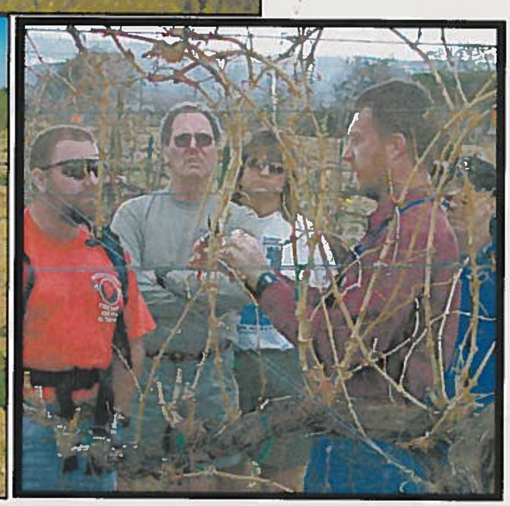
Colorado State University

Technical Report - TR11-11

Agricultural Experiment Station

College of Agricultural Sciences

Extension



Contents

Foreword

During 2010, Dr. Lee Sommers, Director of the Colorado Agricultural Experiment Station (AES) conducted several listening sessions and a survey to determine future program direction for Western Colorado Research Center. Of the four areas identified by respondents, Fruit Production Systems was cited most often followed by Alternative/Specialty Cropping Systems.

A search has been initiated for an Assistant Professor for Fruit Crop Management who will be based at WCRC-Orchard Mesa. The position responsibilities describe a successful candidate as one who will develop an active, extramurally funded and innovative research and extension program in the area of horticultural crop production with an emphasis on fruit orchard management. The program is expected to be systems-based and multidisciplinary in collaboration with other scientists and extension personnel.

The WCRC–Rogers Mesa site will officially close as of June 30, 2011. The operations will wind down through harvest and data collection into October. We thank George Osborn and Dr. Rick Zimmerman for their assistance during this difficult period for them in winding down the site and activities. We wish them well.

We have expanded the content of Western Colorado Phytoworks and this Western Colorado Research Center Annual Report to include some research and extension projects that are being conducted by Tri-River and Western Regional Extension personnel. As you will note from the articles that are included in this Annual Report, some of the research is conducted by AES scientists and Extension personnel on WCRC sites as well as off-site at other locations with cooperators.

Earlier this year, the *2011 Utah-Colorado Commercial Tree Fruit Production Guide* was published by Utah State University Extension and the Western Colorado Research Center, Colorado State University. Copies may be obtained through Utahpests.usu.edu/IPM or www.colostate.edu/programs/wcrc/. In July, we expect the publication release of Colorado State University Agricultural Experiment Station and Extension Technical Bulletin TB11-02 *Intermountain Grass and Legume Forage Production Manual (2nd ed)*. This publication was edited by Dr. Calvin H. Pearson, Dr, Joe Brummer, and Robert Hammon and will be available through Extension Resource Center for $25 each.

Frank Johnson
Associate Director, CAES
Interim Manager and Editor, WCRC

Site descriptions

Fruita Site

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

The Fruita site is located 15 miles northwest of Grand Junction. With an average growing season of 180 days at an elevation of 4600 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
Tel (970) 434-3264 *fax* (970) 434-1035

The Orchard Mesa site is located 7 miles southeast of Grand Junction. Site elevation is approximately 4700 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
Tel (970) 872-3387 *fax* (970) 872-3397

The Rogers Mesa site is located 17 miles east of Delta and 3 miles west of Hotchkiss at approximately 5800 ft. above sea level. With an average growing season of 150 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. Frank Johnson was editor.
Donna Iovanni was publisher.

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Dr. Gennaro Fazio, Plant Genetic Resources, Agricultural Research Service, U.S. Dept. of Agriculture, Geneva, NY
Drs. Raymond Mock and Ruhui Li, National Germplasm Resources, Agriculture Research Service, USDA, Beltsville.
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Chad Humphries
Olathe Spray Service
Gowan Company LLC
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Wayne Brew - Farmer cooperator, Olathe

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Dan Crabtree, Water Conservation Field Services Program, US Bureau of Reclamation
National Resource Conservation Service.
Department of Horticulture & Landscape Architecture, Colorado State University
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Grand Valley Hybrids
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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/.

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SECTION I

Agronomic Crops

The Impact of Field Evaluations of Alfalfa Breeding Material at the Western Colorado Research Center at Fruita 1995-2010

Calvin H. Pearson[1] and Peter Reisen[2]

Summary

Field testing of new breeding material for crops is essential to the success of any public or private research and development program resulting in new crop cultivars that are productive and profitable to producers. It is important to test crop breeding material in a sufficient number of environments to determine in which locations specific breeding material is best adapted. The objective of our research was to evaluate alfalfa (*Medicago sativa* L.) breeding material at the Colorado State University (CSU) Western Colorado Research Center (WCRC) at Fruita to identify alfalfa genetic material developed by Forage Genetics International (FGI) that is best adapted to western Colorado and other similar production environments. Over the 15 years of conducting FGI alfalfa trials from 1995-2010 we have conducted ten trials, three of which evaluated Roundup-Ready alfalfa material. Over twenty varieties have been developed for commercial production in the 15 years of testing. The decision on marketing these cultivars was due, in large part, to their performance in the trials at Fruita. Estimates of acres of these alfalfa varieties planted between 2005 and 2010 (based on seed sales and an 18 lb. seeding rate) are in excess of 3.1 million acres annually. Developing strong university/industry collaborative relationships are valuable in conducting research projects that not only benefit the university and industry but are also highly beneficial to the agricultural industry.

Introduction

At the CSU-WCRC-Fruita we have conducted forage yield performance trials for alfalfa varieties each year for several decades. For commercial forage yield performance trials, industry was solicited to submit alfalfa varieties of their choosing. They paid a fee to the university for each variety they submitted for evaluation. In return, they received yield data by cutting during the three-year testing period. The results of these trials were published annually and were made available to the company and to the public www.csucrops.com (Pearson and Golus, 1990; Pearson and Golus, 1993; Pearson et al., 1996; Pearson, 2007b; Pearson, 2004a; Pearson, 2004b).

We have conducted cooperative research with Forage Genetics International (FGI) since 1995 to test alfalfa germplasm developed by FGI for its forage performance in western Colorado. The

Fig. 1 Alfalfa plants exhibiting "white flagging" are diagnostic for stem nematode infestations. Photo by Calvin H. Pearson.

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data obtained at WCRC-Fruita are invaluable to FGI's evaluation and selection process for developing new alfalfa varieties. Many new alfalfa varieties developed by FGI have been subsequently made available to producers for planting, not only for our producers in western Colorado but in many other locations in the country.

Fig. 2 Automated forage plot harvester used to harvest alfalfa plots at WCRC – Fruita. Photo by Calvin H. Pearson.

In western Colorado we have a severe infestation of alfalfa stem nematodes (*Ditylenchus dipsaci*). These microscopic round worms have an adverse affect on forage yields of alfalfa and as the alfalfa stand gets older the nematode population increases. A diagnostic tool for stem nematodes is white flagging that can be visually observed by the white stems sporadically occurring in a field (Fig. 1). In western Colorado we have observed white flagging to occur in all four cuttings, although white flagging occurs more often in the second and third cuttings. The economic means of coping with stem nematodes is to identify alfalfa cultivars that are tolerant.

The objective of our research was to evaluate alfalfa breeding material at CSU-WCRC-Fruita during 1995-2010 to identify experimental cultivars developed by FGI that are best adapted to western Colorado and other similar production environments where alfalfa stem nematodes are present. The ultimate goal is to provide new and better alfalfa varieties developed by FGI to producers in the region.

Materials and Methods

Studies to evaluate alfalfa breeding materials were conducted at the CSU-WCRC-Fruita beginning in 1995. All FGI alfalfa studies were randomized complete blocks with four replications. The elevation at Fruita is approximately 4600 feet. The average annual precipitation is 8.4 inches and the average frost-free days are 181. Fertilizer applications, mostly phosphorus sources, were broadcast applied and plowed down prior to planting. Application rates were sufficient to meet plant needs for the three-year testing period.

Herbicides were applied in early spring each year to control weeds. On rare occasion, insects, mainly alfalfa weevil, caused economic damage and an insecticide was applied either by air or with a ground applicator to provide control of the insect infestation. Experiments were furrow-irrigated with gated pipe or siphon tubes using irrigation water from the Colorado River delivered through a canal system.

Plots were harvested using an automated, forage plot harvester (Fig. 2, 3: Pearson and Robinson, 1994; Pearson, 2007a).

Fig. 3 Plot area showing alfalfa following harvest. Photo by Calvin H. Pearson.

Results and Discussion

Adequate irrigation water was available each growing season and was not a limiting factor for crop production. Weed control was excellent each year over the testing period.

Over the past 15 years of testing we have conducted ten trials, three of which evaluated Roundup-Ready alfalfa material. The latest of these trials was planted in fall 2010 from which data will be collected during 2011-2013 (Table 1). In most trials, four cuttings were obtained each year. Over this testing period, we planted two trials that were lost because of heavy rains that occurred shortly after planting that caused severe crusting and prevented seedlings from emerging.

In recent years, once plots are harvested the alfalfa is green chopped, trucked from the field, and the field is irrigated within two to three days after harvest (Fig. 4). This allows us to maximize forage production during the growing season and push the genetic potential for forage yield of this breeding material.

The average yield per cutting during this 15-year testing period ranged from a low of 1.15 oven dry tons/acre to a high of 1.56 oven dry tons/acre. This range in yields from trial to trial could be a result of field locations of the trials and/or year effects.

Over twenty varieties have been developed for commercial production in the 15 years of testing. The decision on marketing these cultivars was due, in large part, to their performance in the trials at Fruita. Estimates of acres of these new alfalfa varieties planted between 2005 and 2010 (based on seed sales and an 18 lb. seeding rate) are in excess of 3.1 million acres annually. Primary states in the western U.S. where stem nematode can be a particular problem are Colorado, Wyoming, Montana, New Mexico, Utah, Idaho, Nevada, Oregon, Washington, and Northern California.

There are various primary audiences we target as outlets for our research results and outreach efforts. For our traditional clientele, the hay grower, the information from these trials can help them in selecting adapted varieties best suited for their production practices. For private companies the data from these trials are essential in determining which of their products are best adapted for their market areas in the western states where nematodes are present.

Fig. 4 Once plots are harvested the alfalfa is green chopped and the field irrigated within 2-3 days of harvest. Photo by Calvin H. Pearson.

Developing strong university/industry collaborative relationships, such as the one between CSU and FGI are valuable in conducting research projects that not only benefit the university and industry but are also highly beneficial to the agricultural industry. In the case of CSU and FGI, the results of collaborative research and development efforts are new alfalfa varieties developed for commercial agriculture in the region.

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We thank Fred Judson, Greg Irwin, and former CSU technicians and summer hourly assistants who have, over the years, assisted with the fieldwork associated with this project.

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Trial	Planting date	Trial type	Number of entries	Total yield (tons/acres)	Total no. of cuttings	Average yield per cutting (dry tons/acres)
1995-1997	Aug. 24, 1994	Conventional	24	16.94	12	1.41
1996-1998	May 1, 1996	Conventional	24	17.17	11	1.56
1998-2000	Aug. 29, 1997	Conventional	25	17.21	12	1.43
2000-2002	Aug. 25, 1999	Conventional	25	16.65	12	1.39
2002-2004	Sept. 6, 2001	Conventional	25	16.42	12	1.39
2004-2006	May 11, 2004	Conventional	25	16.77	11	1.52
2005-2007	Aug. 26, 2004	Roundup Ready	30	16.10	12	1.34
2007-2009	Aug. 24, 2006	Conventional	25	14.92	12	1.24
2008-2010	Aug. 23, 2007	Roundup Ready	25	13.78	12	1.15
2009-2011	Aug. 21, 2008	Conventional	30	12.33	8	1.54
2011-2013[1]	Sept. 2, 2010	Roundup Ready	25	na	na	na

Table 1 Eleven alfalfa forage trials conducted at the Western Colorado Research Center – Fruita in cooperation with Forage Genetics International, Inc. during 1995-2011.

[1] na = not available. This is a new study that was planted in fall 2010 and yield data will be collected over the next three years from 2011-2013.

Field Performance of Oat Varieties at Fruita, Colorado 2009-2010

Calvin H. Pearson[1,2]

Summary

Oats (*Avena sativa* L.) are an important crop in Colorado, including western Colorado. Although oats do not command a large acreage, they have been a mainstay in Colorado for decades. A field study was conducted for 2 years during the 2009 and 2010 growing seasons to evaluate new and "old" oat varieties for yield and related characteristics under field conditions at the Western Colorado Research Center (WCRC) at Fruita, which is located in the Grand Valley of western Colorado. Oats were spring-planted and harvested during late July or early August each year. Weed control was excellent both years. Adequate irrigation water was available during both growing seasons. Average grain yield in 2009 and 2010 was 5020 lb/acre (157 bu/acre) and 4623 lb/acre (144.5 bu/acre), respectively. The highest average yield over the 2-year testing period was 6,247 lbs/acre (195 bu/acre) for Monico. Grain moisture content averaged 10.6% in 2009 and 12.6% in 2010. Test weight averaged 41.8 lb/bu in 2009 and 39.1 lbs/bu in 2010. Data were also collected for days-to-flowering and days-to-harvest maturity, plant height at maturity, and lodging. Grain yields of many oat varieties tested in 2009 and 2019 were excellent. The results of this research indicate that several oat varieties should produce high grain yields in the Grand Valley and other similar locations.

Introduction

Oats are an important crop in Colorado, including western Colorado. In 2009, oats were grown on 60,000 acres in Colorado creating a farm gate value of $1.3 million (USDA, 2010). Although oats do not command a large acreage, they have been a mainstay in Colorado for a long time (Table 1).

Production technology is continually changing which creates the need to evaluate new oat varieties and compare them to varieties that have been grown traditionally. We conducted spring oat variety performance trials at Fruita, Colorado in 1999 (Pearson et al., 2000a) and in 2000 (Pearson et al., 2000b).

Fig. 1 Dr. Calvin Pearson taking field notes in the 2010 oat variety performance trial at Western Colorado Research Center at Fruita. Photo by Crosby Rock.

Variety yield performance data can be used by a number of people including 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 have good end-use applications, and university personnel in

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Mention of a trade name or proprietary product does not imply endorsement by the author, the Agricultural Experiment Station, or Colorado State University.

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

Fig 2 Harvesting the oat variety performance trial at the CSU Western Colorado Research Center at Fruita on July 29, 2009. Photo by Calvin Pearson.

The objective of this 2-year field study conducted during the 2009 and 2010 growing seasons was to evaluate new and “old” oat varieties at the Western Colorado Research Center (WCRC) at Fruita, which is located in the Grand Valley of western Colorado.

Materials and Methods

Twenty-two oat varieties were evaluated at WCRC–Fruita during 2009 and 2010. Four of the oat entries (Buff, Lamont, Provena, Streaker) were hull-less or “naked-seeded” oats. This means that when harvested the lemma and palea on the oat seed are removed, similar to that which occurs in wheat.

The trial location for the research center is at N 39° 10.755’, W 109° 41.932’ and at an elevation of 4600 feet. The experiments in both years were randomized, completed blocks with four replications with a plot size of 5 feet wide by 40 feet long. The previous crop was dry bean in 2009 and corn in 2010. Best management practices were used throughout the growing season in both years to optimize grain production. Planting occurred on March 31, 2009 and April 20, 2010 at 88 lbs seed/acre. Seeding rates for naked-seeded varieties were increased by 25% and because of the low seed quality of Powell and Rio Grande, their seeding rates were also increased by 25%,

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

Prior to planting, a broadcast application of 200 lbs/acre of 18-46-0 was made on March 25, 2009. No preplant fertilizer was applied in 2010. A top-dress application of 70 lbs N/acre of urea was applied each year (May 12, 2009; May 18, 2010).

An application of 0.6 oz/acre of Harmony Extra and 12 oz/acre of 2,4-D (4 lbs per gallon) plus 1 qt of Bio90 in 60 gallons of water was applied on May 8, 2009 at 20 gallons per acre and 30 psi for weed control. In 2010, an application of 15 oz/acre of Huskie plus 8 oz/acre of 2,4-D ester plus 1 qt of Activator 90 plus 1 gallon of urea ammonium nitrate fertilizer in 100 gallons of water was applied on May 15 at 20 gallons per acre and 30 psi.

Oats were harvested on July 29, 2009 and Aug. 18, 2010 using a plot combine. Grain moistures and test weights were determined using a Dickey-John GAC 1200B seed analyzer. Grain yields were corrected and reported on a 12% moisture basis.

Fig. 3 Oat Variety Performance Trial at the CSU Western Colorado Research Center at Fruita, Colorado in 2009. Photo by Calvin Pearson.

Results and Discussion

Weed control was excellent in both years (Figs. 1, 2, 3). Adequate irrigation water was available during both growing seasons and was not a limiting factor for crop production. Six irrigations were applied to the oats in 2009 and five irrigations were applied in 2010 (Table 2).

Overall, spring in 2009 and in 2010 was cool during April, May, and on into June, which favored small grain production.

Average grain yield in 2009 and 2010 was 5020 lb/acre (157 bu/acre) and 4623 lb/acre (144.5 bu/acre), respectively (Table 3). The highest grain yield obtained in 2009 was 6,726 lb/acre (210.2 bu/acre) for Monico and the highest grain yield obtained in 2010 was 5917 lb/acre (184.9 bu/acre) for Maverick. The highest average yield over the 2-year testing period was 6,247 lbs/acre (195 bushels/acre) for Monico. The lowest 2-year average grain was 3432 lbs/acre (107 bushels/acre) for Stallion. The 2-year average yield difference between these two varieties was 88 bushels/acre.

Fig. 4 Harvesting the oat variety performance trial at the CSU Western Colorado Research Center at Fruita on August 18, 2010. Photo by Calvin Pearson.

Grain moisture content in 2009 averaged 10.6% and ranged from a low of 9.6% for Ajay to a high of 12.4% for Provena (Table 4). Grain moisture content in 2010 averaged 12.6% and ranged from a low of 11.0% for Ajay and Maverick to a high of 14.5% for SD31128-330.

Test weight in 2009 averaged 41.8 lb/bu and ranged from a high of 50.7 lbs/bu for Buff to a low of 33.4 lbs/bu for Ajay (Table 4). Test weight in 2010 averaged 39.1 lbs/bu and ranged from a high of 46.5 lbs/bu for Provena to a low of 35.2 lbs/bu for Ajay. Ajay had the lowest grain moisture content and the lowest test weight in both years.

Days-to-flowering averaged 65 days in 2009 and 58 days in 2010 (Table 5). Days to flowering were lowest for Buff and Colt in 2009 at 59 days and were also lowest for Buff and Colt in 2010 at 52 days when compared to other varieties in that year. Ajay took the longest time to flower in 2009 at 70 days and Lamont, Maverick, and Provena took the longest time to flower in 2010 at 63 days.

Days-to-harvest maturity averaged 113 days in 2009 and 121 days in 2010 (Table 5). Colt was the first variety to reach harvest maturity in 2009 at 110 days. Provena and SD31128-245 took the most time to reach harvest maturity in 2009 at 116 days. In 2010, all varieties reached harvest maturity within three days of each other.

Fig. 5 Harvested oats in a large poly tote bag from the 2010 harvest at the CSU Western Colorado Research Center at Fruita. Photo by Calvin Pearson.

Average plant height in 2009 and 2010 was 49.7 and 37.6 inches, respectively (Table 5). Beach was the tallest variety at 56.0 inches and Ajay was the shortest at 42.4 inches in 2009. In 2010, Monida was slightly taller (41.9 inches) than Beach (41.8 inches) and again Ajay was the shortest variety at 30.8 inches.

Stallion experienced the most lodging in 2009 and in 2010 (Table 5). Several varieties had lodging scores of less than 1.0 in both years.

Grain yields of many oat varieties tested in 2009 and 2010 were excellent. The results of this research indicate that several oat varieties should produce high grain yields in the Grand Valley and other similar locations.

Acknowledgments

Appreciation is extended to Fred Judson and Greg Irwin (Western Colorado Research Center staff), and Brittanie Steele and Crosby Rock (part-time hourly employees) who assisted with this project.

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Year	Planted	Yield	Value	Total value
	acres	bushels per acre	dollars per bushel	$million
2000	80,000	63	1.90	4.2
2001	80,000	60	2.20	4.2
2002	65,000	50	2.90	1.2
2003	100,000	65	2.06	2.0
2004	75,000	55	2.02	2.2
2005	75,000	75	2.33	2.6
2006	85,000	70	2.70	1.9
2007	75,000	55	3.25	1.8
2008	45,000	70	3.30	1.6
2009	60,000	65	2.30	1.3

Table 1 Number of planted acres, yield per acre, dollars per bushel, and total state value of oats grown in Colorado from 2000-2009 (USDA, 2010).

Date	Irrigation (hours)
2009	
April 17	7.5
April 30	17
May 12	24
May 21	24
June 6	13
June 22	19
2010	
April 22	18
May 20	12
June 10	24
June 16	16
July 16	17

Table 2 Irrigation dates and length of irrigation of oat varieties evaluated at Fruita, Colorado during 2009 and 2010.

Variety	2009 Grain yield[1]		2010 Grain yield[1]		2-year average grain yield	
	bu/acre	lb/acre	bu/acre	lb/acre	lb/acre	bu/acre
Ajay	167.0	5343.8	172.9	5532.5	5438	170
Beach	161.7	5175.0	147.0	4704.5	4940	154
Buff	153.7	4917.8	125.9	4028.5	4473	140
Colt	159.8	5114.0	134.6	4306.3	4710	147
HiFi	146.9	4699.8	157.0	5024.5	4862	152
Jerry	164.6	5268.3	116.5	3728.5	4498	141
Lamont	140.0	4479.8	144.4	4622.0	4551	142
Maida	183.0	5855.3	123.6	3955.8	4906	153
Maverick	189.3	6059.5	184.9	5917.8	5988	187
Monico	210.2	6726.0	180.2	5767.5	6247	195
Monida	192.3	6153.3	165.8	5303.8	5729	179
Otana	152.8	4888.8	149.7	4790.0	4839	151
Park	169.9	5434.2	144.6	4626.5	5030	157
Russell[1]	148.6	4753.0	-	-	-	-
Provena	133.9	4285.0	121.5	3889.8	4088	128
Rio Grande	137.4	4396.0	161.3	5160.8	4779	149
Rockford	160.9	5149.0	152.1	4867.5	5009	157
SD31128-245	157.5	5039.5	127.3	4072.5	4556	142
SD31128-330	149.3	4777.5	119.0	3807.0	4292	134
Souris	169.5	5423.0	144.7	4630.5	5027	157
Stallion	92.2	2950.0	122.3	3914.5	3432	107
Streaker	110.7	3543.5	105.2	3366.5	3455	108
Ave	157	5020	144.5	4623	4802	150
LSD (0.05)	35.2	1125	19.0	608		
CV(%)	15.9	15.9	9.3	9.3		

Table 3 Grain yield of oat varieties evaluated at Fruita, Colorado during 2009-2010.

[1] Table is arranged by alphabetically by variety name. Grain yields are corrected to 12% moisture.
[2] Seed of Russell was not available in 2010.

Variety[2]	2009 grain moisture	2010 grain moisture	2009 test weight	2010 test weight
	---------------%	--------------	--------------lb/bu	-------------
Ajay	9.6	11.0	33.4	35.2
Beach	10.8	11.9	42.4	40.0
Buff	11.5	12.4	50.7	45.7
Colt	10.2	14.1	42.9	38.0
HiFi	10.7	11.9	41.2	37.4
Jerry	10.2	13.5	42.5	37.6
Lamont	11.8	12.2	45.8	45.0
Maida	10.2	14.4	42.7	36.1
Maverick	10.0	11.0	35.8	37.2
Monico	10.3	11.6	40.2	37.8
Monida	10.5	11.9	37.8	36.0
Otana	10.9	12.0	39.0	38.2
Park	9.8	11.8	39.3	36.4
Russell	10.8	-	38.1	-
Provena	12.4	12.8	49.8	46.5
Rio Grande	10.4	12.2	37.5	35.5
Rockford	10.4	12.8	40.9	39.0
SD31128-245	10.5	14.2	44.2	38.3
SD31128-330	10.4	14.5	43.6	39.0
Souris	10.3	14.0	42.2	37.4
Stallion	10.9	11.8	41.1	40.2
Streaker	11.7	13.0	49.5	46.0
Ave	10.6	12.6	41.8	39.1
LSD (0.05)	1.0	1.3		1.8
CV (%)	6.4	7.4	3.2	3.3

Table 4 Grain moisture and test weight of oat varieties evaluated at Fruita, Colorado during 2009-2010.

Variety[2]	2009 days to flowering[3]	2010 days to flowering[3]	2009 harvest maturity[3]	2010 harvest maturity[3]	2009 plant height	2010 plant height	2009 Lodging[4]	2010 Lodging[4]
	days		days		in.		0.2 – 9.0	
Ajay	70	62	111	122	42.4	30.8	1.0	0.4
Beach	67	59	115	121	56.0	41.8	1.5	0.8
Buff	59	52	112	120	43.3	34.8	0.3	0.4
Colt	59	52	110	120	45.7	32.1	0.9	2.0
HiFi	67	59	112	121	52.1	40.9	2.1	1.9
Jerry	62	54	113	121	53.6	38.6	0.6	0.9
Lamont	69	63	115	120	53.0	39.8	0.6	1.2
Maida	62	55	114	121	49.5	38.9	0.8	3.1
Maverick	69	63	114	121	43.1	36.0	0.7	0.5
Monico	66	59	115	121	50.2	36.0	0.9	1.7
Monida	68	61	115	120	53.1	41.9	2.1	3.6
Otana	68	61	115	120	54.7	38.4	4.5	1.2
Park	69	61	113	120	52.8	39.9	1.9	2.7
Russell	66	-	114	-	51.2	-	3.3	-
Provena	69	63	116	121	43.8	35.9	0.3	0.5
Rio	67	55	113	120	48.2	31.3	4.1	1.1
Rockford	67	61	112	121	53.2	40.8	1.0	1.1
SD31128-	62	55	116	121	51.3	38.1	0.4	0.4
SD31128-	62	54	114	121	48.7	36.9	0.3	0.5
Souris	64	55	111	121	48.1	32.9	1.7	0.7
Stallion	64	55	113	120	49.9	39.7	4.8	4.5
Streaker	62	54	114	120	50.0	37.9	4.6	3.2
Ave	65	58	113	121	49.7	37.6	1.7	1.6
LSD	0.5	0.6	2.2	1.3	2.3	3.5		
CV (%)	0.6	0.8	1.4	0.6	3.3	6.6		

Table 5 Days to flowering, plant height, harvest maturity, and lodging of oat varieties evaluated at Fruita, Colorado during 2009-2010.

[2] Table is arranged by variety order as per Table 1.
[3] Determined from day of planting.
[4] lodging scale, 0.2=no lodging, 9.0=completely lodged.

The Impact of Field Evaluations of Corn Grain Breeding Material at the Western Colorado Research Center at Fruita 2007-2010

Calvin H. Pearson[1] and Bill Rooks[2]

Summary

Field testing of new breeding material for crops is essential to the success of any public or private research and development program resulting in new crop cultivars that are productive and profitable to producers. It is important to test crop breeding material in a sufficient number of environments to determine in which locations specific breeding material is best adapted. The objective of this research project was to evaluate corn (*Zea mays* L.) grain breeding material at the Western Colorado Research Center (WCRC) at Fruita in 2007 through 2010 to identify material best adapted and desirable to western Colorado and other similar production environments. Over the four years of testing Grand Valley Hybrids (GVH) advanced corn genetic material we planted and harvested 4,889 plots at WCRC-Fruita and 264 plots at Olathe, CO. Over the testing period for GVH at WCRC-Fruita and at Olathe, approximately 10 new commercial corn hybrids were selected for commercial release by GVH. Typically, 2-3 new hybrids were identified each year. Estimates are that these new corn hybrids were used to plant 20,000 – 22,000 acres across the GVH sales area. These new corn hybrids were estimated to have a 10 bushel per acre yield increase over current GVH commercial hybrids. New GVH corn silage hybrids were estimated to have a 2.5 ton/acre yield increase over current GVH silage hybrids. Developing strong university/industry collaborative relationships are valuable in conducting research projects that result in benefits to the agricultural industry.

Introduction

Field testing of new breeding material for crops is essential to the success of public and private research and development programs. New corn grain hybrids and advanced breeding materials have been evaluated at the Colorado State University (CSU) Western Colorado Research Center (WCRC) at Fruita for several decades. For many years, corn breeding and corn seed companies were solicited to enter corn hybrids of their choosing (released hybrids and advanced lines) to be evaluated at the WCRC–Fruita, acting as a non-biased third party. Evaluations were conducted on a per entry fee basis and the results were published annually and made available not only to the companies

Fig. 1 Field area showing the genetic variation of the corn entries planted for Grand Valley Hybrids at the CSU Western Colorado Research Center at Fruita during 2010. Photo by Calvin Pearson.

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who entered their hybrids but were also made available to the public including producers and other agricultural clientele. The number of entries submitted for evaluation at WCRC-Fruita declined over the years and in 2006 we decided it was no longer worthwhile to conduct commercial corn hybrid testing at WCRC-Fruita; thus, we discontinued this testing project.

Corn hybrids perform differently in different locations creating what is termed a "genotype x environment interaction." Thus, it is important to test corn breeding material in a sufficient number of environments to determine in which locations corn hybrids are best adapted. This is of critical importance to allow companies to determine which hybrids to commercialize and how to market them.

Much of past corn grain breeding efforts and research and development of new corn grain hybrids have been on grain yield, grain quality, disease resistance, stalk strength, root strength, plant height, and others.

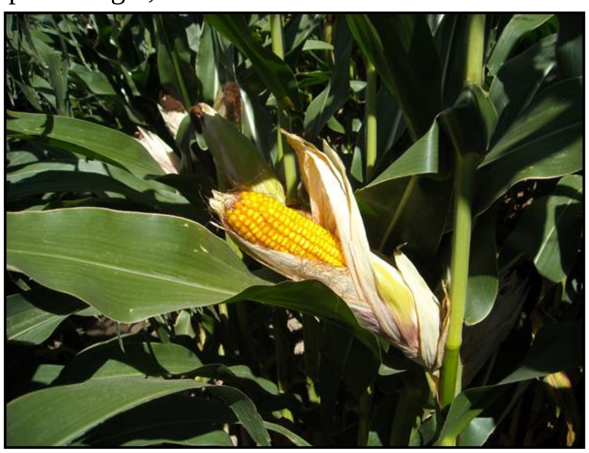

Fig. 2 Mature corn ear grown at the CSU Western Colorado Research Center at Fruita during 2010. Photo by Calvin Pearson.

With the advent of biotechnological tools, new crop traits of commercial value include herbicide resistance, insect resistance, and environmental tolerance such as drought, with many others either in the development process or envisioned.

On September 10, 2010, Dow AgroSciences purchased Grand Valley Hybrids (GVH). Since 2007, we at WCRC-Fruita have conducted advanced corn hybrid genetics testing for GVH. Given the sale of GVH to Dow AgroSciences the testing we have been doing with GVH will come to an end and future corn hybrid genetic materials testing at WCRC-Fruita will be with Dow AgroSciences.

The Grand Valley of western Colorado historically experiences hot, dry weather that can limit the yield potential of grain corn; however, western Colorado has been recognized as an environment in the U.S. for high corn yields [R.C. Muchow, T.R. Sinclair, and J.M. Bennett, Agron. J. 82:336-343 (1990)].

The objective of this research was to evaluate corn grain breeding material at WCRC–Fruita during 2007-2010 to identify GVH corn hybrid genetic material that is best adapted to western Colorado and other similar production environments.

Materials and Methods

Corn grain germplasm was evaluated as a project between CSU-WCRC–Fruita and GVH. A fee was paid by GVH to CSU based on the number of entries evaluated each year. Genetic materials that performed well at Fruita were further evaluated at Olathe, Colorado with a farmer-cooperator. The number of corn plots and planting dates at WCRC-Fruita are presented in Table 1 and those for Olathe are presented in Table 2. Plots were surrounded by border areas to protect the plots and minimize border effects that occur when crop plants are located at the field edge.

The experiments at both Fruita and Olathe were furrow-irrigated with gated pipe. Fertilizers, herbicides, insecticides, and miticides applied each year at Fruita are shown in Table 3 and at Olathe in Table 4.

Plots were harvested at Fruita using a custom-fabricated combine designed to harvest small plots. Harvest dates each year at Fruita are in Table 1 and in Table 2 at Olathe. At Olathe, a commercial grain combine (IH 1460) was fitted with an electronic weighing system and grain from each plot was collected in a weigh bin and weighed to the nearest 0.1 lb. For both locations, a grain sample of approximately 500 grams was collected in a sealable plastic bag during harvest and grain moistures and test weights were determined using a GAC 2010b. All grain yields were calculated on a 15.5% moisture basis.

Results and Discussion

Adequate irrigation water was available each growing season at both Fruita and Olathe and was not a limiting factor for crop production.

Over the four years of testing GVH advanced corn genetic material we planted and harvested 4,889 plots at WCRC-Fruita and 264 plots at Olathe, CO (Tables 1, 2). Plots contained up to three replicates of the same entries and some material was evaluated for more than one year at both Fruita and Olathe.

The corn genetic material evaluated at WCRC–Fruita for GVH had previously been subjected to several generations of screening in Midwest environments prior to being planted at Fruita and Olathe. The corn materials selected for testing at Olathe in most cases were based on their performance at Fruita. Additionally, the corn genetic materials evaluated at WCRC–Fruita and Olathe were compared against commercial corn hybrids that had been grown in many locations under commercial producer conditions within the GVH sales area.

The sales area for GVH was located mainly in western Colorado, Utah, Idaho, and New Mexico. Smaller sale markets were located in eastern Colorado, California, Texas, Wyoming, Kansas, and Nebraska. Corn silage production using GVH hybrids was very important and significant in Idaho and Utah.

Grain yields, grain moistures, and test weights for the corn grain entries evaluated for GVH are summarized in Table 5 for Fruita and for Olathe in Table 6. Over the four years of testing advanced corn genetic material for GVH at WCRC-Fruita and at Olathe, approximately 10 new commercial corn hybrids were selected for commercial release by GVH. Typically, 2-3 new hybrids were identified each year. Estimates are that these new corn hybrids were used to plant 20,000 – 22,000 acres across the GVH sales area. These new corn hybrids were estimated to have a 10 bushel per acre yield increase over current GVH commercial hybrids. New GVH corn silage hybrids were estimated to have a 2.5 ton/acre yield increase over current GVH commercial corn silage hybrids. Additionally, these new hybrids carried special traits such as glyphosate resistant and/or insect resistance. These corn traits were estimated to add another 3% yield increase over current GVH commercial corn hybrids.

Many of the corn hybrids selected for commercial release and production are dual-purpose hybrids, meaning these corn hybrids can be grown for both corn silage and grain. This allows producers to plant a particular hybrid and harvest what is needed for silage and let the remainder of the acreage mature for harvest as grain.

Fig. 3 Plot combine used for harvesting corn grain plots at the CSU Western Colorado Research Center at Fruita. Photo by Calvin Pearson.

Developing strong university/industry collaborative relationships, such as the one between CSU and GVH, are valuable in conducting research projects that are not only beneficial to the university and industry but ultimately have various benefits to the agricultural industry. In the case with CSU and GVH, the result is new corn hybrids for corn grain and silage production developed for commercial agriculture in the region.

Acknowledgments

We thank Fred Judson and Greg Irwin (CSU technicians) who assisted with the fieldwork associated with this project. Our thanks to Wayne Brew as the farmer-cooperator for the trials conducted at Olathe.

References

Year	No. of plots	Planting date	Harvest date
2007	1,281	Apr. 30, May 8, 9	Oct. 29-30; Nov. 11, 15,
2008	1,409	May 6, 7, 8, 12	Oct. 21-22, 23-24, 27-28
2009	1,042	Apr. 29, May 4, May 11	Oct 19-22, Oct. 25-26
2010	1,157	May 14, May 17	Oct. 20-21, Nov. 1-2, Nov. 16-18
Total	4,889		

Table 1 Advanced corn grain genetic material evaluated at the Western Colorado Research Center at Fruita 2007-2010.

Year	No. of plots	Planting date	Harvest date
2007	60	May 10, 2007	Nov. 20, 2007
2008	60	May 9, 2008	Dec. 2, 2008
2009	72	May 12, 2009	Nov. 19, 2009
2010	72	May 20, 2010	Dec. 7, 2010
Total	264		

Table 2 Advanced corn grain breeding material and new hybrids evaluated at Olathe, Colorado 2007-2010.

Year	Herbicide	Fertilizer	Insecticide/Miticide
2007	2.5 qt/acre of alachlor preplant incorporated on May 3	36 lb P_2O_5/acre plus 92 lb N/acre preplant using 18-46-0 and two sidedress applications of 32-0-0 at 85 lb N/acre on June 9	June 28, 2.25 pt/A Comite plus 1 pt/A Dimethoate
2008	1.5 qt/acre of Lasso Microtech preplant incorporated on April 29	Two sidedress applications of 32-0-0 at 85 lb N/acre on June 17	July 8, 2.25 pt/A Comite plus 1 pt/A Dimethoate
2009	2.5 qt/acre of alachlor preplant incorporated on May 8	36 lb P_2O_5/acre plus 92 lb N/acre preplant using 18-46-0 and two sidedress applications of 32-0-0 at 90 lb N/acre on June 10	July 1, 12 oz/A Onager
2010	2.5 qt/acre of alachlor preplant incorporated on May 7	36 lb P_2O_5/acre plus 92 lb N/acre preplant using 18-46-0 and two sidedress applications of 32-0-0 at 100 lb N/acre on June 19	July 9, 10 oz/A Onager

Table 3 Crop production information of advanced corn grain genetic material evaluated at the Western Colorado Research Center at Fruita 2007-2010.

Year	Herbicide	Fertilizer	Insecticide/Miticide
2007	Distinct herbicide at 6 oz/acre during late May	75 lb P_2O_5/acre plus 22 lb N/acre at planting using 10-34-0 and two sidedress applications of 32-0-0 at 100 lbs N/acre on May 30 and 114 lb N/acre on July 1	Comite (1 qt/acre) applied on July 1using a ground rig with drop nozzles
2008	Lasso Microtech preplant at 2 qt/acre and Distinct herbicide at 6 oz/acre during late May	68 lb P_2O_5/acre plus 20 lb N/acre at planting using 10-34-0 and two sidedress applications of 32-0-0 at 100 lb N/acre on June 3 and 100 lb N/acre on July 1	Comite (1 qt/acre) applied during the first week of June using a ground rig with drop nozzles
2009	Lasso Microtech (2 qt/acre) and Distinct (6 oz/acre) during late May	68 lb P_2O_5/acre plus 20 lb N/acre at planting using 10-34-0 and two sidedress applications of 32-0-0 at 100 lb N/acre on June 24 and 100 lb N/acre on July 8	Comite (1 qt/acre) applied during the first week of June using a ground rig with drop nozzles.
2010	Distinct herbicide at 6 oz/acre three weeks after planting	40 lb N/acre and 85 lb P_2O_5/acre using a solution of 10-34-0 and 32-0-0 plus 1.3 lb N/acre, 8 lb P_2O_5/acre, and 8 lb K_2O/acre at planting using 3-18-18 and two sidedress applications of 32-0-0 at 100 lb N/acre on May 29 and 96 lb N/acre on June 26	Comite (1 qt/acre) was applied on June 26 for mite control using a ground rig with drop nozzles

Table 4 Crop production information of advanced corn grain breeding material and new hybrids evaluated at Olathe, Colorado 2007-2010.

Year	Average grain yield	Average grain moisture at harvest	Average test weight at harvest
	bu/acre	%	lb/bu
2007	214	14.6	60.4
2008	177	16.9	60.9
2009	225	16.0	59.4
2010	240	21.8	55.6
Average	214	17.3	59.1

Table 5 Crop yield averages of advanced corn grain genetic material evaluated at the Western Colorado Research Center at Fruita 2007-2010.

Year	Average grain yield	Average grain moisture at harvest	Average test weight at harvest
	bu/acre	%	lb/bu
2007	232	11.7	60.2
2008	226	14.1	58.9
2009	196	13.3	55.4
2010	209	15.4	58.6
Average	216	13.6	58.3

Table 6 Crop yield averages of advanced corn grain breeding material and new hybrids evaluated at Olathe, Colorado 2007-2010.

Evaluation of Aerially Applied Miticides for Banks Grass Mite Control in Field Corn, Olathe CO

Robert Hammon[1,2] & Melissa Franklin[3,4]

Summary

A trial comparing the efficacy of several commercial available and use-registered miticides was conducted near Olathe CO during the 2010 growing season. Treatments were aerially applied by Olathe Spray Service to a commercial grain corn field owned by a cooperating grower. Onager 1E at 10 or 12 oz/A and Oberon 4SC at 4.3 oz/A reduced mite numbers to a greater extent than Comite II at 2.25 pt/A. Onager and Oberon treatments significantly reduced mite counts compared to the untreated control on the 26 and 32 DAT sample dates.

Introduction

Banks grass mite, *Oligonychus pratensis* (Banks), is a major pest of field corn grown in the lower elevation valleys of western Colorado. Mite populations typically begin to build in late vegetative growth stage and can increase to damaging levels after pollen shed. Banks grass mite is a typical spider mite that feeds on the underside of leaves, killing cells and leaving the plant with a brown scorched appearance. Severe infestations can cause significant yield loss or complete crop failure.

Banks grass mite control with Miticides must be preventative in nature. The decision to spray must be made before mite populations build to damaging levels. The majority of commercial corn acreage in the lower valleys of western Colorado is treated annually with Miticides, with propargite (Comite) being the most commonly used product over the past 25 years.

The objective of this project was to evaluate commercially available and use-registered products for efficacy against Banks grass mite in western Colorado grown field corn.

Materials and Methods

The plots were located on the Chad Humphries Farm, Dalia Rd. Olathe, CO. Approximately 60% of the 17 acre field, known locally as the 'Sturgeon property', was utilized for the trial.

Treatments were arranged in a modified block design with two treatments and four sample replications. The Onager and Oberon treatments had two treatment strips, with two sample replications in each strip. The

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untreated control and Comite treatment had a single treatment strip with four sample replications in each strip. Figure 1 shows the field and treatment map.

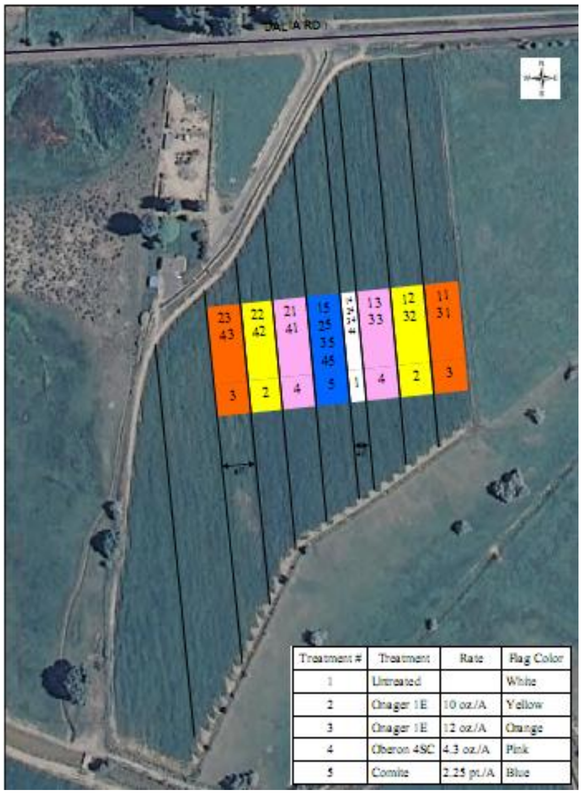

Fig. 1 Field and treatment map of miticide trial location. The plot design was a modified randomized complete block.

Service, on July 24, 2010, using AT402B aircraft equipped with 8 ASC Rotary Atomizers configured to apply an 80 ft spray swath. All treatments were applied in 3 gal/A of final spray material. Dyne-amic was added to all treatments at a rate of 6 oz/A.

The treated area was 80 ft by 900 ft for all sprayed plots; the untreated control was 40 ft wide by 900 ft long. The untreated control was smaller to minimize the mite risk to the grower, who was not compensated for his cooperation.

Samples were taken in the Onager 1E and Oberon 4SC plots by going 75 paces and randomly selecting 5 corn leaves, then taking another 75 paces and selecting 5 more leaves. In the untreated and Comite plots samples were taken by going 75 paces and selecting 5 corn leaves and repeating the process 3 times.

Fig. 2 Treatments were aerially applied using an Air Tractor 402B configured with an ASC rotary atomizer nozzling system. The application was made at 3 gallons/acre.

Plots were sampled 5, 12, 26, and 32 DAT.

Leaf samples were selected from a uniform height on each date starting at 2 ft from ground level on the initial sample and progressing to the ear leaf on the final sample date. Samples were taken to the laboratory and put into Berlese funnels for 24 hours to extract the mites into alcohol. Mobile mites were counted under a dissecting microscope.

Analysis of variance was conducted using MSTAT-C. Mean separation was conducted using LSD ($P<0.05$).

Results and Discussion

Treatments, mite counts and results of statistical analysis are presented in Table 1 and Figure 3. Onager, at either the 10 oz/A or 12 oz/A rate and Oberon reduced mite numbers compared to the untreated control on the 12, 26 and 32 DAT sample dates. Mite counts in the Comite II treated plots did not apparently differ from the untreated control in any sample date. There was an apparent reduction in mite numbers for the Comite II application in the 32 DAT sample, but differences may have been due to the large variability in the count data.

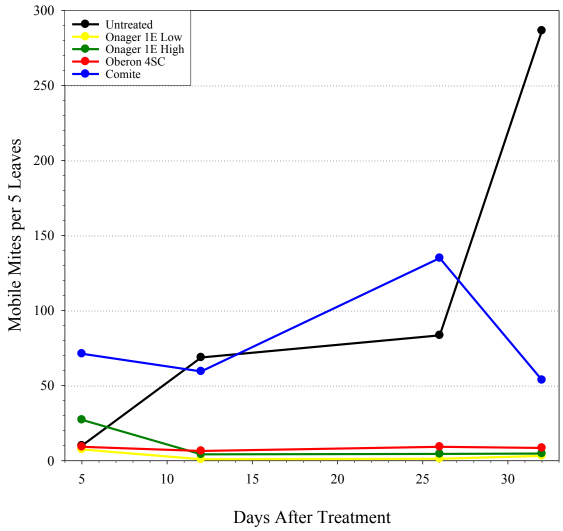

Fig. 3 Banks grass mite populations, as recorded from sampling data, within treatments during the summer of 2010. Mite populations in Onager and Oberon treated plots were less than those in Comite or untreated plots at 32 DAT.

Average Mobile Mites				
Treatment	5 DAT	12 DAT	26 DAT	32 DAT
Untreated	10.0	68.8	83.5	286.5
Onager 1E 10 oz/A	7.5	1.0	1.3	3.3
Onager 1E 12 oz/A	27.3	4.3	4.5	4.8
Oberon 4SC 4.3 oz/A	9.3	6.5	9.3	8.5
Comite II 2.25 pt/A	71.3	59.5	135.0	53.8

Acknowledgments

Chad Humphries provided the crop and land for this project. Olathe Spray Service provided valuable support and provided the application. The project was conducted with financial support from Gowan Company LLC.

SECTION II

Fruit Crops

Palisade Micro-Irrigation Trials: Regulated Deficit Irrigation (RDI) in Commercial Peach Orchards

Denis Reich,[1,2] Wayne Guccini,[3] John Moore[4]

Summary

This report describes the second and third year of monitoring micro-irrigation on Palisade area peaches, and the second year testing Regulated Deficit Irrigation (RDI). In 2009 RDI (strategic withholding of irrigations during the pause in fruit growth after pit hardening) practices were tested in one orchard while 12 hour sets were tested in another (half as much seasonal water applied). The result indicated improvement in yield and fruit color, reduction in foliage (higher in 2009) thereby reducing pruning cost, water saving as much as by four irrigations of 12 hours set (9.6 inches), cost saving ($10 per acre in pumping cost), and reduction in salt load to river (668 lbs/acre/season) by the improved irrigation management system. However, there was loss in profitability of $2.55 per tree and in net return of $11.99 per box for RDI versus $11.96 for full irrigation. Results indicated both irrigation management systems had the potential to significantly reduce salt loading to waterways and conserve the consumptive use of water without hurting fruit yields.

Introduction

Yellowing Peach Syndrome (YPS) or Iron Chlorosis has remained a persistent problem with commercial orchardists in the area. "Chlorosis" is a symptom of trees unable to take up essential micro-nutrients such as Iron. One cause is thought to be a lack of sufficient irrigation leaching fraction. Some well established producers in the Palisade area were curious if there was a need to augment leaching fractions in irrigation schedules to remove potential salts buildup around tree root-zones. The salt rich Mancos Shale soils of Western Colorado do have a strong tendency to raise soil pH and inhibit micro-nutrient uptake. The original objective of this work in 2008 was to address producer concerns with yellowing trees in the Palisade fruit-growing area of Western Colorado through adaptation of efficient water management system such as regulated deficit irrigation (RDI).

In 2010 **(**RDI) testing continued in the same orchard that hosted the trial in 2009. More attention was paid to the economics of RDI in addition to the water conservation and salt loading benefits.

With the installation of soil moisture sensors and examination of soil cores for the 2008 season, there was strong evidence to suggest that not only was a leaching fraction not needed but the chlorosis symptoms were likely a result of *excess* and unnecessary irrigations.

Materials and Methods

For the 2009 growing season two Palisade peach producers agreed to test more efficient irrigation practices including Regulated Deficit Irrigation (RDI) on small irrigation zones. RDI is a proven technique on later maturing varieties that allows for reduced water application and lower evapotranspiration (ET) with little to no impact on yields and sweetness.

Determine the benefits of RDI with orchard trials in the Palisade area and market the results to other producers. Reduced vegetative growth on vigorous trees has the potential to control chlorosis, reduce winter pruning labor and increase return per acre if yields aren't greatly compromised.

Location

The test site is located in the Palisade area at an elevation of about 4800 feet, served by Orchard Mesa Irrigation District (Figure 1)

A four acre orchard at Talbott Orchards of O'Henry peaches irrigated with micro sprays at nominal spacing of 10 feet on a tree spacing of about 5 feet. Row spacing was 17 feet and irrigation zones consisted of about 2.0 acres of RDI alongside of 2.0 acres of normally irrigated trees (Control). This orchard has a gravel-clay soil type: "Gyprockmesa" with a water holding capacity of 1.68 inches per foot.

Regulated Deficit Irrigation (RDI)

RDI is an umbrella term for strategically withholding irrigations, usually from fruit orchards, with the intent of improving seasonal irrigation efficiency and enterprise profitability. The predominant method of RDI with peach orchards takes advantage of the various stages of peach fruit growth in late maturing varieties. During cell division (Phase I) and fruit maturation (Phase III) plant stress will hinder fruit yield and quality, but during the second phase of tree growth where fruit growth pauses (marked by pit hardening at the beginning) the tree can tolerate water stress since the majority of tree energy during this phase is put into vegetative growth. Valves (Figure 2) are used to isolate RDI trees during Phase two. Irrigation water is only applied if soil tension goes above 100 centibars. Soil tension is not allowed to exceed 200 centibars.

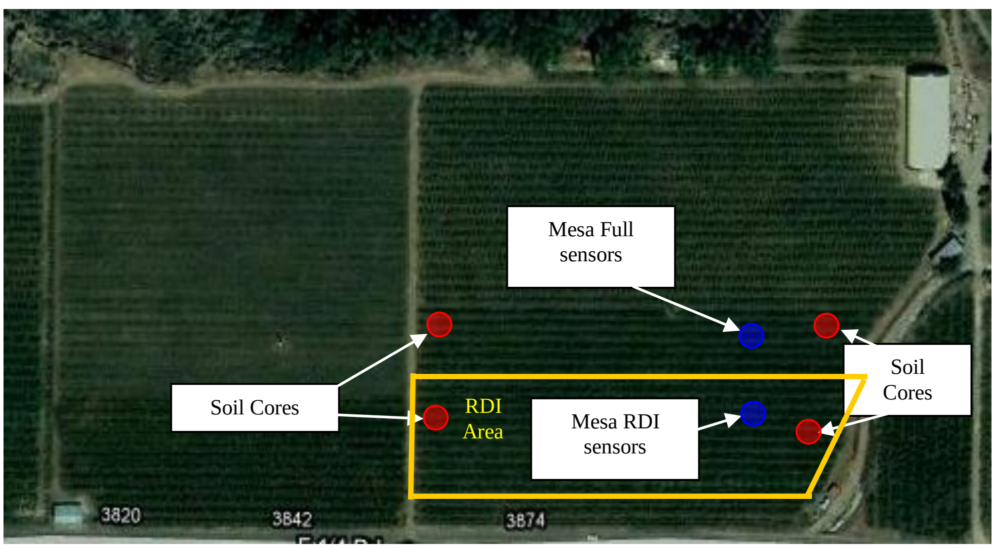

Fig.1 2009-2010 RDI Study Area

Fig. 2 Valves used to isolate RDI trees from irrigation during Phase II at the Mesa site.

Results and Discussion

2009 Testing of RDI was highly encouraging with significant savings in water (9.6 inches not applied), salt loading to the river (668 pounds per acre), without compromising yields. While specific pack-out data was not provided by the grower, the volume of peaches picked (by crate) was higher for RDI than fully irrigated peaches (this does not account for culled fruit). Tree foliage was also greatly reduced (Figure 3) on RDI trees.

2009 soil moisture data (Figures 4 and 5) shows the elimination of two irrigations (marked by upward spikes) during Phase II in the RDI peaches. This savings accounts for an estimated consumptive use of 7.2 inches.

Interval pressure testing of leaves from pre-dawn until full darkness showed that in 2009 and 2010 (Figure 6) deficit irrigated trees showed no additional stress due to RDI and recovered equally well during overnight respiration periods.

2010 showed limited success for RDI after the encouraging results of 2009. This was partly blamed on an unseasonably cool late July and August with above average precipitation interfering with treatments. Also challenges with water availability prevented the rapid recharge of moisture to the root zone required when transitioning from Phase II to Phase III – which likely impacted yield on RDI fruit.

Pack-out data from 2010 (Table 1) showed a return per tree of $2.55 less than fully irrigated trees. Per box RDI trees were fractionally higher than fully irrigation trees at $11.99 per box demonstrating quality was not affected.

Fig. 3 Left and center rows are 2009 RDI peaches with reduced foliage. The right row is fully irrigated.

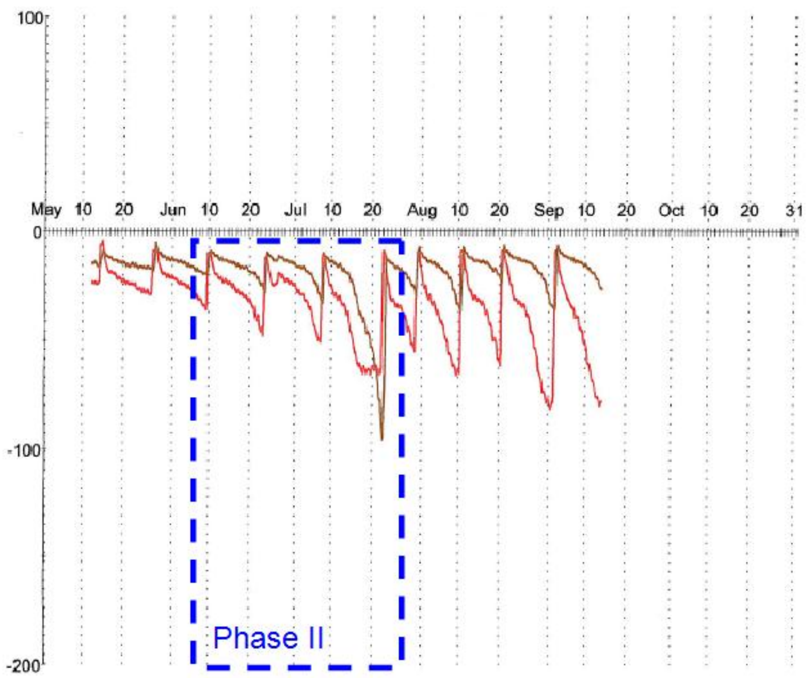

Fig. 4 2009 soil moisture (as centibars of soil tension) on fully irrigated peaches.

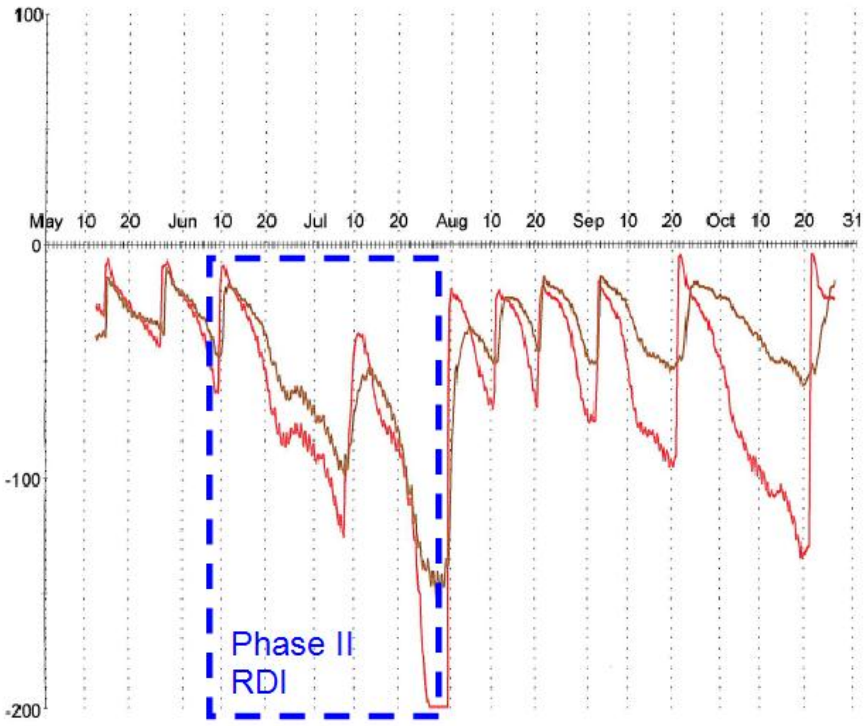

Fig. 5 2009 soil moisture (as centibars of soil tension) on RDI peaches.

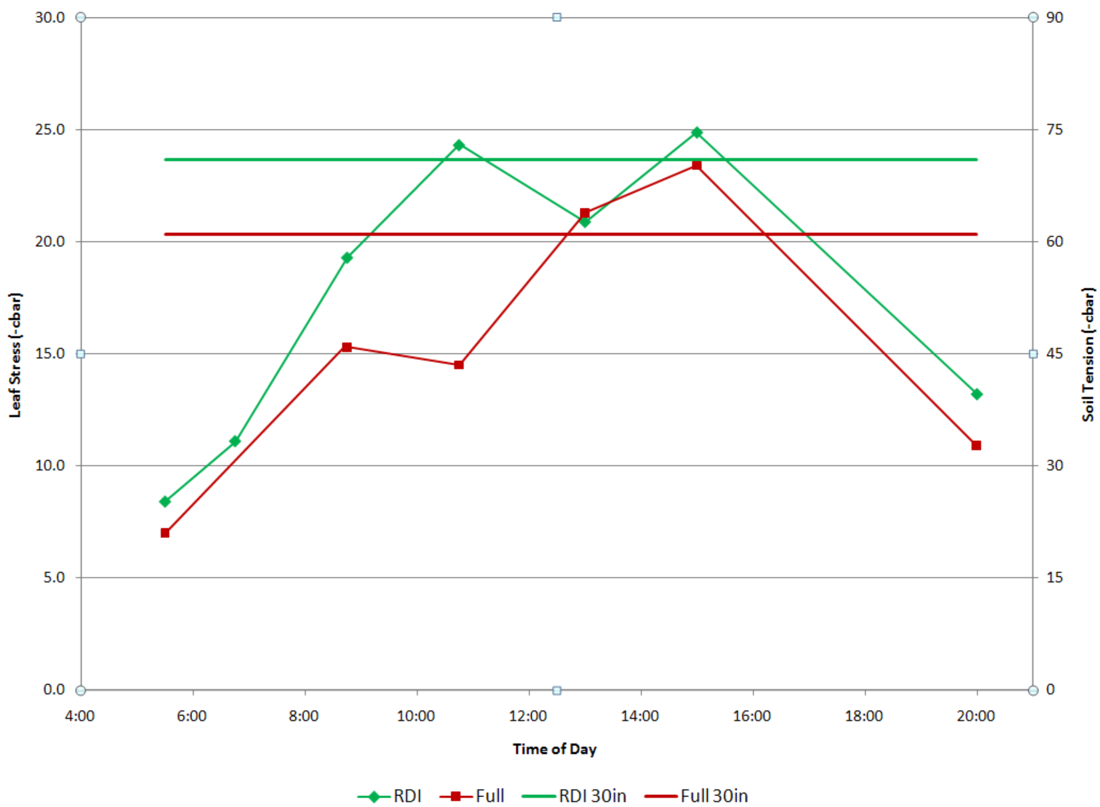

Fig. 6 July 2010 Phase II leaf stress testing (daylong) shows RDI shouldn't create additional tree stress.

	Full Irrigation			RDI		
Counts	1401 trees, 2827 boxes			1162 trees, 2092 boxes		
Cash Flow	**Gross**	**Costs**	**Net**	**Gross**	**Costs**	**Net**
Totals	$43,883	$10,075	**$33,806**	$32,357	$7,279	**$25,078**
Per Tree	$31.32	$7.19	**$24.13**	$27.85	$6.26	**$21.58**
Per Box	$15.52	$3.56	**$11.96**	$15.47	$3.48	**$11.99**

Table 1 2010 cash flow comparison of Full Irrigation vs. RDI.

Conclusions and Recommendations

2010 testing of RDI was largely inconclusive due to atypical weather (scheduling. Yields from RDI trees were less than full irrigated trees but it's not clear to what extent this is attributable to RDI and how much was due to other factors such as soil moisture deficits in RDI trees for the early part of fruit maturation (Phase III).

2009 provided substantial encouragement for RDI testing and prompts the need for more testing that better quantifies what is required to make it successful and how cost it is for Western Colorado producers. The researchers on this project are grateful to the Bureau of Reclamation for two years of funding starting in 2011 to develop these measures for growers. Included in these two years will be an Orchard Mesa Research Center randomized experiment managed by Ramesh Pokharel on Cresthaven peaches.

Acknowledgements

The peach producers of Palisade, especially Bruce Talbott, Harry Talbott, and John Moore. Mesa Conservation District Mesa County NRCS staff. Dr. Horst Caspari and support staff at CSU's Western Colorado Research Center, Orchard Mesa Dan Crabtree and the Water Conservation Field Services Program from the US Bureau of Reclamation for their continued support of this work.

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NRCS Web Soil Survey**: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm**

2009 Peach Rootstock Evaluation

Ramesh Pokharel[1]

Summary

A peach rootstock evaluation study was initiated as a NC collaborative study to find better rootstock for higher yield, better fruit quality, pest resistance, and cold tolerance for western Colorado. Redhaven peach trees grafted to 17 different rootstocks were planted in May of 2009 in a completely randomized block design with 8 replications. Initially, after first and second year tree circumference growths were measured and sucker numbers counted. In second year, trees on Controller 5 (K146-43), *Prunus americana* selection, and Miroback had the least circumference growth (2.2, 2.5, and 3.0 cm, respectively) while Atlas, Guardian R (selection 3-17-7) and KrymskR 86 (Kuban 86) had the greater circumference growth (6.2, 5.9 and 5.9, cm respectively). Sucker numbers ranged from 0.1 (Fortuna) to 2.5 (Microback) in year two and 0.1 (several) to 2.1 (Lovell) in year one. There was no correlation between first and second year's tree circumference growth and sucker numbers. Trees grafted to seven different rootstocks did not have any mortality whereas up to 50% tree mortality was observed with Viking rootstock, and the remaining rootstocks had 12.5% mortality.

Introduction

Peach is the major fruit crop in Colorado. Adaptability, growth, and productivity of trees depend on rootstock's ability to adapt in a soil condition. Western Colorado has different sets of environment and soil conditions characterized by heavy and calcareous soil. The rootstocks performing better in other locations might not perform same in the western Colorado condition. Thus, a peach rootstock experiment was initiated in 2009 as part of a multistate NC-140 collaborative project to assess performance of peach rootstocks under western Colorado conditions. This study aims at identifying rootstocks suitable to local environment and climate. The rootstocks identified in this experiment might be a solution for other areas having similar soil type.

Materials and Methods

Redhaven peach trees grafted to 17 different rootstocks were planted at WCRC-Orchard Mesa site (Grand Junction, CO) on April 6 – 7, 2009 in a completely randomized block design with 8 replications. After two weeks, the trees were marked at 18" above the ground level. Tree measurements were carried out a week after marking the trees, after the first (October, 2009), and second year's (October 2010) growth. Tree growth was calculated by subtracting the initial tree measurements from first year's and first year from the second year's tree circumference measurements at 18" height. Total number of suckers produced in each tree was counted, and tree mortality recorded in each year.

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Results and Discussion

Atlas rootstock had the highest second year growth followed by Guardian R (selection 3-17-7) and KrymskR 86 (Kuban 86) whereas Controller 5 (K146-43), *Prunus americana* selection, and Miroback had lower growth increased in second year (Table 1). The circumference growth increase in year one was not the same as in second year (Table 1). Similarly, KV010127, Miroback, and BH-5 had higher numbers of suckers where four rootstocks did not produce any suckers. The remaining rootstock produced lower number of suckers (less than 2.0 suckers per plant) in second year of growth. However, the sucker numbers produced by different rootstocks were different in year 1 (Table 1). The highest mortality (50%) was observed in Viking rootstock followed by lower mortality rate of 12.5% in seven rootstocks but none in nine rootstocks (Table 1). Most of the tree mortality was observed in year one.

It is too early to come to any conclusion since this study will continue 5-7 years, and none of the rootstocks exhibited any specific trend in growth performance other than higher tree mortality.

Acknowledgments

The funding for this study was provided by Agricultural Experiment Station. Appreciation is extended to John Wilhelm and Bryan Braddy (Western Colorado Research Center staff), who assisted with this project.

No.	Rootstock	Initial	Year 1			Year 2		
		Tree circum-ference (cm)	Tree circum-ference (cm)	% of dead plants	# Suckers	Tree circum-ference (cm))	% of dead plants	# Suckers
1	Viking	4.7	2.0	50.0	0.7	5.8	50.0	0.0
2	Atlas	5.6	1.8	12.5	1.0	6.2	12.5	0.6
3	BH-5	4.7	2.5	0.0	0.5	5.7	0.0	2.0
4	Miroback	4.9	1.3	12.5	1.0	3.0	12.5	2.5
5	Guardian R (selection 3-17-7)	4.1	2.2	12.5	1.0	5.9	12.5	1.0
6	Lovell	4.9	1.4	0.0	2.1	4.9	0.0	0.9
7	KV010123	4.1	0.6	12.5	0.5	4.0	12.5	1.6
8	KV010127	3.9	2.2	12.5	0.4	4.0	12.5	2.6
9	KrymskR 86 (Kuban 86)	3.7	2.1	12.5	1.5	5.9	12.5	0.0
10	Empyrean R2 (Penta)	4.2	2.5	12.5	0.0	5.0	12.5	0.6
11	Imperial (California)	3.6	1.9	0.0	0.0	5.1	0.0	0.4
12	HBOK 10	4.7	1.3	0.0	0.1	4.4	0.0	0.0
13	HBOK 32	4.7	1.4	0.0	0.0	4.2	0.0	0.3
14	*Prunus americana* selection	6.1	0.6	0.0	0.5	2.5	0.0	0.8
15	Fortuna	4.5	1.9	12.5	0.0	5.7	12.5	0.1
16	Krymsk1 (VVA-1)	3.5	1.2	12.5	0.1	4.1	12.5	0.4
17	Controller 5 (K146-43)	4.8	1.3	0.0	0.1	2.2	0.0	0.0

Table 1 Initial trunk circumference measurements, first and second year circumference growths of Redhaven peach grafted to 17 rootstocks, including one standard Lovell rootstock planted in 2009 at the Colo. St. Univ. - W. Colo. Research Center, Grand Junction, CO. Trunk measurements were taken 45 cm (18”) above the graft union.

Cytospora Canker Management Studies from 2007 to 2010

Ramesh Pokharel[1]

Summary

Cytospora canker, a perennial fungal disease of stone fruits infects tree bark, does not have effective management options. Thus, studies focused to manage the disease were conducted from 2007-2010 at Western Colorado Research Center. *Brassica* plant extracts were mixed with pre-soaked oil cakes to make poultices which were applied on top of the gums and after removing the gums exposing the bark surface. In addition to *Brassicas*, several oil products in different concentrations and carrier materials were tested against Cytospora disease in peaches and cherries in the field targeted as organic management option. *Brassica* poultices controlled the disease when applied on top of gums or after removing the gums. Oils such as clove oil, mustard oil and cinnamon oil also reduced the gum formation and killed the fungus, but the results were inconsistent and also did not stop new infection. Chemicals such as Pristine, Captan, and Benlate were tested in water, alcohol, and water+ alcohol as conventional management options. The disease was controlled up to 75% by the application of above chemicals when applied on top of gums. However, there was no difference on disease control with different carrier materials tested (water, alcohol, and water + alcohol at different ratios). Tank mix of Agri-fos with different chemicals including Inspire was tested. Inspire alone or tank mixed with Agri-fos dried out the gums, stopped new gum formation, and even stopped new infection in treated cherry trees but none of the other tank mixes did. Pentabark increased the penetration of chemicals inside the tree bark when it was applied on busted bark surface of a mature tree rather than intact surface. Efficacy of treatments (oil products and chemicals) increased by removing the gum, breaking the bark, and exposing a little bit of wood rather than applying on top of the gums.

Introduction

Peach, one of the important fruit crops for western Colorado, has many problems. Of the existing peach production problems, a disease like Cytospora canker is perennial in nature and is difficult to control. It is essential to control this disease to get potential yield in most of the stone fruits. However, there is a lack of an easy and an effective management option. Cytospora canker causes economic loss worldwide in stone fruits and pome fruits by seriously limiting the productivity and longevity of the trees. The greatest economic damage occurs in orchards of *Prunus persica* (L.) Batsch (peach), *P. avium* (L.) L. (sweet cherry), and *P. domestica* L. (plum). Because peach trees support 3 to 4 main scaffold limbs, loss of one or two of these main limbs to Cytospora canker represents 25 to 50% loss of fruit production (Biggs, 2005). Economically, this disease is very important as it reduces the tree life by almost half.

Replacing the trees in an orchard is expensive and difficult. However, loss in tree productivity due to disease is hard to estimate, especially the impact in tree productivity due to stress and other secondary biotic and abiotic causes. In a current study more than 15-20% trees were found dead, limb/s removed and/or non-productive in western Colorado (Pokharel and Larsen, 2008). If they produce, they produce smaller fruits which mature late and are unable

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to make the market. Most of the time, tree death due to Cytospora canker is associated with plant stress. Cytospora kills the trees which are stressed by other causes or vice versa. Cold damage (winter or spring frost), water stress, yellow peach syndrome caused by micro-nutritional deficiencies aggravated by high soil and water pH, low organic matter resulting in N and many other micronutrient deficiencies, and increased incidences of other pest and disease are some of the important factors prevalent in western Colorado that trigger the trees vulnerable to Cytospora canker.

The most efficient disease management options such as use of resistance varieties, cultural management, and chemical application have inconsistent results in growers' orchards against this disease. Available disease management options are only preventive measures and lack curative measures. Recommended cultural practices to manage this disease are ineffective, unreliable, and uneconomical, especially when the disease has high incidence in an orchard or nearby orchards. Thus, management studies targeted to conventional and organic growers were carried out from 2007 to 2010 aiming at different disease management options.

Materials and Methods

The research work started in 2007 focused to manage the disease for both organic and conventional growers. Most of the conventional research was focused to verify the anecdotal observations whereas organic management options were based on previous related research findings. All the experiments were conducted in completely randomized block designs with 5 replications unless otherwise stated. In all experiments, sprays were carried out by hand sprayer on tree trunk except poultices which were applied by hand. These treatments were applied during March each year.

In 2007, *Brassicas* (yellow mustard and horse radish) were mixed with pre-soaked mustard meal cake, and poultices were made. Such poultices were applied on top of Cytospora canker infection produced gums as well as after removal of gums exposing a few wood tissues. In addition, six Eden's proprietary products obtained to evaluate against dagger nematode were painted and also sprayed separately on top of gums and after removal of gums.

In 2008, management options for both organic and conventional growers were tested against Cytospora canker. The experiments were conducted at WCRC-Rogers Mesa and Orchard Mesa sites. At Rogers Mesa site, mustard oil 25%, neem oil 10%, clove oil 5%, cinnamon oil 1%, camphor oil 1%, thyme oil 1%, were evaluated separately in water + methanol where water and methanol alone served as a control. These oil mixtures were sprayed on June pride peach. Similarly, Captan, Topsin M and Pristine were mixed with water and alcohol alone, and with different ratios of water: alcohol (25:75, 50:50 and 75:25); sprayed on June Pride peaches and Bing cherries at Rogers Mesa site. These treatments were applied separately on top of gums and on exposed bark and some pith after removing the gums.

In 2009, Castor oil 5%, Cinnamon oil 2%, Clove oil 5%, Mustard oil 25%, Benlate in water and alcohol at 1:1 ratio, Topsin M in water and water + alcohol at 1:1 ratio, Liaterine, and water only were tested at WCRC-Rogers Mesa.

In 2010, oil products such as Castrol 5%, Cinnamon oil%, Clove oil 5% along with chemicals such as Topsin M, Agri-fos, Topsin, Benlate, Metran (clove oil base herbicide), and Inspire. In addition, tank mix of Topsin M+ Benlate (1:4), Captan+Agri-fos (1:4), and Inspire +Agri-fos (1:4) were evaluated at Rogers Mesa on Bing cherry. The trees were monitored for drying of gums, new gum production in the infected site and new infection started on the tree.

Results and Discussion

In 2007 poultices of mustard meal cake + mustard green, and mustard meal cake + horse radish blends were effective in controlling Cytospora canker in the field when applied on top of gums or after removal of gums (Fig.1) whereas water only did not (Fig. 2). To increase the efficacy of treatment by increasing the isothiocynite content, mustard accession and/or species with higher isothiocynite content were obtained and seed multiplication is underway in a greenhouse condition to avoid cross pollination. However, preparation and use of such poultices for commercial growers might be a challenge, but could be an option for small scale growers. At the same time, mustard oil was expected as an alternative of mustard extract as the oil also contains same chemical isothiocynate as in mustard extract. In addition, out of six Eden's proprietary materials, one product dried the gums and killed the fungus. Unfortunately, the material could not come to the market as the company went out of business.

Mustard oil, readily available in market and easy to apply, was evaluated against Cytospora canker in addition to other oil products in a separate experiment to find out a solution to organic growers. The result indicated that clove oil, cinnamon oil and mustard oil (Fig. 3) dried the gums and killed the fungus but the control (drying out the gums and stopping new gum production) was up to 80% only when applied on top of gums. However, the wound healed up and no new gum production took place in the applied location when these products were applied after removal of gums and exposing portion of bark. However, the treatments did not stop new infection as there are always multiple and new infection occurring in most of the orchards.

The Colorado stone fruit orchards are severely infected by Cytospora canker where abundance spores are produced whenever favorable conditions prevail. Many production management practices such as continuous wetting of tree trunks by hanging type of sprinkles, inappropriate pruning cuts, etc favor this phenomenon as the temperature is favorable for the spore production during most of the stone fruit growing season in western Colorado.

Captan, Topsin M, and Pristine were evaluated in water+alcohol, water and alcohol separately to verify an anecdotal observation that these chemicals are more effective if mixed with alcohol instead of water as carrier materials. Application of Benlate (Fig. 4), Topsin M and Captan controlled only up to 50% of disease incidence (drying of gums and stopping of gum in the infection court) irrespective of carrier materials tested (water, alcohol, and water + alcohol). The results did not agree with Biggs et al. (1994) with their laboratory study in excised peach twigs. Such twigs treated with above chemicals restricted the growth of the fungus in laboratory condition when the chemical treated twigs were challenged by the fungus.

The difference in the previous laboratory experiment and the current field studies might be due to the fact that the chemicals were not able to reach inside the bark where the fungus colonizes which is very common in fields. Chemicals do not penetrate the bark when applied on top of gums whereas in excised twig in the laboratory study, the fungus might have not penetrated the bark and was not present inside the bark. However, to help the chemical to penetrate the bark surface Pentabark, an adjuvant, was tested in an intact and damaged bark surface. Pentabark was found moving inside the bark when the bark was damaged but very limited movement was observed when applied on intact surface. However, we used Penatbark to increase the efficacy of the treatments starting with the 2008 study. In addition, we always mix white latex paint to help protect the chemicals and tree trunks from sun.

Different chemicals and non-chemicals performing better in 2008 study were repeated in 2009. The results of this study were published in the 2009 WCRC annual report. In 2010, a new approach, tank mixing of chemicals, was evaluated as efficacy of treatments increases by mixing of chemicals with different mode of actions than single chemical.

Tank mixed of Agri-fos with Benlate, Topsin M, Captan, Metran (clove oil based product), and Inspire was compared with these chemical alone. The canker stopped growing, gums dried out and no new gum was produced by application of Inspire alone or in combination with Agri-fos, but none of other tank mixed chemicals worked in the same way. Interestingly, no new infection court was seen on the trees treated with Inspire or Inspire+ Agri-fos (Fig. 5)

In conclusion, scrapping the gum off and removing some bark portion along with gum (Fig. 6) and application of treatments especially with Pentabark, an adjuvant, gave better results than applying chemicals on the top of gums or intact surface and/or without Pentabark.

Brassicas such as mustard or horse radish with higher concentration of isothicynite and horse radish was effective in stopping gum production and canker expansion, however, use of this poultices technique in a commercial setting might be a problem. More research is need in this issue. In addition mustard oils and clove oil controlled Cytospora when applied in exposed surface (removing gums and exposing bit bark). Application of chemicals in alcohol + water did not increase efficacy. The result also indicated that Inspire controlled Cytospora and stopped new gum formation in our preliminary study. Thus, further work on Inspire will be continued. Cytospora canker management studies are ongoing with and different approaches at WCRC-Orchard Mesa site.

Acknowledgments

The funding for this study was provided by Agricultural Experiment Station. Appreciation is extended to Bryan Braddy, George Osborn, and John Wilhelm, (Western Colorado Research Center staff), who assisted with this project. The author would like to thank Syngenta, USA for the experimental Inspire provided.

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Fig. 1 Gum dried and no new gum production even after two years of application of horse radish poultices in Bing cherry at Orchard Mesa Research site applied in 2007.

Fig. 2 When water alone (control) was applied, it did not dry out the gum and did not stop new gum formation.

Fig. 3 Application of mustard oil at 25%, dried out the gum and stopped the production of new gum.

Fig. 4 In 3 out of 5 replications of Benlate used with water and alcohol (50:50), the gums dried out and gum formation stopped.

Fig. 5 INSPIRE application (March 201) dried the gums and stopped gum formation and new infection on Bing cherry at WCRC-Rogers Mesa. Photo taken March 2011.

Fig. 6 Scrubbing off the gum and removing some of the bark will increase the efficacy of the treatments.

2008 Apple Rootstock Evaluation (Normal Planting, Brookfield Gala).

Ramesh Pokharel[1]

Summary

An apple rootstock evaluation study was initiated in 2008 at WCRC-Orchard Mesa to find out the adaptive performance of new apple rootstocks including Cornell series in high soil pH in western Colorado. Brookfield Gala apple trees on 23 different rootstocks were planted in a normal plant spacing and training system in a completely randomized block design with 4-8 replications. Tree circumference was measured initially and at the end of each year's growth (first to third year), and fruit yield data were collected in the third year, 2010. Variability in circumference and yield components were observed with the trees grafted to different rootstocks. Trees on rootstocks G65, G16 and B9 had the least circumference growth of 2.0, 2.5 and 2.5 cm, respectively while the same scion on rootstocks JTE-B, Naga, Maruba and GC 7707 had the greatest growth of 5.4, 5.2, 5.0, and 5.0 cm, respectively during third year of growth. Tree mortality rate varied with rootstocks where 14 rootstocks did not have any mortality, and 11 rootstocks had 11.2 to 33.3% mortality. All rootstocks except three, produced suckers where the sucker numbers varied from 0.1 to 3.0 on average per rootstock. One hundred percent trees on three rootstocks produced fruit whereas none of the trees on three rootstocks produced any fruit. Fruit number, weight (kg), and size (mm) ranged from 0 to 20.9, 0.1 to 2.5, and 5.5 to 13.6 mm per tree, respectively

Introduction

Crop/variety/rootstock combinations best suited to high pH are the best solution for fruit growers in areas with high soil and water pH problems, such as in Western Colorado. Past research has shown that rootstocks react differently to soil pH conditions; apple rootstock P22 was the most tolerant to strong soil acidification. A lower level of tolerance was shown by the rootstock M9 and the lowest by M26. At soil pH of 3.6, the rootstock M26 had the highest concentrations of Al and Mn in the 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 on P22 rootstock had the highest number of flowers and fruitlets, with less on M9 and the fewest on M26. This previous work elsewhere clearly illustrates the potential for finding a rootstock better suited to different soil pH conditions. Thus, an apple rootstock study was initiated in 2008 to evaluate rootstocks suited to high soil pH condition.

Materials and Methods

A total of 23 apple rootstocks of different origins, sources and programs, grafted to Brookfield Gala were obtained through the Apple Rootstock Genetic Materials pool of the USDA, Geneva, NY and planted at the Colorado State University WCRC-Orchard Mesa (Grand Junction, CO) 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. Initial trunk circumferences (in cm) were measured shortly after planting when trees started growing, and at the end of the first year

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of growth in Feb 2009, the second year (Oct. 2009), and the third year's (Oct. 2010) growth. In the third year fruit was harvested, the total number of fruit per tree was counted, and fruit weight taken. Individual fruit weight and circumference were measured in five fruits randomly collected from each tree. Differences in tree measurements (year 1 measurement – initial, year 2 – year 1, and year 3 – year 2) were calculated. Averages were calculated using an Excel spreadsheet, however, mean separation was not done due to high variability in replication numbers.

Results and Discussion

In the third year, the tree circumference increased an average of 3.8 (2 to 5.2) cm across all rootstocks. However, individual rootstock trunk circumference growth was highly variable as in previous years (Table 1). Rootstocks JTE-B, Naga, Maruba and 7707 had higher growth, and rootstocks G65, followed by G16 and B9 had smaller trunk circumference growth as compared to many others. Variable number of suckers (0.1 to 2.6) was found associated with each rootstock. Rootstocks 6874, 4214, 4814 and 5046 had a higher number of suckers. Maruba, Naga, G16 did not produce any suckers. However, association of sucker production in each rootstock was not consistent over the years. There was no additional tree mortality in the third year of growth.

All rootstocks except 6006, Naga, and JTE-B produced fruits in the third year of their growth where all trees grafted to rootstocks G65, G16 and B9 produced fruits. Similarly, more than 50% of trees in seven rootstocks produced fruits, and less than 25% of trees in the rest of the rootstocks had fruits (Table 1). Total fruit weight (kg) per tree ranged from 0.1 to 2.5 where G16, Nic29 and 6874 had higher fruit yield per tree, and Maruba, G30 and B118 had lower yield. The fruit yield was correlated with the number of fruits that range from 1 to 20.9 fruits per tree. The individual fruit weight ranged from 81.4 to 151.4 grams per fruit where Nic29, 6143 and 5179 had fruit with bigger size (Table 1).

Some of the rootstocks exhibited better performance; however, it is too early to come to a conclusion since these observations were made in the third year of establishment and the first year of yield. This study will continue 5-7 years from planting to come to a conclusion.

Acknowledgments

Author would like to acknowledge the support of Dr Gennaro Fazio, Plant Genetic Resources, Agricultural Research Service, USDA, Geneva, NY for proving rootstocks and the cost for the trees. The study was partly funded by Colorado State University Agricultural Experiment Station. Appreciation is extended to John Wilhelm and Bryan Braddy (Western Colorado Research Center staff), who assisted with this study.

Root-stocks	Initial measure ments (cms)	1st year growth (TCA)	2nd year growth (TCA)	3rd Year growth (TCA)	2nd year sucker number	3rd year sucker number	Tree motility% by 3rd year	Third year Fruit Yield				
								Fruit number per tree	Fruit wt./tree (kg)	Fruit size (MM)	Fruit wt/fruit	Trees (%) with fruits
3007	4	0.5	2.6	3.4	0.0	0.3	0.0	7.0	0.9	6.7	131.3	33.3
3041	5.3	0.2	2.2	3.2	0.0	0.2	0.0	3.0	0.3	13.6	138.7	40.0
4214	4.6	0.3	4.0	3.4	0.4	2.1	28.6	7.7	0.9	6.4	120.8	42.9
4814	4.7	0.8	4.0	3.3	0.4	1.6	22.2	5.3	0.7	5.6	130.8	37.5
5046	5.1	0.5	4.1	3.3	0.8	1.6	14.3	5.3	0.7	5.6	131.8	37.5
5087	4.8	0.0	2.7	3.6	0.0	0.8	14.3	5.7	0.7	6.4	125.8	50.0
5179	3.8	0.3	2.4	3.3	0.0	0.3	0.0	4.8	0.7	6.8	141.4	62.5
5890	5.6	0.8	3.9	4.0	0.3	0.8	0.0	3.0	0.4	6.5	127.3	37.5
5935	4.8	0.5	3.1	4.0	0.5	1.6	0.0	4.3	0.6	6.6	133.0	75.0
6006	5.1	0.7	3.9	4.3	0.5	0.5	11.2	0.0	0.0	0.0	0.0	0.0
6143	5.4	0.6	3.2	4.2	0.8	1.8	33.3	3.5	0.5	6.8	148.9	66.7
6253	4.9	0.4	3.5	3.6	0.2	0.5	0.0	4.3	0.5	5.5	81.4	50.0
6874	4.5	0.7	3.2	2.9	1.6	2.6	12.5	10.3	1.2	6.2	113.7	66.7
7707	2.7	1.5	4.2	5.0	0.3	3.0	0.0	2.0	0.3	6.7	133.0	28.6
B.118	5.8	0.5	3.8	4.8	0.0	0.1	0.0	1.0	0.1	6.8	149.4	11.1
B.9	3.5	0.8	3.5	2.5	0.2	0.2	0.0	14.6	1.8	6.6	131.9	100.0
G.16	5.5	0.5	3.2	2.5	0.1	0.0	14.3	20.9	2.5	6.5	124.6	100.0
G.30	3.1	0.6	3.6	4.2	0.2	0.4	0.0	1.0	0.1	6.4	115.7	11.1
G.65	4.3	0.6	3.6	2.0	0.2	1.2	16.7	3.4	0.4	6.6	136.0	100.0
JTE-B	4.8	1.5	4.5	5.4	0.1	0.8	11.2	0.0	0.0	0.0	0.0	0.0
M.6	4.9	0.8	4.4	3.8	0.3	0.3	10.0	5.8	0.8	6.7	138.0	40.0
Maruba	3.2	0.8	3.5	5.0	0.1	0.0	0.0	1.0	0.1	6.6	131.6	12.5
Naga	4.9	0.8	3.9	5.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nic29	2.6	0.6	3.6	3.7	0.0	0.3	0.0	10.0	1.4	6.8	151.4	50.0

Table 1. Initial, first to third year trunk circumference and growth (year 1 measurements – initial measurements, year2 growth –year 1 growth, and year3 growth –year 2 growth) and fruit yield and yielding trees of Gala apple to 24 rootstocks, including one standard M 6 rootstocks planted in 2008 at the Colo. St. Univ. - W. Colo. Research Center, Grand Junction, CO. Trunk measurements were taken 45 cm (18") above the ground.

2010 Apple Rootstock Evaluation (Honeycrisp in close planting)

Ramesh Pokharel[1]

Summary

A NC140 collaborative evaluation study of Honeycrisp apple grafted to 28 apple rootstocks was initiated in 2010 for close plant spacing in tall spindle training system. The trees were marked at 12" from the ground level. Initial tree circumference, after the first year of growth, the number of branches larger than 25 cm and the total growth of these branches were measured in the first year's growth. Tree growth in year 1 was calculated by Year one tree circumference - initial tree circumference. The first year tree circumference growth ranged from 0.6 to 1.9 cm where Bud9, Cornell 202 TC, Bud10 and Bud 71-7-22, Cornell 52027 had less growth as compared to others. Cornell 935, Bud 70-20-20 and Cornell 3001 had higher tree circumference increases. The number of branches per tree ranged from 1.4 in Bud 71-7-22 to 19.0 in PiAu 9-90 where trees on three rootstocks produced less than five, and trees on three rootstocks produced more than 15 branches per tree. The remaining rootstocks produced 5-15 branches. Similarly, the total branch lengths produced in each tree ranged from 11.6 to 41.4 cm in each tree where only one rootstock, Bud 71-7-22 produced less than 20 cm growth and remaining rootstocks produced 20-40 cm of growth in first year.

Introduction

The commercial apple industry worldwide is in the midst of a major change in fruit production management systems. With size-controlling rootstocks, tree size has reduced significantly which can increase the numbers of tree per acre. Some orchards exceeded 5,000 trees per acre, but this practice is not common in Colorado. Increasing the number of trees per acre will increase production and the profit. Many other factors contribute to production including adaptability of rootstock to a soil and environment. In addition, the apple variety Honeycrisp, has better storage quality, price, and market demand, but the production of this variety is rather difficult as compared to other varieties. Thus, evaluation of apple rootstocks for close planting in high soil pH was initiated in 2010.

Only a few growers grow this variety in the local area. That may be due to limited information available on the adaptation of this variety in Mesa County areas. This study will generate information on adaptability of this variety and suitable rootstocks for Mesa County in addition to a better understanding of the efficacy of tall spindle training system and the suitability of close planting distance for apple in our local climate and soil.

Materials and Methods

Honeycrisp apple trees on 28 different rootstocks were planted in a completely randomized block design with 5-10 replications based on the available rootstock numbers. Trees were planted with a spacing of 1.2 m X 3.6m (4ft X 12ft) keeping the graft union at 15cm (6 inches) above the soil line after soil settled. After planting trees were pulled up so that the graft union was 6 inches above the final soil grade and tamped lightly with 2-3 foot stomps. A tall spindle training system was adapted. All feathers below 24 inches(60 cm) were removed using a flush cut without heading leader or feathers. Any feathers larger than 2/3 in

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diameter of the leader were removed leaving a ½ inch stub. Second and third buds below the new leader were rubbed off, and all flowers were removed to avoid fire blight infection. Each feather which was longer than 10 inches (25 cm) was tied down to a pendant position below the horizontal wire. Enough water was applied for the initial phase during planting and irrigation was provided by furrow within 3 weeks of planting. A half pound of $CaNO_3$ per tree was applied 2 weeks after planting and a second application of $CaNO_3$ (1/4 lb) was applied 6 weeks after planting.

Tree trunks were marked at 12 inches (30 cm) from the graft union with a permanent marker a week after planting. Initial trunk circumferences (in/cm) were measured shortly after planting when the trees started growing, and at the end of year one (1 year growth) in Oct. 2010. Tree survival at the end of the season (0=dead, 1=alive, 2=dead from human caused damage). Differences in tree measurements (year 1 measurement – initial) were calculated. Mean separation was not done due to high variability in replication numbers.

Results and Discussion

Rootstocks C935, C3001, and B10 had a higher circumference growth increase in year one whereas B9, B71-7-22, and C5087 had a lower circumference growth increase in year 1. The remaining rootstocks were intermediate in circumference growth increase in first year.

Interestingly C202TC had a lower trunk circumference growth but a higher number of branches. Little difference was observed among the trees produced by tissue culture vs normal propagation in C3041 rootstocks (Table 2). Only nine trees produced suckers in the first year of growth.

A single tree of C4814 produced 3 suckers, and single tree in each of M9T337, B70-20-20, M9P and C4004 rootstocks produced only one sucker, but not all trees produced suckers. Some trees broke due to high wind before trellising was provided. In the first year of growth, 50, 14 and 13 % of C 5202, C4814, and M26 trees respectively, broke due to wind as compared to no breakage in other rootstocks.

There was no correlation in the number of branches and total length of branches produced in each tree. The average number of branches produced in these rootstocks ranged from 1.4 to 19 per tree. Four rootstocks B71-7-22, C 4003, and B9 produced less than 5 branches whereas rootstocks Pi9-90, C202TC, and C4004 produced more than 15 branches. The remaining rootstocks produced 5 to 15 branches. The average total length of branches produced in each tree ranged from 11.6 cm in Bud 71-7-22 to 41.4 cm in C935. However, the rest of the rootstocks produced 20 to 40 cm growth on average.

Acknowledgments

The funding for this study was provided by Colorado State University Agricultural Experiment Station. Appreciation is extended to John Wilhelm and Bryan Braddy (Western Colorado Research Center staff), who assisted with this study.

	Rootstocks	Initial tree Cir.	Growth Year 2.Cir.- Year 1 Cir.	No of branches	Average length (cm)
1	B10	4.9	0.7	7.9	32.6
2	B9	3.8	0.6	4.5	22.6
3	Bud 64-194	4.7	0.9	6.2	22.9
4	Bud 67-5-32	4.0	1.0	4.2	19.9
5	Bud 70-20-20	5.3	1.7	9.8	36.9
6	Bud 70-6-8	4.2	0.8	5.5	22.1
7	Bud 71-7-22	2.6	0.7	1.4	11.6
8	Bud 7-20-21	4.9	1.1	7.1	27.4
9	Bud 7-3-150	4.2	0.8	5.4	28.7
10	Cornell 3001	5.2	1.7	10.0	40.3
11	Cornell 11	4.0	1.0	10.6	26.0
12	Cornell 202N	5.0	1.5	13.2	38.5
13	Cornell 202 TC	5.5	0.6	17.4	34.2
14	Cornell 3041 TC	4.4	1.2	8.1	34.3
15	Cornell 3041N	4.3	1.2	7.9	32.2
16	Cornell 4003	3.8	0.8	4.3	23.6
17	Cornell 4004	4.3	1.6	15.8	31.1
18	Cornell 4214	4.2	0.9	11.0	29.2
19	Cornell 4814	4.3	1.5	13.0	31.6
20	Cornell 5087	4.9	1.4	12.7	33.8
21	Cornell 52027	4.5	0.7	6.3	33.9
22	Cornell 935	4.2	1.8	7.7	41.4
23	M.26EMLA	4.1	1.0	7.0	28.1
24	M.9Pajam2	4.8	1.4	11.3	32.0
25	M.9T337	4.2	1.2	7.6	29.0
26	PiAu 51-11	5.1	1.1	8.6	29.7
27	PiAu 9-90	6.6	1.5	19.0	38.9
28	Supporter 3	3.9	1.1	8.0	29.3

Table 1 Initial trunk circumference (Cir.) measurements, first year circumference growths of Honeycrisp apple grafted to 28 rootstocks planted in 2010 at the Colo. St. Univ. - W. Colo. Research Center, Grand Junction, CO. Trunk measurements were taken 30 cm (12") above the graft union.

Multiple Viruses Found in a Problematic Apple Orchard in Western Colorado

Ramesh Pokharel[1]

Summary

An apple orchard in western Colorado was investigated for the cause of small leaves and small, deformed fruit on Gala and Golden Delicious apple trees. The symptoms on Gala were more severe than on Golden Delicious. To rule out the possible association of viruses and viroids with such problematic trees, three leaf and 20 fruit samples were collected from these trees and from asymptomatic Red Delicious trees in October 2009. The samples were tested by RT-PCR for *Apple chlorotic leaf spot virus* (ACLSV), *Apple mosaic virus* (ApMV), *Apple stem grooving virus* (ASGV), *Apple stem pitting virus* (ASPV) and *Cherry rasp leaf virus* (CRLV) and by dot blot hybridization for *Apple dimple fruit viroid* (ADFVd), *Apple fruit crinkle viroid* (AFCVd), *Apple scar skin viroid* (ASSVd) and *Pear blister canker viroid* (PBCVd). All five viruses were detected in fruit samples with different infection rates, but no viruses were found in leaf samples. ACLSV was detected in all samples. ASGV was detected in all Red Delicious and Golden Delicious trees but only in 3 of 8 Gala trees. CRLV was detected in all Golden Delicious samples, 7 of 8 Gala samples, but in none of the Red Delicious samples. ASPV was detected in 3 Golden Delicious and 1 Gala fruits. ApMV was detected in only one Gala sample. No viroid was detected in any samples collected. Up to two viruses were present on asymptomatic trees, while up to four viruses were observed on symptomatic trees, suggesting a possible synergistic role in symptom expression. This provides a new understanding to look for causes other than physiological and environmental related in symptomatic trees in western Colorado.

Introduction

Apple production in Grand Valley has been greatly reduced because of many production problems. Diseases caused by viruses are difficult to diagnose as the symptoms can often be confused with other plant stress factors, such as micronutrient deficiencies, insect and/or nematode damage. Symptom expression in infected plants varies with host species/cultivars, growth conditions and many other factors, and therefore is not reliable in diagnoses. Some viruses do not induce symptoms, however, they cause yield reductions. Such latent viruses are often more perilous when more than one virus is present or when they are associated with other stress factors in a single tree. Knowledge about the incidences of such viruses is important for western Colorado fruit growers as frost or winter cold injury/damage, high soil pH, drought, and nutritional deficiencies are very common problems in the area.

Very little information is available on the occurrence of fruit viruses in western Colorado (Pokharel et al., 2010) due to a high variability in symptom expression which is often confused with other problems such as physiological disorder, nutritional deficiency, and environmental stress. In the current study, apple fruit displaying symptoms, previously assumed to be caused by physiological disorders, were tested for pome viruses and viroids. This work is the continuation of a tree fruit virus survey in western Colorado started in 2008, focusing on CLRV, a pathogen that causes flat apple disease in apple. Understanding viruses associated with

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symptomatic trees will help with proper disease diagnosis and management.

Materials and Methods

In September 2009, one grower reported severe symptoms on Gala and Golden Delicious trees. The symptoms varied in stunted growth, reduction in size and number of leaves, reduction in internode length, curling of leaf margins, fruit deformation and tree death. Symptom expression was more severe on Gala than on Golden Delicious. Red Delicious trees, separated by open land in the same block, were asymptomatic. One bulked fruit sample and one bulked leaf sample were collected from each variety. These samples were tested for five viruses of pome fruits using RT-PCR (Fig. 1) and for the four viroids known to infect pome fruits by dot blot hybridization (Fig. 2).

In July 2009, leaf samples were collected from different locations including one orchard with known flat apple disease incidence. At the same time, other leaf samples were collected from apple trees which were near a CRLV infection site. These samples were analyzed by RT-PCR and dot blot hybridization.

Mean separation was not done due to high variability in replication numbers.

Results and Discussion

A grower's apple orchard with different types of symptomatic trees was visited for field diagnosis. Physiological or environmental disorders were suspected to produce severe symptoms on apple trees in the orchards with poor growth with short internodes, smaller and fewer leaves, inward turning of leaf margins, deformed fruits (Fig. 3A) and a less dense foliage canopy (Fig. 3B) compared to longer internodes, dense canopy and healthy appearing leaves and fruits in healthy trees (Fig. 4) in a commercial orchard. Fruit symptoms were more severe on Gala than on Golden Delicious, but not in Red Delicious. This type of symptom represents many growers' problems. Two to five viruses were found associated with fruit displaying symptoms that were previously thought to be caused by either physiological disorders or environmental stress. All five viruses were detected in Gala apple fruits (Fig. 5). Four viruses, excluding ApMV, were detected in the fruits of another variety (Fig. 6). A single fruit of Gala and Golden Delicious were infected with up to four different viruses. Smaller fruit from Gala trees had ASPV, ACLSV, CRLV and ASGV viruses (Figure 5), and Golden Delicious fruit had CRLV, ACLSV, ASPV and ASGV (Figure 5). All Red Delicious fruit tested were infected with ACLSV and ASGV (Fig. 7). These data suggests that a tree infected with two different viruses can remain asymptomatic, with normal appearing leaves and fruits. Infection by more than one virus in a single tree is not uncommon. Ten apple leaves including some having Apple Mosaic Virus symptomatic leaves (Fig. 8.) were found negative to those viruses observed in fruits despite the fact the leaf samples came from the same trees where fruit samples were collected and found to be positive for up to five different viruses.

No virus was detected in leaf samples collected in late September from symptomatic orchard trees, the fruits of which had previously tested positive for multiple viruses. One of the Gala leaf samples, with ApMV-like leaf symptoms, tested negative for ApMV by RT-PCR; however, one of the fruit samples was found positive, indicating there may be a higher virus titer in fruit, or an increased level of inhibitory compounds in late season leaves. Fruit samples collected in September from a different Red Delicious orchard suspected to have CRLV had 4 of 5 fruit samples infected with both CRLV and ACLSV (Fig. 9). However, leaf samples collected in July 2009 from the same orchard were found infected with CRLV only. That may be because the ACLSV titer was higher in fruits in September as compared to leaf samples in July. In the 2010 growing season, hail damage and fire blight infection occurred in the same orchard, but the damage was more in those symptomatic trees making the fruits unsuitable for commercial market.

Our results indicated that mixed virus infections might be common in the western Colorado apple orchards. The infection of apple trees by multiple viruses might be related to symptom severity, suggesting a possible synergistic role of these viruses in disease expression. Further work on pome fruit viruses in Colorado is underway.

Acknowledgments

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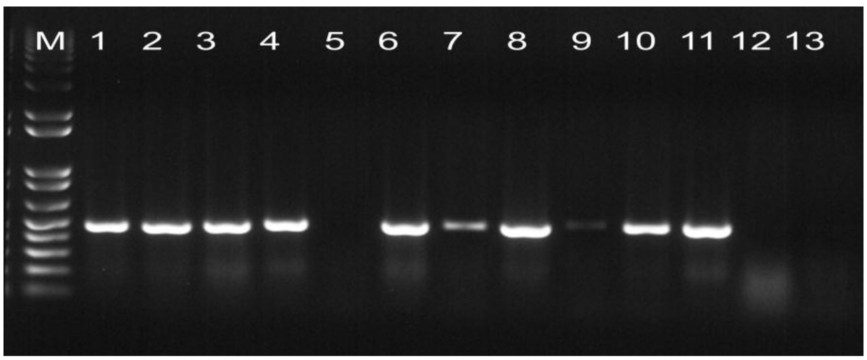

Fig. 1 Gel electrophoresis band showing the clear band for CRLV; Lane 1: 1 Kb+marker; 2: 1 to 10 grower's apple samples; 11: CRLV positive sample; 12: healthy cherry sample; and 13: water control.

1 2 3 4 5 6

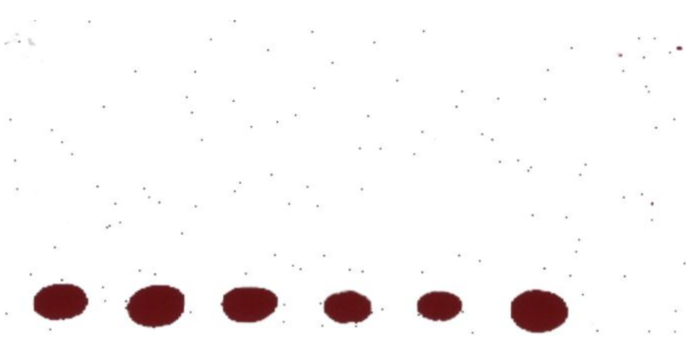

Fig. 2 Dot blot hybridization picture: A1-D7: apple orchard sample; E1-E6 positive samples for ASSVD, ADFVd, PBCVd, and AFCVd; E7: healthy apple sample.

Fig. 3 A symptomatic apple fruits and leaves. Note the fruit shape and size, upward curling, smaller leaves coming from the same place, and reduced internodes (A) and reduction in foliage (B)

Fig. 4 Normal fruits, leaves and internodes in a healthy tree.

Fig. 5 Gala apple fruits found positive to various viruses by RT-PCR where CRLV was found in all fruits except C; ACLSV was detected in all fruits; ApMV detected only in fruit C; ASPV detected only in fruit B; and ASGV detected in fruits B, C, and F.

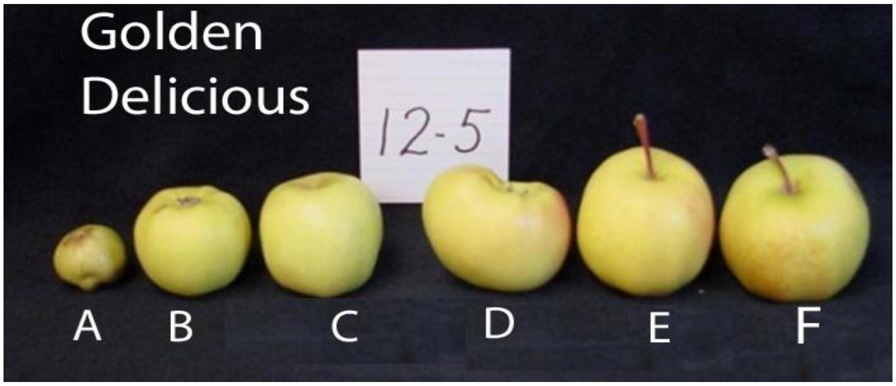

Fig. 6 Golden Delicious apple fruits found positive to various viruses by RT-PCR where CRLV, ACLSV, and ASGV were detected in all fruits whereas ASPV was detected only in B,D, and F fruits only.

Fig. 7 Red Delicious apple fruits found positive to various viruses by RT-PCR; ACLSV, and ASGV were detected in all fruits in the same orchrd with Gala and Golden Delicous in a nearby block.

Fig. 8 Apple leaf showing Apple Mosaic symptom was negative by RT-PRC, but one of the fruits tested was positive to the virus in molecular test.

Fig. 9 Golden Delicious apple fruits found positive to various viruses by RT-PCR; CRLV was detected in all fruits except D whereas ACLSV was detected in all fruits except B in a different orchard in different location.

Efficacy of Different Oils and Tergitol on Apple Blossom Thinning

Ramesh Pokharel[1]

Summary

Thinning in apple is essential to obtain better quality fruit and returning bloom. Limited options are available for apple thinning. Some of the oil products found to be effective in peach thinning were tested for apple blossom thinning. Different concentrations of mustard oil, Stylet-Oil, clove oil, cinnamon oil and clove oil based Metran as well as Tergitol were evaluated for apple blossom thinning in 2010 at WCRC-Rogers Mesa on Honeycrisp apple in a randomized block design with 5 replications. Different concentrations of oil products and Tergitol 2% were applied with a hand spryer at 70-90% bloom opening in one side or both sides of the trees. The numbers of total vs dead flower were counted a week after the oils and Tergitol spraying. Fruits data (yield and fruit numbers) were recorded at harvest from each side (east and west side). Five random fruits were picked from each tree in each side and fruit weight and size were observed. The result indicated that most of the oil products tested killed flowers, reduced fruit numbers, increased fruit sizes and decreased the total fruit yield as compared to water alone sprays. Stylet-oil and mustard oil did not kill flowers as much as clove oil, cinnamon oil, and Tergitol but reduced the fruit numbers. Higher concentrations of clove oil, cinnamon oil and Tergitol had some degree of phytotoxicity during spraying but later these trees recovered and produced fruits.

Introduction

About 20-30 healthy leaves, or a dozen in the case of more energy-efficient dwarf trees are needed to produce a good apple fruit. Trees produce almost 80-90 more flowers than required, and if they are allowed to fruit that leads to too many inferior quality fruits. Thinning is essential in apple production in order to balance tree crop load for optimal fruit size for marketing, and returning bloom avoiding alternate bearing. 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). Bloom thinning increases the availability of stored carbohydrates for cell growth to the remaining flower buds. That results in a 10 to 30% increase in fruit size and yield as compared to fruit thinning later in the season. The magnitude of the effect on the returning bloom in the following year has not been studied. 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.

Rom and Ela (2005) found that organic acreage was steadily increasing with the use of traditional apple cultivars on M.9 or M.26 rootstocks and with tree densities in the 200-500 tree range based on responses of majority respondents during extensive surveys. The surveys represented approximately 7,000 acres of orchards and growers with conventional, transitional, and certified organic acreage. They also found that organic apple production is motivated by economic, environmental and ethical prospectives where fruit thinning was very important to their efficient production. The most common fruit thinning strategy used by organic growers was post-bloom hand thinning.

[1] Contact information: Nematologist/Fruit Pathologist; Colorado State University, Western Research Center-Orchard Mesa, 3168 B ½ Road, Grand Junction, CO 81503-9621, Phone 970-434-3264 x203, Fax 970-434-1035.

Approximately 17% of organic producers use lime-sulfur sprays during bloom to regulate cropping but the success of the treatment rates is less than acceptable. The survey indicated a desperate need for alternative thinning strategies and appropriate technologies. Lack of such technology has limited organic production systems.

In addition, they also evaluated growers' existing organic apple thinning options in 2001 and 2002 in Colorado and Arkansas. Repeating the best treatment from the 2001 test, they found that application of 2% lime-sulfur plus 2% Crocker fish oil applied at full bloom resulted in the greatest reductions in fruit set, the most blank or resting spurs, and the greatest percentage of single fruits per spur. However, they reported a variation in attenuation of treatment results among the two cultivars tested. They concluded that concentrations of lime-sulfur above 2% did not appear to have significantly different effects. Treatments did not significantly reduce fruit set (fruits/100 flower clusters) but reduced the fruits per limb, and reduced fruit set per flower cluster, especially the percentage of clusters with four fruits. Good options for thinning in apple are available for conventional growers, but they also can use the effective fruit thinning practices used by organic growers. However, very limited effective options are available for organic producers.

Materials and Methods

Clove oil 2 and 4%, Metran 4 and 8%, mustard oil 10 and 15%, Stylet oil 5, 10 and 15% in half of the tree and full tree were sprayed at 70% bloom time on Honeycrisp apple trees at WCRC-Rogers Mesa through a hand sprayer. To spray at 70% bloom, spraying had to be done on a windy day.

One week after spraying of these oil products, flowers were evaluated for the effect of oils by counting total numbers of flower in a branch vs numbers of flower killed by the treatments. Ninety to 125 total flowers were counted per tree selecting a random branch. If a selected branch had less than 90 flowers then nearby twig was counted to have up to 125 flowers. At harvest, trees in each treatment were harvested individually and the total fruit weight recorded and numbers counted. Individual fruit weight and size measured in five fruits randomly collected from each tree at harvest. Data were tabulated and analyzed for an average.

Results and Discussion

Different oils were evaluated for apple thinning after successful bloom thinning in peach by clove oil 2-4%, cinnamon oil, and Tergital 2% (Pokharel et al, 2009). More than 80% flowers were killed by the single application of clove oil (4%), Metran (4 and 8%), and Tergitol (2%). Similarly, 60-80% flowers were killed by clove oil (2%) whereas more than 50% flowers were killed by Stylet oil. Trees treated with mustard oil (5 or 15%) or Stylet oil 5% had very few flowers killed, and no flower was killed on water applied (control) trees (Fig.1). The lowest numbers of fruit were observed in Tergitol applied trees followed by Metran 8% and 15 and 10% stylet oil applied trees (Fig. 2). The lower numbers of flower that were killed and lower numbers of fruit obtained might be due to interference during pollination by Stylet oil and mustard oil rather than direct killing of flowers.

The highest fruit yield (lb) per tree was recorded from the trees treated with clove oil 2% which was higher than water alone applied (control) trees. The total yield per tree was lower in trees sprayed with Metran 8%, followed by Tergitol 2%, mustard oil and Stylet oil 10% in trees which were sprayed only half part (Fig. 3).

However, higher individual fruit weight was observed from the trees treated with Metran 4% and Stylet oil 10% sprayed in full tree followed by Tergitol 2%. Where the lower individual fruit weight was observed in the trees sprayed with water alone and clove oil 2% (Fig. 4). Largest fruit size was obtained in the trees sprayed with Tergitol 2% followed by Stylet oil 10% in full tree. The smallest fruit sizes were observed with water only and clove oil (Fig. 5) treated trees. Growers always prefer bigger fruit size and more numbers of fruit, however, fruit size may be more important as small fruits do not pass the packing criteria. Tergitol and higher concentrations of clove and cinnamon oils caused phytotoxicity after spraying but these trees recovered and produced fruits.

From this experiment, Stylet oil 10% could be a potential candidate for apple thinning. However, further confirmation of this result in different years and apple varieties is essential before making any conclusions.

Acknowledgments

The funding for this study was provided by Colorado State University Agricultural Experiment Station. Appreciation is extended to Bryan Braddy and George Osborn (Western Colorado Research Center staff), who assisted with this experiment.
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Rom, C. and S. Ela. 2005. Organic Apple Thinning Strategies. Final Project Report. http://ofrf.org/funded/reports/rom_02s10.pdf

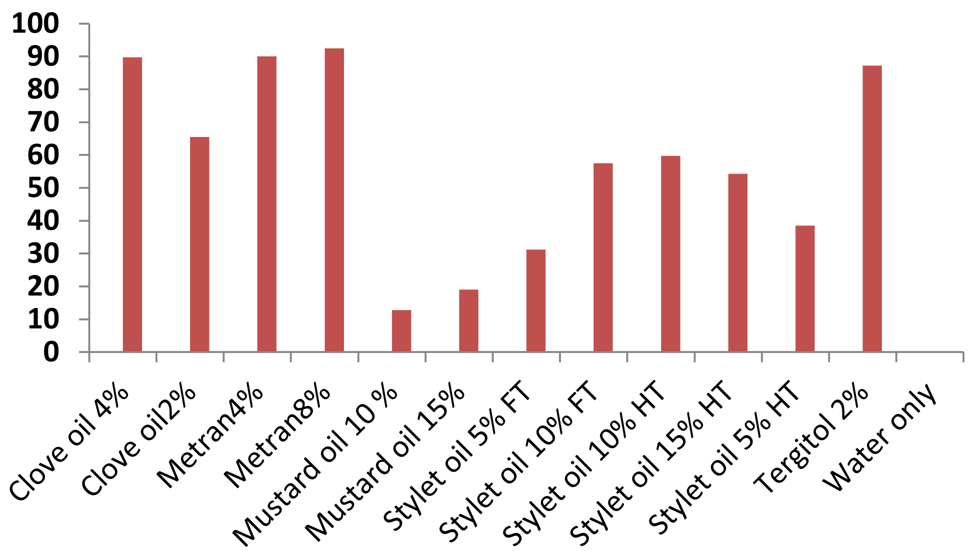

Fig. 1 Percent of flower killed by different treatments in HoneyCrisp Apple at Rogers Mesa Research center, 2010.

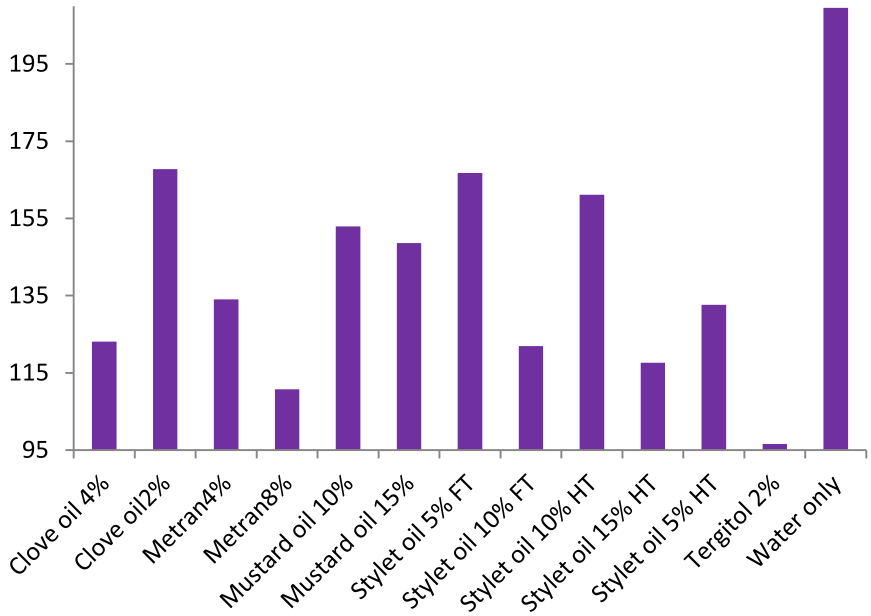

Fig. 2 Total number of fruits per tree in different treatments of HoneyCrisp Apple at Rogers Mesa Research center, 2010.

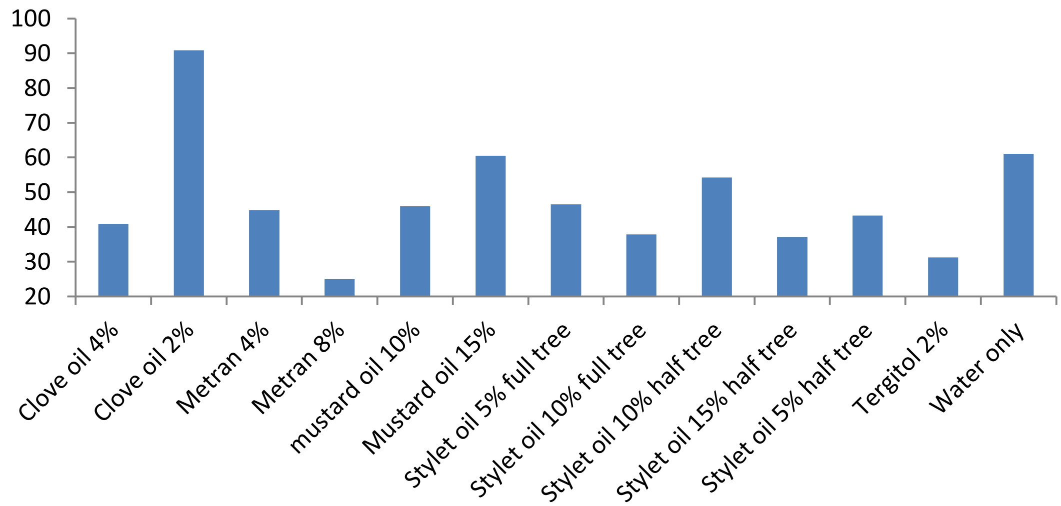

Fig. 3 Total fruit weight (lb) per tree average of five trees in different treatments in HoneyCrisp Apple at Rogers Mesa Research center, 2010.

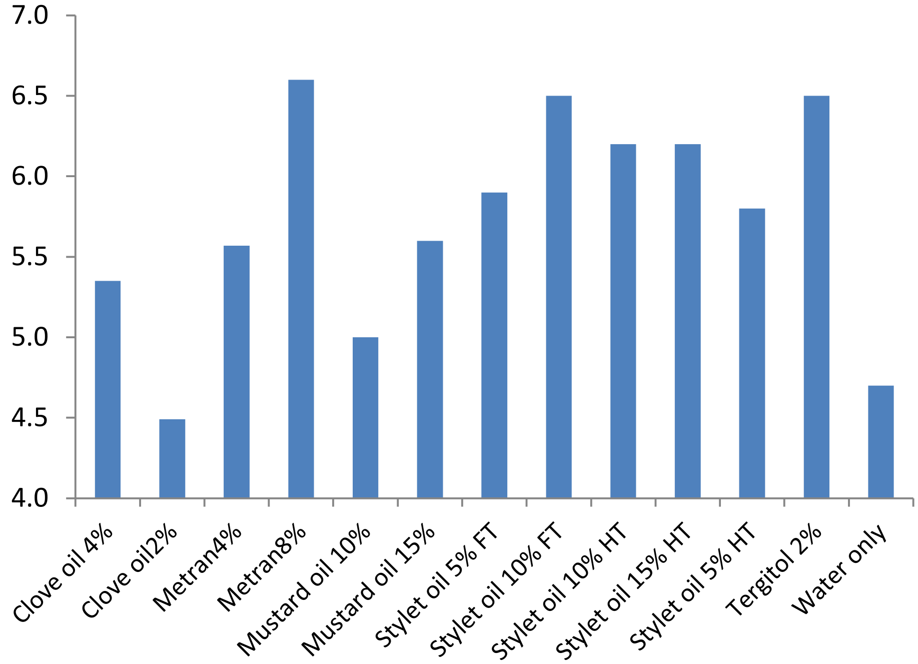

Fig. 4 Fruit weight in ounces per fruit in different treatments applied on HoneyCrisp at WCRC-Roger Mesa 2010.

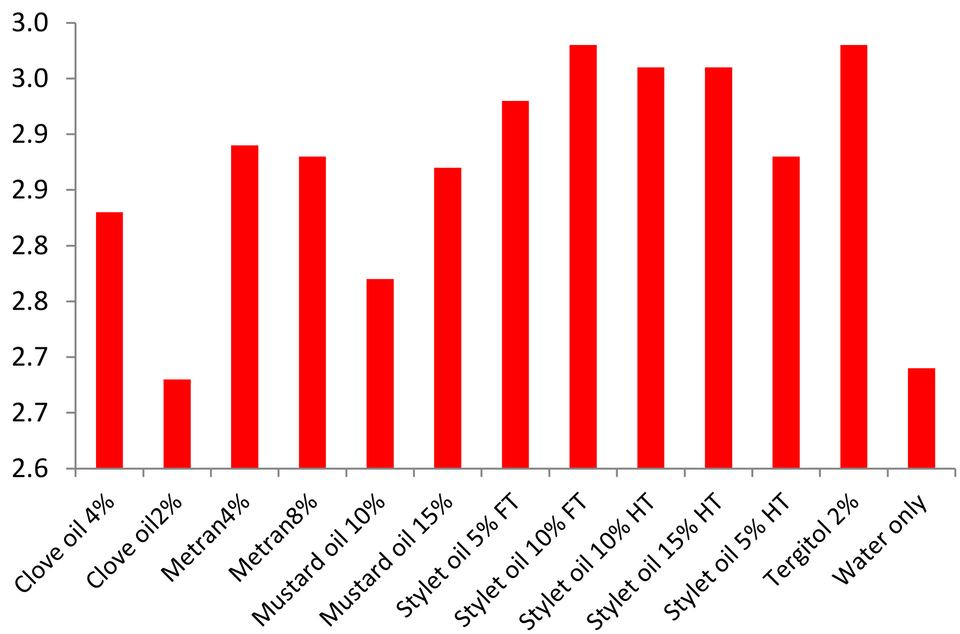

Fig. 5 Fruit size in inches per fruit in different treatments applied on HoneyCrisp at WCRC-Roger Mesa 2010.

SECTION III

Research Projects and Publications

Dr. Horst W. Caspari

2010 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 (Colorado Association for Viticulture and Enology)

Methods to delay bud break of grapevines (Valent Biosciences Corp.)

*Sponsors/Cooperators are noted in parentheses.

2010 Publications

Non-Refereed WEB Publications:

Caspari, H. 2010. 2009 Grower Survey. www.colostate.edu/programs/wcrc/pubs/viticulture/Survey2009.pdf

Caspari, H. 2010. Grape variety evaluation at Rogers Mesa. www.colostate.edu/programs/wcrc/pubs/viticulture/Grape variety evaluation at Rogers Mesa.pdf

Caspari, H. and A. Montano. 2010. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Rogers Mesa near Hotchkiss, Colorado, 2009/10 (7 updates during 2010). www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardinessrm09.pdf

Caspari, H. and A. Montano. 2010. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Orchard Mesa near Grand Junction, Colorado, 2010/11 (10 updates during 2010). www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardiness10.pdf

Caspari, H. and A. Montano. 2010. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Rogers Mesa near Hotchkiss, Colorado, 2010/11 (5 updates during 2010). www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardinessrm10.pdf

Caspari, H., A. Montano, and R. Pokharel. 2010. Fruit bud coldhardiness, western Colorado, 2010/11 (2 updates during 2010). www.colostate.edu/programs/wcrc/pubs/viticulture/fruitcoldhardiness10.pdf

Sharp, R and H. Caspari. 2010. The cost of growing wine grapes in Western Colorado. www.coopext.colostate.edu/WR/costofgrowinggrapes.pdf

Dr. Stephen D. Menke

2010 Technical Publications

Colorado Winery Baseline Survey Assessment, *Western Phytoworks, Fall 2009*, ed. R. Pokharel,
Colorado Sensory Wine Quality Assessment Program: Part 1, Sensory Faults Panel Training Curriculum, *CSU Enology Program Annual Report*, S.D. Menke *et al,*
"Nebraska Wine Quality Assurance Program Feasibility Study", Nebraska Dept. of Agriculture Project Completion Report, August 17, 2010, pp. 1-41

2009 Research Projects

Create and deliver portion of USAID educational program to Serbian winegrape industry, (USAID, M. Chien, P. Bell, T. Wolf, P. Chabot, D. Dmitrijevic, Z. Jovanovic, US Embassy in Belgrade)

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)

2010 Continuing Research Projects

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

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

2010 Research Projects*

Winter wheat cultivar performance test – Hayden (Mike Williams, Dr. Scott Haley)
Alfalfa variety performance test (2008-2010) – Fruita (Dr. Jerry Johnson, seed companies, breeding companies, private industry)
Evaluation of alfalfa genetic material 2010-2012 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of alfalfa genetic material 2008-2010 – Fruita (Dr. Peter Reisen, Forage Genetics)
Alfalfa germplasm evaluations 2009-2011 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of perennial plant species and production input for sustainable biomass and bioenergy production in Western Colorado – (Western Colorado Carbon Neutral Bioenergy Consortium)
Application of bio-stimulant and harvest energy in winter wheat as a sustainable nutrient input – Hayden (Enviro Consultant Service, LLC)
Application of bio-stimulant and harvest energy products in pasture grass as a sustainable nutrient input – Fruita (Enviro Consultant Service, LLC)
An automated control valve for gated pipe to increase furrow-irrigation efficiency – Fruita (Fine Line Industries and Bureau of Reclamation)
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
Legume species for living mulch crop production systems – Fruita (Dr. Joe Brummer, Dr. Neil Hansen)
Co-establishment of legumes and corn in a living mulch cropping system under furrow irrigation (Dr. Joe Brummer)

2011 Research Projects* (Continuing, New, or Planned)

Completion of the Extension and AES publication “Intermountain Grass and Legume Forage Production Manual,” 2nd ed. (Calvin Pearson, Joe Brummer, and Bob Hammon, eds.)
Winter wheat cultivar performance test – Hayden (Mike Williams, Dr. Scott Haley)
Alfalfa variety performance test (2011-2014) – Fruita (seed companies, breeding companies, private industry)
Evaluation of alfalfa genetic material 2009-2011 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of RR alfalfa genetic material 2011-2013 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of perennial plant species and production input for sustainable biomass and bioenergy production in Western Colorado – (Western Colorado Carbon Neutral Bioenergy Consortium)
Application of bio-stimulant and harvest energy in winter wheat as a sustainable nutrient input – Hayden (Enviro Consultant Service, LLC)
Application of bio-stimulant and harvest energy products in pasture grass as a sustainable nutrient input – Fruita (Enviro Consultant Service, LLC)
An automated control valve for gated pipe to increase furrow-irrigation efficiency – Fruita (Fine Line Industries and Bureau of Reclamation)
Evaluation of corn hybrid breeding material for grain and silage – Fruita (DOW Agrosciences)
Evaluation of corn hybrids for blunt ear syndrome – Fruita (Syngenta)
Demonstration using soybean, sunflower, and canola for the production of SVO for use as on-farm biodiesel – Fruita (Denis Reich, Perry Cabot)
Roundup-Ready soybean variety performance trial – Fruita (Syngenta)
Evaluation of Optunia cactus for potential source of biomass for biofuel – Fruita (Morgan Williams, Flux Farm Foundation)

Evaluation of flax and camelina as alternative crops in NW Colorado – Hayden (Mike Williams, CJ Mucklow, and Dr. Jerry Johnson)
Evaluation of winter yellow pea as an alternative crop in NW Colorado – Hayden (Mike Williams, and CJ Mucklow)
Vertical temperature variation in a corn canopy – Fruita
Co-establishment of legumes and corn in a living mulch cropping system under furrow irrigation (Dr. Joe Brummer)

*Cooperators/collaborators/sponsors are noted in parentheses.

2010 Publications

Pearson, C. H., A. D. Halvorson, R. D. Moench and R. W. Hammon. 2010. Production of hybrid poplar under short-term, intensive culture in Western Colorado. Ind Crop Prod. 31:492-498.

Pearson, C. H., K. Cornish, C. M. McMahan, D. J. Rath and M. Whalen. 2010. Natural rubber quantification in sunflower using an automated solvent extractor. Ind Crop Prod. 31:469-475.

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Pearson, C.H. and Sharp, R.L. 2010. Double- cropping pinto bean after winter barley in western Colorado USA. J. Agricultural Science and Technology 4:1-7.

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Pearson, Calvin. 2010. Local Weather Data Available on the Internet. pp. 3. In: Western PhytoWorks (Ramesh Pokharel, ed.). Fall 2010. Newsletter of the Western Colorado Research Center, Agricultural Experiment Station, Colorado State University.

Pearson, C.H. 2010. Performance of fall-planted malting barley at Fruita, Colorado 2008-2009. p. 20-27. in: Western Colorado Research Center 2009 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR10-07. Fort Collins, Colorado.

Pearson, C.H., Brummer, J., and Beahm, A. 2010. Co-establishment of legumes and corn in a living mulch cropping system under furrow irrigation. p. 10-19. In: Western Colorado Research Center 2009 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report 10-07. Fort Collins, Colorado.

Dr. Ramesh Pokharel

Ongoing Projects

NC 140-Apple rootstock evaluation study 2008 in high soil pH for normal plating. Brookfield Gala apple trees, grafted to 23 different rootstocks including dwarf, semi-dwarf and normal, are included in this study.
NC 140-Apple rootstock evaluation study 2010; Honeycrisp apple trees grafted to 23 different rootstocks, focused to dwarf rootstocks are established in close planting in western Colorado.
NC 140-Peach rootstock evaluation study: Seventeen rootstocks including the rootstocks for calcareous soil with high pH are planted.
NC-140- Cherry rootstock training system study 2010: comparison of dwarf rootstock under 3 different training systems in western Colorado.
Evaluation of Cherry varieties under upright fruiting off-shoot (UFO) training systems:
Soil and plant health study in peach focused to produce healthy trees with high yield and better quality fruits.
Peach physiology study
Evaluation of small berries as alternative crops
Production studies of exotic and high value vegetables in western Colorado condition.
Apple thinning studies focused to organic growers
Cytospora Canker management studies
Cherry rasp leaf-dagger nematode complex studies
Evaluation of bio-fumigation, soil solarization, and peach rootstocks on stone fruit replant problem.

New Projects

Evaluation of 10 different peach varieties for western Colorado conditions
Evaluation of two cherry varieties and Zee citation inter-stem for the movement and expression of Cherry Rasp Leaf Virus and yield in western Colorado conditions in a grower's field.
Water management and deficit irrigation in peach and their impact on fruit development and quality. (Denis Reich, Western Regional extension water specialist.
Evaluation of Lavender varieties for western Colorado conditions (Curtis Swift, PI).

Journal publications

Pokharel, R. R**.,** Mock, R. Li, G. Kinard and H. Larsen. 2010¨ Association of multiple virus infections with apple disease in western Colorado. Phytopathology 100(6), S101.

Pokharel, R. R**.**, G. S. Abawi, J. M. Duxbury, X. Wand, J. Brito, 2010. Variability and determination of two races in *M. graminicola***.** Australasian Journal of Plant Pathology 39:326-333.

Johnson, S., R. Anderson, W. Autio, T. Beckman, B. Black, P. Byers, J. Cline, C. Chavez-Gonzalez, W. Cowgill, R. Godin, G. Greene, M. Kaps, J. Kamas, H. Larsen, T. Lindstrom, D. Miller, M. Newell, D. Ophardt, D. Ouellette, R. Parra-Quezada, R. Pokharel, G. Reighard, T. Robinson, J. Schupp, L. Stein, K. Taylor, C. Walsh, D. Ward, M. Warmund, M. Whiting. 2010. Performance of the 2002 NC-140 Cooperative Peach Rootstock Planting. Journal of American Pomological Society 65 (1):17-25.

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, M. Newell, D. Ouellette**,** R. Pokharel, L. Stein, K. Taylor, C. Walsh, D. Ward and M. Whiting. 2010. Six-year Performance of 14 *Prunus* Rootstocks at 11 sites in the 2001 NC-140 Peach Trial. American Pomological Society 65 (1):26-4 1.

Pokharel, R. R. 2010. Impact of dagger nematode and Cherry Rasp Leaf Virus on Colorado's Cherry industry. Journal of Nematology (In press)

Pokharel, R.R**.** and Zimmerman**,** R. 2010. Nematode community analysis as a soil health indicator in organic vs. conventionally managed peaches. Journal of Nematology (In press)

Book chapters

Larsen, H. and R. Pokharel. 2011. Disease Biology and Monitoring. *In* Utah-Colorado Commercial Tree Fruit Production Guide. Marion Murray and Harold Larsen eds. Utah State University Extension and Western Colorado Research Center, Colorado State University. Pp 17-32.

Murray, M., D. Alston, H. Larsen and R. Pokharel. 2011. Pesticide information and Spray Tables. *In* Utah-Colorado commercial Tree Fruit Production Guide. Marion Murray and Harold Larsen eds. Utah State University Extension and Colorado State University Extension. Pp 33-107.

Web publications

Caspari, H, A. Montano, and R. Pokharel. 2011. Fruit bud cold hardiness, western Colorado, 2010/11. Colorado State University, Western Colorado Research Center, Web publication http://www.colostate.edu/programs/wcrc/pubs/viticulture/fruitcoldhardiness10.pdf

Pokharel, R.R., (revised). 2011. Cytospora canker. PP 1-2. Web publication http://www.colostate.edu/programs/wcrc/pubs/research_outreach/Cytospora%20final.pdf

Pokharel, R.R., 2010. Importance of nematodes in Fruits. Web publication http://www.colostate.edu/programs/wcrc/pubs/research_outreach/Nematode%20Problems%20_final%2012-20.pdf

Pokharel, R.R., 2010**.** Soil solarization, a potential solution to replant disease. Web publication http://www.colostate.edu/programs/wcrc/pubs/research_outreach/Soil%20Solarization%20_final%201_.pdf

Swift, C. and R. Pokharel.2010. Rootstocks for Tree Fruit in Heavy Calcareous Soils. Web publication http://www.coopext.colostate.edu/TRA/PLANTS/rootstocks%20Dec%2029%202010.pdf

Others

Pokharel, R.R., 2011. Soil solarization, an alternative to soil fumigants. Colorado State University Extension Factsheet no 0.505.

Pokharel, R.R**.** and .H.J. Larsen 2010. Non-chemical Management of Cytospora canker in stone fruits in Colorado. Technical Report- TR 10-07; 28-32.

Pokharel, R.R**.** and .H.J. Larsen 2010. The 2008 NC-140 Apple rootstock Trial: 2nd year results. Technical Report- TR 10-07; 7-9.

Pokharel, R.R**.** 2010. Field day at Western Colorado Research Center. Western Phytoworks; Fall 2010. P 1.

Pokharel, R.R. 2010**.** Yellow peach syndrome, an increasing concern to the growers. Western Phytoworks; Fall 2010. P 5.

Pokharel, R.R. 2010. Identification and Diagnosis of Fruit Virus/Viroid and Vectors help minimize the production problem. Western Phytoworks; Spring 2010. P 4.