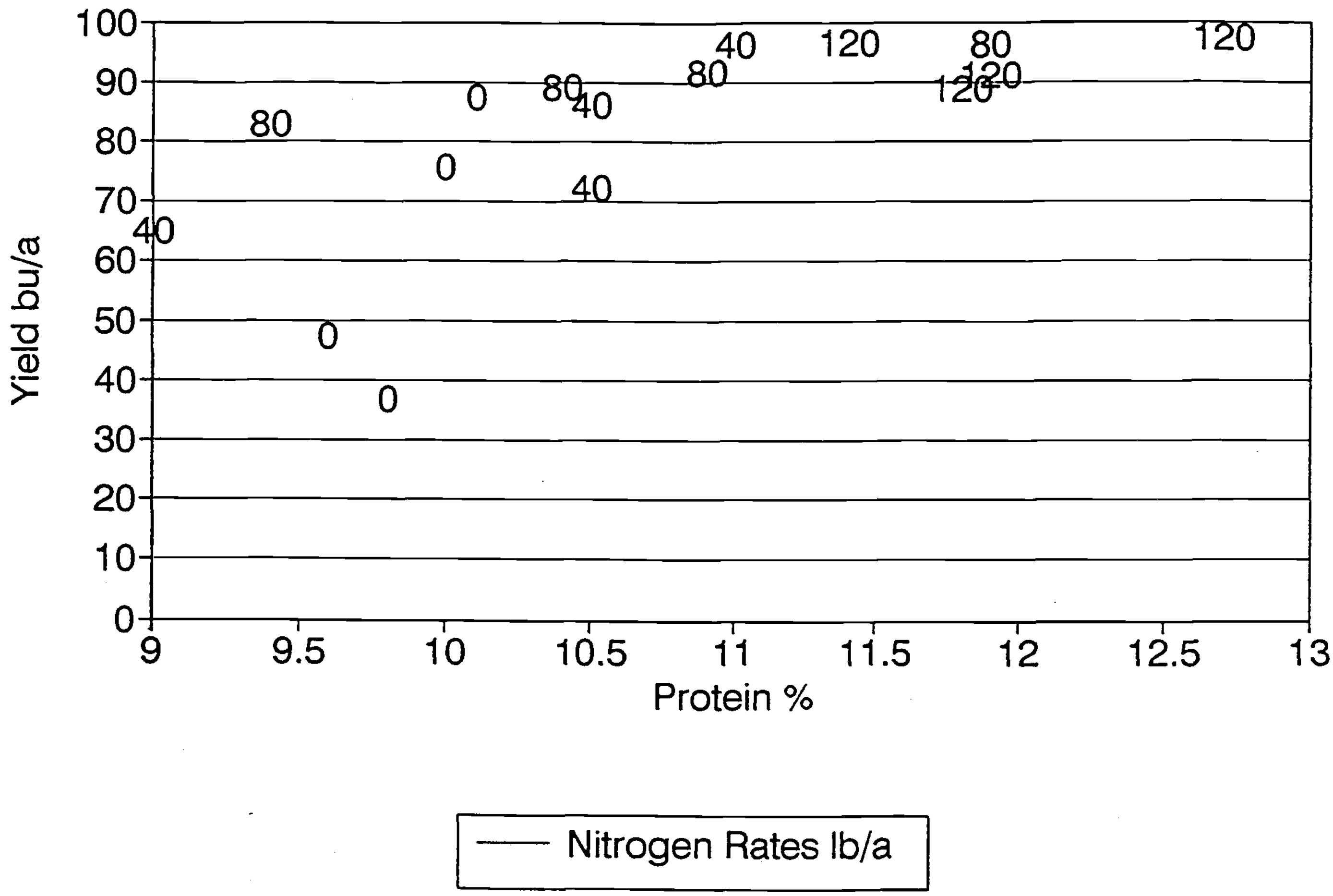
Yield was significantly increased 18.1 bu/ac with the addition of 40 lb N/ac (Table 1). The next 40 lb N/ac increased yield by 10.1 bu/ac but was not a significant increase (14.1 bu/ac at P=.10 was needed for a significant difference), and the 120 N rate increased 3.4 bu/ac over the 80 lb N rate. Percent protein was increased up to the 120 lb N/ac rate, a rate that would put the protein level at a higher than optimum level for the market. Based on the yield and protein level, the optimum fertilizer rate appears to be 80 lb N/ac in this particular trial. Graph 1 shows the protein yield relationship, with yield increases up to the 90 to 95 bu/ac and 11.0 percent protein. There was no increase in yield, and only increases in protein beyond that yield level. There was high fertility background level for the trial, so the rates had variable increases or even decreases in the replications. Height was increased significantly with higher N rates. Lodging was increased with the higher rates of nitrogen fertilizer, though not significantly. Protein yield and grain N uptake at harvest was significantly increased up to 120 lb N/ac.

There is only one year of data for this study and the trial should be run two more years.

Table 1. Agronomic and quality data of Twin soft white wheat as affected by different nitrogen rates on plots established in 1990 at COARC, Powell Butte, OR.

N Rate lb/ac	Yield bu/ac	Test Weight lb/bu	Protein %	Height in	Lodging %	Protein Yield lb/ac	Grain N Uptake lb/ac
0	61.9	55.0	9.9	36	0	368.7	64.7
40	80.0	55.5	10.3	38	0	496.8	76.9
80	90.1	56.0	10.7	39	6	557.1	101.4
120	93.5	56.0	12.0	40	36	671.0	117.9
Mean	81.4	55.6	10.7	38	11	528.6	92.7
PLSD .10	14.1	NS	0.5	2.0	NS	80.4	14.1
PLSD .05	17.4	NS	0.7	2.4	NS	99.2	17.4
CV%	13.3	1.3	3.8	3.9	204.1	11.7	11.7

Graph 1. Protein-yield relationship for the Twin soft white spring wheat nitrogen rate trial established in 1990 at COARC, Powell Butte, OR.



IRRIGATED SPRING WHEAT AND TRITICALE VARIETY TRIALS FOR 1990 AND 1991

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Abstract

Irrigated spring wheat and triticale variety trials were planted in 1990 at Madras. A demonstration trial (1 replication) was planted at Powell Butte. In 1991, a demonstration variety trial (1 replication) was planted at Madras, OR.

Introduction

Spring cereals for grain are planted in central Oregon, but the acreage is not as great as winter cereals. The cereal acreage varies from year to year due to availability of water, markets, rotations, and other cash crops. Cereal variety evaluations have been conducted over the years, but the spring cereals have had less emphasis. The future of spring cereal cultivar evaluation will have more emphasis. Beginning in the fall of 1993, the State-wide Variety Testing Program will evaluate winter and spring varieties at 11 or more sites, including Madras, in the state of Oregon. The Oregon State University Experiment Station, Oregon Grains Commission and Oregon Wheat Commission will be funding the program.

Data from one replicated trial and two demonstration trials are presented in this paper.

Materials and Methods

An irrigated spring wheat and triticale variety trial (randomized block design with four replications) was planted at COARC, Madras, OR, and a demonstration trial (one replication) was planted at Powell Butte. The seeding rate was 96 lb/ac and the planting dates were April 6 and April 13, 1990, respectively, for Madras and Powell Butte. Fertilizer applied was 150 pounds of N and 60 pounds of S per acre in April. The plot size was 5 x 20 feet. The first irrigation started on May 2 and 5 and the last irrigation date was July 27 and August 4 at Madras and Powell Butte, respectively. The data recorded were yield, test weight, percent protein on one replication, hardness factor on one replication, height, and lodging. Flowering date was recorded at Powell Butte. The Madras and Powell Butte plots were harvested on August 27 and September 6, respectively. The plots (5 x 15 feet) were harvested with a Hege plot combine. Percent protein and hardness factor were predicted with near infrared reflectance spectrometry (NIRS) at the Oregon State University Crop and Soil Science Dept.

In 1991, a spring wheat, triticale, and rye variety demonstration trial (1 replication only) was planted on April 23 at Central Oregon Agricultural Research Center Madras site. The 5 x 20 feet plots were planted with a cone type experimental plot drill with 8-inch row spacing at the rate of 96 lb/ac. The trial was fertilized with 52 pounds of N and 60 pounds of sulfur. The soil test revealed a high soil nitrate nitrogen level in the top 1-foot (101 lb N/ac). The first irrigation date was April 24 and the last irrigation date was July 27. A 5 x 15 feet area was harvested with a Hege experimental plot combine on September 23. Data collected included yield, test weight, percent protein, hardness factor, height, and lodging. The percent protein and hardness factor was predicted with near infrared reflectance spectrometry (NIRS) at the OSU Crop and Soil Science Dept.

Data are reported on an air dry moisture basis.

Results and Discussion

In the 1990 replicated trial at Madras (Table 1), there were only three spring wheat and two triticale varieties, with the rest being experimental lines. Juan triticale was the highest yielding cultivar. Two experimental lines yielded slightly over 100 bu/ac. Yecora Rojo outyielded Borah but not significantly. Two experimental lines (4870400 and OR 8501) had test weights above 60 lb/bu. Protein levels from one replication revealed that adequate fertility existed, especially for the hard red spring wheats and triticale, but was over-fertilized for the soft white lines. Lodging was not much of a problem for the trial in general, especially under fairly high fertility conditions.

In the 1990 non-replicated trial at Powell Butte (Table 2), Juan triticale was the top yielder in the trial. The same two experimental lines, (as in the Madras trial), had the best test weights, above 60 lb/bu. Fielder test weight was above 60 lb/bu. Protein percentages revealed that the fertility was adequate for the soft white wheat and triticale varieties but not for the hard reds in general. There were 10 days difference in the flowering dates, The earliest and latest happened to be the two triticale varieties. No lodging occurred.

In the 1991 non-replicated trial at Madras (Table 3), the trial was set out to take an initial look at some new cultivars and increase seed supplies. Klasic, a hard white cultivar, and Westbred Express, a hard red, yielded almost 100 bu/ac, better than the other cultivars. The hard reds, in general, were the highest yielders. There was a rye and triticale variety that yielded the least. Grace triticale is a forage type with what appears to be poor grain reproducing capability. Some of the other varieties at the bottom of the list have yielded better in other trials in previous years. Test weights were good in general. The percent proteins revealed that there was adequate fertility for the hard reds, but the soft whites would have been over-fertilized based on their protein levels. There was a large variation in heights as well as lodging, but lodging was not a problem in general. Seeding rates that would have been planted at 30 seeds/ft^2 from the original seed source and the seeding rate from the seed harvested are in Table 4.

It is important to note that the last two trials discussed had only one replication and great care should be exercised in interpreting the data. It was an initial look at a large number of cultivars.

Table 1. 1990 spring wheat and triticale variety trial agronomic and quality data for plots established at COARC, Madras, OR.

Variety	Yield bu/a	Test Wt. lb/bu	Protein %	Hardness Factor	Height In.	Lodging %
4870279	97.5	58.5	14.8	70.2	32	2
4870249	90.0	57.3	15.4	71.7	32	2
4870332	89.1	55.9	13.9	64.1	33	33
4870355	80.1	57.9	15.8	70.2	36	25
4870456	84.1	58.6	13.9	60.1	33	3
4870400	96.1	60.2	14.7	76.8	36	10
OR 484013	95.4	54.3	13.9	77.4	35	2
OR 487316	92.2	56.9	12.2	22.0	33	22
OR 8501	88.5	60.6	12.5	20.1	36	35
OR 487381	96.4	56.6	14.7	79.8	33	13
OR 58427	75.1	56.9	13.7	25.4	38	3
OR 487462	86.5	57.1	15.2	73.8	33	18
OR 487380	101.2	57.0	15.4	62.9	27	8
OR 487453	102.9	57.1	14.5	83.7	34	3
Yecora Rojo	86.8	56.5	15.7	67.9	26	5
Fielder	83.9	57.5	12.1	14.0	35	28
Borah	77.7	56.5	15.0	61.9	32	12
Yecora Rojo	90.4	57.5	16.1	67.9	27	0
Juan Trit.	97.1	47.4	12.4	42.3	49	23
Karl Trit.	87.4	48.9	11.9	10.4	37	22
Mean	89.9	56.5	14.2	56.1	34	14
PLSD .05	14.4	2.5	one	one	3	35
PLSD .01	19.4	3.4	rep	rep	4	47
CV%	9.7	2.7	only	only	5	158

Table 2. 1990 agronomic and quality data for the spring wheat and triticale variety demonstration trial (1 rep) established at COARC Powell Butte, OR.

Variety	Yield bu/a	Test Wt. lb/bu	Protein %	Hardness Factor	Flower Date	Height In.	Lodging %
4870279	67.0	59.4	10.3	51.7	181	35	0
4870249	67.2	58.6	10.4	59.6	184	33	0
4870332	78.4	56.6	9.7	59.0	185	37	0
4870355	73.3	60.0	11.1	53.8	185	40	0
4870456	85.3	59.1	9.9	47.6	180	43	0
4870400	62.9	60.9	11.5	69.6	184	37	0
OR 484013	79.1	57.6	9.8	58.3	185	34	0
OR 487316	67.9	56.3	9.0	1.2	180	34	0
OR 8501	70.1	61.1	9.6	13.5	181	39	0
OR 487381	68.2	57.8	10.9	65.1	180	35	0
OR 58427	76.7	59.4	10.9	20.6	185	39	0
OR 487462	84.4	58.6	12.9	76.9	180	38	0
OR 487380	82.5	57.6	11.9	36.4	179	28	0
OR 487453	93.7	59.0	11.0	70.0	186	38	0
Yecora Rojo	72.9	58.3	11.6	67.0	179	28	0
Fielder	92.2	60.1	10.4	8.8	178	42	0
Borah	80.6	59.0	12.0	54.4	179	35	0
Yecora Rojo	79.8	58.2	11.4	68.4	178	28	0
Juan Trit.	94.1	52.7	9.2	33.8	187	52	0
Karl Trit.	71.3	50.7	9.2	23.4	177	36	0
Mean	77.4	58.1	10.6	47.0	182	37	0

Table 3. 1991 Agronomic and quality data spring wheat, triticale and rye variety demonstration (1 rep) trial established at COARC, Madras, OR.

Variety	Yield bu/a	Test Wt. lb/bu	Protein %	Hardness Factor	Height In.	Lodging %
Klasic	99.9	60.0	14.0	66.8	33	0
Westbred Express	99.6	58.6	15.1	105.7	33	0
Yecora Rojo	93.5	60.4	15.0	84.1	28	0
Borah	91.6	59.0	13.9	86.1	34	10
Yolo	90.6	58.1	13.6	93.1	35	0
Victoria[1]	90.4	60.3	12.3	52.8	50	0
Wampum	90.1	59.6	13.1	101.5	40	0
ORS 8413	88.2	57.5	14.7	102.5	37	90
Alamos 83[1]	87.8	52.0	12.3	35.5	41	0
ORS 8501	87.6	59.1	12.4	27.6	39	0
Waduel	87.4	58.1	14.3	36.3	41	75
ORS 8510	82.6	59.6	14.2	89.7	37	0
Westbred 906	82.4	57.9	14.8	84.6	40	0
Pennawawa	81.9	58.4	13.2	29.5	39	65
Eronga 83[1]	80.5	48.0	14.0	59.4	48	0
Fieldwin	76.5	59.3	12.9	37.9	40	0
Wakanz	75.2	58.2	12.1	37.7	40	35
Karl[1]	73.3	48.8	12.6	34.4	41	0
Spillman	71.5	54.7	14.2	92.3	37	15
Fielder	70.6	57.4	12.5	33.7	41	0
Bronze Chief	70.2	56.5	16.5	94.1	38	0
Copper	70.0	58.9	13.9	82.9	37	10
Juan[1]	70.0	44.0	11.9	44.1	54	25
McKay	68.8	57.0	13.1	85.8	39	0
Blanca	68.8	58.0	13.1	33.3	42	0
Bliss	67.4	57.4	12.2	35.1	38	0
Frank[1]	66.2	48.5	13.6	51.3	54	0
Owens	66.2	57.4	13.3	26.1	40	0
Westbred 926	64.9	55.9	15.1	71.6	40	0

Table 3. (continued)

Variety	Yield bu/a	Test Wt. lb/bu	Protein %	Hardness	Height In.	Lodging %
Treasure	61.6	51.6	11.6	22.6	36	80
Dirkwin	54.1	53.4	12.6	42.0	39	0
ORS 8427	52.8	56.6	13.1	28.9	38	0
Twin	51.8	54.9	12.6	30.9	40	80
Gazelle[2]	46.7	52.7	13.2	22.0	60	60
Grace[1]	45.6	42.3	15.0	43.5	57	40
Mean	75.0	55.7	13.5	57.3	41	17

[1] Triticale
[2] Rye

Table 4. The seeding rates in pounds per acre that should have been planted (seed rate 2) for 30 seeds/ft^2, instead of the 96 lb/ac rate, and the future seeding rate (seed rate 1) for the harvested seed of the 1991 spring wheat, triticale and rye demonstration trial (1 rep) established at COARC, Powell Butte, OR.

Variety	Seed Rate (1)	Seed Rate (2)	Variety	Seed Rate (1)	Seed Rate (2)
Klasic	112	123	Spillman	110	85
Westbred Express	97	120	Fielder	91	127
Yecora Rojo	111	126	Bronze Chief	102	121
Borah	92	99	Cooper	100	94
Yolo	78	99	Juan Trit.	115	171
Victoria Trit.	98	125	McKay	86	94
Wampum	92	126	Blanca	93	96
ORS 8413	88	83	Bliss	81	111
Alamos 83 Trit.	103	138	Frank Trit.	88	119
ORS 8501	79	100	Owens	83	121
Waduel	102	88	Westbred 926	88	117
ORS 8510	87	107	Treasure	89	127
Westbred 906	103	127	Dirkwin	104	103
Pennawawa	92	80	ORS 8427	94	93
Eronga 83 Trit.	102	104	Twin	81	107
Fieldwin	86	112	Gazelle Rye	75	93
Wakanz	95	119	Grace Trit.	90	133
Karl Trit.	99	118			

IRRIGATED WINTER WHEAT VARIETY TRIALS FOR 1990

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Abstract

A variety trial for soft white wheat and triticale along with one for hard red and white elite winter wheat was planted at Madras in 1989. At the Powell Butte site a winter soft white and hard red wheat and triticale variety trial was established.

Introduction

Depending upon the year, the commercial acreage of winter cereals varies because of water availability, markets, and crop rotations, etc. COARC continues to test cultivars and lines without any outside resource funding because of the importance of cereals in central Oregon. As a result of dwindling resources, this will probably be the last year for the elite trials, and there will be more emphasis placed on testing released or near release cultivars.

Materials and Methods

A winter soft white wheat and triticale variety trial, and a hard red and white elite winter wheat variety trial were planted at Madras in October, 1989 and a soft white and hard red winter wheat and triticale variety trial was established in October, 1989 at Powell Butte. The experimental design was randomized block with four replications for all the trials. The 5 x 20 foot plots were planted at the rate of 96 lb/ac with a cone type experimental drill with 8 inch row spacing. The Madras trials had 150 pounds of N and 60 pounds of S applied in April, 1990, and the Powell Butte trial had 150 pounds of N and 60 pounds of S applied in April, 1990. The first date of irrigation for Madras was April 13 and the last date irrigation was July 16. At Powell Butte, the first irrigation date was May 5 and the last irrigation occurred on July 26. The plots, 5 x 15 feet, were harvested with a Hege plot combine on September 5 at Madras and September 6 at Powell Butte.

Data collected from the trials included yield, percent relative yield of Stephens (Powell Butte only), test weight, percent protein, hardness factor, flowering date, height, and lodging. Percent protein and hardness factor was predicted with near infrared reflectance spectrometry (NIRS) by the Oregon State University Crop and Soil Science Dept.

Results and Discussion

The data for the Powell Butte winter soft white and hard red wheat and triticale trial are presented in Table 1. Malcolm was the highest yielding cultivar (120.4 bu/ac), 15 percent better than Stephens. Gene SW and Hoff HR, new releases, yielded 88 and 69 percent of Stephens. Experimental line OR CW8314 yielded 18 percent better than Stephens. Test weights and percent protein were low in general for the trial. The soft white wheats were very low in protein, while some of the hard red cultivars were higher in protein content. There was only one replication used to test for protein and hardness factor, and to record flowering date. The range of heights was 32 to 44 inches and lodging was mostly a problem for the hard red varieties and lines. Wanser and Hatton lodged greatly, as did Hoff.

The data for the Madras soft white and triticale trial are in Table 2. The yields were low this year. Stephens was the top yielding cultivar at 89.9 bu/ac, while OR 860302 was the highest yielding experimental line at 105.6 bu/ac. Lodging was high for the trial, averaging 85 percent, which may have contributed to the low yields. Stephens and OR 860302 were two of the least lodged entries. Test weight was also low, averaging 51.5 lb/bu. There was a great deal of stress that occurred.

The data for the Madras hard red and white elite trial are listed in Table 3. Stephens was again among the top yielders at 105.3 bu/ac with a number of experimental lines yielding over 100 bu/ac. Hoff, a new hard red release, yielded 96.1 bu/ac which was 30 and 18 bu/ac greater than Batum and Wanser, respectively. Test weights were low in general for this trial and lodging was high, averaging 72 percent, but lower than the soft white trial at Madras. The mean percent protein was 0.4 percent higher in this trial. The majority of the cultivars and lines had acceptable protein levels based on tests from one replication.

Comparing the trials at Madras, the hard red and white wheat trial was at 50 percent flowering three days earlier than the soft white and triticale trial. The mean yield, test weight, and lodging for the hard red and white trial was 8.0 bu/ac and 2.7 lb/bu greater, while lodging was 13 percent less than in the soft white and triticale trial.

Table 1. 1990 agronomic data for the soft white and hard red winter wheat varieties planted in the fall of 1989 at COARC Powell Butte, OR.

Variety	Yield lb/a	% Rel. Yield of Stephens	Test Weight lb/bu	Protein %	Hardness Factor	Flower Date	Height in	Lodging %
Stephens	104.2	100	54.7	9.0	24.1	182	37	4
Hill 81	112.7	108	56.9	8.9	4.4	175	41	6
Malcolm	120.0	115	55.2	8.1	12.4	178	37	6
OSU-21	90.9	87	54.0	9.0	17.5	178	37	6
OR CR8603	86.6	83	53.7	11.5	53.1	177	37	0
OR CW8314	123.4	118	53.2	8.3	6.0	179	38	0
OR CW8519	102.8	99	55.8	9.0	15.5	176	43	18
OR CW8521	84.4	81	55.9	8.5	14.9	177	42	11
Wanser	62.8	60	56.6	8.6	28.7	182	44	93
Hatton	61.0	59	58.3	10.6	55.1	179	42	76
Batum	83.0	80	55.2	12.5	62.6	181	40	25
Hoff	72.4	69	55.6	13.6	48.7	177	37	73
OR CR8601	87.3	84	58.6	12.2	77.7	176	39	8
OR CR8602	85.0	82	55.6	12.7	70.9	176	32	56
OR CR8718	95.2	91	59.0	12.4	70.1	179	39	1
OR CR8619	95.8	92	57.9	11.2	60.8	180	34	18
OR CR8608	93.0	89	58.7	11.5	76.1	179	36	26
Gene	91.3	88	53.2	11.5	35.0	179	34	0
Mean	91.8	88	56.1	10.5	40.8	178	38	24
PLSD .05	13.6	--	1.1	one	one	one	2	32
PLSD .01	18.2	--	1.5	rep	rep	rep	3	42
CV%	10.5	--	1.4	only	only	only	4.0	94

Table 2. 1990 agronomic and quality data for the soft white winter wheat and triticale variety trial established in 1989 at COARC, Madras, OR.

Variety	Yield lb/a	Test Weight lb/bu	Protein %	Hardness Factor	Flower Date	Height in	Lodging %
Stephens	89.9	51.9	14.1	28.6	164	39	66
Hill 81	74.0	54.6	12.2	16.9	167	41	76
Malcolm	78.9	51.2	11.0	16.9	169	37	85
Oveson	72.0	52.9	10.3	6.2	163	36	96
Dusty	78.0	52.7	10.8	13.6	175	38	96
Tres	71.7	52.5	11.7	23.3	169	43	93
Rhode	78.3	52.8	11.9	15.5	171	39	95
Daws	83.7	52.3	12.0	17.0	169	38	90
Hyak	64.0	49.8	12.1	27.1	164	39	98
Madsen	83.6	52.5	13.2	13.6	167	37	89
Whitman Trit.	74.6	47.0	13.4	45.4	161	52	65
OSU-21	72.4	50.6	12.4	18.8	162	38	94
MacVicar	82.9	50.4	10.9	20.0	163	38	80
Flora Trit.	75.4	38.3	11.3	14.9	161	39	70
OR CW8632	89.2	52.4	12.2	22.5	162	38	79
Gene	83.2	49.2	12.3	13.3	165	35	89
OR 8302665	74.0	51.3	12.6	8.9	170	39	84
OR 8303765	79.0	52.9	10.9	9.8	172	42	89
OR 8400838H	75.1	50.6	11.0	17.5	173	40	91
OR CW8626	87.3	54.6	12.3	26.0	164	38	86
OR CW8629	80.2	52.1	11.9	15.5	169	39	93
OR 8303725	93.0	52.2	11.5	10.1	171	41	95
OR 840815	71.8	53.4	10.9	21.6	163	40	86
OR 8400814H	83.9	51.6	11.8	15.4	164	38	69
OR 8303734	77.6	51.7	12.8	28.2	167	38	80
OR 8501005H	78.3	52.0	12.5	20.1	169	42	88
OR 8500933H	97.8	51.1	11.9	14.4	166	38	80
OR 8500594H	94.9	50.5	12.3	15.9	165	35	86
OR 8501048P	80.7	48.5	12.2	27.9	165	38	86
OR 8401074P	77.0	52.4	12.5	20.2	164	41	83
OR 8401952S	63.8	50.9	12.1	19.7	174	40	86
OR 8501139H	72.3	54.9	12.2	29.8	175	42	95
OR 8507847P	80.8	52.0	12.5	23.5	171	40	85
OR 8505311P	66.5	51.9	13.0	34.8	169	39	89
OR 860754	78.1	55.5	12.6	25.8	165	37	78
OR 860297	86.5	51.2	12.1	13.0	162	37	95
OR 860302	105.6	52.4	11.1	20.1	163	35	56
OR 860303	94.8	52.7	11.7	21.2	163	33	91
OR 860576	79.8	51.6	12.6	21.1	174	35	85
OR 860827	76.8	49.3	13.8	7.2	166	37	74
Mean	80.2	51.2	12.1	19.5	167	39	85
PLSD .05	20.8	1.6	one	one	11	3	21
PLSD .01	27.5	2.2	rep	rep	15	4	28
CV%	18.5	2.3	only	only	5.0	5.0	18.0

Table 3. 1990 agronomic and quality data for the hard red and soft white winter wheat elite variety trial established in 1989 at COARC, Madras, OR.

Variety	Yield lb/a	Test Weight lb/bu	Protein %	Hardness Factor	Flower Date	Height in	Lodging %
Wanser	78.5	55.5	12.5	46.5	165	50	91
Stephens	105.3	53.5	12.4	22.9	164	39	64
Hoff	96.1	56.6	13.0	46.4	163	41	94
Federation	65.2	53.6	12.5	16.6	162	45	93
Batum	65.7	52.3	12.3	54.7	166	42	94
OR8602	106.3	54.8	13.5	63.8	162	33	81
OR 83011034	80.5	56.1	12.3	61.4	162	42	94
OR 840157	87.2	57.4	13.4	63.9	161	44	85
OR 841708	84.5	54.2	13.2	75.2	166	44	58
OR 8303372	84.7	52.4	13.1	53.8	162	40	94
OR 8400161P	95.1	58.3	12.9	62.8	166	43	95
OR 860247	100.9	56.0	13.0	55.5	165	36	61
OR 860342	99.1	54.9	12.4	50.4	163	37	66
OR 860455	85.1	50.0	12.7	64.3	166	41	94
OR 860612	82.4	53.6	10.8	20.4	162	38	79
OR 860937	83.6	51.7	12.9	30.3	162	40	54
OR 861202	83.4	53.8	12.7	48.0	161	39	99
OR 861555	103.8	53.5	10.9	35.7	160	39	79
OR 8500701P	87.5	56.1	13.5	66.2	160	42	96
OR 8503882P	78.4	53.0	11.9	18.0	164	37	90
Filler	112.4	53.1	-	-	-	-	-
Filler	94.4	55.8	-	-	-	-	-
Filler	87.5	50.8	-	-	-	-	-
Monopole	67.4	55.5	14.2	65.3	169	41	71
OR 8500513H	103.6	57.4	12.2	45.8	165	34	26
OR CW8632	79.4	52.7	12.1	68.2	164	38	80
OR 8400115H	84.8	50.4	12.4	60.7	165	36	81
OR 860126	104.8	55.5	11.2	61.0	161	39	85
OR 860764	90.7	52.3	12.2	68.4	162	38	68
OR 8500519P	85.1	55.3	12.5	46.6	163	37	78
Mean	88.2	54.2	12.5	50.8	164	40	72
PLSD .05	16.2	1.3	one	one	one	3	23
PLSD .01	21.4	1.8	rep	rep	rep	3	31
CV%	13.0	1.8	only	only	only	5.0	23.0

IRRIGATED WINTER WHEAT VARIETY TRIALS FOR 1991

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Abstract

Winter soft white wheat and triticale, and hard red and white wheat variety trials were planted at COARC, Madras and Powell Butte sites in 1990. Identical trials were planted at the two sites. More hard red and soft white cultivars were tested compared to experimental lines being tested in the past.

Introduction

This year's winter variety trials were set out as uniform trials at both sites to test location effects, but a number of unforseen circumstances prevailed. An attempt was made to test more of the released cultivars rather than continue to test more experimental lines. The experiment station receives no outside resources to fund these trials, but will continue them until budgets are stretched too far. There are a number of new releases in both the trials.

Materials and Methods

Identical hard red winter and soft white winter wheat variety trials were planted at COARC, Madras and Powell Butte sites. The soft white wheat and triticale trial and hard red wheat trial were planted on October 23 and 24, 1990 at Madras and Powell Butte, respectively. Seeding rate was based on 30 seeds/ft^2 (see data tables for actual lb/ac seeding rate). Fertilizer applied was 125 lb N/ac and 60 lb S/ac at the Madras site. The soil test at Madras revealed that 101 lbs/N per acre was in the top one foot of soil. The hard red trial had 50 lb/ac additional N applied at heading. Fertilizer applied at Powell Butte was 150 lb N/ac and 40 lb S/ac. The first date of irrigation at Madras and Powell Butte were April 29 and 18, respectively and the last date of irrigation as July 25 and August 7 at Madras and Powell Butte, respectively. The plots were planted with a cone type experimental drill on 8-inch rows. Plot size was 5 x 20 feet and 5 x 15 feet of the plot was harvested with a Hege plot combine. Harvest date was August 20 at Madras and August 22 at Powell Butte.

Data collected included yield, percent relative yield of Stephens, test weight, percent protein, hardness factor, protein yield, 50 percent flower date (Madras only), height, lodging, percent chaff, grain N uptake, and seeding rate (30 seeds/ft^2) in lb/ac. Percent protein and hardness factor were predicted with near infrared reflectance spectrometry (NIRS) by the Oregon State University Crop and Soil Science Department. Percentage chaff was determined by subtracting the chaff and cleanout from the total uncleaned grain weight and then dividing by the uncleaned weight. The plots were harvested with the Hege combine on one setting and represents a measure of threshabiltity based on only one setting for the plot harvester.

Results and Discussion

Powell Butte: Hard Red Winter Wheat Trial

The data for this trial are in Table 1 and 2. Stephens, the SW check, was the highest yielding cultivar at 127.4 bu/ac. Of the released hard red cultivars, Andrews and Hoff yielded 89 percent of Stephens. The experimental line OR 8522 was the top yielder at 134.7 bu/ac. The yields were very good in general, as were the test weights. Percent protein was very low for hard red quality, almost a full 2.0 percent less than the 12 percent desired. There were no significant differences in percent protein. The same fertility management program for hard reds (see Madras hard red trial) was not followed through because of volunteer wheat in the trial. That is the reason no flower dates were recorded. The trial was abandoned in late spring and then a decision was made to harvest the trial. There is a lot of information on the varieties in Table 1 and 2. The average grain N uptake was 116 lb/ac. The seeding rate (30 seeds per square foot) is interesting, because the range for pounds per acre was 85 to 155 lb/ac.

Madras: Hard Red Winter Wheat Trial

The data are presented in Tables 3 and 4. Low yields in this trial may be attributed to winter injury and a possible missed last irrigation. Stephens, SW check variety, outyielded all the hard reds. Ute, Monopole, OR 830282 and Hoff yielded 98, 95, 95, and 92 percent of Stephens, respectively. Hatton and Hoff test weights were the highest at 60.5 and 59.4 lb/bu. The mean percent protein was 13.7, with Monopole and Hoff having proteins of 14.1 and 14.2 percent. Ute is a short (32 inches) variety that did not lodge much, and Monopole, for a tall variety, had little lodging. Hoff was close to 50 percent lodged. There were large differences in lodging for the entries. Grain N uptake mean was 128 lb/ac for the trial. Seeding rate varied from 85 to 155 lb/ac to achieve 30 seeds/ft^2.

Powell Butte: Soft White Winter Wheat and Triticale Trial

The data for this trial are in Tables 5 and 6. MacVicar and Dusty, significantly, yielded more than Stephens. Malcolm outyielded Stephens, although not significantly. The yields were very good for the year. Rohde, a club type, yielded 114.8 bu/ac. Flora was the top yielding triticale as usual, although it was not significantly higher than Whitman.

Test weights were very good with Nugaines and Rohde having the highest test weights. The average percent protein was 9.1 percent and there were no significant differences between cultivars. Basin, Nugaines, and Gene had heights of 32, 34, and 35 inches, respectively. The range in seeding rates was 83 to 159 lb/ac for the cultivars to obtain 30 seed/ft^2 for equal plant populations. The mean grain N uptake was 116 lb/ac, the same as the hard red trial at Powell Butte, but the mean yield was 10.8 bu/ac more.

Madras: Soft White Winter Wheat and Triticale Trial

The data for this trial are presented in Tables 7 and 8. Winter injury averaged 39 percent for the trial, contributing to decreased yields. There may have been a missed irrigation at the end of the trial also, as the test weights are low. Protein percentages were high as well (averaging 13.8 percent), too high for soft white quality. Basin was the top yielding cultivar at 104.3 bu/ac and had the lowest percent protein at 11.7, which was significantly different from the majority of the entries. Stephens only yielded 84.0 bu/ac but sustained 47 percent winter injury. Rohde yielded within 4 percent of Stephens, and MacVicar outyielded Stephens though not significantly. Some of the entries sustained heavy winter damage and yet still yielded fair to good for the amount of injury. Flora triticale outyielded Whitman, but had much lower test weight. Flora had the least amount of winter injury in the trial. Triticale usually needs another irrigation over the wheat and the low test weights of the triticale and wheats indicate that a major stress happened. The mean flowering date was 3.5 days behind the hard red trial. Grain N uptake averaged 109 lb N/ac, 19 lb less than the hard red trial.

Table 1. 1991 hard red winter wheat variety trial data for yield, percent relative yield to Stephens, test weight, percent protein, hardness factor, and protein yield for plots established in 1990 at COARC. Powell Butte, OR.

Variety	Yield lb/ac	% Rel. Yield of Stephens	Test Weight lb/bu	Protein %	Hardness Factor	Protein Yield lb/ac
Wanser	84.1	66	60.0	11.5	69.2	557
Hatton	95.5	75	62.1	10.3	71.8	588
Batum	104.4	82	59.1	10.2	65.8	641
Stephens	127.4	100	59.1	8.9	36.2	681
Federation	105.6	83	59.8	10.2	34.8	639
Ute	106.9	84	59.0	9.3	57.7	593
Buchannon	91.0	71	58.1	10.0	64.8	538
Andrews	113.2	89	60.5	9.8	53.5	666
Monopole	107.0	84	61.7	10.3	76.1	659
Hoff	113.3	89	61.5	10.3	64.2	702
ORCR8602	107.2	84	60.0	10.2	60.0	655
OR830282	112.2	88	59.9	10.7	72.8	722
ORCR8718	122.9	96	61.3	9.4	57.7	693
ORCR8617	125.3	98	60.4	10.1	52.8	764
ORCR8601	115.8	91	61.0	9.6	54.9	671
OR8300027	99.2	78	60.8	10.7	60.7	638
OR8302306	113.3	89	59.4	10.3	50.4	696
OR8522	134.7	106	59.1	10.3	56.7	833
Mean	110.0	86	60.2	10.1	58.9	66.3
PLSD .10	15.7	-	1.2	NS	9.9	126
PLSD .05	18.8	-	1.4	NS	11.9	151
CV%	10.3	-	1.4	10.0	12.2	13.7

Table 2. 1991 hard red winter wheat variety trial data for flowering date, height, lodging, chaff, grain N uptake, and seeding rate for plots established in 1990 at COARC, Powell Butte, OR.

Variety	Flower Date	Height in	Lodging %	Chaff %	Grain N Uptake lb/ac	Seeding Rate lb/ac
Wanser	No	48	80	6.9	98	109
Hatton	Notes	47	83	4.5	103	111
Batum	Taken	39	50	7.6	113	122
Stephens		36	0	4.2	120	155
Federation		48	52	4.6	112	123
Ute		28	0	3.1	104	85
Buchannon		46	88	8.7	94	120
Andrews		35	50	3.6	117	101
Monopole		42	0	6.6	116	105
Hoff		41	15	4.1	123	121
ORCR8602		32	0	3.0	115	124
OR830282		39	3	3.8	127	126
ORCR8718		42	0	4.5	122	114
ORCR8617		36	3	4.4	134	93
ORCR8601		42	0	4.1	118	124
OR8300027		42	13	4.4	112	126
OR8302306		35	7	3.3	122	123
OR8522		37	12	3.0	146	121
Mean		40	25.4	4.7	116	117
PLSD .10		2.3	26.8	1.3	22	range
PLSD .05		2.7	32.2	1.6	NS	85-155
CV%		4.1	76.6	20.6	13.7	-

Table 3. 1991 hard red winter wheat variety trial data for yield, percent relative yield to Stephens, test weight, percent protein, hardness, and protein yield for plots established in 1990 at COARC, Madras, OR.

Variety	Yield lb/ac	% Rel. Yield of Stephens	Test Weight lb/bu	Protein %	Hardness Factor	Protein Yield lb/ac	Winter Kill %
Wanser	64.0	57	58.2	13.3	91.9	509	7
Hatton	72.0	64	60.5	13.0	109.5	561	7
Batum	71.5	64	55.4	13.7	97.2	588	32
Stephens	112.5	100	57.8	11.9	52.0	801	13
Federation	79.4	71	57.7	13.4	63.9	637	57
Ute	110.8	98	56.4	12.9	94.1	855	47
Buchannon	80.6	72	56.5	13.2	100.0	637	5
Andrews	100.2	89	57.7	13.7	90.7	826	30
Monopole	106.5	95	59.3	14.1	103.1	900	8
Hoff	103.8	92	59.4	14.2	96.4	887	12
ORCR8602	102.9	91	57.3	13.8	106.4	849	18
OR830282	106.7	95	58.6	13.9	109.8	891	33
ORCR8718	70.3	62	59.0	14.0	103.1	588	93
ORCR8617	95.5	85	58.3	13.9	97.7	795	47
ORCR8601	78.5	70	58.4	14.2	106.9	666	82
OR8300027	81.5	72	57.5	14.6	106.4	713	58
OR8302306	77.6	69	52.7	13.8	76.5	638	35
OR8522	88.8	79	54.0	14.2	75.4	748	38
Mean	89.1	79	57.5	13.7	93.4	727	35
PLSD .10	16.7	-	2.0	0.9	6.3	120	22
PLSD .05	20.1	-	2.4	1.0	7.6	144	26
CV%	13.6	-	2.5	4.5	4.9	11.9	45.7

Table 4. 1991 hard red winter wheat variety trial data for flowering date, height, lodging, chaff, grain N uptake, and seeding rate on plots established in 1990 and COARC, Madras, OR.

Variety	Flower Date	Height in	Lodging %	Chaff %	Grain N Uptake lb/ac	Seeding Rate lb/ac
Wanser	173	48	97	10.8	89	109
Hatton	472	46	93	8.4	99	111
Batum	174	42	78	11.6	103	122
Stephens	175	42	23	7.6	141	155
Federation	175	50	7	9.4	112	123
Ute	177	32	15	5.8	150	85
Buchannon	178	47	92	12.0	112	120
Andrews	172	35	52	7.1	144	101
Monopole	175	45	7	9.3	258	105
Hoff	171	40	48	6.9	156	121
ORCR8602	168	34	25	6.9	156	124
OR830282	169	40	0	8.9	156	126
ORCR8718	172	46	0	10.0	103	114
ORCR8617	174	36	26	7.3	139	93
ORCR8601	170	45	2	11.2	117	124
OR8300027	171	44	20	9.6	125	126
OR8302306	170	36	41	9.2	112	123
OR8522	171	38	33	6.7	131	121
Mean	172.6	41	37	8.8	128	117
PLSD .10	one	2.6	20	1.9	21	range
PLSD .05	rep	3.2	25	2.3	25	85-155
CV%	only	4.6	40.2	15.4	11.9	-

Table 5. 1991 soft white winter wheat and triticale variety trial data for yield, percent relative yield to Stephens, test weight, percent protein, hardness, and protein yield on plots established in 1990 at COARC, Powell Butte, OR.

Variety	Yield lb/ac	% Rel. Yield of Stephens	Test Weight lb/bu	Protein %	Hardness Factor	Protein Yield lb/ac
Malcolm	142.5	108	60.2	8.9	25.7	761
Stephens	131.8	100	60.2	9.3	29.4	736
Hill 81	120.8	92	60.5	8.7	32.5	631
Basin	118.7	98	59.1	8.5	20.6	605
Yamhill	103.8	79	57.4	9.6	30.9	599
Oveson	119.3	91	61.0	8.9	19.6	648
Dusty	150.4	114	59.0	8.9	21.3	807
Tres	106.3	81	60.3	9.4	29.1	599
Daws	130.2	99	59.9	9.2	24.5	718
Hyak	108.6	82	59.5	9.1	23.3	595
Madsen	117.0	89	60.1	9.5	27.9	665
KMor	128.6	98	58.9	9.1	28.9	703
Elten	124.2	94	58.5	9.3	25.9	691
OR8302784	105.1	80	60.3	9.7	24.8	609
Nugaines	107.3	81	61.7	8.7	23.6	566
Gene	103.6	79	58.1	9.3	24.0	582
Rohde	114.8	87	61.1	9.1	20.8	623
MacVicar	151.0	115	59.9	8.4	25.1	761
OR8632	115.1	87	59.8	9.1	29.6	632
W301	127.9	97	60.1	9.1	33.6	696
Whitman Trit.	109.6	83	54.6	9.3	49.5	611
Flora Trit.	120.2	91	49.1	9.4	27.7	678
Mean	120.8	92	59.1	9.1	27.2	660
PLSD .10	15.5	-	1.0	NS	8.7	126*
PLSD .05	18.6	-	1.3	NS	10.5	NS
CV%	9.4	-	1.3	9.1	23.4	14.0

* P=.105 level

Table 6. 1991 soft white winter wheat and triticale variety trial data for flowering date, height, lodging, chaff, grain N uptake and seeding rates on plots established in 1990 at COARC, Powell Butte, OR.

Variety	Flower Date	Height in	Lodging %	Chaff %	Grain N Uptake lb/ac	Seeding Rate lb/ac
Malcolm	Notes	37	0	3.4	133	137
Stephens	Not	38	7	4.7	129	129
Hill 81	Taken	38	0	2.5	111	108
Basin		32	0	4.2	106	90
Yamhill		45	0	4.9	105	111
Oveson		36	0	5.0	114	102
Dusty		37	2	3.7	142	102
Tres		40	22	5.9	105	98
Daws		38	12	4.1	126	127
Hyak		40	8	7.1	104	107
Madsen		37	0	3.2	117	109
KMor		38	0	3.2	117	103
Elten		39	95	4.1	121	83
OR8302784		37	0	4.4	107	102
Nugaines		34	0	3.0	99	111
Gene		35	0	4.6	102	107
Rohde		37	0	5.4	109	99
MacVicar		37	0	3.6	134	135
OR8632		37	0	5.2	111	132
W301		38	0	4.6	122	106
Whitman Trit.		53	3	4.0	107	159
Flora Trit.		38	0	4.5	119	102
Mean		38	7	4.4	116	112
PLSD .10		1.7	11	1.3	22*	range
PLSD .05		2.0	13	1.6	NS	83-159
CV%		3.2	119.3	23.0	14.0	-

* = P=.105 level

Table 7. 1991 soft white winter wheat and triticale variety trial data for yield, percent relative yield of Stephens, test weight, percent protein, hardness factor, and protein yield on plots established in 1990 at COARC, Madras, OR.

Variety	Yield lb/ac	% Rel. Yield of Stephens	Test Weight lb/bu	Protein %	Hardness Factor	Protein Yield lb/ac	Winter Kill %
Malcolm	82.8	99	53.9	13.5	36.3	670	8
Stephens	84.0	100	54.2	15.3	55.2	769	47
Hill 81	77.2	92	55.3	14.4	40.8	657	50
Basin	104.3	124	55.7	11.7	21.9	730	18
Yamhill	66.5	79	51.9	15.4	40.7	608	67
Oveson	56.5	67	52.4	14.5	27.6	488	60
Dusty	74.2	88	54.5	13.2	25.5	574	41
Tres	60.3	72	56.7	13.2	53.4	465	30
Daws	81.9	98	54.6	13.0	38.4	628	12
Hyak	68.2	81	54.7	13.1	47.6	537	27
Madsen	79.9	95	53.6	14.7	40.5	707	55
KMor	64.4	77	53.2	13.6	33.0	520	50
Elten	62.4	74	54.6	13.8	34.3	512	10
OR8302784	69.0	82	55.0	14.2	41.0	580	60
Nugaines	72.4	86	54.2	13.7	34.0	580	25
Gene	78.6	94	54.9	13.9	43.8	651	25
Rohde	80.5	96	57.2	13.4	44.8	633	78
MacVicar	88.5	105	53.0	13.3	40.5	704	28
OR8632	98.4	117	54.3	14.2	41.6	837	35
W301	88.9	106	54.3	14.3	42.5	752	48
Whitman Trit.	57.9	69	46.3	15.3	65.0	528	83
Flora Trit.	78.9	94	39.4	13.0	28.3	596	3
Mean	76.2	91	53.4	13.8	39.8	624	39
PLSD .10	15.9	-	2.0	1.4	7.2	110	28
PLSD .05	19.1	-	2.4	1.7	8.6	132	34
CV%	15.2	-	2.7	7.2	13.1	12.9	52.5

Table 8. 1991 soft white winter wheat and triticale variety trial data for flowering date, height, lodging, chaff, grain N uptake, and seeding rate on plots established in 1990 at COARC, Madras, OR.

Variety	Flower Date	Height in	Lodging %	Chaff %	Grain N Uptake lb/ac	Seeding Rate lb/ac
Malcolm	175	37	25	8.8	117	137
Stephens	176	39	23	8.1	135	129
Hill 81	174	41	13	7.4	115	108
Basin	177	34	72	6.9	128	90
Yamhill	175	44	3	8.2	107	111
Oveson	174	37	32	16.4	86	102
Dusty	179	39	45	15.4	101	102
Tres	180	40	78	11.6	82	98
Daws	177	39	70	10.3	110	127
Hyak	176	39	93	11.8	94	107
Madsen	174	39	0	6.3	124	109
KMor	177	38	40	13.6	91	103
Elten	175	40	92	10.7	90	83
OR8302784	175	41	3	8.7	102	102
Nugaines	178	36	60	13.2	102	111
Gene	173	36	7	9.6	114	107
Rohde	173	35	28	12.4	111	99
MacVicar	177	40	8	10.1	123	135
OR8632	175	38	23	7.5	147	132
W301	175	37	18	8.0	132	106
Whitman Trit.	173	49	0	14.3	93	159
Flora Trit.	174	39	2	12.9	105	102
Mean	175.5	39	33	11	109	112
PLSD .10	one	2.5	35	2.6	19	range
PLSD .05	rep	2.9	42	3.2	23	83-159
CV%	only	4.6	76.9	18.2	12.9	-

IRRIGATED WINTER WHEAT VARIETY TRIALS FOR 1992[1]

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Abstract

Separate soft white and hard red winter wheat variety trials were planted at COARC, Madras site in 1991. Yields were low in general with a high amount of lodging in both trials. Test weights and percent proteins were excellent.

Introduction

Two large trials of soft white and hard red winter wheat varieties were established at COARC Madras in 1991. Several new varieties were included this year that were not evaluated in the 1990 and 1991 trials. The next variety trial for winter cereals will be tested in the statewide variety testing program, beginning in the fall of 1992. The Oregon Grains Commission, Oregon Wheat Commission and the Oregon State University Experiment Station have put up funds to test released and near release cultivars at approximately 11 sites across the state of Oregon. COARC Madras will participate as one of the sites. With this program's funding, COARC will continue testing winter (and spring) cereals.

Materials and Methods

Separate soft white winter and hard red winter wheat variety trials were planted at COARC Madras site on October 18, 1991 with a cone type experimental drill (8-inch row spacing) into 5 x 20 ft plots. The experimental design was a randomized block with four replications. Seeding rate was 30 seeds/ft^2 (seeding rates in lb/ac are in Tables 2 and 4). The trials were fertilized with 200 lb N/ac and 60 lb S/ac with a gandy type drop spreader on March 11, 1992. The first date of irrigation was April 18 and the last date was June 24 (the winter triticale trial's last date of irrigation was July 8). 5 x 15 feet area of the plot was harvested with a Hege plot combine on July 29, 30, and 31. All data are reported on an air dry moisture basis.

[1]Dr. Randy Dovel and Greg Chilcoate of Klamath Experiment Station are gratefully thanked for processing the grain from these two trials.

Data collected includes yield, percent relative yield of Stephens, test weight, protein, hardness factor, protein yield, flower date (January 1 = 1), height, lodging, chaff, grain N uptake, and seeding rate. Protein percentage and hardness factor were predicted with near infrared reflectance spectrometry (NIRS) at the OSU Crop and Soil Science Dept.

Results and Discussion

Soft White Winter Wheat Trial

Data are reported in Tables 1 and 2. The trial mean yield was not impressive at 85.8 bu/ac. Basin was significantly higher yielding than all other cultivars except for Nugaines and OR 860302. Other varieties that yielded well above Stephens included Durheim Pride, Rod (new WSU release), Cashup, Malcolm, Hill 81, Daws, Oveson, Madsen, and MacVicar. Just about every cultivar and line outyielded Stephens this year. Yields in an adjacent winter triticale trial were much greater, but Stephens as the check in that trial, yielded about the same. Weatherwise, the crop growth was a month ahead of normal. Lodging was high in the trial as the mean was 62 percent. Test weights and protein percentages were excellent in general, though a few protein levels were a little higher than they need to be to obtain top market price for soft white wheat. Basin, Nugaines, Durheim Pride, Dusty, and KMor led the varieties in low protein in the range of 9.9 to 10.4 percent. There was a large range in heights. Note the shortness of Nugaines, Basin, and Gene in the 31 to 35 inch range. Basin and Nugaines stood well. Gene was 48 percent lodged. Rod, Daws, Oveson, and Madsen were in 29 to 33 percent lodged range. Stephens lodged at 85 percent. Seeding rates ranged from 69 to 127 lb/ac (planting 30 seeds/ft^2).

Hard Red Winter Wheat Trial

Data are presented in Tables 3 and 4. Quantum 555 was the top yielder for cultivars at 93.9 bu/ac. Four experimental lines did outyield Quantum 555, although not significantly. Stephens yield was 84.3 bu/ac. Hoff yielded 78.6 bu/ac. Average lodging for the trial was 70 percent. Test weights were excellent with a mean of 61.8 lb/bu. Quantum 555 and Hatton had 64-pound plus test weights. Lowest test weight was Stephens at 58.0 lb/bu. Percent protein averaged 12.3 percent for the trial, with Tam 109 having the highest at 13.9 percent (very low yielder). Quantum 555 had acceptable protein at 12.1 percent. Stephens had the lowest protein, 11.1 percent. Ute was the shortest cultivar at 29 inches, but had a 90 percent lodging score. Tam 109 was short (34 inches), but had a 98 percent lodging score. Longhorn was the earliest flowering cultivar but was a poor yielder. Monopole, Hoff, and Batum were the least lodged cultivars. A few of the experimental lines stood very well. The seeding rates (30 seeds/ft^2) ranged from 78 to 135 lb/ac.

Table 1. 1992 hard red and hard white winter wheat variety trial data for yield, percent relative yield of Stephens, test weight, percent protein, hardness and protein yield on plots established in 1991 at COARC, Madras, OR.

Variety	Yield bu/ac	% Rel Yield of Stephens	Test Weight lb/bu	Protein %	Hardness Factor	Protein Yield lb/ac
Stephens	84.3	100	58.0	11.1	33.3	560
Ute	84.3	100	60.6	12.1	82.0	611
Buchannon	70.7	84	61.3	11.8	86.1	499
Tam 109	42.8	51	62.8	13.9	72.4	357
Longhorn	78.6	93	63.9	13.2	81.4	621
QT 555	93.9	112	64.0	12.1	77.2	680
XNH 1401	69.1	82	62.8	13.4	79.7	554
Andrews	76.5	91	62.3	12.0	64.2	547
Hoff	78.6	93	62.8	12.9	80.9	604
Hatton	71.8	85	64.4	11.9	89.8	511
Wanser	70.1	83	62.0	11.8	82.0	497
Federation	70.2	83	60.0	11.7	44.9	494
Monopole	84.2	100	62.8	12.2	84.2	613
Batum	67.1	80	60.1	11.7	83.8	464
Tiber	69.0	82	62.0	13.0	71.2	538
OR8602	68.4	81	60.9	12.4	87.3	509
OR830282	81.9	97	61.0	12.5	85.4	615
ORCR8718	89.3	106	62.6	12.6	92.4	674
ORCR8617	96.8	115	61.6	12.3	84.1	715
ORCR8601	72.6	86	61.8	12.9	87.9	562
ORCR8300027	71.8	85	61.0	13.5	90.9	582
OR8302306	77.2	92	60.6	11.8	69.7	545
OR8522	91.5	109	61.0	11.9	76.3	650
OR8500513H	86.0	102	63.6	11.5	66.4	592
OR860126	98.7	117	63.0	11.4	91.3	676
OR860247	100.4	119	62.5	12.5	84.6	750
OR870834	81.6	97	59.0	11.3	46.7	552
OR870859	102.5	122	62.4	11.3	72.6	691
Redwin	73.5	87	62.6	13.8	85.6	606
Winridge	63.6	75	60.6	12.8	84.2	485
Mean	78.9	94	61.8	12.3	77.3	578
PLSD .10	10.9	13	1.1	0.8	7.3	85.0
PLSD .05	13.0	15	1.3	8.7	8.7	101
CV%	11.7	11.5	1.5	5.8	8.0	12.4

Table 2. 1992 hard red and hard white winter wheat variety trial data for flowering date, height, lodging, chaff, grain N uptake, and seeding rate on plots established in 1991 at COARC, Madras, OR.

Variety	Flower Date	Height in	Lodging %	Chaff %	Grain N Uptake lb/ac	Seeding Rate lb/ac
Stephens	147	35	68	9.1	98.3	113
Ute	147	29	90	6.7	107.2	85
Buchannon	147	41	100	9.7	87.6	120
Tam 109	143	34	98	11.9	62.6	94
Longhorn	140	39	65	7.6	108.9	104
QT 555	143	36	68	8.1	119.3	134
XNH 1401	145	43	96	6.4	97.2	125
Andrews	152	35	79	6.8	96.0	88
Hoff	145	39	58	7.6	105.9	109
Hatton	151	43	93	8.5	89.7	98
Wanser	147	45	99	9.7	87.1	101
Federation	149	41	85	10.8	86.7	107
Monopole	149	41	44	10.9	107.5	93
Batum	148	40	65	15.2	81.4	91
Tiber	148	45	83	9.1	94.4	94
OR8602	144	32	84	9.6	89.3	107
OR830282	145	36	73	10.9	107.9	114
ORCR8718	146	40	71	9.6	118.3	106
ORCR8617	144	35	39	8.1	125.5	92
ORCR8601	141	40	85	10.1	98.5	106
ORCR8300027	146	39	80	11.5	102.0	106
OR8302306	145	33	69	9.0	95.5	78
OR8522	149	36	25	6.4	114.0	83
OR8500513H	144	34	75	7.6	104.0	115
OR860126	147	37	36	8.0	118.6	110
OR860247	142	38	18	6.9	131.7	124
OR870834	145	37	86	7.7	96.9	100
OR870859	145	37	25	6.7	121.2	111
Redwin	149	46	54	7.5	106.3	107
Winridge	150	44	93	12.1	85.1	98
Mean	146.1	38	70	4.0	101.5	104
PLSD .10	one	2.0	19	1.5	14.8	range
PLSD .05	rep	3.0	23	1.8	17.7	78 - 135
CV%	-	5.2	23.1	13.9	12.41	-

Table 3. 1992 soft white winter wheat variety trial data for yield, percent relative yield of Stephens, test weight, percent protein, hardness, and protein yield on plots established in 1991 at COARC, Madras, OR.

Variety	Yield bu/ac	% Rel. Yield of Stephens	Test Weight lb/bu	Protein %	Hardness Factor	Protein Yield lb/ac
Rely	73.4	96	59.6	10.8	41.1	475
Nugaines	106.7	139	61.9	9.9	33.7	633
Rod	99.3	130	59.5	10.9	42.4	645
Forty Fold	42.1	55	61.0	12.3	35.6	310
Durheim Pride	99.0	129	61.9	10.3	37.9	610
Basin	111.4	145	60.6	9.9	23.2	660
Cashup	97.2	127	60.4	11.1	27.9	645
Yamhill	67.6	88	58.3	11.8	37.1	479
Rhode)	88.7	116	61.6	10.7	42.8	567
Malcolm	97.5	127	60.0	10.7	36.7	623
Kmor	87.1	114	59.3	10.4	33.4	539
Eltan	71.7	94	59.5	11.3	40.0	482
Hill 81	94.5	123	60.5	11.5	42.9	653
Gene	87.5	114	60.1	11.7	36.4	613
Hyak	70.1	92	59.4	11.1	42.2	465
Tres	78.9	103	59.9	10.8	38.1	510
Daws	91.1	119	60.5	10.9	34.7	594
Oveson	97.1	127	60.6	10.5	28.9	605
Stephens	76.6	100	58.8	11.8	43.6	538
Dusty	82.2	98	60.0	10.4	28.7	506
Madsen	94.5	123	60.0	11.6	36.5	657
OR8632	82.9	108	59.4	11.4	41.9	565
OR8302784	80.6	105	60.0	11.9	35.8	577
MacVicar	86.9	113	58.9	11.2	41.3	581
W301	84.4	110	58.6	11.7	41.1	591
85HR6537	69.4	91	60.4	11.6	42.9	478
85HR5350	75.9	99	58.1	11.0	42.1	496
OR851139H	84.8	111	60.1	12.1	43.5	610
OR857847P	85.2	111	58.9	11.4	38.3	579
OR860302	112.7	147	62.5	11.0	37.5	741
Salmon	84.6	110	59.5	10.9	33.0	551
Syringa	84.2	110	61.0	11.2	44.3	565
Mean	85.8	112	60.0	11.1	37.6	571
PLSD .10	9.9	13	0.9	0.5	5.7	64
PLSD .05	11.8	16	1.1	0.6	6.8	77
CV%	9.8	10.0	1.3	3.9	12.8	9.6

Table 4. 1992 soft white winter wheat variety trial data for flowering date, height, lodging, chaff, grain N uptake, and seeding rate on plots established in 1991 at COARC, Madras, OR.

Variety	Flower Date	Height in	Lodging %	Chaff %	Grain N Uptake lb/ac	Seeding Rate lb/ac
Rely	143	42	78	16.4	83.4	103
Nugaines	146	35	25	10.6	111.0	111
Rod	151	36	33	9.6	113.2	108
Forty Fold	147	47	100	11.1	54.3	106
Durheim Pride	151	37	25	8.7	107.0	113
Basin	150	31	10	7.6	115.8	116
Cashup	151	37	41	11.3	113.2	127
Yamhill	146	41	88	12.0	84.1	112
Rohde	152	35	73	11.6	99.5	94
Malcolm	152	37	53	9.0	109.3	100
Kmor	145	36	81	12.4	94.5	103
Eltan	150	37	94	13.6	84.5	84
Hill 81	151	39	43	8.9	114.6	77
Gene	152	34	48	11.8	107.5	91
Hyak	148	34	80	14.7	81.5	82
Tres	151	40	64	15.4	89.3	79
Daws	150	37	33	11.9	104.1	75
Oveson	149	35	29	13.6	106.2	76
Stephens	149	37	85	10.5	94.5	113
Dusty	150	37	64	11.6	88.7	69
Madsen	146	36	31	7.4	115.3	82
OR8632	149	34	74	9.2	99.1	99
OR8302784	145	39	60	10.2	101.2	80
MacVicar	142	36	71	10.8	102.0	85
W301	149	36	83	10.4	103.7	95
85HR6537	152	41	90	13.7	83.8	104
85HR5350	150	38	95	15.5	87.0	103
OR851139H	152	41	76	9.1	106.9	109
OR857857P	151	35	78	10.0	101.6	119
OR860302	149	34	18	8.1	129.9	108
Salmon	150	37	79	11.0	96.7	111
Syringa	145	36	90	11.1	99.1	104
Mean	177	37	62	11.2	99.4	98
PLSD .10	one	1.8	18	2.3	---	range
PLSD .05	rep	2.2	21	2.7	---	69-127
CV%	only	4.2	24.5	17.2	9.6	---

STATE-WIDE CEREAL VARIETY TESTING PROGRAM TRIALS IN CENTRAL OREGON

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Abstract

A state-wide cereal variety testing program was initiated in 1992-93. Funding for the program is being provided by the Oregon State University Agricultural Experiment Station, Oregon Wheat Commission, and Oregon Grains Commission. Winter and spring barley, triticale, and wheat trials were conducted at Madras as a part of this program. Newer varieties such as Madsen, MacVicar, W301, Gene, Kold, Penawawa, and Maranna out-performed traditionally grown varieties in terms of both yield and quality factors. Trial data is summarized in tabular form. Trial results from across the state will be summarized in a publication that will be available to growers in early 1994. Similar trials will be conducted in 1993-94.

Introduction

New cereal varieties are being released by Pacific Northwest plant breeders yearly. In order to provide growers in all major cereal production regions of Oregon with local data on new and old variety performance, a state-wide cereal variety testing program was initiated in 1992-93. Funding for the program is provided by the OSU Agricultural Experiment Station, Oregon Wheat Commission and Oregon Grains Commission.

The program is centrally coordinated by Russ Karow, OSU Extension cereals specialist, and Helle Ruddenklau, OSU Dept. of Crop and Soil Science Research Assistant. The central team, with the assistance of numerous student workers, packages and distributes seed to cooperators across the state. Cooperators, like Steve James and Mylen Bohle in central Oregon, plant, manage, and harvest the trials. The central team then processes harvested grain, analyzes results and provides summary data to Extension agents, seed dealers, field representatives, and growers across the state.

Eleven sites are included in the testing network. Winter and spring barleys, triticales and wheats from several market classes are being tested. Height, lodging, yield, test weight, and seed size are being determined for all varieties. Heading date, disease reactions, protein content, and other quality factors are determined as time and labor allow.

The program is in the second year of a two-year trial period. An evaluation of program success and efficiency will be made by the funding agencies after harvest, 1994.

Materials and Methods

Plots (5 x 20 ft) were seeded at a rate of 30 seeds per square foot using an Oyjord plot drill. Pound per acre seeding rates varied from a low of 89 lb/ac for Gwen winter barley (14,630 seeds per pound) to a high of 176 lb/ac for W301 winter wheat (7,440 seeds per pound) to achieve the desired 30 seeds per square foot seeding rate. Winter trials were seeded on October 1, 1992, while spring trials were planted on April 26, 1993. All plots had 475 pounds of 16-16-16 preplant incorporated on August 26, 1992. Wheat plots received an additional 240 pounds of 40-0-0-6 on April 12, 1993, as a top dress or pre-plant incorporated application. Herbicide and irrigation programs were typical for central Oregon production. Harvested grain was cleaned with a Peltz rub-bar cleaner. Plot yield and grain test weight and moisture were all determined on cleaned samples. All yields are reported on a 10 percent moisture adjusted basis and in terms of a 60 pound bushel for both wheats and triticales. Wheat and triticale proteins are reported on a 12 percent moisture basis.

Results and Discussion

Winter wheats and triticales Data for winter wheats and triticales are presented in Table 1. The soft white wheats Madsen, MacVicar, W301, and Gene were top performers among the winter wheats. All showed higher yields (though the differences are not statistically different), less lodging, and heavier test weights than Stephens, the dominant variety in central Oregon. MacVicar and W301 also tended toward lower protein levels. Flora triticale had a grain yield equivalent to the highest yielding winter wheat. Celia triticale had a lower yield than, Flora but a significantly better test weight. Poultry feeding trials will be conducted in 1993-94 to determine if the higher test weight of Celia equates to better feed value.

Lodging was significantly different among varieties with Hoff, a hard red winter wheat, having the highest level. Rohde, a tall club wheat just released by Pam Zwer (OSU club wheat breeder), had a lodging percent similar to Stephens. Rod, a newer release from Washington State University, appears to have weaker straw than other newer soft white wheats.

Average seed weight for the trial, as evidenced by seeds per pound data, is high. A typical seeds per pound figure for Pacific Northwest wheats is 10,500 seeds per pound. The trial average was 9,437 with a range of 8,273 to 10,920 seeds per pound. The significance of seeds per pound data is obvious when you calculate seeded plant population resulting from use of a common pounds per acre seeding rate. If W301 (8,273 seeds per pound) and Nugaines (10,920 seeds per pound) were each seeded at a 100 pounds per acre seeding rate, the seed population for W301 would be 827,300 seeds per acre while that for Nugaines would be 1,092,000 - a difference of 32 percent or six seeds per square foot! Seed size must be considered when seeding rate decisions are made.

Average protein level for the trial was high - 11.2 percent. Research has shown that protein levels above 10.5 percent indicate that nitrogen in excess of that needed for optimal yield was present in the soil. A comparison of protein level for Madsen and MacVicar, two varieties with a similar, high yield level, demonstrates that genetics does play a role in protein level. MacVicar consistently produces low protein grain, while Madsen produces high protein grain.

Winter barleys Winter barley data are presented in Table 2. Newer varieties such as Showin and Kold had higher yield levels than traditional varieties such as Steptoe and Hesk, but lodging percent and test weight were not consistently better. Average winter barley yield was approximately 1,000 pounds per acre less than the average winter wheat yield, a difference similar to that between the highest yielding barley and highest yielding wheat. Growers interested in winter feed grains should make economic comparisons between the winter triticales and barleys.

Spring wheats and triticales Spring wheat and triticale data are presented in Table 3. Average spring wheat/triticale yield (64 bu/ac) was 60 percent that of winter grains (108 bu/ac). Yield of the highest yielding spring wheat (Klasic, a hard white wheat; 87 bu/ac) was 72 percent that of the highest yielding winter wheat (Madsen; 121 bu/ac). Given that production inputs were identical for winter and spring wheats in these trials, gross dollar return would have been substantially higher for winter wheat.

Klasic, a Northrup King bred hard white wheat, had the highest yield of spring wheats and triticales. It outyielded Penawawa, the highest yielding soft white wheat, by nearly 10 bushels per acre, and had a significantly better test weight. However, don't plant your farm to Klasic unless you have a contract in hand. Non-contract production of an atypical market class wheat can lead to real marketing problems.

Spring triticale yields were significantly lower than those of the wheats. The triticales tended to be later in heading and showed an extended grain fill period in some environments. They appear to have suffered yield reductions in central Oregon this year because of delayed maturity. Because the trial was cut on the same day, the triticale moisture was 20-24 percent, and yields were not ripe. Celia is a winter wheat with excellent winter hardiness, but a weak vernalization requirement. We experimented with it as a spring- planted grain this year. Our experience across the state indicates that unless it can be planted very early in the spring, spring-planted performance is likely to be disappointing.

Yecora Rojo, the most commonly planted hard red spring in central Oregon, had a higher yield than the other hard red springs tested.

Spring barley Spring barley data are shown in Table 4. Spring barleys, unlike their winter counterparts, did exceptionally well in comparison to the wheats. Average spring barley yield was 6,251 pounds per acre versus a 3,864 pounds per acre average for the wheats and a 5,232 pounds per acre yield for the best wheat! The highest yielding spring barley, Maranna (a new release from OSU; 7,478 lb/ac), had a yield better than that of the best winter wheat (Madsen; 121 bushels or 7,260 lb/ac). Test weights for the highest yielding barleys were adequate. Test weight for Baroness, a variety released by Western Plant Breeders, was superior. Lodging readings were "black and white." Some varieties showed a great deal of lodging, others none at all. In this year, spring barleys performed very well.

Conclusions

From a gross dollar return perspective, assuming $4 per bushel of wheat and $98 per ton for barley, winter wheats and spring barleys fared best in the 1993 growing season. Within these classes of grains, and among winter barleys and winter and spring triticales, there are many choices to be made. Many new varieties have been released by the Pacific Northwest states. Varieties with unique characteristics exist within each grain grouping. Growers are encouraged to use data presented in this report as well as data in previous year field day reports and Extension publications (SR 775, Winter Wheats for Oregon; Crop Science Reports on other spring and winter grains) to make variety selection decisions. These publications are available through your local county Extension office. Carefully consider your available markets and the special needs of your production system as you make choices. All the varieties were harvested on the same day, when the wheats were ripe. The triticale grain moisutre was 20-25 percent so the triticales were at a large disadvantage.

Table 1. 1993 State-wide variety testing program winter wheat and triticale trial at the the Central Oregon Experiment Station, Madras, OR.

Variety	Grain type	Julian heading date	Height (in)	Lodging percent	Yield (bu/ac)	Test weight (lb/bu)	Seeds per pound	Protein percent	Hard-ness
Basin	SW wheat	161	32	0	112.7	58.5	10430	10.5	18
BZ702	SW wheat	153	35	0	101.3	57.9	9040	10.7	38
Cashup	SW wheat	159	36	27	109.4	60.0	9851	11.3	37
Celia	Triticale	151	36	0	110.9	56.1	8957	10.7	50
Daws	SW wheat	158	39	10	106.9	60.7	8743	11.4	43
Durheim Pride	SW wheat	157	36	3	106.4	60.9	9591	10.9	41
Flora	Triticale	151	34	2	120.4	49.7	9487	10.1	36
Gene	SW wheat	154	33	10	114.3	60.0	9323	11.8	42
Hill 81	SW wheat	155	38	7	98.4	60.5	9826	11.6	40
Hoff	HR wheat	151	38	60	108.3	61.1	9730	12.3	78
Lewjian	SW wheat	165	37	43	100.9	61.0	9687	11.4	33
MacVicar	SW wheat	154	38	5	119.7	60.0	8591	10.9	39
Madsen	SW wheat	158	35	0	120.8	60.6	9349	12.1	45
Malcolm	SW wheat	154	37	0	98.6	58.6	8745	11.2	39
Nugaines	SW wheat	159	35	20	109.4	59.1	10920	11.0	24
Rod	SW wheat	161	39	43	110.4	57.7	9074	11.4	41
Rohde	Club wheat	154	39	28	100.5	60.1	10760	12.0	42
Stephens	SW wheat	153	35	27	108.8	57.6	8878	11.1	36
W301	SW wheat	153	35	7	118.9	58.2	8273	10.5	33
Whitman	Triticale	144	43	3	106.1	54.6	9137	11.0	58
Yamhill	SW wheat	159	42	12	84.4	57.0	9795	11.3	31
Mean		156	37	15	108.0	58.6	9437	11.2	40
PLSD (5%)		2	3	33	16.9	0.9	1011	NS	9
PLSD (10%)		2	2	27	14.1	0.7	842	NS	7
CV		1	5	138	9	1	6	7	13

Planted: October 1, 1993
Seeding rate : 30 seed/sq ft
Fertilizer: 475 lb of 16-16-16 PPI August 26, 1992
240 lb of 40-0-0-6 top dress April 12, 1993
Harvested: August 27, 1993; Wintersteiger combine

Table 2. 1993 State-wide variety testing program winter barley trial on the Central Oregon Experiment Station, Madras, OR.

Variety	Grain type	Julian heading date	Height (in)	Lodging percent	Yield (lb/ac)	Test weight (lb/bu)	Seeds per pound
Gwen	6R F	139	34.0	65	6061	48.4	13030
Hesk	6R F	147	37.3	81	5196	47.0	11360
Hundred	6R F	148	33.0	93	4972	43.9	15540
Kamiak	6R F	139	36.0	96	4763	46.2	13540
Kold	6R F	146	34.7	88	5620	47.0	11710
Showin	6R F	147	32.7	70	6247	43.3	12740
Steptoe	6R F	145	36.7	90	4170	46.7	10370
Mean		144	34.9	83	5290	46.1	12610
PLSD (5%)		2	NS	21	NS	1.6	1664
PLSD (10%)		2	NS	17	NS	1.3	1361
CV		1	8	14	17	2	7

Planted: October 1, 1992
Seding rate: 30 seeds/sq ft
Fertilizer: 475 lb of 16-16-16 PPI August 26, 1992
Harvested: August 27, 1993; Wintersteiger combine

Table 3. 1993 State-wide variety testing program spring wheat and triticale trial at the Central Oregon Experiment Station, Madras, OR.

Variety	Grain type	Julian heading date	Height (in)	Lodging percent	Yield (bu/ac)	Test Weight (lb/bu)	Seeds per pound
Calorwa	club wheat	186	30	0	66.2	58.4	13890
Celia	triticale	201	36	0	26.1	42.5	16450
Centennial	SW wheat	186	33	0	70.6	59.0	12900
Dirkwin	SW wheat	189	33	0	65.0	57.3	11930
Juan	triticale	191	45	0	43.5	43.8	12140
Klasic	HW wheat	180	27	0	87.2	61.0	10470
Owens	SW wheat	186	33	0	66.2	59.5	13140
Penawawa	SW wheat	187	35	0	77.6	59.2	13370
Treasure	SW wheat	189	30	0	60.5	61.3	12320
Twin	SW wheat	190	36	0	63.5	57.1	14310
Victoria	triticale	183	40	0	47.7	47.8	12630
WB906R	HR wheat	183	34	0	70.3	60.6	11510
WB926R	HR wheat	183	30	0	66.6	60.5	10350
Yecora Rojo	HR wheat	182	27	0	81.9	60.3	10890
Yolo	HR wheat	187	33	0	73.4	60.4	14760
Average		187	33	--	64.4	56.6	12740
PLSD (5%)		2	4	--	14.2	1.4	1644
PLSD (10%)		2	4	--	11.8	1.2	1365
CV (%)		1	8	--	13	2	8

Planted: April 26, 1993
Seeding rate: 30 seeds/ sq ft
Fertilizer: 475 lb of 16-16-16 PPI on August 26, 1992
240 lb of 40-0-0-6 top dress on April 12, 1993
Harvested: August 27, 1993; Wintersteiger combine

Table 4. 1993 State-wide variety testing program spring barley trial at the Central Oregon Experiment Station, Madras, OR.

Variety	Grain type	Julian heading date	Height (in)	Lodging percent	Yield (lb/ac)	Test Weight (lb/bu)	Seeds per pound
Baroness	2R F/M	176	30	53	6186	51.3	9858
Colter	6R F/M	178	33	50	6680	48.8	10570
Columbia	6R F	182	30	0	6578	44.8	10890
Crest	2R M	185	30	43	5036	49.5	10800
Crystal	2R M	190	29	52	5530	51.7	10030
Gustoe	6R F	190	24	0	7045	45.4	12020
Maranna	6R F	193	28	50	7478	48.3	13720
Micah	6R F	193	27	0	6111	45.3	12540
Russell	6R M	193	32	33	5733	49.5	11720
Steptoe	6R F	194	32	93	6138	47.4	9928
Average		187	29	38	6251	48.2	11210
PLSD (5%)		4	3	29	586	1.3	1339
PLSD (10%)		3	2	24	484	1.1	1105
CV (%)		1	6	45	5	2	7

Planted: April 26, 1993
Seeding rate: 30 seeds/ sq ft
Fertilizer: 475 lb of 16-16-16 PPI on August 26, 1992
Harvested: August 27, 1993; Wintersteiger combine

INFLUENCE OF FOLIARLY APPLIED METHANOL SPRAYS ON THE YIELD AND QUALITY OF RUSSET BURBANK POTATOES

Steven R. James, Alan R. Mitchell, Kenneth A. Rykbost, and Clinton C. Shock

Studies recently conducted in the arid southwestern United States by A. Nonomura and A. Benson have shown that foliar sprays of aqueous 10-50 percent methanol increased growth and development of C_3 crop plants. Plants treated with nutrient-supplemented methanol showed up to 100 percent increases in yields when maintained under direct sunlight. Tomato plants treated with methanol had thicker leaves and stems, fruit development commenced 5-10 days earlier, and fruit averaged 10-12 percent greater sugar content than controls. Water requirements were also reduced for many of the crops tested. Potatoes are a C_3 plant but were not included in these studies, but it is conceivable that methanol could increase potato yields, lower water requirements, and perhaps hasten maturity under central Oregon conditions.

Experiments were established at Madras, Klamath Falls, and Ontario to evaluate the effect of foliarly applied methanol on Russet Burbank potatoes. A preliminary test was conducted in the greenhouse at Powell Butte to establish optimal dose response. Field tests at three locations were later planted to determine the effect of methanol on plant morphology, maturity, water consumption, yield, grade, tuber size distribution, and tuber sugar content (French fry color).

GREENHOUSE STUDY. The following treatments were applied to potted potato plants on June 2, June 16, and July 2, 1993:

Methanol Rate	MEM[1]	Glycine[2]
	-	-
0,15	+	-
30,45	-	+
60, and 75%	+	+

1--1g/l Urea plus 0.05 g/l Triton X-100
2--1% Glycine plus 0.1% Glycerophosphate

Data gathered included foliage weight, root weight, tuber number, and tuber weight.

FIELD STUDIES. Six methanol treatments were applied to two sets of established Russet Burbank plants: 1) untreated check, 2) 20 percent methanol plus 0.1 percent Triton X-100, 3) 40 percent methanol plus 0.1 percent Triton X-100, 4) 80 percent methanol plus 0.1 percent Triton X-100, 5) 20 percent methanol, and 6) 40 percent methanol. The first set of plots was desiccated on September 2, 1993; the second set on September 20, 1993. Soil moisture was monitored throughout the growing season with granular matrix moisture sensors.

Data collected included leaf necrosis, yield, grade, specific gravity, tuber size, and French fry color.

POTATO SEEDPIECE TREATMENT STUDY

Steven R. James and Frederick J. Crowe

Various pathogens have the potential to cause serious problems in cut potato seed. Poor stands caused by seedpiece decay are not an uncommon sight in central Oregon. A wide spectrum of seedpiece treatments are employed in central Oregon including gypsum, various fungicides, and suberization of cut seed.

An experiment designed to evaluate the efficacy of various potato seedpiece treatments was planted June 8, 1993 at the Powell Butte site of the central Oregon Agricultural Research Center. The experiment was arranged in a randomized complete block design with four replications. Individual plots were 15 feet long by three rows wide, separated by an unplanted 5-foot border. Sixty Russet Burbank seed pieces were planted 9 inches apart in each plot; 20 seedpieces per row. Oregon Generation III certified seed provided by a Culver seed grower was planted in the trial.

Seedpiece treatments included an untreated check, Maxim 5D, Maxim 4FS, Captan 5D, Tops 2.5D, fir bark, gypsum, and untreated suberized seed. Tubers were cut and treatments applied two to three hours prior to planting. The seed for the suberized treatment was cut and allowed to suberize for seven days prior to planting. Seedpieces were not inoculated with any pathogens prior to treatment. The experiment was fertilized, cultivated, irrigated, and managed according to practices commonly used in central Oregon.

The total number of plants that emerged in the center plot row were counted 43 days after planting. In addition, 20 seedpieces (10 from each outside row of each plot) were evaluated for Rhizoctonia and Fusarium rots. The number of stems per plant was also obtained at that time. The plots were harvested on October 6 and 7, 1993, and later graded and weighed.

THE EFFECTS OF N-SOURCE ON YIELD IN FOUR WINTER WHEATS AND A TRITICALE

Gary Banowetz and Dale Coats

The form of nitrogen (N-source) applied to wheat can affect crop yield. Cultivar differences in the response to N-source have been documented in many crops. Certain cultivars seem more adapted to nitrate-N compared to ammonium-N, others provide higher yields in response to ammonium-N or to mixed N (fertilizers that contain both nitrate- and ammonium-N). Interest in the effects of N-source on yield in wheat stems from both economic and environmental factors. Ammonium-N is tightly bound by the top few inches of soil and may remain available to plant roots for an extended period of time. Nitrate-N is not tightly bound and consequently is subject to leaching through the soil. This leaching represents a loss of available nitrogen to the plants and a possible source of ground water contamination. The capacity of a specific cultivar to use either ammonium-N or nitrate-N is dependent upon nitrogen uptake and metabolic mechanisms.

Yield responses of four winter wheats (including one club wheat) and a triticale to N-source are being studied. The first year of the study (1991-1992), which used a single fall application of either urea, calcium nitrate, ammonium sulfate or ammonium nitrate, showed no significant differences in yield attributed to N-source. In the second year of the study (1992-1993), a second fertilizer application in the spring was added. Significant differences were noted in both Yamhill and Malcolm. Malcolm yields were highest in plots that received ammonium nitrate, a mixed N-source, whileYamhill yields were highest in plots that received calcium nitrate.

Yields were significantly higher during the second year of the trial, possibly in response to the split application of nitrogen. Soil analyses of plots of Stephens wheat (four replications per N-treatment) conducted just prior to the second fertilizer application indicated that soil nitrogen levels were highest in ammonium-fertilized plots and lowest in plots receiving only nitrate-N. Additionally, as expected, ammonium levels remained highest in the top 4 inches of soil. The trend of nitrate levels suggested higher levels at greater depths.

Protein and 1000-seed weight responses to N-form also are being monitored during the course of this study. No significant differences in either were noted in the first year of the study. This study is being conducted for a third year and again will use a split application of nitrogen. Soil nitrogen levels and specific yield components will be monitored during wheat development and after crop harvest.

INTERACTION OF KENTUCKY BLUEGRASS CULTIVATORS, NON-THERMAL RESIDUE MANAGEMENT, AND NITROGEN FERTILIZATION: A TRI-STATE PROJECT

G.A. Murray and S.M. Griffith

Improved environmental quality through the elimination of burning of KBG seed crop residue and improved nitrogen use efficiency (NUE), combined with a sound economic seed production system are the primary goals of a tri-state research project that began in June 1992.

This project proposes to measure the combined economic effectiveness of (1) the most current mechanical after-harvest residue removal techniques, (2) efficient nitrogen use strategies, and (3) bluegrass variety response, as a production package needed to eliminate burning and to improve NUE of bluegrass. Improved NUE of bluegrass will result in reduced loss of applied N. Improved environmental quality benefits are expected via reduced smoke emissions and nitrate leaching of air and water, respectively. Another benefit is continued production of bluegrass, a crop that provides excellent erosion control of highly erodible soils thus improving surface water quality by reducing soil sediment load. Additional benefits are potential loss of phosphates and pesticides attached to the soil particles. Finally, the studies in improving bluegrass NUE will likely be applicable to most other crops raised in the northwest, thus reducing potential nitrate contamination of water from use of N fertilizer.

This work is being conducted in the major KBG producing regions of Oregon, Idaho, and Washington. Fields have been selected to represent the primary irrigated (near LaGrande and Madras, OR and Coeur d'Alene, ID) and dry land bluegrass regions (Rockford, WA), and at Moscow, ID (University of Idaho Research and Extension Center). Two experiments are being conducted at each location. All field operations except planting, N application, and residue removal are the current best management practices recommended for the area and are performed by the cooperating grass seed grower at the location.

Additional cooperating scientists include: William Young and Neil Christensen, Crop and Soil Science, Oregon State University, Corvallis; Dale Coats, Central Oregon Agricultural Research Center, Madras; Gordon Cook (OSU Ext. Service.) and Gary Kiemnec (Crop and Soil Science, EOSU), LaGrande, OR. Principle funding sources for this work, in addition to USDA-ARS and state funds, include the Pacific Northwest Pollution Prevention Research Center, Seattle and CSRS Grant (STEEP).

FORAGE RESEARCH AND EXTENSION IN CENTRAL OREGON

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Abstract

Completed and present research projects include an annual legume adaptation trial, spring and winter forage cereal variety trial, long term weed control effects on alfalfa production, seedling alfalfa herbicide trials, dormant alfalfa herbicide trial, New Zealand forage species trial, annual legume residual nitrogen effect on Kanota oat hay, and improving nitrogen fertilizer recommendations for hay and pasture to reduce potential ground and surface water non-point pollution in central Oregon. New projects to begin in 1994 will include a forage/eco-zone calendar trial, dormant alfalfa herbicide trial in Fort Rock/Christmas Valley, pasture renovation trial and an alfalfa variety trial. Major Extension activities include a Central Oregon Forage Information Day held annually in January, two field plot tours during the summer and a New Zealand Fencing and Pasture/Grazing Management Tour held annually in September.

Introduction

The following are research summaries of the trials being conducted by the Central Oregon Agricultural Research Center (COARC). Because of the earlier than normal deadline for this annual report, there was insufficient time to completely describe the following projects. If additional information is needed before next publication, please contact the author.

On-station COARC personnel helping out with the day-to-day activities in the forage program include Sylvia McCallum, Peter Tomseth, Pat Foltz, and 1993 summer help Jerod Williams. There has been much cooperation with other personnel not connected directly with the COARC unit. Randy Dovel, Klamath Experiment Station; Larry Burrill, David Hanaway, Shannon Springer, John Hart, Russ Karow, and numerous graduate students from the OSU Crop and Soil Science Dept.; Matt Kolding, Hermiston Experiment Station; Robert Metzger, USDA Retired; and Jim Sims, Montana State University have all aided in major or minor ways with the forage program at COARC.

Forage Research and Extension Projects

Annual Legume Adaptation Trial: Thirty-eight and twenty-two varieties of small and large seeded annual legumes have been tested in 1992 and 1993, respectively. The

COARC (Powell Butte site), Klamath Experiment Station, and Hyslop Research Farm have been cooperating on these trials to assess the compatibility in their respective areas for rotation, forage and cover crop potential, and the post-year effect on subsequent crops due to their nitrogen fixing capabilities (Powell Butte). The trial may be run in 1994 as well.

Spring Forage Cereal Variety Trial: Four years (1990-1993) of testing spring rye, triticale, wheat, barley, and oat species and varieties was completed in 1993. Data on yield, height, lodging, harvest date by growth stage (either at late boot or soft to hard dough), and quality were gathered on these species and varieties. The trial was conducted at the Powell Butte site. Seeding rates in lb/ac based on 30 seeds/ft^2 have been documented. The Oregon Grains Commission has partially funded this study.

Winter Forage Cereal Variety Trial: Three years (1991-1993) of testing winter rye, triticale, wheat, barley, and oat species and varieties was completed in 1993. Yield, height, lodging, harvest date based on growth stage (cut at late boot and soft to hard dough), and quality were measured. Seeding rates in lb/ac based on 30 seeds/ft^2 have been documented. The trial was conducted at the COARC Powell Butte site. The Oregon Grains Commission has partially funded this study.

Long Term Weed Control Effects on Alfalfa Production: Three years of research on the long term effects of chemical weed control on alfalfa production have been completed at the COARC Powell Butte site and Klamath Experiment Station. Five different weed management schemes have been imposed on spring and fall planted alfalfa. The weed management ranges from herbicides applied annually to no weed control. Yield of alfalfa, grass weeds and broadleaf weeds, alfalfa quality, and stand persistence are being measured. The economics of weed control will also be determined. Chemical companies are partially funding this study.

Seedling Alfalfa Herbicide Trials: Three seedling alfalfa herbicide trials have been conducted on and off station (Mike McCabe and Paul Kasberger Farm) with varying degrees of results. The two off-station trials were rated only for percent control. The on station trial was rated visually for percent control of weeds, and three cuttings of hay yields were documented.

Dormant Alfalfa Herbicide Demonstration Trial: One year of testing was conducted comparing sencor, velpar and sinbar in a two-replication trial on station at the COARC Powell Butte site. Hay yields were documented for three cuttings.

New Zealand Forage Species Demonstration Trial: Matua prairegrass, Puna Chicory, Ellet ryegrass, and Wana orchardgrass were planted in the fall of 1991 and are being compared to an older stand of Potomac orchardgrass. The species have been in two years and the orchardgrass in for six years. There are four replications but no randomization at the COARC, Powell Butte site. There are also spring planted 1993 plots of Matua prairegrass that were planted with the 1993 spring forage cereal variety trial.

Annual Legume Residual Nitrogen Effects on Kanota Oat Hay Production: Kanota oats were planted over the 1992 annual legume trial in the spring of 1993. The oats were harvested for hay yield to determine if the oat hay production could be increased by any of the 38 annual legume varieties planted in 1992. This trial will be repeated in 1994.

Improving Nitrogen Fertilizer Recommendations for Hay and Pasture to Reduce Potential Ground and Surface Water Non-Point Pollution in Central Oregon: Two farm sites were chosen in Deschutes county, and four sites in Crook county to look at the effect of 0, 50, 100 and 150 actual units of N per cutting of grass or grass/legume on hay yield, quality, plant nitrogen uptake, and what amount of nitrogen is unaccounted for after two years. Deep soil sampling will be carried out to determine what amount of nitrogen is still left in the soil and what amount is unused or cannot be accounted for. The trial has been conducted in 1992 and 1993 with the soil testing in the fall of 1993. If more funding can be obtained, the soil may be retested in the spring of 1994 for N remaining, and the first cutting of the hay will be harvested. This trial is partially funded by the state of Oregon Regional Strategies fund.

Pasture Renovation Trial: Scheduled to begin in 1993 but postponed to spring 1994, this study will compare different methods of renovating pastures that might offer economic alternatives compared to the traditional destructive method of plowing out and rotating crops to help clean up the pasture before planting back to permanent pasture. This trial will be partially funded by DEQ.

Central Oregon Information Day: There have been three annual information days (1991-1993) held to present COARC research results as well as hear results from other Experiment Station researchers and Extension personnel speakers from other areas. The day is held in the latter part of January. These information days are co-sponsored with Crook, Deschutes, and Jefferson County Extension Service Offices.

New Zealand Fencing and Pasture/Grazing Management Tour: There have been two annual (1991-1992) New Zealand fencing demonstration and pasture/grazing management tours held in September 1992 and 1993. This tour is co-sponsored by Crook, Deschutes and Jefferson County Extension Service Offices.

Experiment Station Forage Plot Tours: To date (1990-1993), usually two plot tours have been held each summer. The dates change from year to year to ensure there is something to see and the trials can be seen at different growth stages.

GARLIC POWDER AS A SOURCE OF GERMINATION STIMULANTS IN THE MANAGEMENT OF INOCULUM OF *SCLEROTIUM CEPIVORUM*, THE ONION & GARLIC WHITE ROT FUNGUS -- A PRELIMINARY REPORT

Fred Crowe, Central Oregon Agricultural Research Center, Madras, and Tom Darnell, Umatilla County Extension, Milton-Freewater, Oregon State University

Previous reports have discussed management of the onion and garlic white rot disease by using soil applied germination stimulants to induce sclerotia of *Sclerotium cepivorum* to germinate in the absence of host plants. Sclerotia of this pathogen do not germinate repeatedly, and it only reproduces on *Allium* species. In nature, germination only results when allyl and propyl sulfides are emitted from roots of *Allium* species (see "Use of Stimulants of Sclerotial Germination to Manage Inoculum Density of *Sclerotium Cepivorum* and to Control White Rot of Onions and Garlic", In Central Oregon Agricultural Research Center Annual Reports, 1990-1992, Special Report 922). Commercial control of white rot has only been attempted with synthetic, petroleum-derived materials, as it has been believed that natural products would be too expensive and variable to adapt for large scale disease control. Below we present preliminary data which suggests that garlic powder may provide affordable control of white rot disease.

A field trial was located in one of the same naturally-infested fields in which petroleum-derived stimulants were used in 1989-92, between Milton-Freewater OR and Walla Walla WA. Pre-treatment soil samples were collected from designated plots areas on October 14, 1991. Treatments were applied October 15, 1991, at which time the soil temperatures were appropriate for germination. Garlic powder (DeFrancesco and Sons, Firebaugh, CA) was applied uniformly over 6 ft x17 ft plots, then tilled to 10 inches. Rates of application are reported below. Powder was mixed with water and sprayed under agitation over plot area. Plots were then tilled to incorporate the powder. Post-treatment soil samples were collected in May of 1992. Twenty 1-inch diameter soil cores were collected to 10-12 inches deep in the soil profile. Two such 20-core sub-samples were taken at each sample date from each plot. Soil was air-dried and stored until processed. Soil was mixed and 500-ml aliquots from each sub-sample were sieved for sclerotia, which were picked from screened residue and viability determined.

The number of viable sclerotia recovered from plots prior to treatment ranged from 3 to 29. The number recovered pre-treatment was considered 100 percent on a per-plot basis. Following treatment, no sclerotia were recovered from plots treated with 470 or 4,700 pounds per acre garlic powder. Such a response may be sufficient for disease control. From untreated plots, 19 sclerotia were recovered post-treatment compared to 29 recovered pre-treatment, which would result in extensive disease if onions or garlic were planted. In plots treated with 47 pounds per acre garlic powder, 4 sclerotia were found compared to 17 recovered pre-treatment, which was insufficient for disease control. The mean percentage recovery from plots treated with 0, 47, 470 and 4,700 pounds of garlic powder per acre was 77.2, 24.0, 0 and 0 percent, respectively, which were highly significantly different ($P \leq 0.01$). If near eradication of sclerotia can be achieved at rates of application substantially less than 470 pound garlic powder per acre, a relatively inexpensive grade of garlic powder (less than $1 per pound) might provide affordable control of white rot.

This investigation will continue with the support of onion and garlic dehydration companies.

FLOODING FOR THE ERADICATION OF THE ONION AND GARLIC WHITE ROT FUNGUS FROM INFESTED SOIL -- EXPERIMENTS IN PROGRESS

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Sclerotium cepivorum, the fungus that incites onion and garlic white rot disease, survives many years in field soil as dormant propagules called sclerotia. These sclerotia can succumb to flooded soil conditions. Temperature plays a major role in this response -- summer flooding is more effective than winter flooding. The previous publication in this special report series contains survey data for sclerotia recovered from an infested commercial field in central Oregon. The survey indicated that many sclerotial bodies remained intact after one month continuous flooding, although about 65 percent of these were dead. After 13 weeks continuous flooding, less than one percent of intact sclerotia recovered were viable (see "Flooding for the Eradication of Onion and Garlic White Rot Fungus from Infested Field Soil," pp. 132-137 In Central Oregon Agricultural Research Center Annual Reports, 1990-92, Special Report 922). The survey data were limited in that initial populations of sclerotia just prior to flooding were not determined. What was potentially missed in the survey were sclerotia that had died and then decayed prior to recovery after various periods of flooding. Decayed sclerotia no longer are intact and are missed during the soil assay process.

More highly managed flooding field trials were initiated at the IREC in Tulelake. In this region, seasonal flooding is being investigated as a potential means of control of various crop pests in reclaimed lakebed soils. Sclerotia from decayed onions were mixed with enough soil to fill 60 mm inner dia x 60 mm high PVC chambers, 1,000 sclerotia per chamber. These were closed at the ends with fine nylon mesh. Soil was non-infested, 20 percent organic volcanic Tulelake muck. Chambers were buried 4 to 6 inches deep with nylon covered ends oriented up and down. Nine chambers per bucket were placed into 5-gallon microplot buckets filled with similar soil. Treatments (flooding durations) were replicated four times each. Soil in microplots was dampened at the time of burial, and flooding was initiated one month later in May, 1992. Since then, chambers from each treatment replication have been recovered on various schedules. For one test, chambers were recovered monthly through continuous seasonal flooding during 1992. Flooding was discontinued, but additional chambers will continue to be recovered yearly for two more years. For another test, chambers were recovered at regular intervals over two periods of seasonal flooding (1992 and 1993). Flooding period is determined by the irrigation season, May through October.

Intact sclerotia were recovered by concentrating them from soil by sieving through screens and flotation on a sucrose solution. Sclerotia then may be washed, surface disinfested, and placed on an appropriate growth medium to induce growth. The number of intact sclerotia and the number of viable-and-intact sclerotia will be reported as portions of the original 1,000 per chamber. Sclerotia can be stored dry or frozen for extended periods of time without deterioration.

The number of intact sclerotia (many of which will not be viable) recovered through August, 1993, suggest that perhaps 30-40 percent of the sclerotia fully decayed in the first few months and could not be recovered. Decay of intact sclerotia has not increased much since the first several months. This information could not be assessed in the earlier survey. Completed recovery of intact sclerotia and viability of recovered intact sclerotia for all dates through 1993 will be determined during the winter of 1993-94. Most data from both tests will be available by spring, 1994.

NEW TOOLS FOR PLANT-RESPONSE NITROGEN TESTING OF PEPPERMINT UPDATE

Alan R. Mitchell, Jennifer Samsel, and Neysa A. Farris

Peppermint, a crop that requires high rates of water and nitrogen fertilizer, was the focus of a nitrate-nitrogen (NO_3-N) sensing study. This project was funded by an Oregon Department of Agriculture Groundwater Research and Development Grant.

Differentially-fertilized 'Murray Mitchum' peppermint was evaluated using three methods of NO_3-N sensing: stem NO_3-N analysis, a CARDY ion meter that measures sap NO_3-N, and a SPAD chlorophyll meter. This study was designed to judge the accuracy of the two real-time sensors against the stem NO_3-N content determined in the laboratory. The three methods were evaluated using data collected on soil NO_3-N, dry matter yield, and fertilizer rates. The 1992 results indicated that all plant-based measurements can be influenced by factors other than NO_3-N stress.

In 1993, the same sensors were evaluated again using more fertilizer rates and three split applications of fertilizer in both 'Murray' and 'Black Mitchum' peppermint. At the time of this report, all the data has been collected and is ready for analysis excluding the soil samples. From preliminary observations, the CARDY measurements were not significantly different for the different N fertilizer levels.

The SPAD meter detected differences between treatments, but the sampling date had a great and inconsistent effect on the readings. The inconsistency appeared to be influenced by the weather that affected the leaf color, which may ultimately limit the usefulness of the SPAD meter.

The stem NO_3-N measurements were markedly distinguishable between N treatments. They were also influenced by cool weather in mid June. The soil data is not yet analyzed.

WATERMARK SENSORS FOR IRRIGATION MANAGEMENT UPDATE

Alan R. Mitchell, Joy E. Light, and Neysa A. Farris

There exists a need for a simple and reliable way to measure soil water content. Farmers need to manage irrigations for proper timing and the amount of water application. Traditional methods have problems of cost, reliability, and maintenance. The Watermark sensors have been developed (Irrometer Co., Riverside, CA) to solve these problems and still be accurate enough for use by researchers.

Watermark soil moisture sensors are modified gypsum blocks designed to accurately measure water retention in the wet soil range. Each soil type retains water differently and will have a different calibration curve. A Groundwater Research and Development Grant from the Oregon Department of Agriculture supported the calibration and placement of the sensors to different soil types in central Oregon and the Willamette Valley. Cooperation from the Eugene Farmers' Co-op helped in testing the sensors on farmers' fields. Placement location for the sensor in the root zone of several crops was also evaluated.

The soil water content calibrations are important to irrigation scheduling to determine the absolute amount of water in the soil and the amount of water depleted by the crop. During the winter of 1993, we evaluated three central Oregon soils and a soil from the Eugene, Oregon area. This winter of 1994, two more central Oregon soils will be evaluated. The calibrations are done in the laboratory by equilibrating the Watermark readings with several different water contents. Each soil will be analyzed according to the exponential model of the Madras loam that was successfully calibrated in 1992 (r^2=97 percent).

Placement location is important for evaluating the leaching or potential for leaching. By placing sensors at the bottom of the root zone and watching for changes, water movement, or leaching can be determined. The manufacturer recommends placing a sensor in the middle of the active root zone, and at a depth past 75 percent of the root zone to sense whether irrigation is sufficient to fill the root zone. In 1993, Watermarks were used in 12 fields of peppermint, potatoes, and Kentucky bluegrass seed.