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Introduction

Agricultural producers continue to face challenges of rising input costs (especially those related to petroleum during 2008) and land values. These challenges continue to encourage farmers to look at and for alternatives for their operations. These include alternative management practices (including organic production for high value horticultural crops), new and alternative crops and varieties / cultivars, and marketing options. The Western Colorado Research Center (WCRC) is a source for needed information and WCRC continues to plan, implement, and conduct research and outreach programs to address regional agricultural needs and to help find new answers and alternatives. This Annual Report provides information from some of the many research topics under investigation during and prior to 2008.

Studies at the Fruita site included variety trials of winter wheat, malting barley, canola, alfalfa, and field corn; other work there included studies on living mulch production systems for field corn production, blunt ear syndrome in field corn, and Foundation Bean breeding program accession evaluations and increases. Plantings were established at the Rogers Mesa (RM) and Orchard Mesa (OM) sites for new, alternative small fruit crops including Goji berry and edible honeysuckle, and a new NE-1020 wine grape variety trial; a new NC-140 apple rootstock trial also was planted at the OM site. Work continued on native seed production methods for the Uncompaghre Plateau and other re-vegetation projects, new and alternative options to manage orchard replant problems, alternative control options for Cytospora canker, phytoparasitic nematode impacts on virus disease spread and crop production, and winter and spring hardiness factors for wine grapes. Addition of Enologist Dr. Stephen Menke in 2008 expanded the Viticulture program to include wine making research and outreach; Dr. Menke has visited numerous wineries and held several enology workshops around the state. The Viticulture / Enology program also initiated a viticulture / enology concentration option in the CSU Department of Horticulture and Landscape Architecture with campus-based classes that started with the spring semester of 2008.

With regard to facilities, construction got underway in Nov. - Dec., 2008 at the WCRC - RM site on a cost-shared upgrade of the irrigation system there (cost-shared with the National Resource Conservation Service in Delta Co.). That project replaces everything from the divide box in the canal down to and including the pump and filter station. The project was to be on-line by the start of the 2009 irrigation season there. A similar replacement of the pump and filter station will be needed at WCRC - OM before the 2009 irrigation season due to burning out the undersized pump for the second season at the end of the 2008 season. And the heating system for the meeting room and greenhouse at OM was upgraded with a new boiler in early fall of 2008; a major freeze event in the greenhouse over the New Year holiday at the end of 2008 necessitated replacing the entire greenhouse heating system early in 2009.

Outreach activities at WCRC in 2008 included workshops for growers and other clientele, field tours of station facilities across all three sites, presentations to industry conventions / annual meetings (e.g., W. Colorado Horticultural Society’s 2008 Convention), and direct assistance to growers and other clientele via numerous telephone calls, office visits, and field site visits. In addition, the FruitFacts and code-a-phone messages were updated on both the phone dial-up system and the WCRC website.

All of this was facilitated by assistance from all our WCRC support personnel. They have worked hard to facilitate the research and outreach program at WCRC and their help is gratefully acknowledged. Finally, February 2008 was the official retirement date of WCRC pomologist, Dr. Matthew Rogoyski. But Matt returned to work on a peach split-pit / soft-suture study in 2008 jointly funded by growers, WCHS, and the CSU Dept. of Hort. and Landscape Architecture. A repeat of that study is needed before results can be written up.

Harold Larsen
Interim Manager, Western Colorado Research Center

Agricultural Experiment Station – Western Colorado Research Center Site Descriptions

Fruita Site:

1910 L Road
Fruita, CO 81521
(970) 858-3629 *Tel*
(970) 858-0461 *fax*

The Fruita site is located 15 miles northwest of Grand Junction. With an average growing season of 180 frost-free days at an elevation of 4,600 ft, a diversity of agronomic research is conducted at the Western Colorado Research Center at Fruita, including variety performance trials in alfalfa, corn silage, corn grain, canola, grasses, small grains; new and alternative crops; irrigation; cropping systems; soil fertility; and new crop trait evaluation. The Colorado Foundation Bean Program is located at Fruita. The specialized laboratory facilities at Fruita allow research to be conducted on tissue culture and natural rubber extraction and quantification in various plant species.

Orchard Mesa Site:

3168 B1/2 Road
Grand Junction CO 81503
(970) 434-3264 *Tel*
(970) 434-1035 *fax*

The Orchard Mesa site is located 7 miles southeast of Grand Junction. Site elevation is approximately 4,750 ft. with an average growing season of 182 frost-free days. The research conducted at this site includes tree fruits, wine grape production, dry bean variety increases, and ornamental horticulture. This site has alternative crops (e.g. pistachio nuts and edible honeysuckle), greenhouses, offices and laboratory facilities.

Rogers Mesa Site:

30624 Highway 92
Hotchkiss, CO 81419
(970) 872-3387 *Tel*
(970) 872-3397 *fax*

The Rogers Mesa site is located 17 miles east of Delta and 3 miles west of Hotchkiss at approximately 5,800 ft. above sea level. With an average growing season of 150 frost-free days, research conducted at this site was historically focused on tree fruit cropping at high altitude. The programs have expanded into grape production at high altitude, forage crops, organic, and alternative crop research. Rogers Mesa has an arboretum, laboratory, offices, and greenhouse facility located on site.

Acknowledgments

Dr. Ron Godin was editor; Harold Larsen assisted. The assistance of the Departmental reviewers on campus is much appreciated, and the assistance of the following people, farmer cooperators, and staff is gratefully acknowledged:

Bryan Braddy, Richard Graff, Fred Judson, George Osborn, & John Wilhelm – Research Associates, Colorado State University, Western Colorado Research Center
John (Chip) Brazelton and Lot Robinson – former Research Associates, Colorado State University, Western Colorado Research Center
Bob Brunick – Coors Plant Breeder
Amanda Davis, Jerry Fry, Arielle Koehler, Ann Opitz, and Brittanie Steele – part-time hourly help, Colorado State University, Western Colorado Research Center
Daniel Dawson – Student hourly, Colorado State University, Western Colorado Research Center
Dr. Gennaro Fazio – Pomologist, U.S. Dept. of Agriculture, Geneva, NY
Derek Godsey – Coors Agronomist
Dr. Matthew Rogoyski –Assistant Professor (retired), Colorado State University, Western Colorado Research Center
Mike Williams – Farmer cooperator

Funding Support

Colorado Agricultural Experiment Station (all reports)
Colorado Association of Viticulture and Enology; Colorado Wine Industry Development Board; & Viticulture Consortium West
Colorado Onion Growers Association
Colorado Wheat Administrative Committee
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Department of Horticulture & Landscape Architecture, Colorado State University
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Grand Mesa Discount
Grand Valley Hybrids
MillerCoors Brewing Co.
San Juan Biodiesel
Syngenta
Triumph Seed Co., Inc.
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Western Colorado Horticultural Society
Yulex Corporation
And the following fruitgrowers and orchard companies: Harry Jackson, Neil Guard, Theresa High, D. Clark, Noland Orchards, Talbott Farms, Richard Mowrer, Brant Harrison, Trent Cunningham, Forte Farms, & John Cox.

2008 Personnel Listing

Ms. Susan Baker, Accounting Technician * (Replaced by Donna Iovanni in Aug., 2009 donna.iovanni@colostate.edu)	3168 B ½ Rd., Grand Junction, CO 81503 Ph. 970-434-3264, x-201; Fax 970-434-1035
Mr. Bryan Braddy, Research Associate bryan.braddy@colostate.edu	30624 Hwy. 92, Hotchkiss, CO 81419 - 9549 Ph. 970-872-3387, x-3; Fax 970-872-3397
Dr. Horst Caspari, Viticulturist horst.caspari@colostate.edu	3168 B ½ Rd., Grand Junction, CO 81503 Ph. 970-434-3264, x-204; Fax 970-434-1035
Dr. Ron Godin, Agronomist / Soil Scientist ron.godin@colostate.edu	30624 Hwy. 92, Hotchkiss, CO 81419 - 9549 Ph. 970-872-3387, x-5; Fax 970-872-3397
Mr. Fred Judson, Research Associate / Foundation Bean Manager fred.judson@colostate.edu	1910 L Rd., Fruita, CO 81521 Ph. 970-858-3629, x-4; Fax 970-858-0461
Dr. Harold Larsen, Interim Manager / Pathologist harold.larsen@colostate.edu	3168 B ½ Rd., Grand Junction, CO 81503 Ph. 970-434-3264, x-205; Fax 970-434-1035
Mrs. Amy Montano, Research Associate amontano@lamar.colostate.edu	3168 B ½ Rd., Grand Junction, CO 81503 Ph. 970-434-3264; Fax 970-434-1035
Mr. George Osborne, Support Staff mailto:george.osborn@colostate.edu	30624 Hwy. 92, Hotchkiss, CO 81419 - 9549 Ph. 970-872-3387, x-4; Fax 970-872-3397
Dr. Stephen Menke, Enologist mailto:stephen.menke@colostate.edu	3168 B ½ Rd., Grand Junction, CO 81503 Ph. 970-434-3264, x-202; Fax 970-434-1035
Dr. Calvin Pearson, Research Agronomist calvin.pearson@colostate.edu	1910 L Rd., Fruita, CO 81521 Ph. 970-858-3629, x-2; Fax 970-858-0461
Dr. Ramesh R. Pokharel, Nematologist / Fruit Pathologist rameshp@lamar.colostate.edu	3168 B ½ Rd., Grand Junction, CO 81503 Ph. 970-434-3264 x-203; Fax 970-434-1035
Donna Rath, former Research Associate	1910 L Rd., Fruita, CO 81521
Mr. Richard Graff, Temporary Research Associate	30624 Hwy. 92, Hotchkiss, CO 81419 - 9549 Ph. 970-872-3387; Fax 970-872-3397
Mrs. Kim Schultz, former Research Associate	30624 Hwy. 92, Hotchkiss, CO 81419 - 9549 Ph. 970-872-3387; x-205; Fax 970-872-3397
Mr. John Wilhelm, Research Associate jwilhelm@lamar.colostate.edu	3168 B ½ Rd., Grand Junction, CO 81503 Ph. 970-434-3264, x-207; Fax 970-434-1035
Dr. Rick Zimmerman, Entomologist rick.zimmerman@colostate.edu	30624 Hwy. 92, Hotchkiss, CO 81419 - 9549 Ph. 970-872-3387, x-1; Fax 970-872-3397

* Deceased, May 5, 2009.

Susan Baker at the WCRC front desk

Advisory Committee

The Western Colorado Research Center (WCRC) Advisory Committee has two roles - advocacy and advisory. The advocacy role is to actively promote WCRC research and outreach activities with policy makers, producers, and the general public. Advocacy is the primary mission of the Committee. The advisory role is to provide input and feedback on research and outreach activities conducted through the programs of the Western Colorado Research Center.

The members of the WCRC Advisory Committee for 2008 are listed below. Committee members serve voluntarily without compensation. WCRC Advisory Committee meetings are open to the public. For the current membership list please visit our web page: http://www.colostate.edu/programs/wcrc/.

Acquafresca, Steve
637 27 ½ Road
Grand Junction, CO 81506
email: Steve.Acquafresca@mesacounty.us

Janes, Nancy
130 31 Road
Grand Junction, CO 81503
email: wwhill@whitewaterhill.com

Kelsey, Frank
2835 Acrin Ct.
Grand Junction, CO 81503
email: fkelsey@highcor.com

Kramer, Randy
2400 Mesa Drive
Olathe, CO 81425
email: randy.kramer@co.nacdnet.net

Moreng, Nathan
2764 Compass Dr., Ste. 232
Grand Junction, CO 81506
email: Nathan.Moreng@ColoState.EDU

Nunamaker, Richard
640 Leon Street
Delta, CO 81416
email: grandmesavineyards@earthlink.net

Peters, Maylon
62757 Jeremy Road
Montrose, CO 81401
Email: mjpeters42@msn.com

Talbott, Bruce
497 34 3/4 Rd.
Palisade, CO 81526
email: bruce@talbottfarms.com

Tashiro, Harvey
3386 C ½ Road
Palisade, CO 81421
email: harvey@luckyducksfarm.com

Fall-Planted Malting Barley at Fruita, Colorado 2008

Calvin H. Pearson[1,2]

Summary

Grain yields of malting barley varieties evaluated in a spring–planted trial in 2007 at the Western Colorado Research Center at Fruita were low. These results were similar to the findings of other research conducted in past years in the Grand Valley with spring-planted wheat and barley. Fall-planted malting barley would be expected to yield higher than spring-planted barley. The objective of this 2008 field study was to evaluate four MillerCoors malting barley varieties when fall-planted in the Grand Valley of western Colorado. Planting occurred on October 16, 2007 and barley was harvested during mid-July 2008, depending on the harvest maturity of each variety. Grain yields were excellent to exceptional. Grain yields for Charles, C-83, C-116, and M-37 were 156, 201, 218, and 190 bushels per acre, respectively. Malting barley did not experience any rain damage prior to or at harvest. The grain had a bright, uniform golden color. C-83 had the best grain quality of the four malting barley varieties. The other three varieties had plumpness or test weights that were lower than the standard. All four malting barley varieties had protein concentrations below 13.5%.

Introduction

Grain yields of malting barley varieties were low in a spring–planted trial conducted in 2007 at the Western Colorado Research Center (WCRC) at Fruita (Pearson, 2008). These results were similar to those of other research conducted in past years in the Grand Valley with spring-planted wheat and barley. The objective of the 2007 research was to evaluate three MillerCoors malting barley varieties when spring-planted in the Grand Valley of western Colorado. Grain yields for M-37, C-84, and M-69 were 53, 37, and 27 bushels per acre, respectively.

Fall-planted malting barley would be expected to yield much higher than spring-planted barley. The objective of this 2008 field study was to evaluate four malting barley varieties when fall-planted in the Grand Valley of western Colorado.

Materials and Methods

Four malting barley varieties were evaluated at the Western Colorado Research Center at Fruita during 2008. The trial location was at N 39° 10.835’; W 108° 42.012’; and at an elevation of 4,590 feet. As per MillerCoors protocol, the experiment was arranged in the field in four blocks, each with an area of nearly 0.5 acres. Each barley variety was planted in a single block. The previous crop was dry bean. Planting occurred on October 16, 2007 at 120 lbs seed/acre.

The experiment was furrow-irrigated with gated pipe using irrigation water from the Colorado River delivered through a canal system.

Prior to planting in the fall, a broadcast application of 200 lbs/acre of 18-46-0 was made. A spring top-dress application (42 lbs N/acre) of urea was applied on March 5, 2008.

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[1] Contact information: Colorado State University Agricultural Experiment Station, Western Colorado Research Center-Fruita, 1910 L Road, Fruita, CO 81521. Ph. 970-858-3629; Fax 970-858-0461; email: calvin.pearson@colostate.edu.

[2] Professor/Research Agronomist, Dept of Soil & Crop Sciences, Agricultural Experiment Station, Western Colorado Research Center at Fruita.

An infestation of stink bugs was observed during the growing season and the perimeter of the field was treated with Lannate insecticide, but because of the migratory nature of stink bugs very little control was noted. However, the stink bugs did not appear to cause any economic damage to the malting barley. No other insect infestations in the malting barley plots were observed during the growing season.

Malting barley was harvested using an International 1440 combine and the harvest date was dependent on the harvest maturity of each variety. Grain for each of the four malting barley varieties was loaded into separate 3,000 lb capacity steel bins. The bins were weighed separately and gross weights were subtracted from a tared bin weight to determine grain yields.

Grain moistures and test weights were determined using a DICKEY-John GAC2100B seed analyzer. Grain yields were corrected to 12% moisture.

Fig. 1. Malting barley field at WCRC-Fruita on July 8, 2008. Photo by Calvin Pearson.

Results and Discussion

Weed control for all four barley varieties was excellent throughout the entire growing season (Fig. 1).

Adequate irrigation water was available during the growing season and was not a limiting factor for crop production. Seven irrigations were applied to the malting barley beginning with the germination irrigation on October 18, 2007 and ending with the last irrigation on June 24, 2008 (Table 1).

Winter temperatures in 2007-08 were more severe than winter temperatures in recent years, but no winter injury or winter kill was observed for any of the four malting barley varieties. Overall, spring 2008 was cool during April, May, and on into June, which was favorable for small grain production.

Charles headed first on May 11 and C-116 headed last on May 17 (Table 2). Charles was also the first variety to reach harvest maturity on July 11 and C-116 and M-37 reached harvest maturity 6 to 7 days later. Charles was the tallest variety and C-116 was the shortest (Table 2). The other two varieties were intermediate in plant height. Lodging was greatest for Charles at 5.6 and this created some problems during combine harvesting. Lodging in the other three varieties was low and did not create problems during harvest.

Grain moisture, grain yield, and test weight for the four malting barley varieties are shown in Table 3. Grain moistures of the four malting barley varieties ranged from 8.3% for Charles to 9.9% for C-116. C-116 was the highest yielding variety at an astonishing yield of 218 bushels/acre. Charles was the lowest yielding variety at a respectable yield of 156 bushels/acre. The yield difference between the two varieties was 62 bushels/acre. C-83 and M-37 had grain yields of 201 and 190 bushels/acre, respectively. In a previous trial conducted in western Colorado at Montrose, the high grain yield for this spring-planted malt barley was 141 bushels/acre (Pearson, 1999). Yields of fall-planted malting barley at Fruita exceeded the yields at Montrose by a substantial amount.

Test weight for Charles was lower than the other varieties at 45.5 lbs/bushel, likely an effect from lodging (Table 3). Test weights of the other three varieties was near 50 lbs/bushel or greater.

Malting barley did not experience any rain damage prior to or at harvest. The grain had a bright, uniform golden color (Fig. 2). Good quality malting barley should have test weight of 50 lb/bu or higher, plumpness of 85% or higher, and protein concentration below 13.5%. Thus, by these standards C-83 had the best grain quality of the four malting barley varieties (Table 4). The other three varieties had plumpness or test weights that were lower than the standard. All four malting barley varieties had protein concentrations below 13.5%.

Grain yields of the fall-planted malting barley varieties were excellent to exceptional. Spring 2008 was favorable for barley production and the cool spring temperatures were likely a contributing factor for such high grain yields.

Malting barley variety trials conducted over several years are important to fully assess the performance of barley varieties when grown in various environments and under different production conditions.

Fig. 2. Grain of malting barley harvested at WCRC – Fruita in 2008.

Acknowledgments

We thank MillerCoors, Bob Brunick (Plant Breeder), and Derek Godsey (agronomist) for their support of this research activity. Appreciation is also extended to Fred Judson and Chip Brazelton (Western Colorado Research Center staff), and Brittanie Steele (part-time hourly employee) who assisted with this project.

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Pearson, C.H. 2008. Spring-planted malting barley at Fruita, Colorado 2007. Pp. 63-65. *In*: Western Colorado Research Center 2007 Research Report. Technical Report TR08-10, Colorado State University Agricultural Experiment Station. Fort Collins, Colorado.

Table 1. Irrigations for malting barley grown at Fruita, Colorado during the 2008 growing season.

Irrigation number	Date	Set time (hours)
1	10/18/07	22.0
2	4/19/08	18.0
3	4/30/08	15.5
4	5/12/08	18.5
5	5/27/08	16.0
6	6/12/08	16.0
7	6/24/08	17.5

Table 2. Agronomic performance of four MillerCoors malting barley varieties grown in single large block replicates at Fruita, Colorado during the 2008 growing season.

Variety	Heading date	Harvest maturity date	Harvest date	Plant height (feet)	Lodging (0.2-9.0)[1]
Charles	May 11	July 11	July 11	3.2	5.6
C-83	May 13	July 14	July 14	2.9	1.2
C-116	May 17	July 17	July 17	2.7	1.2
M-37	May 14	July 18	July 21	3.0	0.8

[1]Lodging, 0.2 = no lodging, 9.0 = completely lodged.

Table 3. Agronomic performance of four MillerCoors malting barley varieties grown in single large block replicates at Fruita, Colorado during the 2008 growing season.

Variety	Grain moisture at harvest (%)	Grain yield (lbs per acre)	Grain yield (bu/A)	Test weight (lbs/bu)
Charles	8.3	7,477	156	45.5
C-83	8.7	9,639	201	51.7
C-116	9.9	10,441	218	49.7
M-37	9.1	9,128	190	51.8

Table 4. Grain quality characteristics of four MillerCoors malting barley varieties grown in single large block replicates at Fruita, Colorado during the 2008 growing season.

Variety	Grain moisture when quality analysis performed (%)	Test weight when quality analysis performed (lb/bu)	Protein (%)	Plumpness (%)
Charles	8.8	52.5	10.4	82.7
C-83	8.5	52.2	11.4	89.3
C-116	8.3	46.0	9.3	89.8
M-37	10.0	49.7	11.4	87.4

Seed Yield, Oil Content, and Oil Yield of Sunflower at Fruita, Colorado

Calvin H. Pearson[1, 2]

Summary

The potential of agriculture to produce vegetable oil for use as a feedstock for biodiesel manufacturing facilities in the United States appears promising. An oilseed sunflower cultivar performance test was conducted at the Western Colorado Research Center (WCRC) at Fruita during 2006 and 2007 to evaluate thirty-two sunflower varieties for seed and oil yield and related agronomic characteristics to assess the potential for commercial production of sunflower under irrigation in western Colorado. This report presents the 2007 test results along with a 2-year seed and oil yield summary. Field production (weed control, insect or disease problems, adequate irrigation water) of sunflower was excellent in both years. The 2-year total seed yield averaged across sunflower varieties was 4,538 lb/acre. Two-year seed yield total ranged from a high of 6,936 lb/acre for Producers Choice 7203 to a low of 1,796 lb/acre for Croplan Genetics 3080 DMR. Several sunflower varieties produced good seed yields, had low seed moisture contents at harvest, and had good seed oil contents and thus oil yields. The 2-year seed oil content averaged 44.8%. Oil contents ranged from a high of 48.0% for Mycogen 8N453DM to a low of 41.6% for Croplan Genetics 343 DMR. The 2-year total oil yield averaged for the thirty-two sunflower varieties was 2,035 lb/acre. Two-year total oil yields among the sunflower varieties ranged from a high of 3,106 lb/acre for Producers Hybrids 7203 to a low of 812 lb/acre of Croplan Genetics 3080 DMR. Based on the agronomic data obtained at Fruita during 2006 and 2007 oilseed sunflower production in western Colorado appears promising. Using the agronomic data presented in this report, agricultural economists can prepare a crop production enterprise budget to determine the profitability of producing sunflower in western Colorado.

Introduction

Agriculture is a foundational industry contributing to a green economy with the potential to contribute much more in the future. While the historical contributions of agriculture to a green economy have been in food, feed, and fiber, agriculture can also provide important contributions in industrial resources and products.

The potential of agriculture to produce vegetable oil as a feedstock to operate biodiesel manufacturing facilities in the United States appears promising (Tickell, 2003). Using vegetable oils for a diversity of applications, particularly in the energy industry, will require

[1] Contact information: Colorado State University Agricultural Experiment Station, Western Colorado Research Center-Fruita, 1910 L Road, Fruita, CO 81521. Ph. 970-858-3629; Fax 970-858-0461; email: calvin.pearson@colostate.edu.

[2] Professor/Research Agronomist, Dept of Soil & Crop Sciences, Agricultural Experiment Station, Western Colorado Research Center at Fruita.

large quantities of feedstocks and will likely increase commodity prices in the short and long-term (Eidman, 2005).

The objective of this research was to evaluate thirty-two sunflower varieties during 2006 and 2007 for seed and oil yield and other agronomic characteristics to determine the potential for commercial production of sunflower under irrigation in western Colorado. This report presents the 2007 test results along with a 2-year seed and oil yield summary.

Materials and Methods

An oilseed sunflower cultivar performance test was conducted at the WCRC–Fruita during 2007. The experiment was a randomized, complete block with four replications. Thirty-two oilseed sunflower cultivars were included in the trial. Plot size was 5-feet wide by 50-feet long (4, 30-inch rows). The previous crop was dry bean.

Prowl herbicide was applied just prior to planting at a rate of 2.5 pts/acre at 25 psi in 20 gals water per acre and incorporated twice with a roller harrow (culti-packer) on 15 May 2007. Planting occurred on 16 May 2007 with a White air planter modified for plot research.

Nitrogen fertilizer was side-dressed at 80 lbs N/acre as 32-0-0 in a split application of 40 lbs N/acre on each side of the plant row on 15 June 2007.

The experiment was furrow-irrigated using gated pipe. A germination irrigation was applied on 16 May 2007 in a 24-hour irrigation set. Sunflower was irrigated six times during the 2007 growing season and averaged 18 hours per irrigation.

Sunflower plots were harvested 22 Oct. 2007 using a plot combine. Data were collected for plant population, flowering date, plant height, plant lodging, seed moisture at harvest, test weight, and seed yield. Seed moisture and test weight were obtained using a Dickey-John GAC2100b seed moisture tester. Seed yields are reported on a 10% moisture basis.

Data were subjected to analysis of variance using Analytical Software Statistix 9 program (Analytical Software, 2008) to determine treatment effects. All statistical comparisons were conducted at the 5% level of probability using least significant difference method for mean separation.

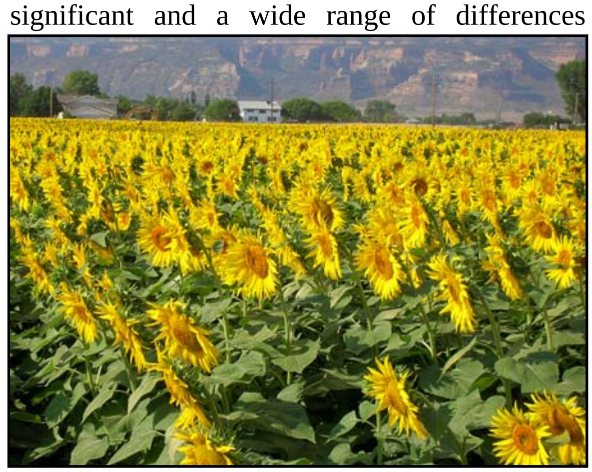
Results and Discussion

The 2007 cropping season in western Colorado was mild. In 2007, there were 15 days during the summer when temperatures reached or exceeded 100°F. The average frost-free growing season for Fruita is 181 days. The 2007 growing season was 182 days.

Field production (weed control, insect or disease problems) of sunflower fields was excellent in both years. Adequate irrigation water was available during the growing season for crop production and water was not a limiting factor for sunflower production.

Seed moisture content of the thirty-two sunflower varieties in 2007 averaged across all entries was 6.2% (Table 1). Seed moisture ranged from a high of 8.0% for ‘Sierra’ to a low of 5.8% for seven of the thirty-two sunflower varieties.

Seed yield for the sunflower varieties in 2007 averaged 2,118 lb/acre (Table 1). There were significant and a wide range of differences



among varieties for seed yield. Seed yields ranged from a high of 3,549 lb/acre for Producers Hybrids 7203 to a low of 998 lb/acre for Croplan Genetics 308 NS. Five of the thirty-two sunflower varieties (Producers Hybrids 7203, Triumph 645, HySun 454, 8H419CL, and 8N453DM) were high yielding.

Seed yield for the sunflower varieties in 2006 averaged 2,420 lb/acre (Table 1). There were significant differences among varieties for seed yield. Seed yields ranged from a high of 3,500 lb/acre for HySun 454 to a low of 701 lb/acre for Croplan Genetics 3080 DMR. Three of the thirty-two sunflower varieties (HySun 454, Producers Hybrids 7203, Garst 454) were high yielding.

The 2-year total seed yield for the sunflower varieties averaged 4,538 lb/acre (Table 1). Seed yields ranged from a high of 6,936 lb/acre for Producers Hybrids 7203 to a low of 1,796 lb/acre for Croplan Genetics 3080 DMR.

The 2-year seed oil content averaged 44.8% (Table 1). Oil contents ranged from a high of 48.0% for Mycogen 8N453DM to a low of 41.6% for Croplan Genetics 343 DMR.

The 2-year total oil yield averaged for the thirty-two sunflower varieties was 2,035 lb/acre (Table 1). Two-year total oil yields among the sunflower varieties ranged from a high of 3,106 lb/acre for Producers Hybrids 7203 to a low of 812 lb/acre of Croplan Genetics 3080 DMR. Seven sunflower varieties had two-year total oil yields that were higher than 2,500 lb/acre.

The standard test weight value for sunflower is 24 lb/bu. The average test weight for the varieties in 2007 was 35.3 lb/bu (Table 2). The three varieties with the highest test weights were Mycogen 8N453DM (37.2 lb/bu), Mycogen 8N462DM (37.2 lbs/bu), and Triumph s678 (36.7 lb/bu). Three varieties had low test weights by comparison and they were Sierra (33.3 lb/bu), DKF 37-31 NS (33.6 lb/bu), and Garst 4668 ns/cl (33.8 lb/bu). Nevertheless, the lowest test weight value for all varieties was still substantially greater than the standard test weight value of 24 lb/bu.

Plant height of sunflower varieties averaged 79.6 inches and the tallest ones were ‘7203’ (90.3 inches) and Sierra (87.6 inches) (Table 2). The shortest variety, as expected, was a dwarf sunflower variety, Triumph s672, with a plant height of 63.0 inches.

Plant population, averaged across all varieties, was 29,903 plants/acre (Table 2). Plant populations ranged from a high of 35,689 plants/acre for Producers Hybrid SF105 NS to a low of 21,831 plants/acre for Croplan Genetics 356. Plant populations among the sunflower varieties differed significantly. Eight varieties had plant populations greater than other varieties exceeding 33,000 plants/acre and four varieties had plant populations lower than other varieties, which were less than 25,500 plants/acre.

The average number of days to flowering was 63.9 days from planting (Table 2). The two sunflower varieties that were the first to flower were Triumph 820 HO (60.0 days) and Producers Hybrids SF105 NS (60.5 days). Five varieties (Triumph s678, Garst 450, Triumph s672, Sierra, and Producers Hybrids 7303) took the most time to reach the flowering stage at 66.2 to 65.8 days. Other sunflower varieties were intermediate in the number of days they needed to reach flowering.

Plant lodging among sunflower varieties varied significantly and there was a wide range in the response of sunflower varieties to lodging (Table 2). The four sunflower varieties with the most lodging were Croplan Genetics 308 NS (34.9%), Sierra (24.6%), Croplan Genetics 3080 DMR (24.2%), and Triumph s672 (21.7%). It was surprising that a dwarf sunflower variety was among the varieties with the highest amount of lodging. The low seed yields of some varieties were clearly affected by the high amount of lodging they experienced. The four varieties with the least amount of lodging were Dyna-Gro 93N05 #2 (2.2%), Mycogen

8H419CL (2.9%), Mycogen 8N453DM (3.2%), and Croplan Genetics 378DMR (4.3%).

In summary, based on 2 years of data, several sunflower varieties established well and exhibited good growth during both growing seasons. Several sunflower varieties produced good seed yields, had low seed moisture contents at harvest, and had good seed oil contents and, thus, good oil yields at Fruita.

Based on the agronomic data obtained at Fruita during 2006 (Pearson, 2007) and 2007 oilseed sunflower production in western Colorado appears promising. Using the agronomic data presented in this report, agricultural economists can prepare a crop production enterprise budget to determine the profitability of producing canola in western Colorado.

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Table 1. Seed moisture, seed yield, oil content, and oil yield of thirty-two sunflower varieties evaluated in the Grand Valley of western Colorado at the Western Colorado Research Center at Fruita during 2006-07.

Cultivar	Source	2007 Seed moisture (%)	2007 Seed yield (lb/acre)	2006 Seed yield (lb/acre)	Two-year total seed yield (lb/acre)	Average two-year oil content (%)	Two-year total oil yield (lb/acre)
7203	Producers Hybrids	5.8	3,549	3,388	6,936	44.8	3,106
HySun 454	HySun	6.9	2,915	3,500	6,415	44.8	2,864
8N453DM	Mycogen	6.0	2,793	3,166	5,960	48.0	2,857
Triumph 645	Triumph	6.0	3,311	2,736	6,047	46.4	2,818
Garst 454	Garst	7.0	2,600	3,377	5,976	44.3	2,641
8H419CL	Mycogen	5.8	2,834	3,024	5,857	44.6	2,610
8N462DM	Mycogen	6.1	2,151	3,269	5,419	46.9	2,540
Croplan Genetics 378 DMR	Croplan Genetics	6.2	2,680	2,898	5,579	44.7	2,491
DKF 37-31 NS	DEKALB	5.9	2,186	3,046	5,233	45.9	2,400
63M80	Pioneer brand	5.8	2,354	2,756	5,110	46.7	2,382
8N520DM	Mycogen	5.8	2,503	2,642	5,146	46.0	2,364
63M91	Pioneer brand	6.1	2,061	2,996	5,058	46.1	2,331
8N386CL	Mycogen	6.0	2,252	3,120	5,372	43.2	2,315
Blazer	Seeds 2000	6.6	2,342	2,374	4,717	46.2	2,180
7303	Producers Hybrids	6.1	2,608	2,298	4,906	44.4	2,178
Croplan Genetics 356	Croplan Genetics	6.5	1,857	2,756	4,613	45.9	2,121
Garst 4668 ns/cl	Garst	6.2	2,396	2,249	4,645	43.0	1,999
Garst 450	Garst	6.0	2,086	2,342	4,428	44.7	1,982
Sierra	Seeds 2000	8.0	1,747	2,632	4,379	42.6	1,876
Croplan Genetics 343 DMR	Croplan Genetics	6.4	2,121	2,362	4,484	41.6	1,866
HySun 450	HySun	6.1	1,924	2,248	4,173	44.5	1,857
DKF 35-10 NS	DEKALB	6.3	2,070	2,126	4,196	42.7	1,792
Croplan Genetics 305 DMR	Croplan Genetics	6.0	2,045	2,010	4,054	42.7	1,733
Garst 521	Garst	6.2	1,873	2,079	3,952	43.5	1,719
Triumph 820 HO	Triumph	5.8	1,840	1,697	3,536	46.3	1,640
Triumph s672	Triumph	5.8	1,305	1,963	3,267	45.2	1,462
SF105 NS	Producers Hybrids	6.3	1,312	1,983	3,295	44.3	1,459
93C05 #4	Dyna-Gro	5.8	1,542	1,645	3,188	44.7	1,423
93N05 #2	Dyna-Gro	6.1	1,349	1,743	3,092	42.5	1,313
Triumph s678	Triumph	6.4	1,090	1,401	2,491	45.4	1,128
Croplan Genetics 308 NS	Croplan Genetics	6.0	998	898	1,897	45.4	861
Croplan Genetics 3080 DMR	Croplan Genetics	6.4	1,096	701	1,796	45.0	812
Ave.		6.2	2,118	2,420	4,538	44.8	2,035
LSD (0.05)[1]		0.5	791	610			

[1] Values within a column must differ by the LSD value to be considered significantly different at the 95% level of probability.

Table 2. Test weight, plant height, plant population, flowering, and lodging of thirty-two sunflower varieties evaluated in the Grand Valley of western Colorado at the Western Colorado Research Center at Fruita during 2007.

Cultivar	Source	Test weight (lb/bu)	Plant height (in)	Plant population (plants/ acre)	Flower (days)[1]	Lodging (%)
7203	Producers Hybrids	35.7	90.3	30,869	64.8	5.8
HySun 454	HySun	35.0	85.3	26,790	64.2	5.7
8N453DM	Mycogen	37.2	83.3	30,591	63.8	3.2
Triumph 645	Triumph	34.6	83.2	35,226	63.5	5.2
Garst 454	Garst	34.7	84.8	26,929	64.5	7.5
8H419CL	Mycogen	35.6	85.2	33,048	65.5	2.9
8N462DM	Mycogen	37.2	85.6	29,664	64.0	20.0
Croplan Genetics 378 DMR	Croplan Genetics	34.8	82.2	28,783	64.2	4.3
DKF 37-31 NS	DEKALB	33.6	76.4	25,261	63.0	12.9
63M80	Pioneer brand	35.6	75.4	30,359	62.8	5.0
8N520DM	Mycogen	35.8	80.6	31,843	65.5	9.6
63M91	Pioneer brand	35.9	78.3	24,751	62.8	3.9
8N386CL	Mycogen	34.2	84.8	30,081	64.2	7.2
Blazer	Seeds 2000	36.1	70.5	26,280	64.2	9.6
7303	Producers Hybrids	35.6	83.7	24,936	65.8	5.8
Croplan Genetics 356	Croplan Genetics	34.6	71.9	21,831	64.2	7.4
Garst 4668 ns/cl	Garst	33.8	84.9	35,041	65.5	18.4
Garst 450	Garst	34.9	76.9	25,725	66.5	17.7
Sierra	Seeds 2000	33.3	87.6	33,048	66.2	24.6
Croplan Genetics 343 DMR	Croplan Genetics	35.3	83.0	27,486	63.2	7.0
HySun 450	HySun	35.5	84.5	31,472	65.2	8.4
DKF 35-10 NS	DEKALB	34.8	83.0	27,995	62.8	10.4
Croplan Genetics 305 DMR	Croplan Genetics	34.9	79.0	31,796	62.5	6.4
Garst 521	Garst	35.1	71.3	34,253	61.0	5.8
Triumph 820 HO	Triumph	36.3	78.1	33,743	60.0	9.8
Triumph s672	Triumph	36.1	63.0	34,021	66.2	21.7
SF105 NS	Producers Hybrids	35.9	72.0	35,689	60.5	12.0
93C05 #4	Dyna-Gro	36.3	84.8	30,081	65.5	6.3
93N05 #2	Dyna-Gro	34.9	72.6	28,830	62.0	2.2
Triumph s678	Triumph	36.7	72.8	31,611	66.5	8.6
Croplan Genetics 308 NS	Croplan Genetics	35.3	76.6	29,247	62.8	34.9
Croplan Genetics 3080 DMR	Croplan Genetics	35.3	77.4	29,618	62.8	24.2
Ave.		35.3	79.6	29,903	63.9	10.4
LSD (0.05)[2]		0.9	4.4	3,685	0.9	13.5

[1]Days from planting. Flowering begins at R-5 (Schneiter and Miller, 1981).

[2] Values within a column must differ by the LSD value to be considered significantly different at the 95% level of probability.

Evaluation of Teff as an Alternative Forage Crop for Western Colorado 2008

Calvin H. Pearson[1,2] and Joe Brummer[3]

Summary

Teff (*Eragrostic tef* Zucc.) is a warm-season annual grass recently promoted as a forage crop in the United States. Teff has the potential to be used in several applications including – as an annual hay, pasture, or silage crop; as an emergency hay, pasture, or silage crop for planting in mid-summer; as a summer annual crop for erosion control; as a green manure crop; or for use in crop rotation as part of a cropping system. The objective of this research was to evaluate the potential of teff as an alternative forage crop in western Colorado and to determine its response to nitrogen fertilization. Forage yields in the first and second cutting averaged 1.8 and 1.2 tons/acre, respectively. Application of 40 lbs N/acre after each cutting resulted in a higher total 2008 yield of 3.4 tons/acre. Forage quality of teff was similar to that of other grasses that have been grown at Fruita. Based on one year's data, producing teff in western Colorado may have potential when grown to meet specific production objectives. Forage yields at Fruita were similar to those obtained in other locations around the country where teff has been grown.

Introduction

Teff (*Eragrostic tef* Zucc.) is a warm-season annual grass recently promoted as a forage crop in the United States. The species is native to Ethiopia where farmers have grown it as far back as recorded history (Mengesha, 1965). Teff has traditionally been grown there for grain. Flour is made from the grain and used to make injera, which is a sourdough, flat bread. Teff is a major food staple for Ethiopia (Stallknecht et al., 1993) and also is used to make porridge and home-made alcoholic beverages (Hunter et al., 2007; Johnson, 2007).

In India, Australia, South America, and other countries in Africa, teff is grown as a forage crop. It produces good quality hay that is fed to dairy cattle, sheep, and horses (Norberg et al., 2008). It has a shallow root system (Stallknecht et al., 1993) and foraging animals can pull up plants by the roots (Johnson, 2007).

Teff is known in foreign languages by various names including, tef, tafi, taf, Ttheff, Tteff, Thaff, Tcheff, Thaft, Tcheff, and in English, as teff, summer lovegrass, lovegrass, annual bunch grass, and warm season annual bunch grass (Stallknecht et al. 1993). This array of common names from several languages can create confusion in printed and oral communications.

Teff has the potential for use in various applications in the U.S. including, as an annual hay, pasture, or silage crop; as an emergency

Teff being furrow irrigated at the Western Colorado Research Center. Photo taken July 3, 2008 by Calvin H. Pearson.

[1] Contact information: Colorado State University Agricultural Experiment Station, Western Colorado Research Center-Fruita, 1910 L Road, Fruita, CO 81521. Ph. 970-858-3629; Fax 970-858-0461; email: calvin.pearson@colostate.edu.

[2] Professor/Research Agronomist, Dept. of Soil & Crop Sciences, Agricultural Experiment Station, Western Colorado Research Center at Fruita

[3.] Associate Professor, Dept. of Soil & Crop Sciences, Fort Collins.

hay, pasture, or silage crop for planting in mid-summer; as a summer annual crop for erosion control; as a green manure crop; or for use in crop rotation as part of a cropping system (Hunter et al., 2007). The agronomy of teff as a forage crop are presented by Norberg et al. (2008). Teff has been shown to be a useful forage crop in several locations in the United States including: New York (Hunter et al., 2007); Oregon (Norberg et al., 2008; Norberg et al., 2006); South Dakota (Twidwell et al., 2002); and Delaware (Johnson, 2007). The objective of our research was to evaluate the potential of teff as an alternative forage crop in western Colorado and to determine its response to nitrogen fertilization.

Teff grown at the Western Colorado Research Center as a forage crop during 2008. Photo by Calvin Pearson, July 30, 2008.

Materials and Methods

Teff is not frost tolerant and must be planted after the threat of frost has past. Teff seed was broadcast on 9 June 2008 using a hand-held fertilizer spreader and then pressed into the soil using a roller packer. The seeds are small, 1.25 million seeds per pound (Stallknecht et al., 1993; Hunter et al., 2007). The recommended planting rate is 4-5 lbs/acre at a planting depth of 1/8 to 1/4-inch (Hunter et al., 2007).

Two nitrogen fertilizer treatments, 1) no nitrogen fertilizer and 2) nitrogen fertilizer, were arranged in a randomized, complete block with 4 replications. Plot size was 10 feet wide x 40 feet long. Nitrogen fertilizer (urea, 46-0-0) at 40 lbs N/acre was applied just prior to irrigation after each cutting using a hand-held fertilizer applicator. Two cuttings were obtained during 2008. The first cutting occurred on 29 July 2008 and the second on 9 Sept. 2008. Plots were furrow irrigated using gated pipe.

Plots were harvested using an automated, forage plot harvester (Pearson, 2007). A biomass subsample from each plot was collected at harvest to determine moisture content. Subsamples were weighed immediately after harvest, oven-dried at 65ºC until a constant weight, and reweighed for dry matter determinations.

Results and Discussion

Germination and emergence were slower than the 3 days reported by other researchers (Roseberg et al., 2005). Under our conditions, plants began to emerge approximately 7 days from planting. Weed invasion during establishment and during the growing season was minimal. Barnyardgrass and pigweed were present during establishment and in the first cutting. Lesser amounts of these two weeds were present in the second cutting.

Adequate irrigation water was available during the growing season and was not a limiting factor for crop production. Ten irrigations were applied to teff during the 2008 growing season. Irrigation began with the germination application and ended with the last irrigation during mid-September. The average irrigation set was 10.6 hours.

Forage yields in the first and second cutting averaged 1.8 and 1.2 tons/acre, respectively (Table 1). By comparison, forage yields of teff in South Dakota State University studies ranged from 1.3 to 5.3 tons/acre (Twidwell et al., 2002). In Oregon, teff typically yields a total of 4 to 6 tons/acre (Norberg et al., 2008).

Although adding 40 lbs N/acre to each cutting did not significantly increase forage production at Fruita on a per cutting basis, it did result in a higher annual forage yield of 3.4 tons/acre during 2008. Hunter et al. (2007) found the optimum fertilizer application rate in New York to be 50 lbs N/acre at planting.

Fertilizing with 40 lb N/acre did not improve forage quality (Table 2). Forage quality analyses included crude protein, neutral detergent fiber, and acid detergent fiber. Forage quality of teff was similar to the quality of other grasses grown at Fruita (Pearson, 2000). Forage quality of teff was affected by cutting, which was also similar to that observed in previous research with other grass species (Pearson, 2000).

We observed that cutting teff too low to the ground adversely affected regrowth. Hunter et al. (2007) also noted this problem and they recommended a 3 to 4-inch cutting height for teff.

Based on one year's data, producing teff in western Colorado may have potential when grown to meet specific production objectives. Forage yields at Fruita were similar to those obtained in other locations around the country where teff has been grown.

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Table 1. Forage yield of teff grown at the Western Colorado Research Center – Fruita during 2008.

Nitrogen rate (lbs N/acre)	Cut 1 July 29 (tons/acre)	Cut 2 September 9 (tons/acre)	Total Yield (tons/acre)
0	1.6	0.9	2.5
40	1.9NS	1.5NS	3.4*

NS, Means within a column are not significantly different at the 10% level of probability.
*, Means within a column are significantly different at the 10% level of probability.

Table 2. Forage quality of teff grown at the Western Colorado Research Center – Fruita during 2008.

Nitrogen rate (lbs N/acre)	Crude Protein (%)		NDF (%)[1]		ADF (%)[2]	
	Cut 1	Cut 2	Cut 1	Cut 2	Cut 1	Cut 2
0	11.6	9.5	70.6	68.1	33.7	31.8
40	10.6	8.5	71.2	68.4	34.5	32.9

[1]NDF = neutral detergent fiber.
[2]ADF= acid detergent fiber.

Teff harvested at the Western Colorado Research Center as a forage crop during 2008. Photo by Calvin Pearson, Sept 9, 2008.

Winter Canola Variety Performance Trials at Fruita, Colorado 2005-2008

Calvin H. Pearson[1,2] and Jerry Johnson[3]

Summary

Canola is a desirable source of vegetable oil because of its high seed oil content. Recently, canola has received considerable attention for its potential use as a biofuel. During a four-year testing period from 2005-2008, winter canola variety performance trials were conducted each year in which canola varieties were evaluated for grain yield and other agronomic characteristics at Fruita, Colorado. Average seed yield during each of the four years of testing was 2,324 lb/acre in 2005, 1,790 lb/acre in 2006, 2,339 lb/acre in 2007, and 2,760 lb/acre in 2008. The highest seed yield obtained for a variety during the four-year testing period was Sitro at 3,724 lb/acre in 2008. The variety with the highest yield in 2005 was Baldur at 3027 lb/acre. The variety with the highest yield in 2006 was DSV 05101 at 2,556 lb/acre and the variety with the highest yield in 2007 was SLM0402 at 3,621 lb/acre. Average oil concentration during each of the four years of testing was 35.3% in 2005, 39.5% in 2006, 39.7% in 2007, and 43.9% in 2008. Based on the agronomic data from these trials, production of canola in western Colorado appears promising. Furthermore, using the agronomic data presented in this report, agricultural economists can prepare a crop production enterprise budget to determine the profitability of producing canola in western Colorado.

Introduction

Biodiesel has attracted interest in recent years because of the increasing cost of petroleum diesel. Biodiesel has similar properties, can improve air quality, and is safer to handle than petroleum diesel. Several oilseed crops, including canola, are suited for biodiesel production. Canola is a desirable source of vegetable oil because of its high seed oil content.

Over four years (2005, 2006, 2007, 2008) yield trials were conducted at the Western Colorado Research Center (WCRC) at Fruita to evaluate canola entries (cultivars and breeding lines) for oil content, seed yield, and related agronomic characteristics and to assess the potential for commercial production of canola in western Colorado (Pearson, 2006a,b; Pearson, 2007; Pearson, 2008). The canola trials at Fruita are part of the National Winter Canola Variety Trial that include numerous testing locations in the U.S. and in which specific information about variety performance are evaluated. The National

Fig. 1. Canola during flowering at the Western Colorado Research Center at Fruita. May 16, 2008. Photo by Calvin H. Pearson.

[1] Contact information: Colorado State University Agricultural Experiment Station, Western Colorado Research Center-Fruita, 1910 L Road, Fruita, CO 81521. Ph. 970-858-3629; Fax 970-858-0461; email: calvin.pearson@colostate.edu.

[2] Professor/Research Agronomist, Dept. of Soil & Crop Sciences, Agricultural Experiment Station, Western Colorado Research Center at Fruita;

[3.] Associate Professor/Extension Crop Specialist, Dept. of Soil & Crop Sciences, Fort Collins.

Winter Canola Variety Trial is coordinated through Kansas State University by Dr. Mike Stamm and is funded by several sources including USDA-Cooperative States Research, Education, and Extension Program. This report summarizes the results of canola variety performance trials conducted at WCRC–Fruita during this four-year testing period.

Fig. 2. Canola variety performance plots being harvested at the Western Colorado Research Center at Fruita during the 2008 growing season.

Materials and Methods

Four winter canola variety performance trials were conducted during 2005-2008 at the WCRC–Fruita (Fig. 1). Experiments each year were randomized, completed blocks with three replications. A broadcast application of Eptam (0.6 oz/acre plus 8 oz/acre of 2,4-D amine plus 1 qt of Activator 90 in 100 gallons of water, 23 gal water/acre at 30 psi) was applied preplant incorporation each year for weed control. An application of 200 lb/acre of 11-52-0 was also applied preplant incorporated each year. In the spring of each year a top-dress application of nitrogen was applied. Dates and application amounts are shown in Table 1.

The trials were furrow-irrigated using gated pipe or siphon tubes. Canola plots were harvested each year using a plot combine (Fig. 2). Grain moistures and test weights were determined using a Dickey-John GAC 1200B seed analyzer. Oil concentration was determined by the University of Idaho Brassica Research Program in Moscow, ID.

Results and Discussion

The number of entries evaluated, planting and harvest dates, previous crop, and the number of irrigations for each year are shown in Table 1. Plants established well and survived the winter in good condition in all four years (Table 1).

Weed control was very good during the growing season in all four years. Adequate irrigation water was available during each growing season of the four-year testing period and was not a limiting factor for crop production.

Average bloom dates for each of the four years of testing ranged from 109 days to 119 days (Table 1). Plant height data were collected in 2005 and 2006 and averaged 64 and 49 inches, respectively. Plant lodging did not occur in 2008 and was less than 10% in 2005 and 2006, but was high at 70% in 2007. These data show that plant lodging can vary considerably depending on the year.

The standard test weight value for canola is 50 lb/bu; however, test weights for the twenty-eight canola entries in 2005 averaged only 36.1 lb/bu. Test weights in 2006, 2007, and 2008 were much higher and approached nearly 50 lb/bu. A severe infestation of false chinch bugs occurred during the 2005 growing season and could have negatively impacted test weights in that year.

During the four-year testing period from 2005-2008 seed moisture contents ranged from a low of 5.5% in 2008 to a high of 11.2% in 2007.

Average seed yield during the four years of testing was the highest in 2008 at 2,760 lb/acre and lowest in 2006 at 1,790 lb/acre (Table 1). The highest seed yield obtained for a variety during the four year testing period was Sitro at 3,724 lb/acre in 2008 (data not shown). The variety with the highest yield in 2005 was Baldur at 3,027 lb/acre. The variety with the highest yield in 2006 was DSV 05101 at 2,556 lb/acre and the variety with the highest yield in 2007 was SLM0402 at 3,621 lb/acre. In a spring-planted trial conducted in the region under irrigation in the Utah Valley near Provo, Utah in 2006, the highest canola seed yield obtained was 2,088 lb/acre for H1750 (Muñoz-Valenzuela and Easton, 2007).

During the four-year testing period, average annual seed oil concentration ranged from 35.3% in 2005 to 43.9% in 2008 (Table 1). Average seed oil concentration was similar in 2006 and 2007 at approximately 39.6%. The highest oil concentration obtained for a variety during the four-year testing period was Dimension at 46.8% in 2008 (data not shown). The variety with the highest oil concentration in 2005 was ARC92007-2 at 37.7%. Two varieties had the highest oil concentrations in 2006. They were KS7436 and TCI Exp 983 at 41.6%.

Based on the agronomic data from this four-year testing period, production of canola in western Colorado appears promising. Furthermore, using the agronomic data presented in this report, agricultural economists can prepare a crop production enterprise budget to determine the profitability of producing canola in western Colorado.

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Table 1. Agronomic performance of canola grown at WCRC – Fruita, 2005-2008.

Year	No. of entries	Planting date	Harvest date	Previous crop	Top-dress fertilizer	No. of irrigations	Fall stand[1]
2005	28	8 Sept 2004	26 July 2005	soybean	3/28/05 – 74 lbs N/acre of NH_3NO_4	4	9.4
2006	36	7 Sept 2005	24 July 2006	sweet corn	4/4/06 – 75 lbs N/acre of urea	7	9.8
2007	57	12 Sept 2006	30 July 2007	fallow	3/26/07 – 75 lbs N/acre of urea	7	9.4
2008	55	31 Aug 2007	21 July 2008	alfalfa	3/5/08 – 42 lbs N/acre of urea	6	9.4

Table 1 (continued). Agronomic performance of canola grown at WCRC – Fruita, 2005-2008.

Year	Winter survival (%)[2]	Bloom date (days)[3]	Plant Height (inches)[4]	Plant Lodging (%)[5]	Seed shatter (%)[6]	Test weight (lb/bu)	Seed moisture (%)[7]	Seed Yield (lb/acre)	Oil conc. (%)
2005	99.9	109	64	8.3	2	36.1	6.3	2,324	35.3
2006	100	115	49	1.1	4	48.6	5.6	1,790	39.5
2007	NA[8]	109	NA	70	15	49.5	11.2	2,339	39.7
2008	NA	119	NA	0	1	49.7	5.5	2,760	43.9

[1] Visual rating based on a 0 to 10 scale with 10 = excellent and 0 = no stand.
[2] Visual estimate of the percent of established plants that survived the winter.
[3] Date at which 50% of canola plants have one or more open flowers. Reported as days from Jan. 1.
[4] Average plant height from the soil surface to the top of plants.
[5] Plant lodging, a visual estimate of the percent of plants that have lodged.
[6] Visual estimate just prior to harvest of the percent of seed lost due to shattering.
[7] Seed moisture content.
[8] Not available

Winter Wheat Variety Performance Trial at Fruita, Colorado 2008

Calvin H. Pearson[1,2], Scott Haley[3], and Jerry Johnson[4]

Summary

During 2007 an irrigated winter wheat variety trial was conducted in which 18 varieties were evaluated for grain yield and other agronomic characteristics. The trial was repeated during the 2008 growing season and several of the same varieties were tested. The two-year results are of value to farmers, crop consultants, seed industry representatives, and others in helping them select winter wheat varieties for western Colorado. Grain yields of the winter wheat varieties in the 2008 trial averaged 7,574 lb/acre (126.2 bu/acre). Grain yields ranged from a high of 8,811 lb/acre (146.9 bu/acre) for Tubbs 06 to a low of 5,565 lb/acre (92.8 bu/acre) for Hawken. Grain yields of the winter wheat varieties in 2007 averaged 7,361 lb/acre (122.7 bu/acre) and ranged from 8,526 lb/acre (142.1 bu/acre) for Bond CL to 5,833 lb/acre (97.2 bu/acre) for Hayden. Grain moisture in 2008 averaged 9.2% and test weights averaged 61.1 lb/bu. Protein concentrations in 2008 averaged 8.1% and ranged from a high of 9.0% for Keota to a low of 7.3% for Brundage. Some of the new varieties such as Tubbs 06 (143.4 bu/acre, soft white winter wheat), Bill Brown (135.2 bu/acre, hard red winter wheat), and Bond CL (134.5 bu/acre, hard red winter wheat) had grain yields (2-year average) that were comparable to or greater than those of varieties that have been traditionally grown in the Grand Valley.

Introduction

The production acreage of irrigated winter wheat in western Colorado has varied over the years. After years of limited production, producers in the area have again become interested in growing winter wheat. It has been several years since we have conducted a winter wheat variety performance trial in the Grand Valley (Pearson et al., 2000). Eighteen winter wheat varieties were evaluated for grain yield and other agronomic characteristics in 2007 (Pearson et al., 2008).

Various factors influence producer crop choices. Recently, wheat prices have encouraged growers to again plant winter wheat. Other factors that may encourage producers to plant wheat are: 1) winter wheat often fits crop rotations in western Colorado, 2) growing winter wheat may spread growing season workloads, and 3) growing winter wheat may free up irrigation water to be used later in the growing season for other crops.

Production technology is continually changing which creates a need to evaluate recently released winter wheat varieties and compare them to varieties that were popular in past years.

Variety yield performance data can be used by various people - farmers when selecting varieties to plant on their farms, seed growers in knowing which varieties to produce and nuances about growing the varieties, companies to determine which varieties to market and in which locations they are best adapted and are best in end-use applications, and university personnel in

[1] Contact information: Colorado State University Agricultural Experiment Station, Western Colorado Research Center-Fruita, 1910 L Road, Fruita, CO 81521. Ph. 970-858-3629; Fax 970-858-0461; email: calvin.pearson@colostate.edu.

[2] Professor/Research Agronomist, Dept. of Soil & Crop Sciences, Agricultural Experiment Station, Western Colorado Research Center at Fruita;

[3] Professor/Wheat Breeder, Dept. of Soil & Crop Sciences, Fort Collins; Associate

[4] Professor/Extension Crop Specialist, Dept. of Soil & Crop Sciences, Fort Collins, respectively.

developing new wheat production technology and in educating people about the varieties that are currently available.

During 2008 we repeated the trial conducted in 2007 in which several of the same 18 winter wheat varieties were evaluated again to compare recently released varieties with those traditionally grown in Western Colorado.

Winter wheat plots at the Western Colorado Research Center at Fruita at maturity 25 July 2008. Photo by Calvin Pearson.

Materials and Methods

Eighteen winter wheat varieties were evaluated at the Western Colorado Research Center at Fruita during 2008. The trial location was at N 38° 10.826’, W 108° 42.046’; and at an elevation of 4,583 feet. The experiment was a randomized, complete block with four replications. The previous crop was pinto bean.

An application of 200 lb/acre of 18-46-0 was applied preplant incorporated in fall 2007. Planting occurred on Oct. 16, 2007 at 120 lbs seed/acre. Urea at 42 lbs N/acre was applied topdress on 5 Mar. 2008. A tank mixture of Harmony Extra at 0.6 oz/acre plus 8 oz/acre of 2,4-D amine plus 1 qt of Activator 90 in 100 gallons of water was applied by ground in 23 gal water/acre at 30 psi on 17 Apr. 2008.

The experiment was furrow-irrigated using gated pipe. Winter wheat plots were harvested on 25 July 2008 using a plot combine. Grain moistures and test weights were determined using a Dickey-John GAC 1200B seed analyzer. Protein concentration was determined by whole grain near infrared reflectance spectroscopy (NIRS) with a Foss NIRSystems 6500 (reported on a 12% moisture basis).

Results and Discussion

Weed control was excellent during the growing season. Water was not a limiting factor for crop production. Seven irrigations were applied to the winter wheat beginning with the germination irrigation in fall 2007 and the last irrigation occurred during late-June 2008 (Table 1).

Grain moisture in the winter wheat variety performance trial at Fruita averaged 9.2% and ranged from a high of 9.8% for Darwin to a low of 8.8% for UT9743-42 (Table 2).

Grain yields of the winter wheat varieties averaged 7,574 lb/acre (126.2 bu/acre) and ranged from a high of 8,811 lb/acre (146.9 bu/acre) for Tubbs 06 to a low of 5,565 lb/acre (92.8 bu/acre) for Hawken (Table 2). Grain yields of the winter wheat varieties at Fruita in 2007 averaged 7,361 lb/acre (122.7 bu/acre) (Pearson et al., 2008) and ranged from a high of 8,526 lb/acre (142.1 bu/acre) for Bond CL to a low of 5,833 lb/acre (97.2 bu/acre) for Hayden. Many winter wheat varieties were high yielding in both years. Statistically in 2008, there were four groups in which the means were significantly different from one another with the highest yielding group containing 15 varieties.

Stephens, a soft white winter wheat, has been grown traditionally in the area for many years. Tubbs 06 is also a soft white winter wheat from Oregon and is considered to be a replacement variety for Stephens. Tubbs 06 yielded 18.8 bu/acre more than Stephens in 2007 and yielded 19.3 bu/acre more than Stephens in 2008.

Test weights averaged 61.1 lb/bu and ranged from a high of 64.4 lb/bu for Danby to a low of 58.1 lb/bu for Simon (Table 2). Danby had the highest test weight among the varieties evaluated in both 2007 and 2008.

Days to heading averaged 142 days. Bond CL, Hawken, and Aspen headed at approximately 136 days while Gary, Simon, Bitteroot, and

Tubbs 06 required 146-147 days to begin heading (Table 3).

Plant height averaged 33.6 inches and ranged from a high of 40.4 inches for Darwin to a low of 28.4 inches for UT9743-42 (Table 3).

A small degree of lodging occurred (Table 3). Tubbs 06 had the highest degree of lodging at 2.1 and Bond CL, Darwin, Simon, and ORN-553 did not lodge. Lodging did not adversely affect combine harvesting and thus did not affect grain yields.

Protein concentration averaged 8.1% and ranged from a high of 9.0% for Keota to a low of 7.3% for Brundage (Table 3).

Some of the new varieties such as Tubbs 06 (143.4 bu/acre, soft white winter wheat), Bill Brown (135.2 bu/acre, hard red winter wheat), and Bond CL (134.5 bu/acre, hard red winter wheat) had 2-year average grain yields comparable to or greater than those of traditionally grown varieties in the Grand Valley. Clearly, these new high yielding varieties merit consideration for planting by growers in the Grand Valley and other western Colorado locations.

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Table 1. Irrigations for winter wheat grown at Fruita, Colorado during the 2008 growing season.

Irrigation number	Date	Set time (hours)
1	10/18/07	18
2	4/19/08	18
3	4/30/08	16
4	5/12/08	18
5	5/27/08	16
6	6/12/08	16
7	6/24/08	18

Table 2. Market class, grain moisture, grain yield, and test weight of winter wheat varieties evaluated at Fruita, Colorado during 2008.

Variety	Market class[1]	Grain moisture (%)	2008 Grain yield[2]		2007 Grain yield	2-year average grain yield	Test weight (lb/bu)
			(lb/acre)	-------------(bu/acre)-----------------			
Tubbs 06	SWW	9.1	8,811	146.9	139.9	143.4	59.4
UT9743-42	HRW	8.8	8,501	141.7			61.4
Fairview	HRW	9.1	8,021	133.7	121.9	127.8	60.8
Bitteroot	SWW	9.2	7,996	133.3			60.2
Bill Brown	HRW	8.9	7,968	132.8	137.6	135.2	62.1
Hatcher	HRW	9.5	7,930	132.2	121.5	126.9	61.9
Danby	HWW	9.4	7,903	131.7	123.8	127.8	64.4
Gary	HWW	9.7	7,829	130.5	128.2	129.4	61.1
Stephens	SWW	8.9	7,654	127.6	121.1	124.4	58.4
Bond CL	HRW	9.3	7,604	126.8	142.1	134.5	60.8
Brundage	SWW	9.7	7,572	126.2	120.0	123.1	60.6
NuDakota	HWW	9.0	7,527	125.4			62.4
Keota	HRW	9.0	7,526	125.4			61.5
Simon	SWW	9.0	7,513	125.2	126.7	126.0	58.1
Darwin	HWW	9.8	7,338	122.3	119.5	120.9	63.3
Aspen	HWW	9.1	6,944	115.9			62.4
ORN-553	HRW	9.0	6,124	102.0			59.7
Hawken	HRW	9.1	5,565	92.8			62.1
Ave		9.2	7,574	126.2			61.1
LSD (0.05)		0.4	1,278	21.3			0.9
CV(%)		3.0	14.3	14.3			1.5

[1]HRW = hard red winter wheat; HWW = hard white winter wheat; SWW = soft white winter wheat, CL = Clearfield* wheat.

[2] Table is arranged by decreasing grain yield and are corrected to 12% moisture.

Table 3. Agronomic characteristics of winter wheat varieties evaluated at Fruita, Colorado during 2008[1].

Variety[2]	Market class	No. Days to heading[3]	Harvest maturity (days)	Plant height (in.)	Lodging (0.2 - 9.0)[4]	Protein (%)
Tubbs 06	SWW	146	193	35.8	2.1	7.7
UT9743-	HRW	144	193	28.4	0.6	7.6
Fairview	HRW	144	190	37.6	1.2	8.5
Bitteroot	HWW	147	194	37.2	1.3	8.4
Bill Brown	SWW	140	189	32.9	0.5	7.9
Hatcher	HRW	141	192	35.0	0.6	8.4
Danby	HWW	142	187	28.7	0.4	7.9
Gary	SWW	147	191	39.3	1.2	8.1
Stephens	HWW	142	188	32.8	1.6	8.0
Bond CL	SWW	136	188	34.0	0.2	7.7
Brundage	SWW	142	188	32.4	0.8	7.3
NuDakota	SWW	138	188	31.4	1.6	8.2
Keota	HRW	140	188	37.1	0.4	9.0
Simon	HRW	147	194	33.0	0.2	7.6
Darwin	HRW	145	188	40.4	0.2	8.1
Aspen	HWW	137	186	30.6	1.9	8.4
ORN-553	HRW	144	194	30.1	0.2	8.1
Hawken	HWW	135	186	29.3	0.4	8.4
Ave		142	190	33.6	0.8	8.1
LSD		0.5		6.4		
CV (%)		1	1	13.0		

[1] HRW = hard red winter wheat; HWW = hard white winter wheat; SWW = soft white winter wheat, CL = Clearfield* wheat.
[2] Table is arranged by variety order as per Table 1.
[3] Determined from 1 January.
[4] lodging scale, 0.2 = no lodging, 9.0 = completely lodged.

Plant Parasitic Nematodes, Soil and Root Health of Colorado Onion Fields

Ramesh R. Pokharel[1], Harold Larsen[2], Bob Hammon[3], Thaddeus Gourd[4], Michael Bartolo[5]

Summary

Different genera and high populations of plant parasitic nematodes (PPNs) associated with onion crops reduce potential yield. Often such a limitation is compounded by more than one cause or the simultaneous presence of multiple PPNs. At the same time, number of PPNs genera and numbers of free living nematodes can help to predict the balance of microorganisms present in the soil that can relate to soil health and sustainability of the system. We surveyed six counties in Colorado by collecting 70 samples of soil and plants representing 12 different fields (one presumed healthy and one problematic in each county). Nematodes were extracted, identified and counted. The result indicated the association of 11 different plant parasitic nematode genera with onion. Out of these, root-lesion (*Pratylenchus penetrans*), aerial feeding nematodes (*Aphelenchoides)* and stem (*Ditylenchus dipsaci)* nematodes had the highest frequencies and densities, especially in problematic fields. The only exception was in Montrose County where both field categories had a high number of root-lesion nematodes. In addition, other genera such as *Aphelenchus, Helicotylenchus, Hemicriconemoides, Hemicycliophora*, *Hoplolaimus, Meloidogyne, Longidorus, Trichodorus*, and *Xiphinema* were observed with low frequencies and densities. Most fields had less than 50% of free-living nematode populations, a potential indication of poor soil health in these fields. Some root samples had pink root and brown root infections. Fields with higher nematode densities and frequencies need management planning to improve potential onion yield.

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[1] Contact information: Research Associate, Colorado State University Agricultural Experiment Station, Western Colorado Research Center, 3168 B ½ Rd., Grand Junction, CO 81503; Ph: 970-434-3264, x-203; email: ramesh.pokharel@colostate.edu.

[2] Professor/Interim Manager, Western Colorado Research Center – Orchard Mesa, 3168 B ½ Road, Grand Junction, CO 81503.

[3] Area Extension Agent (Entomology/Agronomy), Tri River Area Extension, P.O. Box 20,000-5028, Grand Junction, CO 81502-5028.

[4] Extension Agent - Agriculture. Brighton, CO 80601-8114.

[5] Research Scientist (Vegetable Crops), Arkansas Valley Research Center, 27901 Road 21, Rocky Ford, CO 81067.

Introduction

Colorado has the fifth highest storage onion production in the U.S. Onion production is highest in the northern part of the state (50%), followed by the Arkansas Valley and the Western Slope (25% each) (Anonymous, 2004). Soil-borne problems (including plant parasitic nematodes) are one of the major constraints limiting potential onion yield. The difficulty of making appropriate management decisions on nematode control is compounded by the fact that nematodes are only one of many possible causes of root disease problems and sub-optimal crop yields. Nematode damage to the onion often aggravates the poor growth of the plants due to fungal pathogens (e.g. *Pythium*, *Phytophthora*, *Fusarium*, *Rhizoctonia,* and *Sclerotinia*), bacterial pathogens (e.g. *Dickeya* , *Pectobac-terium*, etc) and root feeding arthropods (e.g. white grubs, symphylids), nutritional imbalances (deficiencies, excesses or unavailability), soil conditions (compacted, poorly aerated soils, salinity, moisture stress, poor drainage, water logging) and pesticide damage. Moreover, PPNs predispose plants to other soil-borne plant pathogens by creating a venue for entry and vector plant viruses. The first step in managing soil-borne problems, especially the plant pathogens, is to manage PPNs.

Nematodes may be either foliar or root feeders, and both endoparasitic and ecto-parasitic nematodes are important constraints for onion production. The most common nematodes on onion in Colorado, Idaho, eastern Oregon, Utah, and Washington are the stem and bulb nematode, lesion nematode, northern root-knot nematode, and stubby-root nematode (Anonymous, 2004). However, nematodes such as root-lesion (*Pratylenchus* spp.) may be a constraint in onion production anywhere. Most PPNs, especially root-lesion nematode (a migratory endoparasite), are concerns to onion growers because they reduce yield indirectly by reducing plant vigor and increasing stress on the plants, thereby leaving the plants more susceptible to other biotic (pathogens) and abiotic (environmental and management) problems. This nematode causes brown lesions around the root cortex; such lesions coalesce, turn black, and are often invaded by other soil microorganisms, which can cause weakening of root systems, reduction in water and nutrient uptake, loss of plant vigor, and reduction in yield. Northern root-knot nematode (*Meloido-gyne hapla*) feeds on roots, producing root-galls and causing stunting, chlorosis (yellowing), wilting, and premature death of plants. Below ground symptoms include small galls on the roots with infected plants tending to have fewer secondary roots. Damage from the northern root-knot nematode may be most severe following alfalfa hay crops and during years with warm spring temperatures. The number of root-galls and egg masses on the roots vary with the nematode population densities in the soil, host susceptibility, and environmental factors (Anonymous, 2004).

Similarly, stem and bulb nematode (*Ditylenchus dispsaci*), an endoparasitic nematode, feeds on root, stem, and leaf tissues of the onion plant. High populations can cause damping-off of seedlings, deform foliage, and change leaf color from pale green to yellow; it also can cause bulbs to become soft, swollen, and misshapen, causing "bloat" (stem swelling) Yellow spots, swellings, or open lesions may appear on the leaves of stunted plants. Stems and necks are often softened and there is a high incidence of doubles, cracked bulbs, and culls. Stubby-root nematodes (*Paratrichodorus* and *Trichodorus* spp) are migratory ectoparasites that remain in the soil and feed on the roots, externally causing the roots to be short and yellow-brown in color and stunting plant growth. The root tips become darker, stubby, and more branched by the continued feeding by the nematodes; this results in a reduction in bulb size. They have the ability to adapt to unfavorable conditions by migrating downward in the soil (Johnson and Roberts, 2008b).

Niles and McIntyre (1997) reported eight genera of plant parasitic nematodes associated with onion in Colorado based on 15 samples studied with *Aphelenchus*, *Aphelenchoides*, and *Pratylenchus* found to be the predominant species. Based on distribution and cropping pattern, *Ditylenchus* is believed to be a major nematode in Colorado onion producing regions. Very limited information on nematode problems in Colorado onion is available. Similarly, numbers of free-living nematodes can indicate the soil health condition of the fields. These nematodes can help to estimate the abundance of fungi, bacteria, and other microorganisms present in soil that are essential for good crop yield. Thus, the surveys were carried out to understand the PPN and free-living nematodes associated with different onion fields in Colorado.

Materials and Methods

Surveys: Two fields were sampled in each of Adams, Morgan, Weld, Otero, Delta, and Montrose Counties of Colorado at onion bulb formation to maturation stage during the 2008 growing season. Two fields were selected in each county, one field representing normal looking or random fields and the other field with known/observed symptomatic plants growing poorly, showing stunted growth, or yellowish in patches or galls on roots or abnormal root growth. Five soil samples of about 7.06 oz (200 cc) from each site along with two onion plants were collected and shipped to the WCRC-

Orchard Mesa via overnight FedEx to minimize nematode loss. These samples were kept moist in a cool room at 34 ^{o}F (1 ^{o}C). Special care was given not to expose the plastic bag to direct sun, especially closed bags. The samples were processed as soon as possible. Each soil sample was collected at a depth of up to 12 inches (30 cm). Special care was taken to represent all soil layers while collecting soil samples. The plants included had intact roots, but most of the secondary (feeding) roots were left behind during digging.

Extraction of nematodes from soil: Field soil samples were mixed well in the laboratory, clods broken-up and a 100 cc (3.6 fl. oz., approx. 120-140 g) representative soil sample taken. Milk filter papers were placed on top of an approx. 18 cm (7”) diameter stainless steel wire screen and covered with two layers of facial quality tissue papers. The 100 cc soil sub-samples were then spread uniformly over the tissue paper, and the screen, filters, tissue paper, and soil sample were placed in an approx. 18 cm (7”) diameter pie pan; sufficient water was added to ensure the submergence of the soils. Each was then covered on top by another aluminum foil pie pan to minimize evaporation. After 72 hours, the tissue paper, milk filter, and soil were discarded. The remaining nematode suspension from the pie pan (clear water with nematodes) was collected in a beaker and put in a cold room until the nematodes were counted later. The nematode suspension was reduced to 250 cc (8.5 fl oz), a 20 cc (0.68 fl oz) aliquot sample taken, and the nematode genera identified and counted under an inverted compound microscope scope with 10x ocular and 4x, 10x, and 20x objectives. An average was calculated for the five samples per field and presented. The two plants collected from each plot were washed free of soils and observed for any types of symptoms (galling, discoloration and abnormal growth pattern).

Results and Discussion

Plant parasitic nematode densities and frequencies: Root-lesion nematode *(Pratylenchus penetrans)*, a migratory endoparasite, was among the most predominant PPNs out of 11 different nematode genera observed during surveys of onion fields in Colorado in 2008. All stages of this nematode were recorded in soils during surveys. That might be due to recurrent growth and reproduction of the nematode in the field. The life cycle can be completed in as little as 20 days depending on an ideal soil temperature (20-30 °C [68-86 ºF]), moisture tension (moderate is optimum), and host. Brown root-lesions on some onion roots (possibly caused by root-lesion nematodes) were observed in some fields. All stages of the root-lesion nematode feed in the root cortical tissue of the onion plant, stunt plants and prevent development of fine roots. Small necrotic lesions are often present on root epidermal tissue. They are small and light colored initially, but turn darker with time. The amount of damage or degree of virulence is usually, but not always, related to the extent of discoloration or necrosis. The necrosis is the result of direct feeding as well as the interaction between plant glycosides and hydrolytic enzymes from the nematode, which release phenolic substances.

The root lesion nematode densities ranged from 12 to 352 per 100 cc of soil and the nematode densities in six fields out of 12 fields surveyed had >1 nematode per cc of soil. The nematode density was the highest in Montrose followed by Weld County. One *P. penetrans* nematode per gram of soil is sufficient to cause moderate damage to onion and most vegetables (Potter and Olthof, 1993). At 7-13 ^{o}C (44.6 to 55.4 ^{o}F), < 100 nematodes per g of roots caused significant root weight reduction, but >400 nematodes were required to produce injury at 16-21 ^{o}C (60-70 ^{o}F; Ferris, 1970). Losses in marketable yields ranged from 14% at 67 nematodes per 100 g soil to 71% at 1,800 nematodes per 100 g soil (Olthof and Potter, 1973]. However, economic thresholds may vary with crop, variety, environment, and soil types. Moreover, economic threshold alone may not be enough to indicate the economic importance of the nematode as the nematodes in a field are not uniformly distributed. The six fields with nematode densities higher than the economic threshold level had 100% frequencies. Nematode densities and frequencies can relate directly to the economic importance of the nematode. Densities higher than economic threshold level and frequencies higher than 80%

in all five samples in each field were considered important to the particular field. According to published reports, root-lesion nematode observed on onions and garlic in other states suppressed the growth and yield of these crops. However, the impact of this nematode, especially in those fields with densities higher than the economic threshold level, is not known for Colorado onion fields. Moreover, the role of heavy soils on the yield impact, especially economic threshold level, is not clear since the nematodes pose a higher risk in sandy soils as compared to heavy soils. Samples collected in corn fields indicated medium level populations of this nematode with all stages in western Colorado (Table 2). Colorado onion growers, especially in western Colorado, follow an onion-corn crop rotation. Corn is a good host for root-lesion nematode and all active nematode stages were observed in corn. The role of other PPNs (*Aphelenchoides, Ditylenchus, Heterodera, Hoplolaimus, Meloidogyne* and *Pratylenchus)* observed in cornfields (Table 2), is not known in onion rotated with corn. The present crop rotation seems to provide favorable conditions for the growth and multiplication of the root-lesion nematode. However, this nematode has a very wide host range and crop rotation is frequently of little value unless combined with other nematode management tactics (Johnson and Roberts, 2008b).

Ditylenchus dipsaci, stem feeding nematode, was another common nematode observed with densities and frequencies higher than other genera, but lower than root-lesion nematodes. However, the plant samples did not show any of the aerial symptoms described for infection by *D. dipsaci*. According to published reports, the nematodes can invade young plants at any point whereas they usually enter mature plants through the basal plate. Symptoms of the stem and bulb nematode include erratic stands, stunting, looping and bending of leaves below the soil surface, swelling, and extensive longitudinal splitting of cotyledons and leaves. Leaves appear short, thickened, often with brown to yellow spots, and bloat. Infected seedlings twist, enlarge, deform, and can die. Leaves eventually collapse, and the bulbs soften with rots from the neck down. Scales become light gray and soft. Often such bulbs usually become infected with secondary pathogens. The stem and bulb nematodes usually penetrate the germinating seed before the cotyledons emerge. One field each in Delta and Montrose counties had densities of the nematode higher than the economic threshold level whereas all the fields surveyed except one in Otero County had 100% frequencies. Absence of such symptoms in the present study could be due to variability in virulence level of the nematode populations or the plants not being in an appropriate stage to express the symptoms. *D. dipsaci* completes its life cycle on onion seedlings in 19-23 days at seedlings in 19-23 days at 15 °C (59 ºF). Nematodes become active during heavy rains, move up the plant in a film of water, and can enter the plant through stomata. Population densities of stem and bulb nematode in soil can fluctuate depending on soil type and host plants, but an infected plant can harbor as many as 50,000 nematodes. Damage can occur at infestation levels as low as 10 nematodes per 500 g (17.6 oz) of soil (Johnson and Roberts, 2008a). Low soil moisture and soil temperature near or below freezing are optimum for nematode survival. A soil temperature of 21°C (70 ºF) favors penetration of onion seedlings, movement, reproduction, and symptom severity by stem and bulb nematode (Johnson and Roberts, 2008a). However, a lot of free-living *Ditylenchus* nematodes are observed in soils, thus, understanding their role in onion production is needed.

Root-knot nematode (*Meloidogyne*), a common sedentary endoparasitic nematode in many onion growing areas of the USA, was not common in Colorado in 2008. This nematode was present only in 33% of the soil samples and the densities also were low. However, 70% of the samples in Montrose County had this nematode present. The low number could be due to presence of the nematode inside the roots or to the soil types being unfavorable to this nematode. No root-galls, caused by the nematode infestation, were observed; possibly due to the fact that the feeder roots with the nematodes and galls were left behind in the field. Nonetheless, a greenhouse bioassay has been initiated to observe the infection and root symptoms assessment in onion due to these nematodes. In addition, *Paratylenchus*, *Trichodorus, Hemicriconemoides, Hemicycliophora, Aphelenchoides*, *Aphelenchus*, *Hoplolaimus*, *Longidorus*, and *Xiphinema* were observed in low densities and frequencies (Table 3).

Soil and root heath: Soil health, a complex dynamic issue characterized by soil physical, chemical, and biological indicators, can be estimated by the ratio of free-living nematodes and PPNs. A higher ratio of free living nematodes to PPN suggests the soil health is better. If the soil has more than 50% free living nematodes, then the soil is considered sufficiently healthy to promote reasonable crop yield. During our surveys, none of the fields had such numbers (most of the soils had less than 30% free living population) as compared to total nematodes observed in the field (Fig. 1). Thus, the present study observed a lack of beneficial soil microorganisms in Colorado onion fields surveyed; these soil microbes are essential for soil health and crop production. Moreover, the root-health often is correlated with soil health. Thus, efforts to encourage these beneficial free-living nematodes and improve soil health will benefit onion production in these fields.

Root symptoms: Various types of root symptoms were observed on onion roots due to soilborne pathogens including PPNs. During the surveys, roots symptoms such as discoloration and stunting (possibly caused by fungal soil-borne pathogens) were commonly observed. Out of these, pink root disease caused by *Phoma terrestris* was the most common and prevalent in many onion fields. This disease was high in incidence in Montrose Country where higher densities and frequencies of *Pratylenchus* are observed irrespective of difference in field symptoms used for selecting the fields. Pink root symptoms were less frequent in Delta followed by Weld as compared to Montrose. In addition, brown lesions in root tips were observed in many samples from different locations. Undersized onion bulbs were associated with poor root growth; these nematodes may start feeding early in root development and thereby severely affect root development and subsequent onion development.

Further studies on nematode damage and management are needed, especially in those fields suspected to have potential economically significant nematode problems. Since soil health seems to be an issue in these fields with soil fungal pathogen problems that could have been aggravated by the nematode damage, further research to improve soil and root health is warranted.

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Table 1. Densities and frequencies of major plant parasitic nematode genera in 12 onion fields of Colorado, 2008.

Nematode	*Pratylenchus*		*Ditylenchus*		*Aphelenchoides*	
County	Density [a]	Frequency [b]	Density [a]	Frequency [b]	Density [a]	Frequency [b]
Weld	32	60	112	100	107	60
Weld	**344**	100	276	100	35	60
Adams	**244**	100	276	100	60	60
Adams	48	80	176	100	70	60
Delta	28	80	112	100	60	20
Delta	**144**	80	**528**	100	620	0
Morgan	68	100	208	100	0	0
Morgan	12	40	116	100	40	0
Montrose	**108**	100	**648**	100	230	0
Montrose	**352**	100	120	100	67	0
Otero	**240**	100	160	100	140	40
Otero	40	40	192	20	145	60

[a] number of nematodes per 100 cc soils (average of five samples per field).
[b] percentage of samples with the nematode in each field.
Numbers in bold are higher than economic threshold level.

Table 2. Plant parasitic nematode genera, their frequencies and densities in corn fields, which are often rotated with onion.

Nematode Genera	Grain corn		Vegetable corn	
	Density[a]	Frequency[b]	Density[a]	Frequency[b]
Aphelenchoides	46.7	60	20.0	60
Ditylenchus	126.7	80	80.0	80
Heterodera	60.0	60	213.3	100
Hoplolaimus	0.0	0	6.7	20
Meloidogyne	26.7	20	6.7	20
Pratylenchus	80.0	20	106.7	60
Paratylenchus	13.3	20	53.3	60
Free	60.0	80	126.7	100

[a] number of nematodes per 100 cc soils (average of five samples per field).
[b] percentage of samples with the nematode in each field.

Table 3. Densities of minor plant parasitic nematode genera in 12 onion fields of Colorado, 2008.

	Nematode genera[a]								
County	1	2	3	4	5	6	7	8	9
Weld	40	0	0	0	0	0	0	0	0
Weld	80	47	30	20	0	0	0	0	0
Adams	96	0	30	0	0	0	0	0	0
Adams	40	10	0	0	0	0	0	0	0
Delta	0	0	0	0	80	0	0	0	0
Delta	0	20	20	0	57	0	20	0	0
Morgan	0	0	20	0	0	20	0	0	0
Morgan	0	0	0	0	0	0	0	0	0
Montrose	30	0	10	0	0	0	0	0	0
Montrose	20	40	20	0	0	0	0	0	0
Otero	0	0	40	0	0	0	0	20	20
Otero	0	0	47	0	0	0	0	0	0

[a] 1 = *Aphelenchus*, 2= *Helicotylenchus*, 3= *Meloidogyne*, 4= *Trichodorus*, 5= *Longidorus*, 6= *Hemicriconemoides*, 7= *Hemicycliophora*, 8= *Hoplolaimus* and 9 = *Xiphinema*.

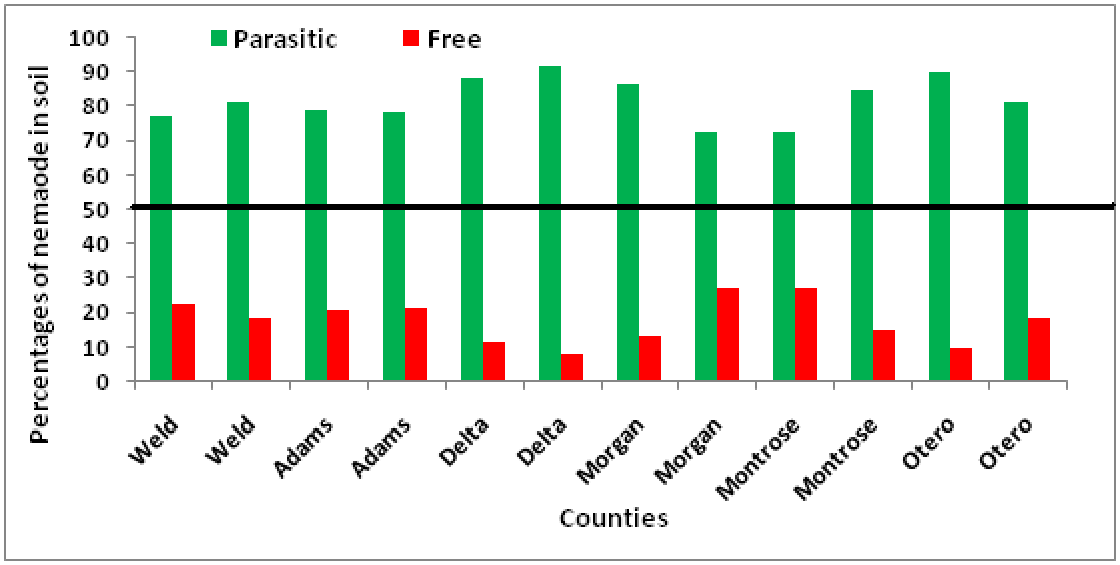

Fig. 1. Comparative percentages of plant parasitic and free-living nematodes in onion fields of Colorado, 2008.

Plant Parasitic Nematodes and Plant Health of Western Colorado Home and Golf Lawns

Ramesh R. Pokharel[1]

Summary

Plant parasitic nematodes (PPNs) are important for both home lawns and golf greens. Soil samples were collected from one home lawn and one golf green lawn with severely symptomatic plants and suspected PPN infection. Nematodes were extracted from lawn soil samples to determine the association of PPNs with the symptoms. *Aphelechoides*, *Ditylenchus*, *Pratylenchus*, *Heterodera*, *Meloidogyne*, *Hemicriconemoides*, *Paratylenchus* and *Trichodorus* were observed from the home grown lawn. High density and frequency of *Ditylenchus* was observed with the density of *Ditylenchus* being higher where the plants were dead or severely necrotic as compared to healthier looking plants. Seven genera of PPNs, *Aphelenchoides*, *Belonolaimus*, *Ditylenchus*, *Helicotylenchus*, *Hoplolaimus*, *Pratylenchus* and *Trichodorus*, were observed in the golf green soil associated with two types of plant symptoms (chlorotic and necrotic patches). In this golf green, higher frequency and density of *Pratylenchus* were observed from the patches of chlorotic plants than normal looking patches. Similarly, higher density and frequency of *Hoplolaimus* and *Belonolaimus* were observed in the soils having severely necrotic or dying plants as compared to less necrotic nearby patches. These survey results indicated the potential of severe nematode problems in lawns (home grown or golf greens) in Colorado and need for further investigations of plant parasitic nematodes, especially in such problematic lawns (home grown or golf greens). Proper diagnosis of such problems in golf courses and homes and their timely management might help to reduce pesticide use in future.

Introduction

Colorado has 302 golf courses including eight in the city of Grand Junction (Anonymous, 2009). Golf contributes to the quality of life of many residents and visitors to the state and city. Some of the criteria that are used to designate a "good" course are speed and evenness of the playing surface, including green and healthy-appearing grass on the greens, tees, and fairway. Golf managers struggle to maintain the above qualities because several factors are involved in turf health. These include pests and diseases, including plant-parasitic nematodes (PPNs). Of all the pests that commonly affect golf greens in Colorado, nematodes are probably the least understood and most difficult to manage. In a general survey of golf greens, Niles and McIntyre (1997) reported 15 genera of PPNs from ten samples collected in different areas. More recently, the nematode problems have increased and become more severe in the golf greens. Most of the time the nematode infestation remains unnoticed or neglected until a severe problem arises. Also, nematode damage is often confused with other causes such as soil nutritional deficiencies. In Colorado, limited information is available on PPNs in home lawns.

Different types of plant parasitic nematodes feed on turf. *Aphelenchoides* and *Ditylenchus* feed on aerial plant parts, whereas most other PPNs feed on roots and cause damage to the root system. Nematode feeding reduces the ability of the grass to obtain water and nutrients from the soil. In addition, they predispose plants to infection by soilborne pathogens. Thus, the nematode infected plants can suffer from multiple problems, e.g. nematodes, fungi,

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[1] Contact information: Research Associate, Colorado State University Agricultural Experiment Station, Western Colorado Research Center, 3168 B ½ Rd., Grand Junction, CO 81503; Ph: 970-434-3264, x-203; email: ramesh.pokharel@colostate.edu.

bacteria or nutrition. In addition, plants infected with PPNs are prone to stress and are less able to compete with weeds, ultimately increasing water and nutrient input demand.

Aerial plant symptoms due to nematode feeding are not distinct unless severe damage occurs. Such aerial symptoms are often confused with other problems due to soilborne diseases or plant nutrition. However, such infected plants may produce distinct root symptoms ranging from root-knot, forked roots, stubby roots to root lesions that indicate the nematode infection and damage. Often the roots appear "cropped off" an inch or so below the soil surface in a cup-cutter sample. Root galls or knots associated with such nematode damage to other crops may not be evident on many grasses. When nematode population densities get high enough or there are environmental stresses, aboveground symptoms may become evident. Such symptoms include yellowing, wilting, browning, or thinning out. Often, as the grass thins out weeds (particularly leafy spurge), may become prominent. Grass will die under extreme nematode infection and environmental stress. Nematode damage usually occurs in irregularly shaped patches that may enlarge slowly over time. Similar conditions may be caused by other factors such as localized soil conditions, fungal diseases, or insects.

For nematode activity, soil fertility and crop management have a major role in combination with temperature, crop species grown, and soil texture (Mashela *et al*., 1991). Most of the PPNs that damage turf grasses favor sandy soil. Tolerance to nematode damage decreases as sand content increases, a function of low water holding capacity and a high rate of nutrient leaching. Many putting greens are constructed of >90% sand content, an ideal habitat for most plant-parasitic nematodes. Other areas of most golf courses (fairways, tees, roughs) are usually constructed of native soil, so soil texture is much more variable. Therefore, nematode problems are most common on putting greens but can occur in other areas where conditions are favorable.

Knowledge of nematode genera and their feeding habit is important for efficient management. Usually, systemic nematicides work much better on endoparasites than do contact nematicides. Also, the potential for disinfesting planting material by washing, or by use of hot water or chemical treatments, is greater for ectoparasitic than endoparasitic species. Several genera and species of these nematodes are reported in lawn greens in different parts of the world. However, such information for Colorado is limited. Recently, an association of PPNs with problematic greens has been reported in local areas.

Materials and Methods

Surveys: A home lawn and golf green lawns suspected / reported to have nematode problems were sampled in the city of Grand Junction to understand the association of PPN in such symptomatic plants. In the home lawn, two sites, one with many dead plants and the other with healthier plants, were selected. Five soil samples in each site were collected in a random manner with a 12 inch soil probe and placed in labeled Ziploc® plastic bags. These samples were brought to the WCRC laboratory and processed as described later. A golf course in the city of Grand Junction was reported to have problematic plants and was suspected to be infested with plant parasitic nematodes. In the field two distinct types of symptoms were observed: 1) yellowing plants in patches (site one) and 2) patches of dead and/or necrotic plants with very poor root systems (a second site on the same golf course). Five soil samples in each location were collected as in the home lawn. These soil samples were collected and placed in well-labeled Ziploc® plastic bags, brought to the WCRC laboratory and processed separately.

Extraction of nematodes from soil: Field soil samples were mixed well in the laboratory, clods broken-up and a 100 cc representative sample taken. Milk filter papers were placed on top of stainless steel wire screen (6.5 inches diameter) and covered with two layers of facial quality tissue papers. The 100 cc soil sub-samples were spread uniformly over the tissue paper; the screen, filters, tissue paper and soil sample assembly was then placed in a pie pan (7 inches diam.) and sufficient water was added to ensure the submergence of soils. Each was then covered on top by another aluminum foil pie pan to minimize evaporation. After 72 hours, the tissue, milk filter and soil were discarded. The remaining nematode suspension from the pie pan (clear water with nematodes) was collected in a beaker and stored in a 34 ^{o}F cold room until the nematodes were counted. The nematode suspension was reduced to 250 cc, a 20 cc aliquot sample taken, and the nematode genera identified and counted under an inverted compound microscope with 10x ocular and 4x, 10x, and 20x objectives. An average was calculated for the five samples per orchard and recorded. Frequencies (defined as percentage of samples with the nematode) were calculated in order to understand the distribution patterns of these nematode genera.

Results and Discussion

Nematodes in home lawn: Eight genera of plant parasitic nematodes were observed in the soils of home grown lawns (Table 1). Foliage feeding nematodes (*Aphelenchoides*) and stem feeding nematodes (*Ditylenchus*) were commonly observed in home lawns. Endo-parasitic root feeding nematodes such as root-lesion (*Pratylenchus*), cyst (*Heterodera*), and root-knot (*Meloidogyne*) and ectoparasitic nematodes such as *Hemicriconemoides*, *Paratylenchus* and *Trichodorus* were less common in both the sites (Table 1).

Fig. 1. Patches with dead plants and higher numbers of PPNs in a home lawn (home, site 1), Grand Junction, CO (Photo by R. Pokharel).

Interestingly, higher densities and frequencies of *Ditylenchus*, associated with severe dieback of plants in site 1of the home lawn (Fig. 1) were observed than for other plant parasitic nematode genera (Table 1). These results indicate that this nematode might have a direct or indirect role in such a malady. Similarly, higher densities and frequencies of *Ditylenchus* nematodes were also observed in site 2, where *Meloidogyne*, *Pratylenchus*, and *Heterodera* were also observed with higher frequencies but low in densities. However, patches of plants in site 2 had lower numbers of dead plants (Fig. 2). Lower densities of the nematodes in soil in these locations might be due to the fact that PPNs might be still feeding in plant roots, so lower numbers might have appeared in the soils.

Since no other obvious reasons (other than water stress) were associated with the death of these plants, it is possible that these plants were stressed by water first and then severely infected and damaged by the nematodes or vice versa. However, further detailed study is needed to make any definitive conclusion regarding the host/pathogen interaction between the lawn fescue and the stem nematode.

Nematodes in Golf greens: Golf lawns differ from home lawns where different plant species are grown and maintained with different

Fig. 2. Patches with healthier plants and low numbers of PPNs in a home lawn (home, site 2), Grand Junction, CO (Photo by R. Pokharel).

management approaches. However, both are considered for recreation. Only seven genera of PPNs (*Aphelenchoides*, *Belonolaimus*, *Ditylenchus*, *Helicotylenchus*, *Hoplolaimus*, *Pratylenchus* and *Trichodorus*) were observed in golf green soil during the survey of problematic areas. These problematic areas had different types of aerial plant symptoms with similar genera of PPNs, but with different nematode densities. All nematode genera, except *Trichodorus*, were observed in both the sites. Densities and frequencies of *Pratylenchus*, *Helicotylenchus* and *Ditylenchus* in site 1 and *Belonolaimus*, *Ditylenchus*, *Hoplolaimus* and *Pratylenchus* in site 2 were surprisingly high. Only seven genera of PPNs were found in this survey, almost half of the genera observed by Niles and McIntyre (1997), who found very low densities of 15 PPN genera associated with golf greens. The fewer genera and higher numbers of PPNs observed in the present study as compared to Niles and McIntyre (1997) could be due to difference in coverage of the samplings. The samples in the present study were collected from a single site with problematic plants, but Niles and McIntyre (1997) collected samples randomly from different sites.

In the present study, differences in densities and frequencies among different plant parasitic nematode genera were observed in both the sites (Table 2). Soil samples were collected from two different locations associated with different types of aerial plant symptoms. The patches of yellow plants yielded higher density and frequency of *Pratylenchus* whereas the patches of necrotic or dead plants had higher density and frequencies of *Hoplolaimus* and *Belonolaimus*. Surprisingly, more numbers of these nematode genera with 100% frequencies were observed with the aerial symptomatic plants. However, the combined effect of different nematode genera feeding in or on roots of golf greens to produce such symptoms can't be ignored. Looking at the symptoms in site 2, association of the secondary pathogens or cause could easily be guessed. This might have caused rapid death of those plants, PPNs being a primary cause.

In site 1, where patches of yellow plants were observed (Fig. 3), high frequencies and densities of *Pratylenchus* were observed, followed by *Ditylenchus* and *Helicotylenchus* (Table 2). Site

Fig. 3. Golf green with yellow plant patches where a higher number of root lesion nematodes (*Pratylenchus*) were observed as compared to a healthy looking patch in Grand Junction, CO (Photo by R. Pokharel).

2, where patches of dead plants were observed, had higher densities and frequencies of *Hoplolaimus* followed by *Ditylenchus*, *Pratylenchus* and *Belonolaimus* (Table 2). This result indicated that infection by *Pratylenchus* in golf green grass produced chlorotic plants in irregular patches that might be confused with nutritional deficiency. Despite this, death of plants in wider patches might be due to damage by *Hoplolaimus* and/or *Belonolaimus*. However, the densities of *Helicotylenchus* in site 1, and *Belonolaimus* and *Hoplolaimus* in site 2 were higher than economic threshold levels. Economic thresholds for golf greens are 300 *Helicotylenchus*, > 60 *Hoplolaimus* and more than 10 *Belonolaimus* per 100 cc soil (Sikora et al., 1999).

Several species of lance nematodes (*Hoplolaimus* spp.) feed on roots as an ecto-parasite and predispose plants to other infections; they are the most common nematode problem on putting greens nation-wide in the USA. In other areas, lance nematodes were usually associated with discolored or rotting roots, a lack of feeder root, and areas with declining turf grass (Settle et al., 2002). Sting nematode (*Belonolaimus longicaudatus*), a large ectoparasite feeding primarily on root tips and stopping root growth, is considered the most damaging plant-parasitic nematode on turf grasses. Severe infestations can cause complete destruction of the turf root system, leading to wilting, thinning, and death of the turf (Rhoades, 1987). This is the first report of *Belonolaimus* in turf grass in Colorado. Sting nematode is sensitive to soil texture and is limited to soils with >80% sand content (Robbins and Barker, 1974). Golf course greens are built on sandy soil.

This is a preliminary study and indicates a possible role of PPNs in severe damage observed in golf green turf. Estimating the potential nematodes in golf greens and treating greens where needed might prevent such damage and save resources and the environment since low PPN densities are easier to manage. Despite the fact that nematodes may be primary or secondary pathogens along with other causes, they ought not be ignored. Thus further investigation on the role of these nematodes in such malady is warranted.

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Table 1. Density and frequency of plant parasitic and free living nematodes observed in home lawn soils in Grand Junction, CO during 2008.

	Home lawn, site 1		Home lawn, site 2	
Nematode genera	Density[1]	Frequency	Density[1]	Frequency
Aphelenchoides	20	20	20	40
Ditylenchus	9,800	100	400	100
Heterodera	40	40	0	0
Hemicrconemoides	0	0	20	20
Meloidogyne	200	60	0	0
Pratylenchus	170	60	40	60
Paratylenchus	0	0	20	20
Trichodorus	0	0	30	40
Free living	200	100	540	100

[1]Per 100 cc of soil.

Table 2. Plant parasitic and free living nematode genera in golf green grass in Grand Junction, CO during 2008.

	Golf green, site 1		Golf green, site 2	
Nematode genera	Density[1]	Frequency	Density[1]	Frequency
Aphelenchoides	20	20	40	40
Belonolaimus	20	30	98	80
Ditylenchus	400	100	1,140	100
Hoplolaimus	20	20	1,740	100
Helicotylenchus	540	80	40	60
Pratylenchus	680	100	300	80
Trichodorus	0	0	20	40
Free living	200	100	80	60

[1]Per 100 cc of soil.

Effects of Different Ground Management Techniques on Bacteria, Fungal and Protozoan Populations in an Organic Apple Orchard

Rick Zimmerman[1]

Summary

In this study, seven ground cover management options were evaluated for their effect on bacterial, fungal and protozoan populations. The treatments were mowing, flaming, landscape fabric, shredded paper, shredded bark, mowing of alleyway and throwing clippings into the tree row (Mow and Throw) and a control (Farmers Favorite - weeds were allowed to grow). After two years, this study found no significant differences in bacteria, fungal or protozoan populations between treatments or within the same treatment over time. Differences may have not been seen due to the fact that the orchard had been under organic management for several years prior to this study. Also, the treatments may have to be applied for several years beyond this two year study in order to cause significant changes in populations of soil organisms.

Introduction

Ground cover management in organic fruit orchards has an important impact on weed control, nutrient flow and soil moisture levels (Edwards, 1998). Nielsen et al. (2003) observed that some organic mulch can increase growth and yield of apple trees grown in high density systems. There are two distinct areas within the orchard that can have two different management strategies: the alleyway and the tree row. The alleyway is located between the tree row. Typically the plant cover in the alleyway is a mix of grass species, alfalfa, clovers and dandelions. Alleyway management includes periodic mowing and irrigation. The tree row includes a strip that is 6-8 foot in width in which the trees are planted directly down the center. Ground cover decisions in the tree row strip can impact tree growth, soil fertility and ultimately fruit production. Ground cover management in the tree rows can be either some type of mulch (landscape cloth, compost, paper mulch or bark) or no ground cover. Ground cover can be removed either through the use of mechanical cultivation, heat source or herbicides.

Nutrient flow in organic agricultural production systems is highly dependent on the soil microbial and faunal community (Brady and Weil, 1996). In perennial organic agricultural systems, an effective soil food web and subsequent "adequate" nutrient flow to the trees or vines is in part dependent on the management of the orchard floor. Ground cover management can have a significant effect on populations of soil biota (Paoletti et. al., 1991; Lundquist et al., 1999).

In this study bacterial, fungal and protozoan populations were measured. Fungi and bacteria belong to a category called the microflora while the protozoans belong to a major group called the microfauna (Swift et al., 1979). Bacteria and fungi play significant roles in the breakdown of organic compounds, formation of humus, stabilization of soil structure and the cycling of nutrients (Brady and Weil, 1996). The protozoans can be categorized into the four major types: flagellates, naked amoebae, testate amoebae and ciliates (Coleman and Crossley,

[1] Contact information: Research Scientist, Colorado State University Agricultural Experiment Station, Western Colorado Research Center-Rogers Mesa, 30624 Hwy 92, Hotchkiss, CO 81419; Ph: 970-872-3387, x-1; Fax 970-8723387; email: rick.zimmerman@colostate.edu.

1996). Protozoans are significant predators of bacteria (Clarholm, 1985).

The purpose of this experiment was to investigate the impact of in-row weed management techniques on soil populations of bacteria, fungi and protozoans within an established organic apple orchard.

Materials and Methods

The research for this project was conducted in a commercial, certified organic block of nine-year old Gala on EMLA 26 rootstocks at Silver Spruce Orchards, Hotchkiss, Colorado. Tree spacing was 6 feet in-row and 13 feet between rows. The in-row tree strip was 6 feet wide. The experimental design was a randomized block with seven treatments. The treatments were mowing, flaming, landscape fabric, shredded paper, shredded bark, mowing of alleyway and throwing clippings into the tree row (Mow and Throw) and a control (Farmers Favorite - weeds were allowed to grow). Flaming was applied using a Red Dragon Flamer. Mowing and flaming was conducted every two weeks. The mow and throw was applied approximately once a month when the alley way was mowed. The shredded paper mulch and the shredded bark mulch were applied in the spring to a depth of approximately 8 inches. The landscape fabric was put into place in the spring. In the fall, the fabric was pulled back from the tree row to facilitate the application of fertilizer and also to prevent mouse damage to the tree trunks during the winter months. There were eight replications per treatment. Each plot consisted of five trees.

The vegetation in the alley way consisted of a mix of grasses, alfalfa, red clover and dandelions. Weed management in the tree rows included mechanical cultivation and flaming via a propane weeder. Irrigation was applied via a micro-sprinkler irrigation system. Water was applied every 5-10 days as needed. Each year 160 lbs of N was applied to the experimental plots in the form of blood meal (13-2-1; year 1) and Nature Safe Fertilizer (12-2-0, Griffin Industries, Coldwater, KY; year 2). All mulches were pulled back prior to fertilizer application.

Soil Biota Sampling: Soil cores (5 in X 2 in) were taken monthly from April (2003 only) through September. Soil cores were taken between trees 2 and 4 in each plot. Each core sample was placed into a labeled zip lock bag and transported to the laboratory in a portable cooler. The soil samples were placed in a walk in cooler at 47 ^{o}F until processed. Soil samples were processed within 48 hours.

Bacteria numbers were estimated using a standard plate count method. 1 g of soil was placed in 9 ml of sterile distilled H_2O, creating a 10^{-2} dilution: this was repeated until a 10^{-6} dilution was obtained. From the 10^{-4}, 10^{-5}, and 10^{-6} dilutions, 0.5 ml of the solution was placed on labeled Petri dishes with standard plate count agar. The solution was allowed to soak into the agar for approximately two hours, at which time the plates were inverted and placed in an incubator at 25 ^{o}C for three days. Using a colony counter, the number of colonies on each plate were counted and recorded. The number of colony forming units was calculated using the following equation: dilution number + $\log_{10}$(average number of colonies) + $\log_{10}$(moisture correction factor).

Total fungal hyphal length was estimated according to techniques described by Lodge and Ingham (1991). Ten grams of soil was placed in 90 ml of phosphate buffer solution (pH 7.6) and blended for one minute, creating a 10^{-1} dilution. One milliliter of the 10^{-1} dilution was placed in 99 ml of phosphate buffer solution, creating a 10^{-2} dilution. Two 50 µl aliquots of the 10^{-2} dilution were placed on six microscope slides and covered with 22 mm^2 cover slips. Using a light microscope at 20x magnification with a lined ocular, each slide was examined along four transect lines. Each hyphal fragment that crossed the line was recorded. The number of hyphal intersects was converted to meters of hyphae per gram of dry soil using the following equation: (R/0.00025)x(moisture correction factor); where R=piNA/2H, N=number Hyphae crossing transect line, A=area of cover slip and H=total length of transects scanned.

Protozoa were isolated and enumerated using a dilution technique modified from Ingham (1994). Ten grams of soil was added to 90 ml of sterile soil extract. One ml of the 10^{-1} dilution was obtained. The resulting dilutions (10^{-1} through 10^{-6}) were laced (0.5 ml) into a sterile 24 well plate. After plating, each of the twentyfour wells received live *Alcaligenes faecalis*. *A. faecalis* is a bacterium food source for protozoa. The plates were wrapped in damp paper towels, placed in plastic ziplock bags and the allowed to incubate for seven days at 25 ^{o}C. Using an inverted microscope, each well was examined along a minimum of five transect lines. The presence of flagellates, ciliates and amoebae was noted and their numbers were determined using the most probable number (MPN) technique (Darbyshire et al., 1974). Data was analyzed by analysis of variance comparing means of treatments with SNK comparison test.

Results

Bacteria: There were no significant differences in bacterial numbers between treatments on the same sampling period for 2002 and 2003 (Tables 1 & 2). There were also no significant differences when comparing bacterial numbers for the same treatment over time. Considerable variability was observed in the data.

Fungi: In 2002 and 2003 there were no significant differences in the meters of hyphae between treatments on the same date or for the same treatment over time (Tables 3 & 4). Similar to the bacteria data, there was considerable variability between samples.

Protozoans: Protozoans numbers were categorized into three major groups: flagellate, ciliate and amoeba. There were no significant differences in the numbers of flagellates, ciliates and amoebae over time for the same treatment during 2002 or 2003 (Tables 5 – 10). There were also no significant differences between treatments for the all three protozoan groups between treatments for the same sample date. There was also considerable variability within the data sets.

The distribution and abundance of soil microorganisms are so patchy that it is very difficult to determine their mean abundances with accuracy without dealing with a very high variance about the mean (Coleman and Crossley, 1996; Parkin, 1993). This uneven distribution of microbes is due to the patchy distribution of pockets of organic matter throughout the soil profile. These pockets include the area around plant roots, fecal matter, etc.

Discussion

The intent of this study was to determine if different types of organic mulches would differentially affect populations of soil organisms such as bacteria, protozoans and fungi. Soil organisms play an important role in creating a sustainable farming system in which growers can minimize outside inputs, maximize yields and ultimately maintain economic sustainability.

The results of this experiment suggest that established organic systems are resilient to short term change despite the addition of different types of organic matter to the soil. The yearly additions of Nature Safe Fertilizer (composted chicken manure) and other organic mulches to this system more than likely stabilized soil fauna populations. Thus the addition of these different mulches had no significant impact on the bacteria, protozoan or fungal populations. However, Godin et al. (2006) did note there were increases in percent organic matter from the additional two years of mulching.

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Table 1. Total bacteria colony forming units (CFU) per gram of soil sampled monthly in 2002 from seven different weed control treatments in an organic apple orchard near Hotchkiss, Colorado in 2002.

	May	June	July	August	September
Mow	**2.65 ± 2.43[ab]**	**2.14 ± 2.61**	**4.28 ± 3.59**	**2.00 ± 2.24**	**1.43 ± 1.13**
Flamer	**4.02 ± 3.97**	**3.57 ± 2.88**	**1.43 ± 0.53**	**4.86 ± 3.53**	**1.87 ± 1.86**
Landscape Fabric	**4.19 ± 2.84**	**4.57 ± 3.21**	**3.71 ± 2.29**	**3.71 ± 1.79**	**1.43 ± 0.79**
Paper	**3.91 ± 2.69**	**3.26 ± 2.06**	**4.86 ± 2.54**	**2.71 ± 2.98**	**1.29 ± 0.76**
Farmers Favorite[c]	**2.93 ± 3.11**	**1.86 ± 2.27**	**2.14 ± 1.86**	**3.57 ± 3.05**	**1.57 ± 1.13**
Bark	**3.81 ± 2.85**	**3.57 ± 3.78**	**1.57 ± 1.51**	**1.71 ± 1.11**	**1.57 ± 0.53**
Mow & Throw	**4.86 ± 3.41**	**4.43 ± 3.10**	**4.57 ± 3.05**	**1.43 ± 1.13**	**1.86 ± 2.27**

[a] All data was transformed using a Log 10 transformation.
[b] No significant differences were found between means within columns or rows (n=8, P<0.05).
[c] Control treatment.

Table 2. Total bacteria colony forming units (CFU) per gram of soil sampled monthly in 2003 from seven different weed control treatments in an organic apple orchard located near Hotchkiss, Colorado.

	April	May	June	July	August	September
Mow	**8.42 ± 0.54[ab]**	**8.23 ± 0.29**	**7.88 ± 0.18**	**7.60 ± 0.49**	**8.09 ± 0.85**	**7.66 ± 0.43**
Flamer	**9.21 ± 1.08**	**8.42 ± 0.36**	**8.06 ± 0.18**	**7.67 ± 0.75**	**8.04 ± 0.84**	**8.01 ± 0.84**
Landscape Fabric	**7.95 ± 0.29**	**7.86 ± 0.56**	**8.05 ± 0.37**	**7.76 ± 0.55**	**7.77 ± 0.07**	**8.08 ± 0.44**
Paper	**8.65 ± 1.07**	**8.19 ± 0.47**	**7.98 ± 0.19**	**7.69 ± 0.37**	**7.69 ± 0.25**	**7.66 ± 0.61**
Farmers Favorite[c]	**8.44 ± .06**	**8.35 ± 0.12**	**8.09 ± 0.38**	**7.67 ± 1.07**	**7.87 ± 0.31**	**7.79 ± 0.21**
Bark	**8.53 ± 1.05**	**7.95 ± 1.03**	**7.91 ± 0.23**	**8.05 ± 0.24**	**8.15 ± 0.82**	**7.89 ± 0.41**
Mow & Throw	**7.99 ± 0.23**	**7.45 ± 0.82**	**7.97 ± 0.16**	**7.53 ± 0.54**	**7.75 ± 0.36**	**7.93 ± 0.41**

[a] All data was transformed using a Log 10 transformation.
[b] No significant differences were found for means within columns or rows (n=8, P<0.05).
[c] Control treatment.

Table 3. Meters of fungi hyphae found in 1 gram of soil sampled monthly in 2002 from seven different weed control treatments in an organic apple orchard located near Hotchkiss, Colorado.

	May	**June**	**July**	**August**	**September**
Mow	**329.5 ± 411.1 a[a]**	**515.4 ± 888.5 a**	**265.1 ± 306 a**	**275.7 ± 473.0 a**	**151.0 ± 399.5 a**
Flamer	**202.6 ± 371.5 a**	**245.5 ± 472.3 a**	**157.1 ± 272.7 a**	**203.4 ± 381.9 a**	**204.5 ± 358.9 a**
Landscape Fabric	**273.8 ± 429.7 a**	**391.4 ± 506.9 a**	**129.0 ± 341.3 a**	**137.5 ± 363.9 a**	**149.3 ± 296.2 a**
Paper	**315.7 ± 561.3 a**	**518.2 ± 674.8 a**	**359.2± 395.3 a**	**111.0 ± 293.6 a**	**212.9 ± 158.3 a**
Farmers Favorite[b]	**196.0 ± 319.4 a**	**221.4 ± 447.3 a**	**348.7 ± 365.3 a**	**134.1 ± 354.9 a**	**128.2 ± 339.4 a**
Bark	**1121.5 ± 524.8 a**	**1378.2 ± 364.6 a**	**586.8 ± 102.4 a**	**121.7 ± 322.0 a**	**443.0 ± 836.6 a**
Mow & Throw	**191.6 ± 374.5 a**	**298.2 ± 510.8 a**	**483.6 ± 417.2 a**	**148.8± 215.7 a**	**110.4 ± 292.1 a**

[a] No significant differences were found between means within columns or rows (n=8, P<0.05).
[b] Control treatment.

Table 4. Meters of fungi hyphae found in 1 gram of soil sampled monthly in 2003 from seven different weed control treatments in an organic apple orchard located near Hotchkiss, Colorado.

	April	**May**	**June**	**July**	**August**	**September**
Mow	**2.14 ± 2.1**	**2.61 ± 2.92**	**2.57 ± 3.78**	**1.14 ± 3.02**	**2.71 ± 2.36**	**0.00 ± 0.00**
Flamer	**2.57 ± 2.44**	**3.13 ± 2.51**	**3.43 ± 3.26**	**0.29± 0.49**	**1.29 ± 1.89**	**1.14 ± 3.02**
Landscape Fabric	**1.86 ± 2.12 b[a]**	**4.29 ± 3.71 a**	**5.86 ± 3.93 a**	**1.14 ± 0.38 a**	**1.57 ± 1.99 a**	**0.00 ± 0.00 b**
Paper	**2.71 ± 3.49**	**2.91 ± 2.17**	**1.14 ± 3.02**	**0.57 ± 0.79**	**2.43± 1.99**	**1.43± 3.36**
Farmers Favorite[b]	**1.43 ± 2.44**	**2.85 ± 3.41**	**3.71 ± 3.68**	**2.29± 3.59**	**1.71 ± 2.14**	**3.57 ± 4.50**
Bark	**0.87± 1.36**	**1.19 ± 3.49**	**1.57 ± 2.44**	**0.14 ± 0.38**	**1.14 ± 1.95**	**1.43± 2.99**
Mow & Throw	**2.00 ± 1.63**	**2.09 ± 2.18**	**2.14 ± 3.39**	**1.43± 3.36**	**2.00 ± 1.91**	**2.86± 3.89**

[a] Lower case letters in the same row, if different, denote significant differences; no significant differences were found between means within columns (n=8, P<0.05).
[b] Control treatment.

Table 5. Number of flagellates per gram of soil sampled monthly in 2002 from seven different weed control treatments in an organic apple orchard located near Hotchkiss, Colorado.

	May	June	July	August	September
Mow	**3.65 ± 4.32x10^{3} [a]**	**0.68 ± 1.73 x10^{5}**	**2.98 ± 4.00 x10^{6}**	**1.01 ± 0.92 x10^{4}**	**2.82 ± 7.94 x10^{6}**
Flamer	**0.50 ± 1.19 x10^{4}**	**0.66 ± 1.20 x10^{4}**	**4.61 ± 8.34 x10^{5}**	**1.53 ± 1.46 x10^{4}**	**2.19 ± 3.14 x10^{3}**
Landscape Fabric	**801 ± 1243**	**2.23 ± 4.58 x10^{3}**	**1.18 ± 2.43 x10^{5}**	**0.83 ± 1.41 x10^{4}**	**2.81 ± 7.95 x10^{7}**
Paper	**1.69 ± 2.89 x10^{3}**	**1.78 ± 4.63 x10^{5}**	**2.06 ± 1.38 x10^{4}**	**1.61 ± 4.31 x10^{5}**	**1.82 ± 4.30 x10^{7}**
Farmers Favorite[b]	**116 ± 138**	**85 ± 150**	**1.27 ± 1.31 x10^{6}**	**1.46 ± 1.01 x10^{4}**	**4.35 ± 8.49 x10^{7}**
Bark	**2.78 ± 4.97 x10^{5}**	**77 ± 111**	**8.58 ± 1.48 x10^{5}**	**7.75 ± 1.56 x10^{4}**	**5.62 ± 1.04 x10^{7}**
Mow & Throw	**2.79 ± 6.94 x10^{3}**	**1.71 ± 4.08 x10^{3}**	**9.66 ± 1.43 x x10^{5}**	**1.68 ± 4.28 x10^{5}**	**1.06 ± 2.51 x10^{6}**

[a] No significant differences were found between means within columns or rows (n=8, P<0.05).
[b] Control treatment.

Table 6. Number of amoebae per gram of soil sampled monthly in 2002 from seven different weed control treatments in an organic apple orchard located near Hotchkiss, Colorado.

	May	June	July	August	September
Mow	**16.9 ± 9.3 a[a]**	**18.3 ± 10.4 b**	**0.54 ± 1.14 x10^{4} b**	**19.3 ± 9.9 b**	**1.12 ± 1.20 x10^{7} b**
Flamer	**20.2 ± 11.5**	**15.3 ± 4.2**	**0.23 ± 6.54 x10^{4}**	**20.4 ± 13.8**	**1.55 ± 4.33 x10^{3}**
Landscape Fabric	**21.7 ± 8.6**	**27.7 ± 13.0**	**1.87 ± 3.28 x10^{3}**	**14.3 ± 4.4**	**0.59 ± 1.62 x10^{4}**
Paper	**15.4 ± 12.7 a**	**20.3 ± 9.2 b**	**39.1 ± 8.4 b**	**24.6 ± 15.2 b**	**8.43 ± 1.16 x10^{6} a**
Farmers Favorite[b]	**25.0 ± 8.9a**	**22.3 ± 12.7 a**	**2.88 ± 6.49 x10^{3} a**	**18.4 ± 0 a**	**2.96 ± 7.90 x10^{6}**
Bark	**1.17 ± 1.45 x10^{3}**	**1.39 ± 3.86 x10^{3}**	**1.39 ± 3.86 x10^{5}**	**27.3 ± 12.2**	**2.81 ± 7.96 x10^{6}**
Mow & Throw	**62.6 ± 38.6**	**17.4 ± 2.9**	**81.2 ± 139.8**	**35.6 ± 60.9**	**0.58 ± 1.16 x10^{4}**

[a] Lower case letters in the same row, if different, denote significant differences; no significant differences were found between means within columns (n=8, P<0.05).
[b] Control treatment.

Table 7. Number of ciliates per gram of soil sampled monthly in 2002 from seven different weed control treatments in an organic apple orchard located near Hotchkiss, Colorado.

	May	June	July	August	September
Mow	**5.9 ± 7.3**	**4.2 ± 6.8**	**13.5 ± 11.6**	**0 ± 0 a**[a]	**53.8 ± 69.6**
Flamer	**8.5 ± 6.9**	**9.7 ± 6.9**	**10.3 ± 6.2**	**3.2 ± 4.7 a**	**0.61 ± 1.12 x10^{3}**
Landscape Fabric	**10.9 ± 7.8**	**11.4 ± 14.0**	**7.8 ± 7.8**	**1.3 ± 3.6 a**	**280.9 ± 794.9**
Paper	**11.5 ± 8.7**	**6.3 ± 4.6**	**8.3 ± 3.8**	**3.2 ± 4.7 a**	**57.9 ± 54.4**
Farmers Favorite[b]	**13.8 ± 4.9**	**9.1 ± 7.2**	**8.9 ± 3.6**	**4.2 ± 6.8 a**	**77.4 ± 155.2**
Bark	**16.6 ± 9.8**	**17.3 ± 10.7**	**13.3 ± 4.2**	**10.3 ± 9.2 b**	**329.4 ± 444.5**
Mow & Throw	**7.4 ± 8.3**	**5.1 ± 5.5**	**14.9 ± 17.2**	**4.9 ± 7.2 a**	**1.03 ± 1.39 x10^{3}**

[a] Lower case letters in the same column, if different, denote significant differences; no significant differences were found between means within rows (n=8, P<0.05).
[b] Control treatment.

Table 8. Number of flagellates per gram of soil sampled monthly in 2003 from seven different weed control treatments in an organic apple orchard located near Hotchkiss, Colorado.

	April	May	June	July	August	September
Mow	**1.15 ± 2.79 x10^{3}**[a]	**4.16 ± 3.93 x10^{3}**	**8.36 ± 8.43 x10^{3}**	**2.98 ± 1.00 x10^{6}**	**1.09 ± 0.92 x10^{4}**	**2.82 ± 7.94 x10^{6}**
Flamer	**1.12 ± 4.61 x10^{5}**	**0.32 ± 1.40 x10^{6}**	**5.37 ± 1.50 x10^{6}**	**4.61 ± 8.34 x10^{5}**	**1.53 ± 1.46 x10^{4}**	**2.19 ± 3.14 x10^{3}**
Landscape Fabric	**2.96 ± 1.35 x10^{5}**	**8.62 ± 2.96 x10^{5}**	**1.38 ± 3.86 x10^{6}**	**1.18 ± 2.43 x10^{5}**	**0.83 ± 1.41 x10^{4}**	**2.81 ± 7.95 x10^{7}**
Paper	**3.87 ± 4.91 x10^{5}**	**1.31 ± 4.56 x10^{6}**	**2.41 ± 6.52 x10^{6}**	**2.06 ± 1.38 x10^{4}**	**1.61 ± 4.31 x10^{5}**	**1.82 ± 4.30 x10^{7}**
Farmers Favorite[b]	**0.43 ± 1.65 x10^{4}**	**1.39 ± 2.93 x10^{4}**	**2.29 ± 4.21 x10^{4}**	**1.27 ± 1.31 x10^{6}**	**1.46 ± 1.01 x10^{4}**	**4.35 ± 8.49 x10^{6}**
Bark	**0.006 ± 1.28 x10^{7}**	**0.52 ± 3.46 x10^{6}**	**0.75 ± 1.01 x10^{7}**	**0.86 ± 1.48 x10^{6}**	**0.78 ± 1.56 x10^{5}**	**0.56 ± 1.04 x10^{7}**
Mow & Throw	**0.87 ± 5.85 x10^{3}**	**1.55 ± 9.81 x10^{3}**	**4.47 ± 5.09 x10^{3}**	**0.97 ± 1.43 x10^{6}**	**1.68 ± 4.28 x10^{5}**	**1.06 ± 2.51 x10^{6}**

[a] No significant differences were found between means within columns or rows (n=8, P<0.05).
[b] Control treatment.

Table 9: Number of amoebae per gram of soil sampled monthly in 2003 from seven different weed control treatments in an organic apple orchard located near Hotchkiss, Colorado.

	April	May	June	July	August	September
Mow	**1.2 ± 2.0**[a]	**2.2 ± 4.0**	**20.2 ± 16.2**	**1.5 ± 3.9**	**10.1 ± 10.0**	**32.1 ± 16.9**
Flamer	**2.0 ± 3.1**	**2.1 ± 2.7**	**20.3 ± 10.2**	**1.4 ± 2.4**	**12.5 ± 13.6**	**18.4 ± 11.1**
Landscape Fabric	**1.9 ± 2.8**	**2.2 ± 4.0**	**32.7 ± 34.7**	**2.2 ± 4.0**	**18.3 ± 11.2**	**19.9 ± 17.2**
Paper	**0.0 ± 0.0**	**0.7 ± 1.9**	**17.7 ± 11.9**	**2.9 ± 4.9**	**11.5 ± 7.3**	**16.5 ± 14.2**
Farmers Favorite[b]	**1.6 ± 3.4**	**0.7 ± 1.9**	**13.2 ± 5.3**	**1.5 ± 3.9**	**16.1 ± 4.0**	**15.3 ± 12.6**
Bark	**3.4 ± 2.8**	**5.1 ± 4.2**	**21.1 ± 23.3**	**2.2 ± a 4.0**	**16.1 ± 13.a**	**17.9 ± 12.3**
Mow & Throw	**3.9 ± 2.3**	**4.4 ± 5.5**	**12.7 ± 7.7**	**3.6 ± 4.8**	**27.3 ± 14.0**	**20.8 ± 12.8**

[a] No significant differences were found between means within columns or across rows (n=8, <0.05).
[b] Control treatment.

Table 10: Number of ciliates per gram of soil sampled monthly in 2003 from seven different weed control treatments in an organic apple orchard located near Hotchkiss, Colorado.

	April	May	June	July	August	September
Mow	**9.6 ± 3.9**[a]	**11.1 ± 6.2**	**8.4 ± 5.8**	**10.5 ± 10.8**	**4.3 ± 4.6**	**4.1 ± 7.4**
Flamer	**8.4 ± 4.8**	**9.2 ± 5.6**	**10.1 ± 7.6**	**12.9 ± 5.4**	**2.2 ± 4.0**	**5.5 ± 6.8**
Landscape Fabric	**10.3 ± 7.1**	**8.5 ± 6.5**	**3.6 ± 4.8**	**9.2 ± 5.6**	**0.7 ± 1.9**	**2.9 ± 4.9**
Paper	**14.6 ± 6.9**	**12.3 ± 6.8**	**13.2 ± 13.7**	**14.9 ± 4.4**	**1.4 ± 2.4**	**2.1 ± 2.7**
Farmers Favorite[b]	**19.7 ± 11.3**	**21.6 ± 17.9**	**7.2 ± 7.3**	**16.8 ± 12.9**	**0.8 ± 1.9**	**2.2 ± 4.0**
Bark	**16.1 ± 14.9**	**22.1 ± 14.5**	**8.9 ± 6.0**	**6.59 ± 1.74**	**4.1 ± 7.4**	**2.9 ± 4.9**
Mow & Throw	**8.7 ± 6.7**	**11.5 ± 6.2**	**4.8 ± 7.1**	**12.3 ± 6.8**	**7.0 ± 7.2**	**2.2 ± 4.0**

[a] No significant differences were found between means within columns or rows (n=8, P<0.05).
[b] Control treatment.

Incidence, Severity and Management of Cytospora Canker in Stone Fruits in Colorado

Ramesh R. Pokharel[1], and Harold J. Larsen[2]

Summary

Peach, cherry, and plum orchards in western Colorado were surveyed for incidence and severity of Cytospora canker using a disease severity rating scale of 1 to 9 (1 = healthy and 9 = dead). All orchards surveyed had Cytospora infection (15 to 100% of trees within each orchard) with severity ratings ranging between 1.6 to 5.6 across crop, variety, tree age, and management approach (conventional vs organic). Berenda Sun, June Pride, and Elegant Lady peaches, Bing sweet cherry, and Stanley European plum had the highest incidence and severity. Poultices of seed meal + ground leaf material of 1) brown mustard (*Brassica juncea*), 2) yellow mustard (*B. hirta*), or of 3) canola (*B. napus*) seed meal mixed with root and leaf material of horseradish (*Armoracia rusticana*) were applied to naturally infected cankers during fall 2007. Gum production (evidence of canker activity) lessened or dried up during the 2007 growing season on cankers treated with either the brown mustard or the canola/horseradish mix. Bark samples were collected from treated and non-treated cankers and plated out onto PDA media. The causal fungus was recovered and grew well from the non-treated cankers but not from treated cankers. Further studies of *Brassica* materials and other chemicals for Cytospora management for organic and conventional growers are in progress.

Introduction

Cytospora canker, caused by fungi in the genus *Cytospora* Ehrenb.:Fr., is a worldwide problem and affects more than 70 species of woody shrubs and trees (Biggs and Miles, 2005). The disease is also referred to as Cytospora canker, Valsa canker and perennial canker. Orchardists in Western Colorado often refer to this disease as “gummosis". *Cytospora chrysosperma* is a common pathogen of willow and poplar species and other deciduous trees and shrubs. *Leucostoma cincta* is found on apple while *L. persoonii* is common on stone fruit trees (peach, nectarine, sweet and tart cherry, apricot, prune and plum trees) and shrubs. Cytospora canker is an important disease in cooler portions of North American regions suitable for stone fruit production, including Canada and the northeastern United States; it also occurs in South America and Japan (Biggs, 1995; Biggs and Miles, 2005). This disease is associated with the complex set of factors that result in the peach tree short life syndrome in the southeastern United States and is important on other stone fruits including prune and plum in California and Idaho and cherry in the Pacific Northwest. In Europe, the disease is important on apricot, peach, sweet cherry and is part of the stone fruit disease complex called 'apoplexy'.

Cytospora canker reduces the bearing surface of productive trees and shortens tree longevity. In Colorado, at least one-third of the producing peach trees have Cytospora cankers on trunks, scaffold limbs, or in the fruiting wood. Within a couple of seasons these infections can cause severe dieback; eventual death of the tree is likely. In highly susceptible peach varieties, the canker can weaken an entire orchard in three or four years. Cytospora is highly infectious and

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[1] Contact information: Research Associate, Colorado State University Agricultural Experiment Station, Western Colorado Research Center, 3168 B ½ Rd., Grand Junction, CO 81503; Ph: 970-434-3264, x-203; email: ramesh.pokharel@colostate.edu.

[2] Professor/Interim Manager, Western Colorado Research Center – Orchard Mesa, 3168 B ½ Road, Grand Junction, CO 81503.

damaging, particularly when trees are under stress such as too heavy a crop, poor nutrition, drought, winter injury, wet feet or improper watering, spray/insect injury and insufficient renewal pruning (Barakat et al., 1995). Canker development can take place throughout the year. However, the greatest canker growth occurs in the spring as temperatures warm up just before tree activity resumes. Cytospora generally does not attack healthy, vigorous peach bark. Pruning wounds, winter injury, insect damage, and mechanical injury are common types of wounds serving as entry points. The fungi survive the winter in cankers or in dead wood. During spring and summer, spores produced in the cankers are spread over short distances by wind and rain to wounds on the same or nearby trees. Infection and canker development depend on temperature and the species of fungus involved. *L. cincta* is favored by lower temperatures than *L. persoonii*

Identification of the species of Cytospora that causes Cytospora canker is difficult even for the professional plant pathologist because numerous species of Cytospora cause the disease. Cytospora fruiting and vegetative structures, as well as spore size, vary greatly. A poor understanding of the host range of each species also contributes to the difficulty of identification (Spielman, 1985). Widespread occurrence and prevalence of higher variability of the fungus in fruit trees grown in different agro-climates and belonging to different species have complicated the management program of this disease. Growers claimed that, due to a lack of effective management options (chemical and non-chemical) for both conventional and organic growers, they have to replant trees/orchards when the trees are still productive because of losses to Cytospora canker. Thus we initiated projects to measure disease severity and identify management options for both conventional and organic growers.

Materials and Methods

Incidence and severity of Cytospora canker: Based on previous field observation, experience and literature (James and Davidson, 1971), a modified severity scale was developed where 1= healthy tree and, 2= one to few minor infection, 3= few infection sites, 4= major infection (canker bigger than 5 cm diameter) and some main trunk infection, 5= major trunk infection with multiple infection sites, 6= Major canker > 10 cm in main trunk or scaffold. 7 = with major infection in multiple locations, 8 = some braches already dead and or trees dying, but not dead, and 9 = tree dead due to Cytospora. Using the scale, we examined 20 fruit orchards (2,200 plants) with trees of 2 - 15 year-old peach, cherry, and plum in Western Colorado to verify and assess the severity of Cytospora. These randomly selected orchards had Berenda Sun, Redhaven, Cresthaven, Newhaven, June Pride, Elegant Lady, Rosa, Garnet Beauty, Suncrest, and PF-25 peach varieties, Stanley plum, and Bing, Stella, Hudson, Benton sweet cherries. Observations were made from January to March of 2007.

Non-chemical management studies: With the increasing demand for organic fruit production and lack of effective chemicals to manage the disease, we initiated a study of the effect of *Brassica* mustard seed meal products; poultices of seed meal + ground leaf material of 1) brown mustard (*Brassica juncea*), 2) yellow mustard (*B. hirta*), or of 3) canola (*B. napus*) seed meal mixed with root and leaf material of horseradish (*Armoracia rusticana*) were applied to naturally infected cankers during fall 2007. We soaked the seed meal of the above *Brassica*'s with enough water to make a thick paste for 2-4 hours, horseradish leaves were ground in a blender along with equal amount of water and mixed at a 2:1 ratio with soaking meal cakes to make a paste. These poultices were applied over the infected site (on top of the gum) and applied on the wounds after scrubbing the gum. Similarly, six proprietary materials (organic products) were applied on different trees over the gum and on the scraped gum by paintbrush. The drying of gum and severity of gummosis was monitored weekly for 4 months. Bark samples were collected from treated and non-treated cankers and plated out onto PDA media.

Results and Discussion

Cytospora canker is a serious problem to Western Colorado stone fruits growers that can kill trees of any age; from young trees (Fig. 1A) to established trees (12 year-old tree, Fig. 1B). It appears to be the biggest problem for stone fruit growers and lacks an effective disease management option. The infection can start naturally in the orchard without any obvious tree injury and lead to severe gummosis in trees of any ages (Fig. 2A). However, cold injury, insect damage, salt damage and inappropriate pruning cuts aggravate the infection.

Cytospora canker drastically reduces tree stand in an established orchard and necessitates tree replacement within as few as 10 years of planting. We observed infections starting without any obvious injury (winter, insect or cutting) in trees of all ages. However, pruning cut orientation and location may affect canker initiation as we observed higher infection incidence with horizontal cuts made near to the main trunk (Fig. 2B). The extent of damage by this disease varied with orchard, crop, variety and location. Incidence and severity of the disease were evaluated in order to monitor disease progress and develop a management plan. The Cytospora rating scale developed by James and Davidson (1971) was modified to provide a more easily applied disease rating scale.

Incidence and severity of Cytospora canker varied with crop (peach, cherry and plum), variety (Berenda Sun, Redhaven, Cresthaven, Newhaven, June Pride, Elegant Lady, Rosa, Suncrest and PF 25 in peach; Bing, Stella, Hudson, Rainer and Benton in Cherry), tree age (3 to 22 years) and the growing system (conventional vs organic; Table 1). However, the highest incidence (100 %) was observed in conventional blocks of five year-old plums, 10 year-old June Pride peaches, and 14 year-old Bing cherries whereas the lowest incidence (15 %) was found in a conventional block of 14 year-old Benton cherry. The highest severity rating was 5.6 (average of 150 trees) in a conventional 10-year-old Berenda Sun peach block and the minimum was 1.6 (average of 118 trees) in a conventional Benton cherry block (Table 1). Disease incidence and severity were not specific to crops, varieties, growing systems. However, Berenda Sun, June Pride, and Elegant Lady peaches, Bing sweet cherry, and Stanley European plum had the highest incidence and severity. In addition, there was no correlation between the incidence and severity of this disease in the survey. Based on the survey, sweet cherry loss was greatest (30% of trees) during their second year of growth. In contrast, few peach trees were killed until they reached maturity.

To understand the efficacy of isothiocyanate contained in *Brassica* seed meal, a byproduct after oil is extracted, seed meal of different *Brassica* species were tested. We used seed meal cake of different *Brassica* species reported to have different amount and type of isothiocyanates. The response of Cytospora canker in a 10 year-old Berenda Sun peach block at WCRC – Orchard Mesa to different *Brassica* seed meal cake treatments varied with canker pretreatment preparation. Efficacy of *Brassica* treatments was higher when the gum (tree exudates) was removed and poultices were applied compared to poultices applied over the gum. This might be due to the better contact of the treatment materials with the fungus when applied to a scraped surface as compared to application over the gum. Cankers treated with either the brown mustard seed meal or the canola seed meal + horseradish mixture had better results, i.e. the gum dried out, the canker size did not increase, and the fungus was killed in situ (Fig. 3). The causal fungus was recovered and grew well from the non-treated cankers but not from treated cankers. These materials might have higher concentrations of isothiocyanate in the products. Isothiocyanate controls many soil borne fungal pathogens, but its potential role in Cytospora management has not been studied. Horseradish is reported to have higher concentration of isothiocyanate than other *Brassica* species. This treatment method seems to work in treating Cytospora disease and provides hope of a treatment for organic growers. Of the six proprietary oil products, one dried out the gum and killed the fungus. However follow-up studies are needed to confirm the results. Moreover, easier and more efficient methods of application and treatment with the seed meal cake need to be worked out for both organic and conventional growers.

The high incidence and severity of this disease and lack of effective management practices have necessitated early replanting of trees and orchards. New control/management options are needed, and the studies reported here provide a start on this. Other studies on efficient management strategies have been initiated here to follow up these efforts. Morphological characterization of this fungus is difficult, so molecular level studies of variability are needed to develop an effective management plan.

Once the trees in an orchard are severely infected with Cytospora canker, both curative and preventative comprehensive management strategies are required to manage the disease because of secondary and new infections in untreated parts of the trees. And different management options have to be evaluated for both conventional and organic growers.

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Table 1. Incidence and severity of Cytospora canker in Western Colorado Fruit orchards, 2007.

Location	Crop	Variety	Organic / conventional	Tree age (yrs)	Total # of trees	Incidence (%)	Severity ratings[z]
Orchard Mesa	Peach	Cresthaven	Conventional	10	150	99	5.6
Orchard Mesa	Peach	Redhaven	Conventional	10	175	58	2.0
Orchard Mesa	Plum	Stanley	Conventional	10	5	100	3.6
Rogers Mesa	Peach	Cresthaven	Conventional	9	160	73.4	2.4
Rogers Mesa	Peach	Newhaven	Conventional	9	160	73.8	2.6
Rogers Mesa	Peach	June Pride	Conventional	9	160	100	3.8
Rogers Mesa	Peach	Cresthaven	Organic	9	120	16.8	1.4
Rogers Mesa	Peach	Newhaven	Organic	9	120	50	2.6
Rogers Mesa	Peach	June Pride	Organic	9	120	97.5	2.9
East Orchard Mesa	Peach	Newhaven	Conventional	10	100	46	2.0
East Orchard Mesa	Peach	Elegant Lady	Conventional	10	100	82	3.2
Palisade	Peach	Rosa	Organic	4	120	62	3.5
Palisade	Peach	Suncrest	Conventional	3	120	53	1.7
Rogers Mesa	Cherry	Bing	Conventional	10	160	93.2	3.2
Rogers Mesa	Cherry	Stella	Conventional	22	14	90.9	3.3
Rogers Mesa	Cherry	Hudson	Conventional	22	14	85.8	2.9
Rogers Mesa	Cherry	Rainer	Conventional	22	14	85.8	3.0
Rogers Mesa	Cherry	Bing	Conventional	22	14	100	4.5
Palisade	Cherry	Benton	Conventional	4	118	15	1.6
Palisade	Peach	PF-25	Conventional	4	120	39.6	2.3
Palisade	Peach	Garnet Beauty	Conventional	4	150	37.5	2.7

[z] Severity ratings from 1 (healthy) to 9 (dead).

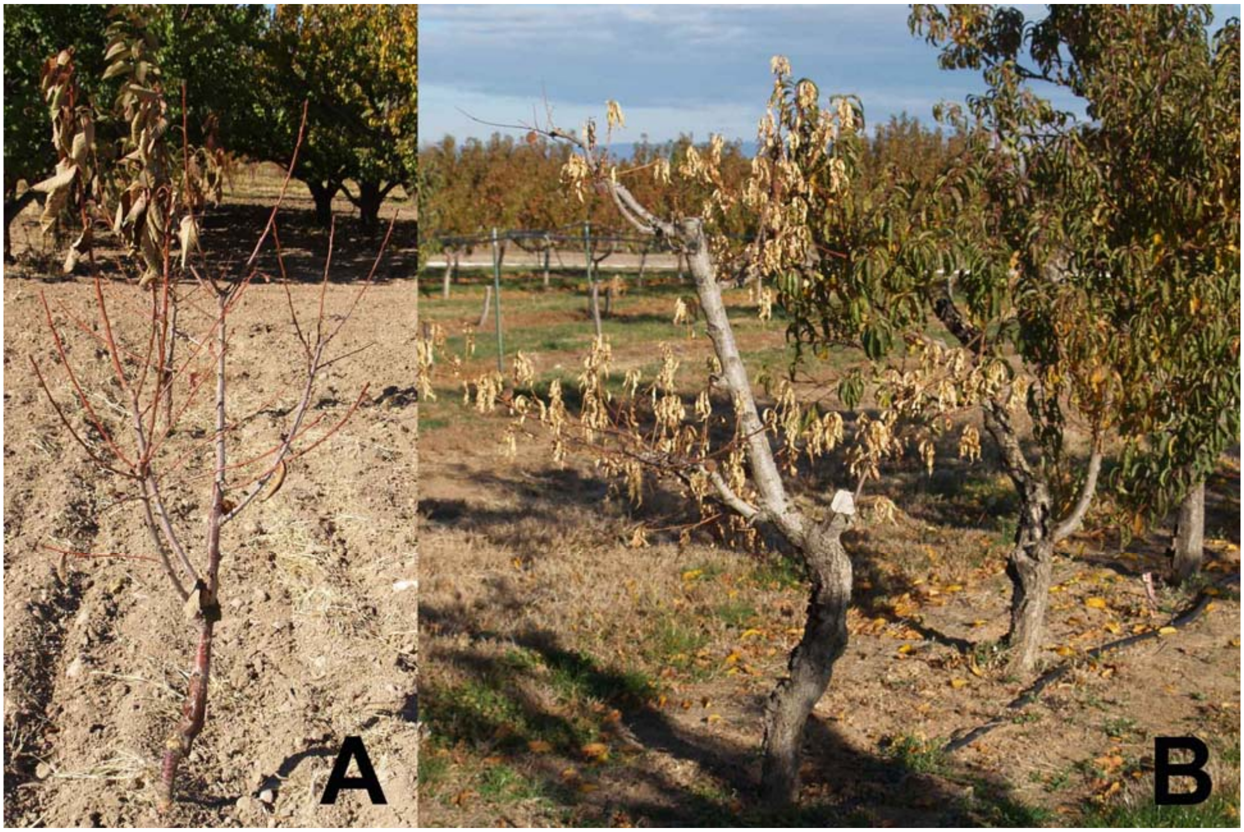

Fig. 1. Trees killed by the Cytospora canker; A) 2-year-old cherry tree, and B) mature 12-year-old Berenda Sun peach (Photos by R. Pokharel)

Fig. 2. Typical Cytospora infections in peach: A) multiple natural infections, and B) a single infection facilitated by a bench cut (Photos by H. J. Larsen).

Fig. 3. Cytospora canker 6 months after application of mustard seed meal + horseradish leaf mixture; gum dried out and the fungus killed beneath applied material (Photo by R. Pokharel).

Evaluation of Apple Rootstocks Planted in High pH Soil

Ramesh R. Pokharel[1] and Harold Larsen[2]

Summary

Twenty-three rootstocks, grafted to Brookfield Gala apple, were planted in 2008 at the WCRC orchard Mesa site in a completely randomized block design with 5-10 replications. Trunk circumferences, measured at 45 cm above the graft unions, were collected at planting (June, 2008) and after one season's growth (Feb 2009). Substantial variability was observed in first year tree growth. Rootstocks CG 7707 and JTE-B performed best (almost 60 and 55% better than average) while rootstocks CG 5087 and G 41 had the least growth. This project will continue for several years.

Introduction

Fruit tree growth in arid climate soils is complicated by high soil and water pH and high salt content. Both situations reduce availability of micronutrients to the tree roots and impact tree growth, survival, and productivity. High soil and irrigation water pH has been addressed historically by acidification. But soil acidification is not an easy practice; moreover, there is no information on the impact of soil acidification chemicals such as sulfuric acid on soil microbial populations. Such chemicals are suspected to cause change in soil microbial-biota essential for efficient crop production. Thus, it is vital to screen potential rootstock candidates or breeding materials for susceptibility to stresses, biotic and abiotic (e.g. temperature, and soil pH conditions). Using traditional plant breeding and genetic engineering approaches, researchers can incorporate resistant characters against pests, disease and abiotic factors such as soil pH into existing rootstock material. This can help develop rootstocks with enhanced horticultural performance as a result of greater understanding of the physiology of multiple genetic systems. Obtaining genetic material from research programs around the world and testing these new rootstocks cooperatively is faster and easier than breeding as other horticultural characteristics are already known/incorporated. Choice of a suitable rootstock for a new orchard has both economic and orchard management consequences. As with cultivars, there are many rootstocks available for apple - but only few are likely to be suitable for local conditions.

Past research has shown rootstocks react differentially under different soil pH conditions. Among the examined apple rootstocks, P.22 was the most and M.26 the least tolerant to strong soil acidification. At pH 3.6, M.26 had the highest concentrations of Al and Mn in roots and shoots. The leaves of apple rootstocks grown in the most acidic soil contained the highest concentrations of Al and Mn when compared to rootstocks grown at pH 6.0. Both 'Jonagold' and 'Gala' grafted onto P.22 had the highest number of flowers and fruitlets, with less on M.9 and the fewest on M.26 (Sas and Mercik, 2004). This illustrates the potential for finding a rootstock better suited to different soil pH conditions.

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[1] Contact information: Research Associate, Colorado State University Agricultural Experiment Station, Western Colorado Research Center-Orchard Mesa, 3168 B ½ Rd., Grand Junction, CO 81503; Ph: 970-434-3264, x-203; email: ramesh.pokharel@colostate.edu.

[2] Professor/Interim Manager, Western Colorado Research Center - Orchard Mesa, 3168 B ½ Road, Grand Junction, CO 81503.

Western Colorado is characterized by high soil and water pH. This is a problem for growers because available varieties and rootstocks often are evaluated only under conditions of low soil pH. The lack of information on response of apple rootstocks to high pH conditions like those in Colorado is a need for all apple producers in arid regions. This study is intended to address that knowledge gap.

Materials and Methods

A total of 23 apple rootstocks of different origin, source and programs, and grafted to Brookfield Gala were obtained through the apple rootstock genetic materials pool of USDA, Geneva and planted at the WCRC Orchard Mesa site of Colorado State University in 2008. A completely randomized block design was used with 5-10 replications based on the available rootstock numbers. Tree trunks were marked at 18" (45 cm) from the ground with a permanent marker. The trunk circumference (in cm) were measured when tree started growing and after 1 year growth in Feb 2009. Difference in tree measurements (final- initial) was calculated. Due to high variability in replication number, no mean separation was done. However, averages were calculated using Excel spreadsheet.

Results and discussion

Observations reported are only preliminary (first year growth), but may provide some preview of trends to develop later. Average first year growth in trunk circumference was 0.595 cm across all rootstocks; individual rootstock growth in trunk circumference was highly variable (Table 1). Nine rootstocks had larger than average tree circumference growth while 13 rootstocks had smaller than average. Rootstock CG 7707 had the greatest growth followed by rootstock JTE-B, while rootstocks CG 5087 and G 41 had the least growth (Table 1). The results are similar to those reported by Robinson et al. (2003) who stated that, among vigorous stocks, CG.7760, CG.6239, CG.6253, CG.8189 and CG.7707 were the top performers in other parts of the USA.

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Table 1: Initial and first year trunk circumference (cm) for Brookfield Gala apple on different rootstocks planted in 2008 at the WCRC, Grand Junction, CO. Trunk measurements were taken 45 cm (18”) above the graft union.

Rootstock	Initial circum. (cm)	Yr 1 circum (cm)	Difference (cm)
CG 3007	5.08	5.53	0.45
CG 4214	4.47	4.71	0.24
CG 4814	5.04	5.70	0.66
CGC 5046	5.30	5.70	0.40
CG 5087	4.89	4.91	0.03
CG 5179	4.41	4.66	0.25
CG 5890	5.56	6.34	0.79
CG 6006	5.90	6.63	0.73
CG 6143	5.59	6.10	0.51
CG 6253	5.78	6.13	0.35
CG 6874	4.90	5.53	0.63
CG 7707	4.50	5.99	1.49
B 118	5.43	5.97	0.53
B 9	4.32	5.13	0.81
G 16	5.45	6.00	0.55
G 30	5.19	5.73	0.54
G 935	4.86	5.33	0.46
G 41	5.18	5.36	0.18
JTE-B	4.97	6.28	1.31
M 6	4.65	5.18	0.53
Maruba	5.15	5.95	0.80
Naga	4.87	5.71	0.84
Nic-29	4.48	5.06	0.59
Average	5.04	5.64	0.59

Efficacy of plant and mineral oils, and Tergitol on peach thinning.

Ramesh Pokharel[1], Harold Larsen[2], and Bryan Braddy[3]

Summary

Peach thinning, an essential operation to get better fruit size and higher return, is done manually. Plant and mineral oil products such as Stylet Oil (5 and 10% v/v), pure clove oil (2, 3, 4 and 6%, v/v) and different grades of cinnamon oil (2, 3, and 4% v/v) and combination of clove oil (1 % v/v) and cinnamon oil (1% v/v) with water as carrier applied at 70% bloom were evaluated for their efficacies for bloom thinning on Redhaven and Cresthaven peaches. Similarly, Tergitol (wetting agents and penetrants [2,6,8-trimethyl-4-nonanol with ethylene oxide]) of different batch ages (3+ years old vs. fresh) and their different concentrations (0.75, 1 and 2% v/v) were evaluated for peach thinning at 30 and/or 70% bloom on the same varieties in separate experiments. In all studies, numbers of dead flowers were counted a week after treatment application. Similarly, post-treatment fruit counts were done 45 days after treatment application. Only pure cinnamon oil and pure clove oil killed an effective percentage of flowers (> 60%) and reduced fruit numbers effectively (> 70% reduction) in repeated experiments. Neither Stylet-Oil nor food grade cinnamon oil killed flowers, but 5 and 10% Stylet-Oil treatments had 50 and 67% less fruits, respectively, whereas the food grade cinnamon oil treatment had only 30% less fruits than the water only treatment. In separate experiments, fresh batch Tergitol at 0.75, 1, and 2% reduced flower numbers variably when applied twice (at 30 and 70% bloom), but old batch Tergitol did not. A single spray of 1% fresh batch Tergitol at 70% bloom might be economical for conventional growers. Further studies are needed to validate the results, and a cost benefit analysis comparing the above treatments to manual peach thinning is planned.

Introduction

Thinning is essential in peach production in order to balance tree crop load for optimal fruit size for marketing. Thinning can be done at different reproductive stages of the fruit trees such as pre-bloom (dormant floral buds), during bloom (active flowers) and post-bloom (fruits/fruitlets). According to Byers et al. (2008), pre-bloom thinning increases the availability of stored carbohydrates for cell growth to the remaining flower buds. That results into a 10 to 30% increase in fruit size and yield when compared to hand thinning at 40 to 50 days after bloom opening (fruit thinning). The magnitude of the effect on the following year's crop has not been closely studied, but some increase in yield and size may be expected in the following year. Cultivars that naturally produce smaller fruits, produce more flower buds per tree, and/or ripen early in the season usually have a greater economic benefit from pre-bloom and bloom thinning. The crop value

[1] Contact information: Research Associate, Colorado State University Agricultural Experiment Station, Western Colorado Research Center-Orchard Mesa, 3168 B ½ Rd., Grand Junction, CO 81503; Ph: 970-434-3264, x-203; email: ramesh.pokharel@colostate.edu.

[2]Professor/Interim Manager, Colorado State University Agricultural Experiment Station, Western Colorado Research Center-Orchard Mesa, 3168 B ½ Road, Grand Junction, CO 81503.

[3]Research Associate, Colorado State University, Western Colorado Research Center-Orchard Mesa, 3168 B ½ Road, Grand Junction, CO 81503.

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of early thinned trees may increase up to three-fold due to increases in fruit size, yield, and price. Although it is unrealistic to expect all fruit to reach the optimal size and yield when thinned early (bloom thinning), the increased crop value from timely, thorough thinning should be significantly greater than from late (fruit) thinning. Costs of bloom thinning, by hand or chemicals plus follow-up by hand thinning of fruit need to be compared with the costs of hand thinning of fruits one time at 40 to 50 days after blooming.

Trees that are not thinned or are thinned very late (60 days after bloom) may fail to produce an optimal number of flower buds per node or fruiting wood the following year. This phenomenon can resemble biennial bearing in apples. Additionally, over-cropping with commensurate reduction in tree vigor can increase stress and susceptibility to disease, cold injury and shorter tree life. That also results in smaller crops and/or undersized fruit in subsequent years. Extra nutrients through fertilization following an over cropped year cannot compensate for the reduction in carbohydrate reserves stored in the trees from the previous season (Greene et al., 2001). Cultural practices, particularly prudent thinning, are extremely important in assuring level production of flower buds and profitable fruit size. Keeping good records of crop load, yield, and fruit size will help to determine the thinning requirements for a particular variety. In years following bloom thinning or crop loss due to spring weather, counting flower bud numbers prior to thinning is especially helpful in determining the best thinning strategy.

Plant hormone sprays were very effective for apple thinning and were examined for use with peaches. Ethephon (ethylene), naphthalene acetic acid (NAA) salts, and similar hormone formulations can be applied during early fruit development to cause weaker fruitlets to abscise and drop off. However, results with these chemicals in peaches have been inconsistent compared to apples and, thus, these hormones are no longer used for peach thinning. In the Northwest, Tergitol-TMN-6 is an excellent blossom thinner for peach and nectarine at rates of 7.5 to 12.5 ml/liter and sprayed at a liquid volume of 1,870.8 liter/hectare when about 75% to 80% blooms are open (Fallahi et al., 2006). Currently, growers rely on expensive hand thinning and labor shortages often occur during this time. The materials tried in peach thinning in the past can be applicable to conventional growers, but organic growers have no alternatives to manual peach thinning (Fallahi et al., 2006). Thus, two experiments were conducted to compare different plant and mineral oils at different rates and bloom times. Similarly, two separate experiments were conducted with different concentrations of different-aged batches of Tergitol. This information will help growers minimize thinning labor, reduce costs, and achieve higher return.

Methods and Materials

Efficacy of plant and mineral oils on peach thinning: Two experiments testing potential materials for organic producers was conducted during 2008 with treatments applied at 70% bloom. At the WCRC-Orchard Mesa site Redhaven peaches were treated with Stylet-Oil (JMS Flower Co.) at 5 and 10% v/v, pure clove oil at 2, 4 and 6% v/v, and food grade cinnamon oil at 2 and 4% v/v. At the WCRC-Rogers Mesa site Cresthaven peaches were treated with pure cinnamon oil at 2 and 4% v/v, pure clove oil at 2 and 3% v/v, and a combination of pure clove oil at 1% v/v and pure cinnamon oil at 1% v/v. In both experiments these oils were prepared with water and applied to drip via hand sprayer and the control was a spray of water alone.

Efficacy of Tergitol in peach thinning: Two experiments were conducted during 2008 to evaluate the efficacy of Tergitol® TMN-6 (90% Aqueous; Union Carbide Corp.) on peach thinning. One study was conducted on Redhaven peaches at the WCRC-Orchard Mesa site including different concentrations (0.75 and 1% v/v) and ages of Tergitol (fresh batch vs. an old, 3+ year-old batch) applied at 30% bloom or at 30% + at 70% bloom. Similarly, at 1% v/v and at 2% v/v of fresh Tergitol and 1% v/v old Tergitol were applied to drip via hand sprayer on Cresthaven peaches at the WCRC-Rogers Mesa site at 70 % bloom only. Each concentration was diluted in water and the control treatment was a water only application.

Fig. 1. Non-damaged Redhaven peach blossoms in the water-only control treatment at the W. Colo. Research Center – Orchard Mesa station, Grand Junction, CO in 2008. (photo by R. Pokharel).

All these thinning experiments used a randomized block design with five replications. Formal statistical analysis awaits the repetition of the study in 2009. The trees were tagged with different colored flags just before treatment applications. To avoid drift effect, only one side of the trees was sprayed and the other side left untreated. In all experiments, numbers of flowers killed per treatment were counted out of total of 100 flowers observed in a twig/limb a week after treatment application; if a twig had less than 100 flowers, a nearby twig was included to make a hundred. The numbers of fruits on the treated sides of the trees were also counted at 45 days after treatment application to evaluate the thinning efficacy of the different treatments and the data expressed in percentages.

Fig. 2. Fruit set on water-only control treatment in Cresthaven peach at the W. Colo. Research Center – Rogers Mesa station, Hotchkiss, CO in 2008 (photo by R. Pokharel).

Results

Efficacy of plant and mineral oils: Results from the two sites were similar. The water control killed no flowers and did not reduce fruit numbers at either site (Tables 1 & 2, Figs. 1 & 2). At the Orchard Mesa site (Table 1), all concentrations of pure clove oil (2%, 4%, and 6%) had high flower mortality of 78 - 88% (Fig. 3)and substantial reductions in fruit numbers of 61 - 70% (Fig. 4). Stylet-Oil at 5% and 10% killed no flowers, but fruit numbers were reduced by 50 and 67%, respectively. Food grade cinnamon oil at 2% and 4% had fruit numbers reduced by 30 and 32%, respectively, despite having killed only 5% of the flowers for each treatment. At the Rogers Mesa site (Table 2), where pure cinnamon oil was used, the pure cinnamon oil at 2% and at 4% killed the greatest number of flowers (79% and 87%, respectively) while pure clove oil at 2% and at 3% killed 66% and 69% of flowers, respectively; however, both the pure oils had the same reduction in fruit numbers, 62 - 64%. The combination of pure clove oil at 1% v/v + pure cinnamon oil at 1% killed only 55% of flowers and had only 45% reduction in fruit numbers; the water control again killed no flowers and had no reduction in fruit numbers. It was noted that shoot stems and newly emerged leaves were also damaged by the pure clove oil treatments, especially the 6% v/v

Fig. 3. Cresthaven peach blossoms killed by application of 2% clove oil at 70% bloom at the W. Colo. Research Center – Rogers Mesa station, Hotchkiss, CO in 2008. (photo by R. Pokharel)

treatment, at both sites (Fig. 5); no comparable phytotoxicity to foliage or shoot stems was observed for the Stylet-Oil or the food grade cinnamon oil treatments at the Orchard Mesa site. But branches with the damaged leaves and shoots showed little impact of this damage later in the season as treated branches had better foliage coverage and more desirable fruit densities at fruit maturity.

Efficacy of Tergitol: At both sites, neither the water-only control nor the "old" batch of Tergitol killed more than a few flowers, and neither reduced fruit numbers. In contrast, applications of fresh Tergitol reduced both flower survival and fruit numbers impressively; both single applications of 1% and 2% fresh Tergitol at 30% or at 70% bloom and double applications of 1% fresh Tergitol at 30% and 70% bloom were effective (Tables 3 & 4, Figs. 6 & 7). The only exception for fresh Tergitol was the application of fresh Tergitol at 0.75% v/v at 30% bloom at the Orchard Mesa site. No leaf phytotoxicity was observed at either site for any of the Tergitol treatments, but widespread necrosis of flower parts (sepals, petals, pistils, stamens, and peduncles) was observed on treated branches.

Fig. 4. Cresthaven peach fruit set following treatment with 2% clove oil applied at 70% bloom at the W. Colo. Research Center – Rogers Mesa, Hotchkiss, CO in 2008. (photo by R. Pokharel).

Discussion

The differences in flower mortality responses at the two sites for pure clove and pure cinnamon oil compared to that for food grade cinnamon oil are striking. It would appear that the food grade cinnamon oil probably is not as effective as the pure cinnamon oil or the pure clove oil. Stylet-Oil was omitted in the treatments at the Rogers Mesa site based, in part, on the lack of flower mortality observed within the days immediately following treatment. In retrospect, both concentrations of Stylet-oil probably should have been included at the Rogers Mesa site as well, given the comparable efficacy in fruit count reduction observed for the 10% v/v Stylet-Oil (67%) to that observed for the pure clove oil at 4% and 6% v/v (69 - 70%). It would appear that Stylet-Oil at 10% v/v applied at 70% bloom merits additional study because of its current organic registration for use on peach and the lack of any observed phytotoxicity to leaves or shoot stems. Similarly, 2 - 4% dilutions of pure clove and of pure cinnamon oil applied at 70% bloom also merit additional study, given their 60 - 70% reduction in fruit counts they produced; but these materials currently lack EPA registration needed for this

Fig. 5. Redhaven peach blossoms killed by application of 6% clove oil at 30% bloom at the W. Colo. Research Center – Orchard Mesa station, Grand Junction, CO in 2008. (photo by R. Pokharel)

Fig. 6. Redhaven peach blossoms killed by application of 1% fresh Tergitol solution at 30% and again at 70% bloom at the W. Colo. Research Center – Orchard Mesa station, Grand Junction, CO in 2008. (photo by R. Pokharel)

use on peaches (and other stone fruit), and it will be necessary to identify an entity to back that process.

Only fresh Tergitol was effective in thinning blossoms and fruit; the "old" batch was not, regardless of concentration used or whether applied one time or two times. The use of 1% fresh Tergitol applied at 70% bloom might be the most effective use of material and labor given the response to that concentration at both sites. Reduction in blossom and fruit numbers were very similar for that concentration of fresh Tergitol when applied at 70% bloom at the Rogers Mesa site (Table 4) and when applied once at 30% bloom and when applied twice, at both 30% and again at 70% bloom, at the Orchard Mesa site (Table 3).

It appears that the Tergitol material used should be fresh, not stored for several years as was the case for the "old" Tergitol material (3+ years old) used in these studies. Tergitol® TMN-6 (90% Aqueous) is a nonionic wetting agent. It is chemically manufactured by the reaction of 2,6,8-trimethyl-4-nonanol with ethylene oxide (Anonymous, 1996). According to the manufacturer, slow degradation of Tergitol will occur under air storage (Anonymous, 1966); that is a probable reason for the ineffectiveness of the "old" Tergitol materials used in these studies.

The efficacies observed for fresh Tergitol are comparable to those found by Fallahi et al. (2006) and demonstrate the validity of those results for Colorado conditions.

Conclusions

The results support the proposal that cinnamon oil, clove oil, and mineral oils such as Stylet-Oil could be used for peach thinning by organic growers and Tergitol used for the same by conventional growers.

Costs of each of these must be competitive with manual thinning. We compared the cost for manual thinning vs. cinnamon oil or clove oil and found the cost of plant oils to be very similar. Thus there isn't a strong economic benefit for using these instead of manual thinning unless less costly sources can be found

Fig. 7. Cresthaven peach fruit set after application of 1% fresh Tergitol solution at 70% bloom at the W. Colo. Research Center – Rogers Mesa station, Hotchkiss, CO in 2008. (photo by R. Pokharel)

for these plant oils or for Tergitol. Advantages and disadvantages exist for both options, so the best option might be to use a combination of both in order to minimize frost injury risk, enhance uniform fruit distributions, and enhance consistent cropping. And oils might provide an alternative for fruit thinning in peaches should labor become a limiting factor. The search for effective peach thinning options with reduced costs will be continued.

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Greene, D. W., K.I. Hauschild, and J. Krupa. 2001**.** Effect of blossom thinners on fruit set and fruit size of peaches. HortTechnology 11(2): 179-183.

Table 1. Impact and efficacy of plant mineral oils and concentration applied to drip via hand sprayer at 70% bloom on Redhaven peach flower mortality and fruit reduction during 2008 at the Western Colorado Research Center-Orchard Mesa, Grand Junction, CO.

Treatments (% v/v)	Flower mortality (%)	Fruit count reduction (%)
Stylet-Oil, 5%	0.0	49.9
Stylet-Oil, 10%	0.0	66.7
Clove oil, 2%	77.6	60.8
Clove oil, 4%	86.0	70.3
Clove oil, 6%	88.2	69.0
Cinnamon oil (food grade), 2%	5.0	29.5
Cinnamon oil (food grade), 4%	5.0	31.8
Water only	0.0	0.0

Table 2. Impact and efficacy of oil type and concentration for sprays applied to drip via hand sprayer at 70% bloom on Cresthaven peach flower mortality and fruit reduction during 2008 at the Western Colorado Research Center-Rogers Mesa, Hotchkiss, CO.

Treatments (% v/v)	Flower mortality (%)	Fruit count reduction (%)
Clove oil, 2%	66.2	64.1
Clove oil, 3%	68.8	62.4
Cinnamon oil (pure), 2%	78.8	63.4
Cinnamon oil (pure), 4%	86.6	63.4
Cinnamon oil (pure), 1% + Clove oil, 1%	55.0	44.8
Water	0.0	0.0

Table 3: Effect of Tergitol formulation age (F=fresh; O=old), concentration (0.75% vs. 1%) , and bloom stage application (30% bloom or at 30% +70% bloom) on Redhaven peach flower mortality and fruit number reduction at the Western Colorado Research Center-Orchard Mesa during 2008.

Treatments (% v/v)	Flower mortality (%)	Fruit count reduction (%)
Tergitol (F), 0.75% @ 30 % bloom	4.2	3.8
Tergitol (F), 1% @ 30% bloom	75.4	80.5
Tergitol (F), 0.75 @ 30% + 70% bloom	76.5	71.4
Tergitol (F), 1% @ 30% + 70% bloom	95.4	83.5
Tergitol (O), 0.75% @ 30 + 70% bloom	1.0	4.5
Tergitol (O), 1% @ 30 + 70% bloom	2.4	6.8
Water only	0.0	0.0

Table 4: Efficacy of Tergitol formulation age (fresh F, old, O) and concentration (1% vs. 2% v/v) applied to drip via hand spryer at 70% bloom on Cresthaven peach flower mortality and fruit number reduction during 2008 at the Western Colorado Research Center-Rogers Mesa, Hotchkiss, CO.

Treatments (% v/v)	Flower mortality (%)	Fruit count reduction (%)
Tergitol (F), 1%	85.4	70.5
Tergitol(F), 2%	77.2	83.2
Tergitol (O), 1%	0.0	0.0
Water only	0.0	0.0

Dr. Horst W. Caspari

2008 Research Projects*

Viticulture and enology programs for the Colorado wine industry (Colorado Wine Industry Development Board; H. Larsen, S. Menke, R. Pokharel & R. Zimmerman, CSU)*

Coordinated wine grape variety evaluations in the western US (Viticulture Consortium West)

Coordinated wine grape variety evaluations in the western US (Rocky Mountain Association of Vintners and Viticulturists)

*Sponsors/Cooperators are noted in parentheses.

2008 Publications

Refereed:

Fernández, J.E., S.R. Green, H.W. Caspari, A. Diaz-Espejo and M.V. Cuevas. 2008. The use of sap flow measurements for scheduling irrigation in olive, apple and Asian pear trees and in grapevines. Plant and Soil 305 (1-2):91-104.

Conference Papers:

Einhorn, T., H.W. Caspari, and S. Green. 2008. Estimation of containerized single-stem and split-rooted, non-fruiting apple tree water use using miniaturized heat pulse probes. 7th International Workshop on Sap Flow, 21 -24 October 2008, Seville, Spain.

Non-Refereed WEB Publications:

Caspari, H. 2008. 2007 Grower Survey. on the web at: www.colostate.edu/programs/wcrc/pubs/viticulture/Survey2007.pdf

Caspari, H., and A. Montano. 2008. Cold hardiness of own-rooted grapevine buds grown at the Western Colorado Research Center - Orchard Mesa near Grand Junction, Colorado, 2007/08 (14 updates during 2008). On the web at: www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardiness07.pdf

Caspari, H., and A. Montano. 2008. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Rogers Mesa near Hotchkiss, Colorado, 2007 (6 updates during 2008). On the web at: www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardinessrm07.pdf

Caspari, H., and A. Montano. 2008. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Orchard Mesa near Grand Junction, Colorado, 2008/09 (9 updates during 2008). On the web at: www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardiness08.pdf

Caspari, H., and A. Montano. 2008. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Rogers Mesa near Hotchkiss, Colorado, 2008/09 (8 updates during 2008). On the web at: www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardinessrm08.pdf

Caspari, H., A. Montano, and H. Larsen. 2008. Fruit (and grape) bud cold hardiness, western Colorado, 2008 (1 update during 2008). On the web at: www.colostate.edu/programs/wcrc/pubs/viticulture/fruitcoldhardiness08.pdf

Dr. Ron Godin

2008 Research Projects:*

Irrigation research and demonstration project. (Delta Conservation District, U.S. Bureau of Reclamation, National Resource Conservation Service).
Investigating native grass seed production. (Routt/Medicine Bow National Forest).
Organic hops fertility. (F. Stonaker, Specialty Crops Grant).
Researching native grass and forb seed production under cultivation. (Uncompahgre Plateau Project, U.S. Forest Service, Bureau of Land Management, Public Lands Partnership).
Sunflowers for oil production variety trial. (Bob Hammon, San Juan Biodiesel).

*Collaborators and sponsors in parentheses

Workshops and Presentations:

Four Corners WSARE Organic Weed Management Workshop (Durango, CO)
- Cover crops & green manures for weed management
- Organic weed management research update

Sustainable Hops Growing Workshop (Hotchkiss & Paonia, CO)
- Growing sustainable hops: From rhizomes to beer

Interpreting the Land – Plateau Restoration and Utah Guides and Outfitters (Moab, UT)
- Desert soils
- Land restoration and revegetation

New Mexico Organic Farming Conference (Albuquerque, NM)
- Organic weed management

USAID Farmer-to-Farmer program (Crimea, Ukraine)
- Requirements for long-term vegetable storage.

Dr. Harold J. Larsen

2008 Research Projects:

Viticulture and enology programs for the Colorado wine industry (Colorado Wine Industry Development Board / H. Caspari, R. Zimmerman, R. Pokharel)

Remediation of stone fruit replant problems in Colorado Orchards (R. Pokharel)

Nematode control materials (R. Pokharel)

Resistance to cherry rasp leaf virus infection in Bing sweet cherry on Zee interstem on Citation rootstock (3-yr pot-in-pot study at WCRC-OM; Dave Wilson Nursery / Talbott Farms, Inc.; R. Pokharel)

Peach Split-pit / Soft-suture management study (fruit growers, WCHS, COCMA / M. Rogoyski)

2009 -- New or Continuing Research Projects:

Viticulture and enology programs for the Colorado wine industry (Colorado Wine Industry Development Board / H. Caspari, R. Zimmerman, R. Pokharel)

Remediation of stone fruit replant problems in Colorado Orchards (R. Pokharel)

Management options for Cytospora canker (R. Pokharel)

Nematode control materials (R. Pokharel)

Resistance to cherry rasp leaf virus infection in Bing sweet cherry on Zee interstem on Citation rootstock (3-yr pot-in-pot study at WCRC-OM; Dave Wilson Nursery / Talbott Farms, Inc.; R. Pokharel)

*Cooperators/collaborators/sponsors are noted in parentheses.

2008 Publications:

Refereed:

Pokharel, R.R. and H.J. Larsen. 2008. Incidence, severity and management of Cytospora canker in stone fruits. Phytopathology 98:S126. (abstr.)

Pokharel, R.R. and H. J. Larsen. 2007. The importance and management of phytoparasitic nematodes in western Colorado fruit orchards. J. Nematol. 39(1):96. (abstr.)

Technical Reports / Other Publications / Written Works:

Larsen, H. 2008. Fruit industry outlook -- 2008-2009. Colo. Ag-Forum. 1 p + abstract.

Pearson, C.H. and H.J. Larsen. 2008. The value of agriculture and conducting agricultural research in western Colorado. p. 7-30. *In*: Western Colorado Research Center 2007 Annual Report. Colo. St. Univ., Colo. Agric. Exp. Sta. Technical Report TR08-10. Fort Collins, Colorado. 76 p. (on the web at: http://www.colostate.edu/programs/wcrc/pubs/publications/annrpt/cropyear07/tr08_10.pdf

Pokharel, R.R. and H.J. Larsen. 2008. Plant parasitic nematodes associated with fruit crops in western Colorado. p. 40-48 *In*: Western Colorado Research Center 2007 Annual Report. Colo. St. Univ., Colo. Agric. Exp. Sta. Technical Report TR08-10. Colo. Agric. Exp. Sta. 76 p. (on the web at: http://www.colostate.edu/programs/wcrc/pubs/publications/annrpt/cropyear07/tr08_10.pdf

Pokharel, R.R. and H.J. Larsen. 2008. Effect of season and soil solarization on nematode populations in western Colorado peach orchards. p. 49-57 *In*: Western Colorado Research Center 2007 Annual Report. Colo. St. Univ., Colo. Agric. Exp. Sta. Technical Report TR08-10. Colo. Agric. Exp. Sta. 76 p. (on the web at: http://www.colostate.edu/programs/wcrc/pubs/publications/annrpt/cropyear07/tr08_10.pdf

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Lang, G., J. Freer, H. Larsen, R. Pokharel, T. Robinson, and T. Valentino. 2008. Differences in mineral nutrient contents of dormant cherry spurs as affected by rootstock, scion, and orchard site. Poster presented at the the 9th International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems. Aug. 4-8, 2008 in Geneva, NY.

Non-Refereed WEB Publications:

Caspari, H., A. Montano, and H. Larsen. Fruit (and grape) bud cold hardiness, western Colorado, 2008. http://www.colostate.edu/programs/wcrc/pubs/viticulture/fruitcoldhardiness08.pdf

Larsen, H. Code-A-Phone Message (weekly update during growing season). http://www.colostate.edu/programs/wcrc/pubs/research_outreach/codemessages08.pdf

Larsen, H. Crop phenology program output data report for Cedaredge, CO. (weekly update during spring) http://www.colostate.edu/programs/wcrc/pubs/research_outreach/budscedge.pdf

Larsen, H. Crop phenology program output data report for WCRC-Orchard Mesa, Grand Junction, CO. (weekly update during spring) http://www.colostate.edu/programs/wcrc/pubs/research_outreach/budswcrcom.pdf

Larsen, H. Crop phenology program output data report for WCRC-Rogers Mesa, Hotchkiss, CO. (Weekly update during spring) http://www.colostate.edu/programs/wcrc/pubs/research_outreach/budswcrcrm.pdf

Larsen, H. Western Colorado temperature records for WCRC-Orchard Mesa & WCRC-Rogers Mesa. (as MS Excel spreadsheet files, updated quarterly; Orchard Mesa link: http://www.colostate.edu/programs/wcrc/pubs/research_outreach/tempsom.xls; Rogers Mesa link: http://www.colostate.edu/programs/wcrc/pubs/research_outreach/tempsrm.xls)

Dr. Stephen D. Menke

2008 Research Projects:

Creation of HLA-WCRC position of Associate Professor of Enology and State Enologist, and February 2008 hire of Dr Stephen D. Menke (/Western Colorado Research Center/ Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

Baseline survey of Colorado wineries: status of wine quality and winery economic status (H. Caspari, H. Larsen, S Wallner/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture, Western Colorado Research Center)

Needs assessment, provisions, and operation of enhanced enology laboratory at WCRC-OM (H. Caspari, H. Larsen, R. Pokharel/ Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture,)

Creation of course content for HORT 277 and HORT 477(H. Caspari, H. Hughes/ CSU Department of Horticulture and Landscape Architecture, Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology)

Production of varietal and blended experimental wines from WCRC grapes (H. Caspari/Western Colorado Research Center/ Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture

2009 New or Continuing Research Projects:

Baseline survey of Colorado wineries: status of wine quality and winery economic status (H. Caspari, H. Larsen, S Wallner/ Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture,)

Production of varietal and blended experimental wines from WCRC grapes (H. Caspari/Western Colorado Research Center, Grande River Winery/ Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture

Development of Colorado Wine Quality Training and Assessment Program (D. Caskey, H. Caspari, M. Mazza/ Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture,)

Establishment of baseline aroma profiles for several Colorado varietal wines by GC/MS analysis (H. Caspari, J. Weinke/ Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture,)

Development of proposal for enology, culinary, and agri-tourism center, with CSU commercial shared-premises winery (S Smith, N. Shepherd-Smith/ S Wallner, F. Johnson, L. Sommers, C. Beyrouty, Western Colorado Research Center /Grande River Winery, Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture,)

Microorganism ecology of grapevine rhizosphere and grape bunch by vineyard location and seasonal timing (J. Vivanco, H. Caspari/Peach Fork Farms, Whitewater Hill Vineyards,Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

*Cooperators/collaborators/sponsors are noted in parentheses

Dr. Calvin H. Pearson

2008 Research Projects*

Winter wheat cultivar performance test – Hayden (Mike Williams, Dr. Scott Haley)
Winter wheat cultivar performance test – Fruita
Malting barley cultivar evaluation and demonstration – Fruita (Coors Brewing Co.)
Alfalfa variety performance test (2008-2010) – Fruita (Dr. Jerry Johnson, seed companies, breeding companies, private industry)
Alfalfa germplasm evaluations 2007-2009 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of alfalfa genetic material 2008-2010 – Fruita (Forage Genetics and Monsanto)
Canola cultivar performance test – Fruita (Dr. Jerry Johnson, Kansas State Univ.)
Evaluation of corn hybrid breeding material evaluation – Fruita (Grand Valley Hybrids)
Corn grain variety performance test – Delta (Grand Valley Hybrids)
Evaluation of corn hybrids for blunt ear syndrome – Fruita (Golden Harvest)
Effect of nighttime chilling of aerial phytomass of corn on blunt ear syndrome – Fruita (Golden Harvest Seed Company)
No-till crop production using a kura clover living-mulch system – Fruita (Dr. Joe Brummer, Dr. Neil Hansen)
Establishment of legume species for use in living mulch crop production systems – Fruita (Dr. Joe Brummer, Dr. Neil Hansen)
Evaluation of teff as an alternative crop for western Colorado 2008 (Dr. Joe Brummer, Dr. Neil Hansen)
Pollen movement and outcrossing of sunflower confined in pollination cages – Fruita and Ames, IA (Drs. Candace Gardner and Laura Marek, USDA North Central Regional Plant Introduction Station)
Lep resistant (MIR162) corn: efficacy and yield vs corn earworm – Fruita, Colorado 2008. (Syngenta)
Rubber and resin analysis of guayule tissue using the ASE 200 (Yulex Corporation)

2009 Research Projects* (Continuing, New, or Planned)

Winter wheat cultivar performance test – Hayden (Mike Williams, Dr. Scott Haley)
Malting barley cultivar evaluation and demonstration – Fruita (MillerCoors Brewing Co.)
Alfalfa variety performance test (2008-2010) – Fruita (Dr. Jerry Johnson, seed companies, breeding companies, private industry)
Evaluation of alfalfa genetic material 2010-2012 – Fruita (Forage Genetics and Monsanto)
Alfalfa germplasm evaluations 2007-2009 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of alfalfa genetic material 2008-2010 – Fruita (Forage Genetics and Monsanto)
Alfalfa germplasm evaluations 2009-2011 – Fruita (Dr. Peter Reisen, Forage Genetics)
Oat cultivar performance test – Fruita
Canola cultivar performance test – Fruita (Dr. Jerry Johnson, Kansas State Univ.)
Evaluation of corn hybrid breeding material evaluation – Fruita (Grand Valley Hybrids)
Corn grain variety performance test – Delta (Grand Valley Hybrids)
Vertical temperature variation in a corn canopy – Fruita
Establishment of legume species for use in living mulch crop production systems – Fruita (Dr. Joe Brummer, Dr. Neil Hansen)
On-farm demonstration of a living mulch crop production systems using corn – Loma (Dr. Joe Brummer, Dr. Neil Hansen, Wayne Guccini)
Rubber and resin analysis of guayule tissue using the ASE 200 – Fruita (Yulex Corporation)
Irrigation monitoring for improved efficiency – Fruita (Wayne Guccini, Denis Reich, NRCS)

*Cooperators/collaborators/sponsors are noted in parentheses.

2008 Publications

Pearson, C.H. and D.J. Rath. 2008. A hydraulic press for extracting fluids from plant tissue samples. Industrial Crops and Products doi:10.1016/j.indrop.2008-08-006. available online 23 October 2008.

Pearson, C.H., D.J. Rath, C.M. McMahan, K. Cornish, and M. Whalen. 2008. Standard operating protocol for growing transgenic sunflower plants in contained environments. Online. Crop Management doi:10.1094/CM-2008-0910-01-PS. Published 10 Sept. 2008.

Pearson, C.H., S.M. Ernst, K.A. Barbarick, J.L. Hatfield, G.A. Peterson, and D.R. Buxton. 2008. *Agronomy Journal* turns one hundred. Agron. J. 100:1-8.

Pearson, C.H., S.M. Ernst, K.A. Barbarick, J.L. Hatfield, G.A. Peterson, and D.R. Buxton. 2008. *Agronomy Journal* turns one hundred. p. S19-26. *In*: *Celebrate the Centennial: A collection of articles to commemorate 100 years of Agronomy Journal*. A supplement to *Agronomy Journal.* American Society of Agronomy. Madison, WI.

Pearson, C.H. 2008. Western Colorado alfalfa variety performance test at Fruita 2008. [Online] Available at: http://www.extsoilcrop.colostate.edu/CropVar/.

Pearson, C.H. and H.J. Larsen. 2008. The value of agriculture and conducting agricultural research in western Colorado. p. 7-30. *In*: Western Colorado Research Center 2007 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR08-10. Fort Collins, Colorado.

Pearson, C.H. S. Haley, and J.J. Johnson. 2008. Small grain variety performance test at Hayden, Colorado. p. 31-35. *In*: Western Colorado Research Center 2007 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR08-10. Fort Collins, Colorado.

Pearson, C.H. S. Haley, and J.J. Johnson. 2008. Winter wheat variety performance trial at Fruita, Colorado 2007. p. 36-39. *In*: Western Colorado Research Center 2007 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR08-10. Fort Collins, Colorado.

Pearson, C.H. 2008. Spring-planted malting barley at Fruita, Colorado 2007. p. 63-65. *In*: Western Colorado Research Center 2007 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR08-10. Fort Collins, Colorado.

Pearson, C. H., and Scott Haley. 2008. Irrigated winter wheat variety performance trial at Fruita, Colorado 2007. p. 44-46. *In*: Making Better Decisions: 2007 Colorado Winter Wheat Variety Performance Trials. Colorado State University, Agricultural Experiment Station and Cooperative Extension, Technical Report TR08-08. Fort Collins, Colorado.

Pearson, C. H., S. Haley, and J. Johnson. 2008. Small grain variety performance test at Hayden, Colorado 2007. p. 47. *In*: Making Better Decisions: 2007 Colorado Winter Wheat Variety Performance Trials. Colorado State University, Agricultural Experiment Station and Cooperative Extension, Technical Report TR08-08. Fort Collins, Colorado.

Pearson, C. 2008. 2007 National winter canola variety trial. M. Stamm and C. La Barge (senior authors). Report of Progress 990. Kansas State Univ., Agricultural Experiment Station and Cooperative Extension Service. Manhattan, KS. (I conducted a variety trial at Fruita and the data were published in this report along with numerous other locations around the country.)

Pearson, C. H. 2008. Preface to *Celebrate the Centennial: A collection of articles to commemorate 100 years of Agronomy Journal*. A supplement to *Agronomy Journal.* American Society of Agronomy. Madison, WI.

Pearson, C. 2008. Fertilizer Prices Skyrocket – What Should I do? *In*: Western PhytoWorks (R. Pokharel, ed.). Spring 2008. Newsletter of the Western Colorado Research Center, Agricultural Experiment Station, Colorado State University.

Pearson, C. 2008. Wheat Prices Entice Spring Plantings. *In*: Western PhytoWorks (R. Pokharel, ed.). Spring 2008. Newsletter of the Western Colorado Research Center, Agricultural Experiment Station, Colorado State University.

Pearson, C., and J. Brummer. 2008. Competitive Grant Funds Living Mulch Research Project. *In*: Western PhytoWorks (R. Pokharel, ed.). Spring 2008. Newsletter of the Western Colorado Research Center, Agricultural Experiment Station, Colorado State University.

Dr. Ramesh Pokharel

2008 Research Projects

Internally funded projects (on- going as PI; collaborators in parenthesis).

Cytospora management

Study of chemicals (new materials), *Brassica* byproducts and plant oils for the management of Cytospora disease in stone fruits" (Harold J. Larsen).

Study of carrier materials on the efficacy of chemicals for the management of Cytospora diseases of stone fruits" (Harold J. Larsen).

Nematode management

Efficacy of chemicals such as Basamid and Vydate to plant parasitic nematode, especially the dagger nematodes in fruits and other crops.

Diversity, density and importance of plant parasitic nematodes associated with fruit crops in western Colorado orchards".

Replant management

Efficacy of chloropicrin, methyl iodide and terpene-blend materials on the replant problem of stone fruits. (Harold J. Larsen; partially funded through Arysta).

Effect of soil solarization, mustard green manure, chicken manure, compost and mustard meal cake for the management of replant problems in peach.

Integration of *Brassica* cakes, chicken manure and compost to increase the efficacy of soil solarization in western Colorado. (Rick R. Zimmerman).

Rasp leaf virus and dagger complex

Incidence and severity of cherry rasp leaf virus in western Colorado fruit orchards". (Harold. J. Larsen)

Study of rasp leaf virus and dagger nematode (vector) relationship of cherry." (Harold J. Larsen and Allen Szalanski, University of Arkansas).

Evaluation of cherry rootstock susceptibility to dagger nematode and cherry rasp leaf virus acquisition.

Alternative crops

Study on adaptive performance of alternative fruit crops (Goji berry, edible honey suckles, pistachio and Asian pears) to western Colorado." (Harold J. Larsen).

Vegetables (onion)

Increase efficacy of biofumigation by soil sterilize and integrating with Brassica seed meal cake and poultry manure to manage soil-borne problem in onion (Robert Hammon, 2008-2009) Funded by EPA, PESP.

Response of red and white onions to soilborne pathogens and use of nematicides followed by turkey manure and *Bassica* oil and seed meal cakes.

Survey of plant parasitic nematodes associated onions in Colorado (ongoing). Colorado Onion Growers Association (Bob Hammon).

Other on-going projects

Chemical and non-chemical alternatives to manual thinning in peaches.

Evaluation of apple rootstock performance in saline soils of western Colorado.

Also participating in NC 140 rootstock evaluation trials; peach rootstock and physiology study experiments in 2009, and apple rootstock evaluation trial in 2010.

Non-chemical management of powdery mildew in grapes using oil from different plant species. (Horst Caspari, WCRC Viticulturist).

Initiation and development of a simple molecular laboratory facility at the Western Colorado Research Center - Orchard Mesa (Stephen Menke, WCRC Enologist).

Publications

Refereed:

Pokharel, R. R**.** and H.J. Larsen. 2008. Incidence, severity and management of Cytospora canker in stone fruits. Phytopathology 98: S126.

Workshops:

Reighard, G.L., T. Beckman, R. Belding, B. Black, J. Cline, W. Cowgill, R. Godin, R. S. Johnson, J. Kamas, M. Kaps, H. Larsen, T. Lindstrom, D. Ouellette, R. Pokharel, L. Stein, K. Taylor, C. Walsh, D. Ward and M. Whiting. 2008. Performance of *Prunus* Rootstocks in the 2001 NC-140 Peach Trial. Poster presented at the 9th International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard System. August 4-8, 08, Geneva, NY.

Lang, G., J. Freer, H. Larsen**,** R. Pokharel, T. Robinson, and T. Valentino. 2008. Differences in mineral nutrient contents of dormant cherry spurs as affected by rootstock, scion, and orchard site. Poster presented at the 9th International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard System. August 4-8, 2008 in Geneva, NY.

Annual reports:

Pokharel, R. and H. J. Larsen. 2008. Effect of season and soil solarization on nematode population in western Colorado peach orchard. p. 49-57 *In*: Western Colorado Research Center 2007 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR08-10. Fort Collins, Colorado. (on the web at: http://www.colostate.edu/programs/wcrc/pubs/publications/annrpt/cropyear07/tr08_10.pdf

Pokharel, R. and H. J. Larsen. 2008. Plant parasitic nematodes associated with fruit crops in western Colorado. p. 40-48 *In*: Western Colorado Research Center 2007 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report 06-07. Fort Collins, Colorado. (on the web at: http://www.colostate.edu/programs/wcrc/pubs/publications/annrpt/cropyear07/tr08_10.pdf

Newsletter articles:

Pokharel, R. 2008. Natural and Bio-fumigants: Potential Options for Disease Management in Western Colorado. *In*: Western PhytoWorks. Spring 2008. Newsletter of the Western Colorado Research Center, Agricultural Experiment Station, Colorado State University.

Dr. Rick Zimmerman

2008 Research Projects:*

Impact of different organic soil amendments on nematode populations. (Pokarel, R.).
Using trap crops to manage beet leafhopper populations and the transmission of beet curly top virus to commercial tomato plantings.
Utilizing the interactions between sunflowers, sunflower aphids and European paper wasp as a method for minimizing European paper wasp feeding damage on table and wine grapes.
Evaluation of Cobalt insecticide for control of corn earworm, *Heliothis zea*, in sweet corn.
Potential of strip planting of buckwheat to provide nectar and pollen to native natural enemies and honeybees
Survey for exotic lepidopteran and coleopteran pests of fruit and ornamental plantings. Delta County, Colorado. (Cooperative Agricultural Pest Survey, NAPIS, USDA/APHIS).
Survey for European corn borer in commercial Western Colorado Sweet Corn fields. (Western Colorado Sweet Corn Administration Committee).

*Collaborators and sponsors in parentheses

Reports:

Zimmerman, R. 2008. Survey Results: Exotic Lepidopteran and Coleopteran Pests of Fruit and Ornamental Plantings. Delta County, Colorado. Prepared for: the Cooperative Agricultural Pest Survey, NAPIS, USDA/APHIS.
Zimmerman, R. 2008. Survey Results: European Corn Borer in commercial Western Colorado Sweet Corn fields. Prepared for: the Western CO Sweet Corn Admin. Com. and the Colorado State Dept. of Agriculture.