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Colorado State University

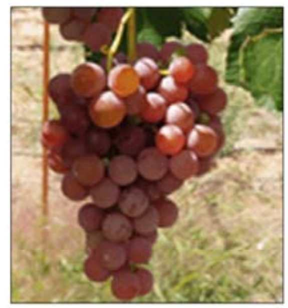
Agricultural Experiment Station

College of Agricultural Sciences

Western Colorado Research Center

Cooperative Extension





Western Colorado Research Center

2006 Annual Report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Front Cover Photos clockwise from top left:
"Alfalfa Harvest" – Photo by Calvin Pearson
"Fruit Tree Pruning Class" – Photo by Harold Larsen
"Grapes" – Photo by Harold Larsen
"Grapevine Pruning Workshop" – Photo by Harold Larsen
"Sunflower" – Photo by Calvin Pearson
Composition by Susan E. Baker

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Introduction

Low commodity prices and rising land values continue to encourage farmers to look at new and alternate crops, alternate management approaches (including organic production), and marketing. The Western Colorado Research Center (WCRC) continues its mission of planning, implementing, and conducting research and outreach programs to address regional agricultural needs and help farmers find new answers and alternatives. 2006 was a busy year for WCRC personnel and staff. This Annual Report for 2006 provides information from some of the many research topics under investigation in 2006 (and prior in some cases). These include row and field crops, forage crops, orchard and vine fruit crops, and vegetable crops.

We completed the hybrid poplar agroforestry project, moved ahead on the Uncompaghre revegetation projects, continued to work on the sunflower latex rubber studies, shifted focus in the grape powdery mildew control studies to look at spot treatment options, and looked at new and alternative options for orchard replant problems. The viticulture project continued to expand as does the wine grape acreage within the state.

We continue to update and expand our web page and link to the Tri-River Cooperative Extension web pages for other information. This is increasingly important as more farmers adopt computers as an information management tool. We realize they have access to a wealth of free information on the worldwide web, and we are trying to do our part to provide information of value to them in that venue.

Staffing changes included John Brazelton, who came as an hourly worker in fall 2005 to help at the WCRC – Fruita site (replacing Lot Robinson who resigned fall 2005). That Research Associate position was made a temporary full-time Research Associate position and filled by John in Feb. 2006. He has been a most welcome addition to the WCRC – Fruita staff.

We also welcomed a new Research Associate (Post-Doctoral) at WCRC – Orchard Mesa with the arrival of Dr. Ramesh Pokharel. He has a Ph.D. in Plant Pathology from Cornell University (with emphasis on nematodes), is responsible for the fruit pathology research program, and is "learning the ropes" for the fruit Extension/Outreach aspect that I have covered in the past. He also has assumed responsibility for our NC-140 Rootstock trials as of fall, 2006. With the stone fruit replant studies, NC-140 studies, Cherry Rasp Leaf Virus / rootstock-interstem susceptibility studies, and new fruit crop / nematode population studies currently underway, he is a most busy individual. He is a native of Nepal and came to the U.S. by way of India. We look forward to the contribution he is providing (and will continue to provide) to our knowledge base for agriculture in western Colorado.

We were pleased to receive word in May that Susan Baker, our all-around administrative support person, was approved for reclassification to Accounting Tech III effective July 1. Susan's contributions to the administrative aspects of WCRC have been extremely important to the smooth operation of the Center, and the promotion is extremely well deserved.

I gratefully acknowledge the effort that support staff and faculty have made in ensuring the successful completion of this year's projects. The accomplishments reported herein would not have been possible without their cooperation & effort, as well as that of the Colorado Agricultural Experiment Station and the department heads associated with this center. And funding support has been provided by many sources; most, if not all, of these are acknowledged in the individual reports by the authors.

Harold Larsen
Interim Manager, Western Colorado Research Center

Agricultural Experiment Station - Western Colorado Research Center Site Descriptions

Fruita Location: 1910 L Road
Fruita, CO 81521
(970) 858-3629
(970) 491-0461 *fax*

WCRC - Fruita is an 80-acre property 15 miles northwest of Grand Junction. Site elevation is 4510 feet, average precipitation is slightly more than 8 inches, with an annual frost-free growing season of up to 175 days. Average annual daily minimum and maximum temperatures are 41° F and 64° F respectively. The primary soil types are Billings silty clay loam and Youngston clay loams. Irrigation is by way of gated pipe and furrows with ditch water from the Colorado River. Facilities at the Fruita site include an office building, shop, equipment storage building, field laboratory, tissue culture laboratory, and a dry bean conditioning facility. The Colorado State University Foundation Bean Project operations are managed at WCRC - Fruita. A comprehensive range of agronomic equipment is based at the site to facilitate research on a variety of agronomic crops.

Orchard Mesa Location: 3168 B ½ Road
Grand Junction, CO 81503
(970) 434-3264
(970) 434-1035 *fax*

WCRC - Orchard Mesa is located seven miles east and south of Grand Junction on B ½ Road. It lies at an elevation of 4,750 feet with Mesa clay loam and Hinman clay loam soil types. High temperatures average 93° F in July and 39° F in January. Lows average 64° F in July and 18° F in January. While the frost-free growing season averages 182 days, spring frost damage is frequent enough to be a production problem. Frost protection is provided by wind machines. Irrigation is by pressurized drip, micro-sprinkler and gated pipe systems supplied by ditch water from the Colorado River. Facilities at the Orchard Mesa site include an office-laboratory building with labs for plant pathology and viticulture research. Other buildings include a conference room, shop, and separate climate controlled and retractable roof greenhouses. Approximately twelve of the center's 80 acres are devoted to experimental orchards, principally apples, peaches and pears. Three acres are dedicated to wine grape variety trials and research. The balance of acreage is utilized for hybrid poplar research, grass and alfalfa production, and small demonstration plantings of tree fruits including sweet cherry, sour cherry, apricot, and plum. Additional acreage is also utilized annually for dry bean variety trials and seed increases in conjunction with the CSU dry bean breeding project and Foundation Seed Project.

Rogers Mesa Location: 30624 Highway 92
Hotchkiss, CO 81419
(970) 872-3387
(970) 872-3397 *fax*

WCRC - Rogers Mesa is located 17 miles east of Delta and 3 miles west of Hotchkiss on Colorado Highway 92. Site elevation is approximately 5,800 feet, average annual precipitation is about 12 inches, and the average frost-free growing season is 150 days. The soil type is clay loam. High temperatures average 88° F in July and 42° F in January. Lows average 57° F in July and 18° F in January. Frost protection is provided by wind machines. Irrigation methods used include drip, micro-sprinklers, and furrow, all supplied from the Fire Mountain canal water. Facilities include an office-laboratory-conference room building, shop, residence, and greenhouse. Experimental orchards occupy approximately 8 acres, approximately half of which is managed organically. An organic table grape variety trial was planted in spring 2003, and wine grapes were planted in spring 2004. Research plots for seed production of native forages and shrubs were established in 2004. Research efforts on conventional vegetable production began in 1998 and have since expanded to include organic options.

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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 2006 are listed below. Committee members serve voluntarily without compensation. WCRC Advisory Committee meetings are open to the public. For the current memberhip list please visit our web page (http://www.colostate.edu/programs/wcrc/).

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Application of Crop Modeling for Sustainable Grape Production

Horst W. Caspari[1] and Harold J. Larsen[2]

Summary

Alternatives to a calendar-based spray program for the control of grape powdery mildew (*Uncinula necator*) were investigated in Western Colorado vineyards over five seasons (2002-2006). Participating growers used a calendar-based program on approximately half of a vineyard block while using an integrated disease management program on the other half. Weather stations installed in those vineyard blocks provided the climatic data used to guide spray recommendations. Conclusions are as follows. First, powdery mildew does not appear to overwinter in infected buds under the growing conditions of western Colorado. Second, the establishment of powdery mildew requires a primary infection originating from overwintering cleistothecia. The weather conditions required for a successful primary infection are thought to be a minimum of 0.1" of precipitation, a minimum temperature of 50 ^{o}F, and at least 8 hours of continuous leaf wetness. Weather conditions inside grape canopies can easily be monitored, and the information can be used in the decision-making process regarding mildew control. Third, spray recommendations from established regions like California with very different climatic conditions are inappropriate for Western Colorado locations. Due to the absence of bud perennation and hence the lack of early-season inoculum, fungicide applications shortly after bud break are not needed unless weather conditions are conducive for a primary infection. Finally, grape powdery mildew can be effectively controlled with a spray program that is reactive (treating only infection hotspots plus a buffer) rather than preventative in nature. Using such a program can lead to significant reductions in both spray applications and the costs for spray materials. Combining weather monitoring with field observations of powdery mildew infections can greatly reduce, if not entirely eliminate, powdery mildew sprays within a season. Survey data from 2004-2006 indicate that many Colorado growers have adopted a response-type approach to powdery mildew control.

Introduction and Objectives

Grape powdery mildew is the primary disease of *Vitis vinifera* grapes in Colorado. Historically, the typical grape powdery mildew control program in western Colorado vineyards has been preventative in nature. Growers began applying prophylactic sprays when shoots were about 4-6 inches long and continued through veraison at intervals determined by the spray longevity of the materials used. This approach has historically resulted in four to as many as eight sprays applied each season.

Our previous studies examined the combined use of weather monitoring, computer modeling for grape powdery mildew risk based on the collected weather data, crop development stage, field scouting, and prescribed fungicide sprays when powdery mildew infection is found. We have shown that it is possible to substantially reduce the number of pesticide applications to control grape powdery mildew by basing the applications on model assessment of mildew infection risk and observed infection confirmation (Caspari and Larsen, 2005). As a result, much of the wine grape industry in western Colorado has adopted our recommendations and reduced the number of mildewcide sprays by applying them only when needed, not simply on a calendar basis. For example, survey data from 2004 indicate that growers used on average only 2.3 fungicide sprays to control powdery mildew, while data for 2005, a year with a higher disease pressure, show an average of 3.1 sprays. Data from this year (2006), again a year with low powdery mildew pressure, show an average of 2.6 sprays.

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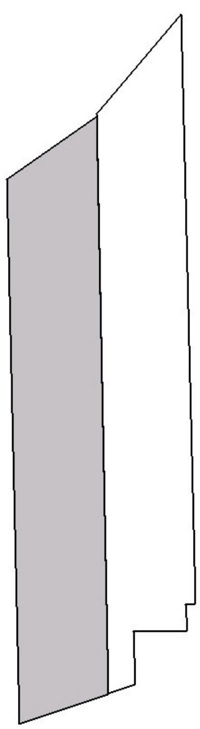
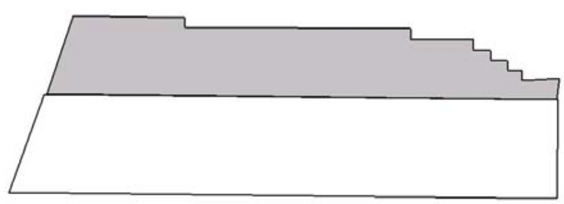
[1]Viticulturist and [2]Research Fruit Pathologist / Extension Fruit Disease Specialist, Department of Horticulture and Landscape Architecture, Colorado State University.

In the studies conducted from 2002-2004 it was observed that powdery mildew infections within the study vineyards might arise seasonally from vineyard “hot spots.” The infection then spreads to other parts of the vineyard if not controlled by fungicide sprays. Once an infection is noticed, growers then typically apply fungicide sprays to the entire vineyard to protect developing fruit from infection. This vineyard-wide application results in spray materials being applied to substantial portions of the vineyard that have no observable infection. The current study investigates if the amount of fungicides applied can be further reduced by use of closer field monitoring, identification of “infection hot spots” within the plots by fine discrimination GPS coordinates, and prompt application of effective fungicides to these “hot spots.” Results from the 2005 season showed that it is indeed possible to effectively control powdery mildew when applying sprays to "hot spots" and a buffer zone as long as the infected areas are correctly identified (Caspari and Larsen, 2006). But they also showed that incorrect identification of the "hot spots" and/or mistakes when applying sprays to the target areas can lead to re-infection from the "hot spots", and rapid spread of powdery mildew. Further, restricting spray applications to "hot spots" plus buffer is not feasible when powdery mildew infection is widespread throughout the vineyard. Under those circumstances the whole block needs to be treated.

Materials and Methods

Two cooperator vineyards were identified with a minimum 2 acres of Chardonnay. The blocks are the same as used continuously since 2002 for our previous study. Grower cooperators were to use their choice of control programs (grower’s standard control program) for grape powdery mildew control on one half of the block (minimum of 1 acre) and to use the control program designated by the researchers for the other half of the block (minimum of 1 acre, which included the site of a remote weather station described below). The two different blocks/treatments will be referred to as "grower" and "model" (Fig. 1). In addition, Colorado State University's entire research vineyard was





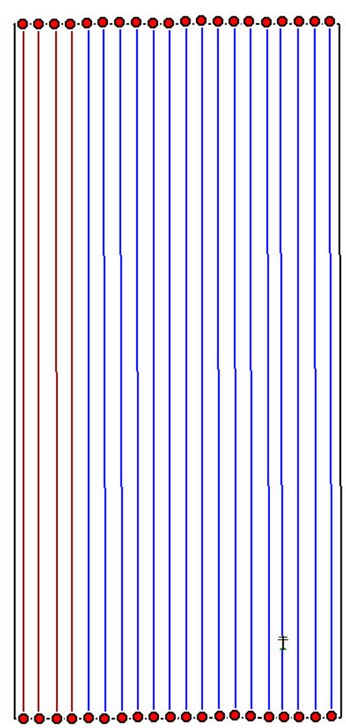


Fig. 1: Boundary maps (not to scale) of vineyard A (left) and B (top), and CSU's research vineyard (right). Vineyards A and B are Chardonnay, and the "model" plot is shown in gray. The eastern 16 rows (blue lines) of the CSU vineyard are Chardonnay while the western four rows (brown lines) contain 20 different varieties. The entire CSU vineyard was managed according to the "model" approach.

Table 1. Powdery mildew spray programs used at cooperator vineyard A during the 2006 season.

Grower's Standard Mildew Program			Integrated Disease Management Program		
Date	Materials & rates used	Cost[z]	Date	Materials & rates used	Cost[z]
5/8	Sulfur 6 @ 0.5 gal/a	$2.50	5/8	Sulfur 6 @ 0.5 gal/a	$2.50
5/26	Sulfur 6 @ 0.5 gal/a	$2.50			
7/14	Nova 40W @ 4 oz./a + Stylet-Oil @ 1.25 gal/a	$33.50	7/14	Nova 40W @ 4 oz./a + Stylet-Oil @ 1.25 gal/a	$33.50
7/29	Sovran @ 4 oz./a + Stylet-Oil @ 1 %	$39.75	7/29	Sovran @ 4 oz./a + Stylet-Oil @ 1 %	$39.75
Total Spray Program Cost		**$78.25**	Total Spray Program Cost		**$75.75**

[z] Costs per acre for spray material only.

Table 2. Powdery mildew spray programs used at cooperator vineyard B during the 2006 season.

Grower's Standard Mildew Program			Integrated Disease Management Program		
Date	Materials & rates used	Cost[z]	Date	Materials & rates used	Cost[z]
5/9	Microthiol @ 4 lbs/a	$3.40	5/9	Microthiol @ 4 lbs/a	$3.40
5/24	Nova 40W @ 3.75 oz./a	$15.00			
6/20	Sovran @ 4 oz./a	$27.29			
7/14	Sovran @ 4.8 oz./a + Stylet-Oil @ 1.5 %	$57.15	7/14	Sovran @ 4.8 oz./a + Stylet-Oil @ 1.5 %	$57.15
8/3	Stylet-Oil @ 1 %	$17.50	8/3	Stylet-Oil @ 1 %	$17.50
Total Spray Program Cost		**$120.34**	Total Spray Program Cost		**$78.05**

[z] Costs per acre for spray material only.

Table 3. Powdery mildew spray programs used at the CSU vineyard during the 2006 season.

Date	Materials & rates used	Cost[z]	Area treated (%)
6/15	Pristine 38WDG @ 8 oz./a	$18.75	7
7/14	Nova 40W @ 5 oz./a + Stylet-Oil @ 1.5 %	$62.00	100
	Total Spray Program Cost	**$80.75**	

[z] Costs per acre for spray material only.

managed as a "model" block according to the researchers' protocol. The spray programs varied from two to five sprays per season between sites (Table 1-3).

Automated Adcon weather stations were installed at the three sites in 2002. Each station is equipped with sensors to measure air temperature, humidity, leaf wetness, precipitation, wind speed and direction, and solar radiation. Data was relayed back to a base station at CSU's Western Colorado Research Center via radio telemetry on 15-minute intervals. The base station database was then accessed using the Thomas-Gubler powdery mildew disease model to assess mildew infection risk.

As in previous years, field scouts assessed powdery mildew infection incidence and severity on variable intervals, typically once a week. Incidence and severity of powdery mildew infections on leaves were recorded from late May to early August 2006 (about veraison). Samples included both basal (near the fruit zone) and more apical leaves at each sampling time. Sampling was at random although an effort was made to sample all areas of the blocks. At each sampling date, the incidence and severity of powdery mildew was determined on two leaves per vine on a total of 50 vines per plot (i.e. 100 samples per plot, and 200 samples per site). Field scouts were equipped with a Global Position System receiver (Trimble AgGPS 114 receiver connected to HP iPAQ handheld computer). The AgGPS 114 receiver uses Differential GPS to achieve high, submeter accuracy. The use of this system allowed the calculation of a 3D position (latitude and longitude, altitude, and time) of the disease data. After downloading the field data to a desktop PC, the sample locations as well as the disease incidence could then be visualized using a dedicated software program (FarmGIS, Red Hen Farming Systems, Fort Collins, CO), and maps showing the distribution of powdery mildew (if present) by severity were created using MapCalc software (Red Hen Farming Systems, Fort Collins, CO). This information on distribution and severity was then used to determine if a fungicide application should be applied, and to what areas of the "model" plot. Although we provided information about powdery mildew severity and distribution to the cooperating growers, any fungicide application in the "grower" plot was always to the entire plot.

Results

Results from the 2002-2005 seasons have been reported previously (Caspari and Larsen, 2003, 2006; Larsen and Caspari, 2004, 2005). Here we concentrate on the results from the final year of this project. Weather conditions in May 2006 were dry and warm, and only two days had measurable rainfall. However, rainfall amounts were too small and leaf wetness duration too short to cause a primary infection. The first significant rainfall and leaf wetness period occurred on June 9, 2006. Although rainfall amounts and leaf wetness durations at all three sites appeared sufficient for primary infections, no mildew was found at the grower vineyards until after a second significant rainfall event on July 9, 2006. In contrast, some powdery mildew was found in a small area of CSU's research vineyard (Fig. 2). In response to the mildew observation, this area and a buffer zone was treated on June 15, 2006. The treated area was only 7 % of the total vineyard area. It is worth noting that the vines in this area are the most vigorous within the entire vineyard, and although not quantified, had the highest canopy density within the vines in the block. This denser canopy might indeed be the reason why the mildew infection got established in this area as the dense canopy might have caused a longer leaf wetness period. However, the fungicide

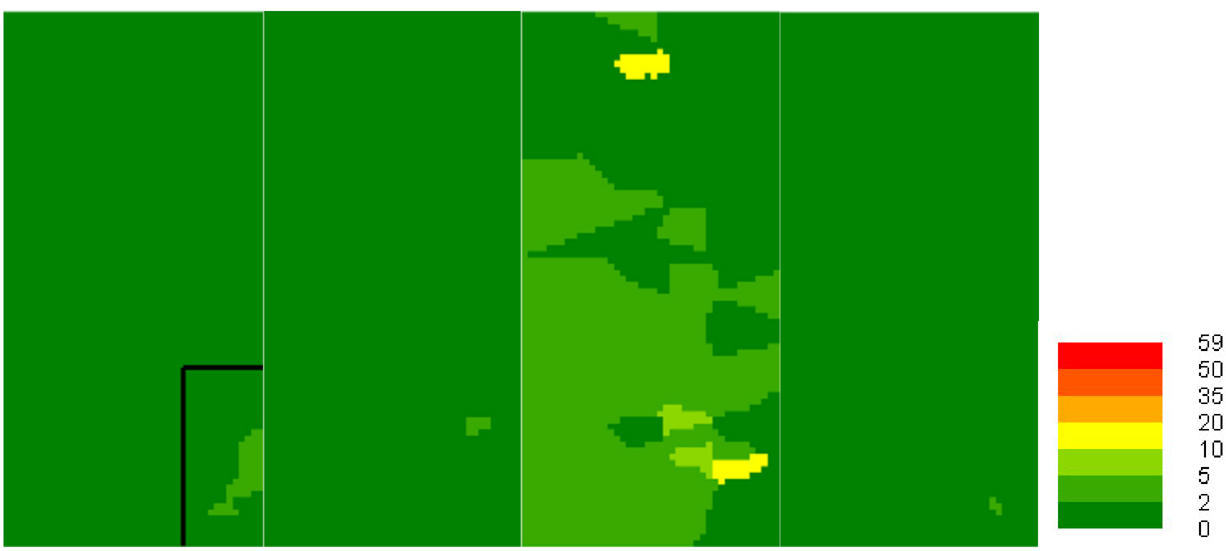


Fig. 2: Distribution and severity of grape powdery mildew at the CSU research vineyard on 13 and 22 June, 13 and 27 July, 2006 (left to right). Different colors represent different severities. The black line in the map for 13 June shows the approximate boundary for the southeastern edge of the vineyard that was treated on 15 June, 2006. Note that no mildew was found at any other date between 23 May and 3 August, 2006.

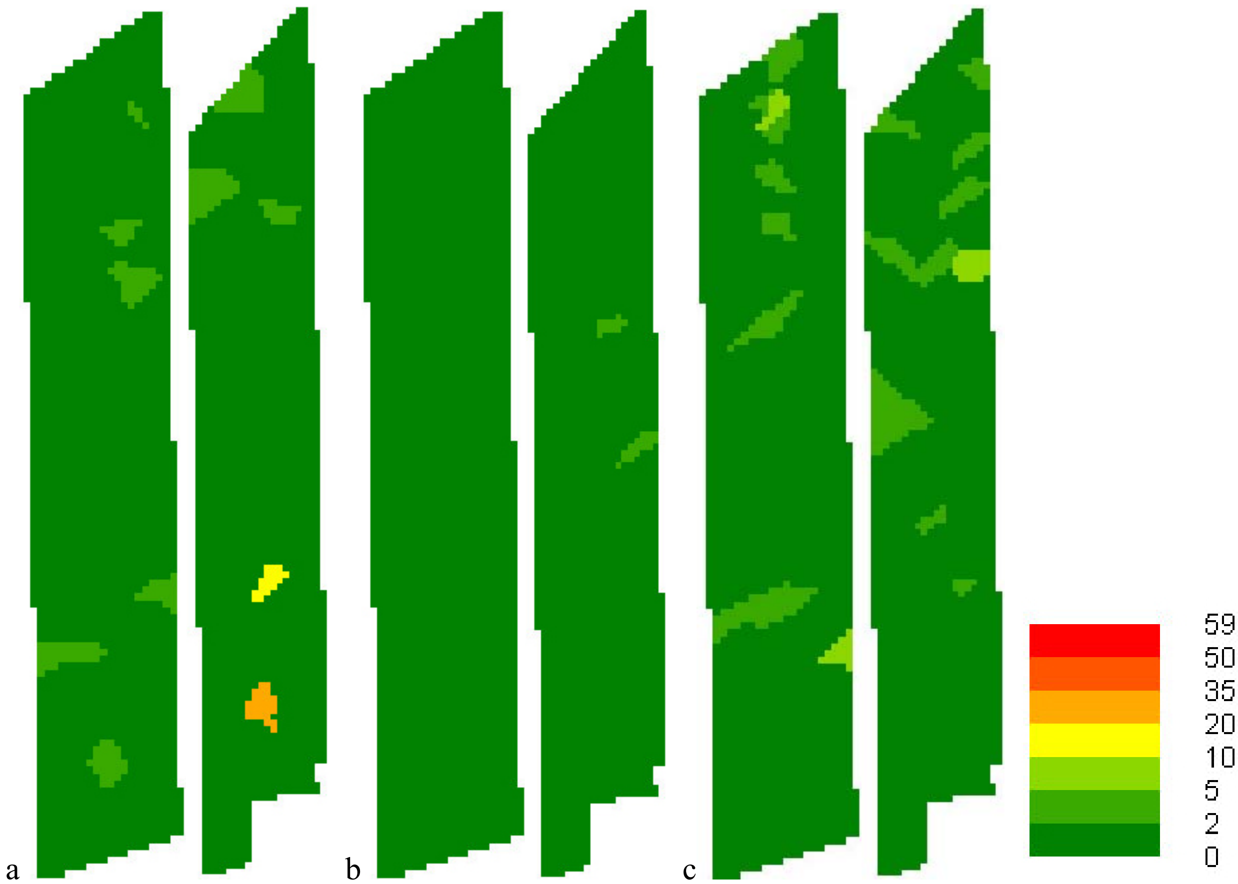


Fig. 3: Distribution and severity of powdery mildew on Chardonnay grape leaves at vineyard A. From left to right: 12, 21 & 28 July. For each date, the model block is on the left, the grower block on the right. Note that no mildew was found at any other date between 31 May and 3 August, 2006.

application to this area provided good mildew control for the remainder of June, although some mildew was found within the area treated on June 22 (Fig. 2).

No mildew was observed on the cooperator vineyards until 12 July (vineyard A; Fig. 3a) or 13 July, 2006 (vineyard B "model" block only; Fig. 4). The occurrence of powdery mildew at the cooperator vineyards, as well as at CSU's research vineyard at the same time (Fig. 2), is likely the result of an extended rainy period from 7-10 July, 2006. At vineyard A, powdery mildew was found in several areas of both blocks, and the entire vineyard was treated on 14 July, 2006 (Table 1). Scouts did not observe any mildew in the "model" block on the next visit 6 days after the fungicide application, but there were two small infection spots within the "grower" block (Fig. 3b). On 28 July, 2006, i.e. 14 days after the fungicide application, powdery mildew was again evident in several areas in both blocks (Fig. 3c). The final spray for the season was applied on 29 July, 2006 (around veraison and before applying bird netting) and no mildew was found on the final observation on 3 August, 2006.

At vineyard B, powdery mildew infections were spread throughout the "model" block on 13 July, 2006 (Fig. 4, top), but no mildew was found in the "grower" block. It appears that the fungicide application in the "grower" block on 20 June, 2006 (Table 2) still provided protection during the extended wetness period. However, both blocks were treated on 14 July, 2006 (Table 2). This spray provided good protection as no mildew was observed on the next two visits (20 and 27 July) in the "model" block with only a

Fig. 4: Distribution and severity of powdery mildew on Chardonnay grape leaves at vineyard B. Top: 13 July, 2006 (model). Bottom: 20 July, 2006 (grower). Note that no mildew was found at any other date between 26 May and 27 July, 2006.

very small area showing infection in the grower block on 20 July, 2006 (Fig. 4, bottom). The cooperator applied a final fungicide to both blocks at the time of veraison just prior to the application of bird netting (Table 2). Powdery mildew pressure was low to moderate during late summer and fall of 2006, and no fruit infection was found at any of the monitored vineyards.

Discussion

Alternatives to a calendar-based spray program for the control of grape powdery mildew (*Uncinula necator*) were investigated in Western Colorado vineyards over five seasons (2002-2006). Participating growers used a calendar-based program on approximately half of a vineyard block while using an integrated disease management program on the other half. Weather stations were installed in those vineyard blocks and the climatic data received from the stations were used to guide spray recommendations. Under favorable weather conditions, i.e. dry spring and early summer, it was feasible to control powdery mildew with as little as 1-2 spray applications per year compared to up to 8 applications in a calendar-based program. In most vineyards, powdery mildew was not observed until early-mid July in 3 out of 5 years, irrespective of the early-season spray program. As a result, a control strategy that is reactive, rather than preventative, in nature has the potential to substantially reduce both the number of spray applications and application costs compared to a calendar-based spray program while providing the same level of control.

Over the five years of this project we have never found "flag shoots" - shoots arising from overwintering buds that are infected with powdery mildew. At vineyard B, powdery mildew was never detected prior to July - irrespective of the control strategy used during the early part of the season. Likewise, mildew wasn't found at vineyard A until July during 2002, 2004 and 2006, while it was late June in 2003. Only in 2005 did we observe the first mildew of the season in early June at vineyard A. During 2003 and 2004 we also monitored powdery mildew infections in three other vineyards, and mildew was generally not observed until July (Larsen and Caspari, 2004, 2005). In almost all cases the first mildew infections of a season were found after a rainy period.

Based on observations in the first three years (2002-2004) that powdery mildew infections within study vineyards might arise from “hot spots”, we investigated the potential to use GPS technology to a) identify and delineate infected versus non-infected areas, and b) target spray applications to the infected areas only (plus a buffer zone) during the 2005 and 2006 season. This alternative control strategy was evaluated on two commercial vineyards as well as Colorado State University's research vineyard. On the commercial vineyards, approximately half of a mature Chardonnay block received the grower's standard spray program ("grower") while the other half was managed according to powdery mildew modeling and the results of weekly, GPS-referenced disease assessments ("model"). At the CSU vineyard, the entire block was managed according to the "model" approach.

Powdery mildew incidence varied greatly between the three Chardonnay blocks as well as between years. In 2005, mildew was present and widespread in early June on one site and required a season-long spray program. At the second site, a localized powdery mildew infection was found in the "model" block in early July and controlled by treating the "model" block only. Similar control of powdery mildew was achieved with three fungicide applications in the "model" block compared to five applications in the "grower" block. At the CSU vineyard, the first (mid June) and second (early July) application was restricted to infected areas, treating 56 and 37 % of the vineyard area, respectively, while the final application in late July was to the entire vineyard. In 2006, no mildew was observed in the two commercial vineyards until mid July. Excellent powdery mildew control was achieved with either control strategy, yet with a reduction in the number of spray applications and application costs in the "model" blocks. At the CSU vineyard, only 7 % of the vineyard block was treated in response to a very localized powdery mildew infection in mid June, which provided good control until a rainy period during 7-10 July. A final spray was applied to the entire vineyard area following this infection period.

The results from all seasons illustrate both the potential and limitations of this alternative control strategy. Early, widespread disease pressure found at one site in one year required a continuous spray program with no advantage of the "model" over the "grower" standard. However, excellent control of powdery mildew was achieved with a reduced ("model") spray program during other times, and at other sites. In addition, targeted fungicide applications at the CSU vineyard resulted in the elimination of the equivalent of one spray in 2005, and only 7 % of the vineyard area was treated with the first spray in 2006. Timely analysis of GPS data and proper identification of spray target areas are required to reduce the risk of re-infection from non-treated "hot spots". Further, wetness periods appear to be required to cause powdery mildew infections, and spray applications early in the season prior to a primary infection are not needed. The number of spray applications and application costs can be reduced when combining weather monitoring with field observations. Survey data from 2004-2006 indicate that many Colorado growers have adopted a response-type approach to powdery mildew control.

A number of conclusions can be drawn from our results. First, powdery mildew does not appear to overwinter in infected buds under the growing conditions of Western Colorado. Second, the establishment of powdery mildew requires a primary infection originating from overwintering cleistothecia. The weather conditions required for a successful primary infection are thought to be a minimum of 0.1" of precipitation, a minimum temperature of 50 ^{o}F, and at least 8 hours of continuous leaf wetness. Weather conditions inside grape canopies can easily be monitored, and the information can be used in the decision-making process regarding mildew control. Third, spray recommendations from established regions like California with very different climatic conditions are inappropriate for Western Colorado locations. Due to the absence of bud perennation and hence the lack of early-season inocculum, fungicide applications shortly after bud break are not needed unless weather conditions are conducive for a primary infection. Finally, this project has shown that grape powdery mildew can be effectively controlled with a spray program that is reactive rather than preventative in nature. Using such a program can lead to significant reductions in both spray applications and the costs for spray materials. When combining weather monitoring with field observations of powdery mildew infections it is possible to greatly reduce, if not entirely eliminate, powdery mildew sprays.

A noteworthy, if somewhat unexpected outcome of our research on powdery mildew management has been a better grower understanding about fungicide choices and rotations to minimise the risk of resistance development. During the past five years we conducted several workshops on pest and disease management and have presented the results from this study at several meetings. We also had numerous one-on-one discussions with the collaborating growers. Prior to this study many growers mistakenly thought that they were minimising the risk of resistance development by alternating fungicides. For example, an actual spray program used by a Colorado grape grower in 2001 was a rotation of Bayleton, Nova, and Rubigan. All three of those products are DMI fungicides, i.e. they share the same mode of action; so rather than reducing the risk of resistance development, this spray program increases it. Changing fungicide product and not the mode of action was indeed a common mistake among Colorado growers. As a result of our workshops and seminars as well as the online publication of the Grape Pest Management Options for Colorado (where funigicides are listed by class) growers today are more aware of the various products that are available, and the correct procedure to rotate the mode of action.

Acknowledgments

Field evaluations in 2006 were done by Tana Archuleta, Christa Hawk, and Ben Cantrell. Sprays were applied by the field staff of the cooperating vineyards: Canyon Wind Cellars and Grande River Vineyards (Riverview Vineyard). Cooperation was provided by Norm Christianson (Canyon Wind), and Jim Mayrose and Stephen Smith (Riverview Vineyard).

The weather station network was initially established using partial funding from the Rocky Mountain Association of Vintners and Viticulturists (RMAVV), and through partial funding from the Colorado Specialty Crops Program granted to RMAVV. Funding for the technicians/scouts and GPS hardware and software has been obtained through an EPA grant that was awarded in July 2002, and amended in July 2004.

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Small Grain Variety Performance Tests at Hayden, Colorado 2006

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Summary

Each year small grain variety performance tests are conducted at Hayden, Colorado to identify varieties that are adapted for commercial production in northwest Colorado. Twenty-six varieties were evaluated in 2006 in a winter wheat variety performance test conducted at Hayden, CO. Growing conditions during the 2006 cropping season in Hayden were favorable for winter wheat production. Grain yield in the winter wheat variety performance test averaged 4454 lbs/acre (74.2 bu/acre). The highest yielding entry was Golden Spike at 5357 lbs/acre (89.3 bu/acre). Many winter wheat varieties were high yielding with ten varieties having higher yields than the other sixteen. Protein concentration averaged 13.13% and ranged from a high of 14.91% for Postrock to a low of 12.11% for Golden Spike.

Introduction

Small grain variety performance testing has been ongoing in northwest Colorado for many years (Pearson, et al., 2005; Pearson et al., 2004; Pearson, et al., 2003; Golus et al., 1997). Small grain variety performance tests are conducted in northwest Colorado to identify varieties adapted for commercial production in the region. The 2006 winter wheat variety performance test was conducted at Hayden, CO.

Materials and Methods

Twenty-six winter wheat varieties and breeding lines were evaluated during the 2006 growing season at the Mike Williams Farm near Hayden, Colorado (Fig. 1). The experiment design was a randomized complete block with four replications. Plot size was 4-ft. wide by 40-ft. long with six seed rows per plot. The seeding rate was 680,000 seeds/acre and planting occurred on 27 Sept. 2005. No fertilizer, herbicides, or insecticides were applied to the plots. Harvest occurred on 10 Aug. 2006 using a Hege small plot combine. Grain samples were cleaned in the laboratory using a small Clipper cleaner to remove plant tissue that remained in the grain sample following combining. Grain moistures and test weights were determined using a DICKEY-john GAC2100b™ Grain Analysis Computer[1]. Grain yields were calculated at 12% moisture content. Protein concentration was determined by whole grain near infrared reflectance spectroscopy with a Foss NIRSystems 6500 (reported on a 12% moisture basis).

Fig. 1: Fred Judson standing in the winter wheat variety performance test plots at Hayden, Colorado just prior to harvesting them on 10 Aug 2006. Photo by Calvin H. Pearson.

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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.

Results and Discussion

The 2005-2006 growing season in the Craig/Hayden area was favorable for winter wheat production. The average maximum temperature for July 2006 at Hayden, Colorado was 87.3ºF (Fig. 2). Precipitation at Hayden during the 2005-06 winter/spring growing season (September 2005 through July 2006, 11-month period) totaled 17.81 inches. Winter moisture in the Hayden area was good. During September 2005 through February 2006 a total of 11.11 inches of precipitation was received and from March through July 2006 a total of 6.7 inches of precipitation was received at Hayden (Fig. 3).

Precipitation in the Craig/Hayden area varies considerably from month to month and year to year and is a critical factor affecting crop production. If timely precipitation occurs, grain yields of winter wheat can be increased significantly as occurred in 2006. If precipitation does not occur in a timely fashion, grain yields of wheat can be low. Because precipitation is so variable during the growing season in the Craig/Hayden area, wheat yields often vary considerably from year to year.

Grain moisture in the winter wheat variety performance test at Hayden averaged 9.3% (Table 1). Grain moisture content ranged from a high of 11.6% for NuGrain to a low of 8.7% for Juniper.

Grain yields of the winter wheat varieties averaged 4454 lbs/acre (74.2 bu/acre). Grain yields ranged from a high of 5357 lbs/acre (89.3 bu/acre) for Golden Spike to a low of 1770 lbs/acre (29.5 bu/acre) for NuGrain. NuGrain was low yielding mainly because the plant stand was poor. The low plant population was possibly caused by poor quality seed that was planted. Many winter wheat varieties were high yielding with ten varieties yielding greater than 78 bu/acre (Table 1).

Test weights averaged 60.6 lbs/bu. Test weights ranged from a high of 63.0 lbs/bu for Hayden to a low of 57.8 lbs/bu for NuDakota.

There was no lodging in the winter wheat variety performance test in 2006 (Fig. 1).

Plant height averaged 29.4 inches. Plant height ranged from a high of 38.8 inches for Juniper to a low of 20.8 inches for NuGrain.

Protein concentration averaged 13.13% and ranged from a high of 14.91% for Postrock to a low of 12.11% for Golden Spike. Three varieties (Postrock, NuHills, and Hayden) had protein concentrations above 14%.

Acknowledgments

The farmer-cooperator for this trial was Mike Williams. We thank Mike for his willingness to participate with us year after year in conducting this research. We also thank C.J. Mucklow, CSU Cooperative Extension, for his support of our small grain research in northwest Colorado. Appreciation is also expressed to Fred Judson and Chip Brazelton (Western Colorado Research Center staff), and Daniel Dawson (part-time hourly employee) who assisted with this research. Appreciation is also extended to the Colorado Wheat Administrative Committee for funding this research.

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Table 1. Winter wheat variety performance test at Hayden, Colorado 2006. Farmer-Cooperator: Mike Williams.

Variety	Market class[1]	Grain moisture	Grain yield		Test weight	Plant height	Protein
		(%)	lbs/acre	bu/acre	lbs/bu	in.	(%)
Golden Spike	HWW	9.0	5357	89.3	59.9	31.3	12.11
Deloris	HWW	9.3	5323	88.7	61.3	31.9	13.22
Gary	HWW	9.4	5024	83.7	61.0	30.5	12.36
Lakin	HWW	8.9	5003	83.4	58.8	27.0	12.54
Above	HRW (CL)	9.0	4925	82.1	60.3	28.6	12.61
NuDakota	HWW	9.0	4879	81.3	57.8	25.9	12.47
UT9508-88	HRW	9.5	4848	80.8	62.3	30.3	12.34
IDO616	HRW	9.6	4782	79.7	61.6	35.0	12.93
UT9508-157	HRW	9.4	4771	79.5	61.7	31.4	12.75
Fairview	HRW	9.1	4719	78.6	61.2	31.8	13.42
Danby	HWW	9.4	4665	77.7	62.9	28.0	13.43
Bond CL	HRW (CL)	9.0	4617	77.0	60.0	29.2	12.20
TAM 111	HRW	9.8	4568	76.1	61.2	27.3	13.08
UI Darwin	HWW	9.6	4463	74.4	61.8	30.7	13.52
Ankor	HRW	9.7	4460	74.3	59.8	28.2	12.87
Avalanche	HWW	9.1	4441	74.0	60.9	29.1	13.59
Jagalene	HRW	8.8	4434	73.9	60.3	29.0	13.48
IDO573	HWW	9.2	4414	73.6	61.6	33.3	13.99
Juniper	HRW	8.7	4366	72.8	61.3	38.8	13.99
NuFrontier	HWW	9.4	4345	72.4	59.8	28.6	12.42
Hatcher	HRW	9.2	4298	71.6	60.4	26.6	12.08
Hayden	HRW	9.6	4279	71.3	63.0	34.4	14.05
Postrock	HRW	9.0	3948	65.8	60.9	26.6	14.91
Ripper	HRW	9.4	3750	62.5	58.8	25.6	12.71
NuHills	HWW	9.0	3363	56.1	59.8	25.1	14.66
NuGrain	HWW	11.6	1770	29.5	58.4	20.8	13.60
Ave.		9.3	4454	74.2	60.6	29.4	13.13
LSD (0.05)		0.8	652	10.9	0.9	1.7	
CV (%)		6.20	10.4	10.4	1.0	4.2	

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

Hayden 2005-06

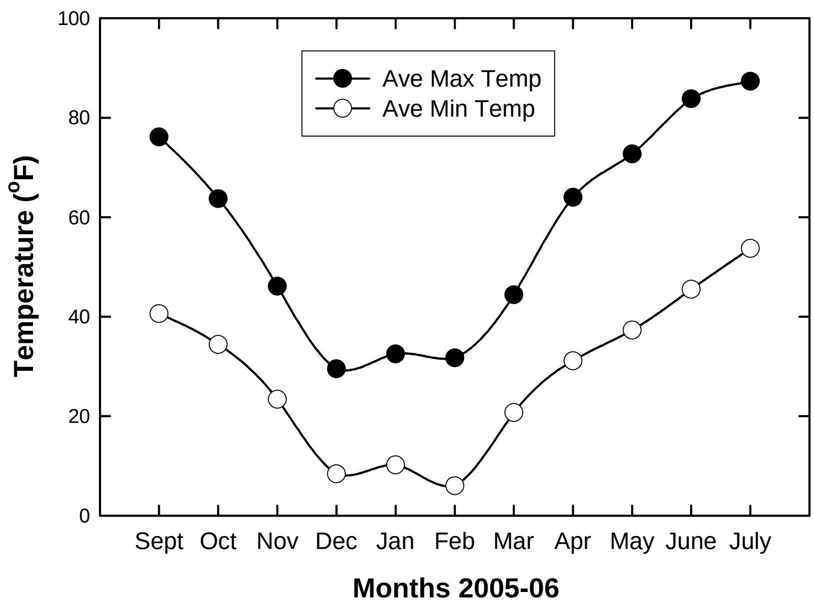

Fig. 2: Average maximum monthly and average minimum monthly temperatures for Sept 2005 through July 2006 at Hayden, Colorado.

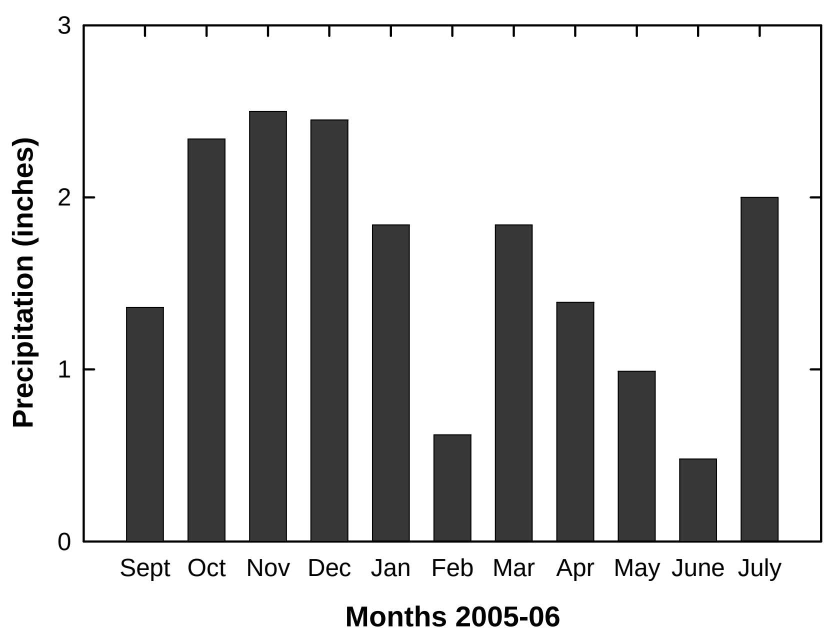

Fig. 3: Monthly precipitation for Sept. 2005 through July 2006 at Hayden, Colorado.

Evaluation of Sweet-Cherry Rootstocks in Western Colorado (NC 140)

Ramesh R. Pokharel[1], Ron Godin[2], and Harold J. Larsen[3]

Summary

A sweet-cherry rootstock evaluation trial for Colorado with Bing cherry on 13 rootstocks (five Giesela, five Weiroot, Edabriz, Mahaleb, and Mazzard) and coordinated with the NC-140 program was completed in 2006. Annually collected data included tree growth parameters, tree survival, number of rootsuckers produced, and (when present) fruit production and yield data. After nine years of growth, rootstock GI 209-1 produced the smallest tree size as reflected in trunk cross-sectional area, about 35% that of the Mazzard and Mahaleb control trees. GI 148-2 and GI 148-8 were the next smallest at 45% and 52%, respectively. Edabriz and Weiroot 53 and Weiroot 72 were next smallest with 56% and 57%. The remaining GI 148-1 and GI 195-20) and Weiroot 10, Weiroot 13, and Weiroot 158) rootstocks all ranged between 72% and 94% of standard size. Only Mazzard, Gi 209-1, Mahaleb, and Weiroot 72 rootstocks suffered any mortality; Mazzard and Gi 209-1 both had just over 50% survival and Mahaleb and Weiroot 72 both had 86% survival. Over years 2003-200 (years 6-9 in the study), GI 148-1 and Weiroot 13 had the best average fruit production (6.5 kg/tree) and Mazzard had the poorest (0.9 kg/tree), probably because of the delay in onset of fruit production in Mazzard. During that 4 year period, GI 148-2 had the best and Mazzard the poorest yield efficiency (65.1 and 7.8 g/cm^2 trunk cross-sectional area, respectively); Mazzard's poor performance again was due to delay in onset of fruit production. GI 148-1, GI 148-2 and GI 195-20, along with Mahaleb and GI 209-1, had the fewest number of rootsuckers / year over the 2003-2006 period. Giesela 148-1 and Weiroot 13 appeared to be the best rootstocks for western Colorado. Plant parasitic nematode (PPN) populations associated with the different rootstocks were studied in 2006. Nine PPN genera were recorded, including the virus vector dagger nematode. All had variable population densities, but the more promising rootstocks tended to have lower total populations of PPN overall. Study of PPN populations and relationships with the different rootstocks will continue in the coming years even though the formal NC-140 ended in 2006.

Introduction

Sweet cherry is a crop of increasing interest to fruit growers in western Colorado. Consumer demand for large, organically grown sweet cherries has driven prices up and increased grower returns / acre to levels comparable to those for peaches. As a consequence, acreage planted to sweet cherry is increasing.

At the same time, sweet cherry rootstocks are no longer limited to Mazzard or Mahaleb, each of which produced full sized trees. An increasing number of size-controlling dwarfing or semi-dwarfing rootstocks are becoming available. These offer producers the hope for high density, small trees that can minimize or eliminate the need for ladders in harvesting the fruit. Large trees that require ladders for harvest are less attractive to pickers (they can harvest more fruit more easily from the ground) and, as labor becomes more difficult to find, such small trees can help greatly in locating harvest labor. In addition, pedestrian-sized trees have potential for "U-Pick" operations where consumers can harvest their own fruit. And, where combined with microsprinkler or drip irrigation options, uneven ground beneath the trees is eliminated and liability insurance costs can be reduced (no ladders, no furrows for people to trip in).

These new rootstocks also provide opportunity for earlier fruit production. Trees on Mazzard and Mahaleb rootstocks typically do not begin producing until year 6 or 7. Many of the new

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dwarfing or semi-dwarfing rootstocks induce fruit production to begin as early as in year 3.

But new rootstocks come with risks. Precocious trees can easily overproduce and stunt tree growth below an optimum size that allows development of sustainable fruiting structure. The result can be lots of fruit that is too small to market effectively. Disease susceptibility, tree longevity, and eventual incompatibility with scion cultivars are other unknowns that growers need information about when selecting rootstocks for their new orchard planting. Assessment of these risks and benefits is needed to enable knowledgeable choices by the growers. It is for this reason that the NC-140 Regional Research Committee exists and has established coordinated rootstock trials in multiple locations and environments in North America.

One such trial is the 1998 NC-140 sweet cherry rootstock trial. Based on Bing sweet cherry grafted to 13 different rootstocks, the Colorado planting was established at the Western Colorado Research Center – Rogers Mesa site (elevation 5,600 ft) near Hotchkiss, CO. The study included Mazzard, Mahaleb, Edabriz, five Giesela rootstocks, and five Weiroot rootstocks. The study ended after the 2006 growing year and nine years of data collection. During 2006, studies were begun on the relationships of plant parasitic nematodes (PPN) with the root systems of the rootstock study trees. This report provides both a summary of the tree growth, survival, and production data for 2003-2006 period and a preliminary overview of nematode populations associated with the root systems of the study trees.

Materials and Methods

A sweet cherry rootstock trial consisting of Bing sweet cherry grafted on thirteen sweet-cherry rootstocks was planted in 1998 at Western Colorado Research Center – Rogers Mesa site near Hotchkiss, CO. Trunk circumferences, number of root suckers, and fruit yield and number were recorded annually. Trunk cross-sectional area (TCA) was calculated from the trunk circumference values, and yield efficiencies (g fruit/cm^2 TCA) calculated. Nematode populations were assessed by sampling soils beneath the rootstock study trees. Nematodes were extracted from 100 cc of soil from each tree using the pie-pan extraction method. Nematodes were identified under an inverted compound microscope and tabulated. Due to time limits, only four replications were included in the nematode study.

Results and Discussion

Performance of rootstocks: A severe spring frost as sweet cherries neared full bloom on April 19 & 20, 2006 killed the susceptible blossoms, so there was no fruit data this year. Data on vegetative aspects were collected, however. Mazzard and Mahaleb had the highest TCA and GI 209-1 had the lowest TCA (Table1). Nine out of 13 cherry rootstocks had no mortality; GI 209-1 and Mazzard had the lowest survival (52.8 and 57.2%, respectively). All the trees produced suckers; W 158 followed by W 72 had the most, and GI 209-1 and Mazzard had the least. GI 148-1and W13 had the highest 3-year average yield (2003-06) and 86 and 100% survival, respectively. Mahaleb and Mazzard had the highest and second highest TCA, respectively, and W13 and GI 148-1 had medium TCA measurements (Table 1).

Plant parasitic nematode (PPN) studies: Nine PPN genera were found in soils beneath the study trees; these varied from rootstock to rootstock (Table 2). High numbers of root-knot nematode (*Meloidogyne*) were observed with W10 followed by Edabriz and the lowest with W13. Similarly, higher numbers of root lesion nematodes (*Pratylenchus* spp.) were observed with W 153 and GI 148-2, but lower with GI 148-8 and Edabriz. Numbers of *Tylenchulus* were highest with GI 148-2 and lowest with W13. However, the above endoparasitic PPN genera were observed in almost all rootstocks in relatively high densities and, thus, might have a role on the tree health and yield potential of these rootstocks. Highest numbers of dagger nematodes (*Xiphinema* spp.) were observed with W 158 followed by W 10; W 72 and Edabriz had the lowest number of dagger nematodes (Table 2). Variability in population densities observed with each rootstock could be due to the distribution pattern of the individual PPN genus and/or differing reactions of the different rootstocks. It warrants further investigation.

Since dagger nematode (Fig. 1) is a vector of rasp leaf and stem pitting viruses and one viruliferous nematode per 100 cc soil may be enough to transmit the virus, dagger nematode populations are potentially important to the cherry growers as these viruses are already present in the areas. In contrast, the remaining PPN genera were less frequently observed with variable numbers and, thus, may have less potential importance. The PPN numbers observed could allow the rootstocks in the study to be categorized into three groups: rootstocks with high, medium and low PPN populations.

Table 1. Summary of the 2006 and average (2003 to 2006) observations for Bing cherry on 13 rootstocks grown at Western Colorado Research Center - Rogers Mesa, Hotchkiss, CO.

	2006			Average values over 4 years, 2003-2006			
Rootstocks	TCA[a]	Alive (%)	No. Suckers	No. Suckers /Yr.	TCA	Fruit Yield (Kg/tree)[b]	Fruit Yield Efficiency (g/cm^2)
GI 148-1	146.8 b[z]	86 c	15.3 ef	3	120	6.5	54.2
GI 148-2	75.9 bc	100 d	5.0 f	2	63	4.1	65.1
GI 148-8	87.7 bc	100 d	66.3 cd	44	83	3.4	41.0
GI 195-20	144.1 b	100 d	24.7 e	11	113	5.1	45.1
GI 209-1	62.0 c	53 a	31.3 e	10	52	2.1	40.4
Edabriz	97.2 bc	100 d	56.8 d	39	77	3.8	49.4
Mahaleb	170.8 ab	86 c	7.2 f	4	128	3.4	26.6
Mazzard	170.0 ab	57 a	31.8 e	22	115	0.9	7.8
Weiroot 10	150.7 b	100 d	118.0 b	90	113	5.2	46.0
Weiroot 13	159.8 b	100 d	156.7 a	89	127	6.5	51.2
Weiroot 158	121.8 b	100 d	72.7 c	47	97	4.9	50.5
Weiroot 53	95.5 bc	100 d	62.0 cd	53	80	4.4	55.0
Weiroot 72	98.2 bc	86 c	120.3 b	51	78	3.5	44.9

[z]Means in column are not significantly different with the same letter Tukey (P = 0.05)
[a]TCA = Trunk cross-sectional area (cm^2)
[b]Fruit Yield (kg/tree) average of 3 years.
Means in column are not significantly different with the same letter Tukey (P = 0.05)

Table 2. Genera and average numbers of plant parasitic nematodes / 100 cc soil associated with 13 sweet-cherry rootstocks at the Western Colorado Research Center - Rogers Mesa, Hotchkiss, CO.

Rootstock	Meloid[z]	Helico	Pratyl	Tylen	Xiph	P-tyl	Ty-chul	Dityl	P-trich	Free	TP
148/1	141.3 ab [y]	11.3	37.5 ab	0.0	19.4 b	26.3	73.8 ab	5.0	0.0	407.5	314.4 b
148/2	108.1 ab	55.0	86.3 a	3.8	33.8 ab	56.9	69.4 ab	12.5	0.0	274.4	425.6 ab
148/8	118.5 ab	37.0	10.3 b	13.5	33.3 ab	36.3	126.5ab	5.5	2.8	520.5	383.5 ab
195/20	148.1 ab	35.6	36.3 ab	22.5	21.9 b	81.3	106.3ab	36.3	3.1	364.4	491.3ab
209/1	118.8 ab	48.4	62.1 ab	20.6	22.2 b	49.1	90.1 ab	17.8	1.6	312.3	430.6ab
Edabriz	235.6ab	11.9	20.6 ab	12.5	16.9 b	110.6	126.3ab	45.6	3.1	474.4	583.1ab
Mahaleb	71.1 b	39.8	61.6 ab	0.0	42.9 ab	14.1	74.9 ab	7.9	25.0	423.1	337.3 b
Mazzard	183.3 ab	26.7	53.3 ab	0.0	20.0 b	56.7	173.3a	6.7	3.3	465.0	523.3 ab
W10	316.3a	56.3	28.8 ab	30.0	55.0 ab	25.0	188.8a	35.0	61.3	323.8	796.3 a
W13	52.5 b	13.8	60.0 ab	3.8	22.5 b	22.5	27.5 b	3.8	0.0	225.0	206.3b
W158	133.6 ab	46.8	94.9 a	0.0	108.3a	113.6	68.3 ab	11.3	36.8	348.8	630.1a
W53	81.3 b	28.0	31.9 ab	0.0	20.6 b	18.8	50.6 ab	2.5	0.0	375.1	236.1b
W72	108.8 ab	22.5	26.3 ab	6.3	13.8 b	11.3	78.8 ab	0.0	8.8	375.0	276.3 b

[z]Genus code: Meloid = *Meloidogyne* spp., Helico = *Helicotylenchus* spp., Pratyl = *Pratylenchus* spp., Tylen = *Tylenchorhynchus* spp., Xiph = *Xiphinema* spp., P-tyl = *Paratylenchus* spp., Ty-chul = *Tylenchulus* spp., Dityl = *Ditylenchus* spp., P-trich = *Pratrichodorus* spp., Free = Free living species, and TP = Total parasitic nematode counts per sample.

[y]Means within a column with different letters differ at the p=0.05 level (by LSD test).

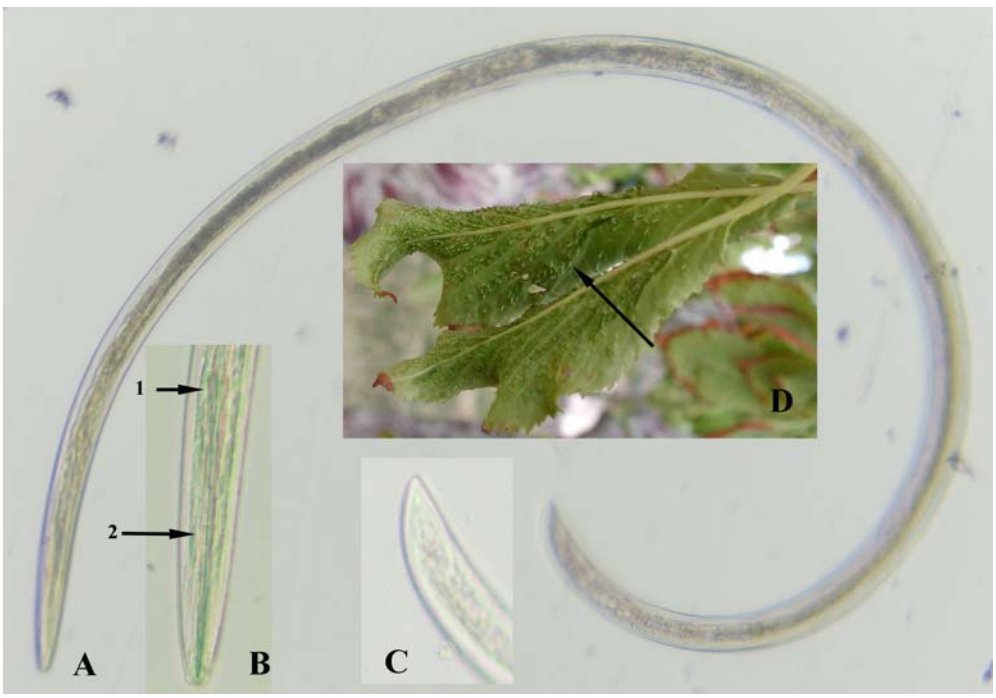

Fig. 1: Dagger nematode, rasp leaf virus vector, is identified by the long slender body (A), longer stylet (B) having distinct basal flanges (arrow 1) and guided ring (arrow 2) and tail tip (C). Symptoms of rasp leaf infection (arrow D), outgrowth on underside of cherry leaf.

Acknowledgments

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Efficacy of Chloropicrin, Methyl Iodide and Terpene-Blend Materials on Replant Problem of Stone Fruits in Western Colorado

Ramesh Pokharel[1] and Harold Larsen[2]

Summary

Replant is one of the important constraints in stone fruit production and, with the loss of methyl bromide, the search for an alternative is ongoing. Eleven different studies in seven growers' fields were carried out to evaluate the efficacy of different concentrations of chloropicrin (Pic), methyl iodide (MI)/Pic blends (MIDAS), and a proprietary blend of terpenes. In the first set of experiments chloropicrin (1, 0.5 and 0.25 lb/tree) was compared with MIDAS 98 (98% MI: 2% Pic; applied at 1.0, 0.5 and 0.25 lb/tree) and terpene-blend materials (1000 and 500 ppm) in four different growers' fields replanted to peach and sweet cherry. Highly variable results were obtained in these experiments, possibly due to site preparation and treatment application conditions. The results in one peach orchard where fumigation was properly done with optimal site preparation and application conditions showed that MIDAS 98 (1.0 or 0.5 lb/tree) could be as effective as chloropicrin (1 lb/tree). Higher dose of MI (1.0 lb/tree) was toxic to sweet cherry but not to peaches. The second set of experiments compared chloropicrin, MIDAS 98 (98 % MI : 2 % Pic) and MIDAS 33 (33 % MI : 67 % Pic) in three different growers' fields for peach and cherry. Results were highly variable and even chloropicrin failed to enhance tree growth even in the orchard with optimal site preparation and application. However, MIDAS (especially MIDAS 33) worked as well as chloropicrin. In the third set of experiments, terpene-blend materials (1000, 500, 250 and 125 ppm) were compared. Except for 500 ppm of terpene-blend materials in sweet cherry, none of these concentrations enhanced tree growth over the control. However, the tree growth response observed in sweet cherry justifies further studies as few choices are available for organic growers and terpene-blend materials can be certified for organic growing.

Introduction

"Replant disease" (RD) is a serious concern among stone fruit growers. RD pathology of *Prunus* species can complicate establishment of stone fruit and nut orchards planted after removal of a closely related crop. According to McKenry (1999) RD is a very serious and common problem that reduced production in renewed orchards unless treated. Trees in a RD site have reduced growth and light green to yellow-green leaves rather than dark green ones. Fruit production is delayed and yields are reduced. Significant economic losses from RD continue for the lifespan of the orchard (Larsen, 1990). Stone fruit replant disease has been documented as a major impediment to renovation of stone fruit orchards in western Colorado.

Peach responded to soil loosening (sub-soiling and back hoeing) followed by soil fumigation with various formulations of methyl bromide, chloropicrin, and methyl isothiocynate (Vorlex) (Larsen, 1990). Metam sodium (Vapam) has been used in recent years, but efficacy of this material in earlier studies was relatively low, possibly due to application methods. Of these materials, only the chloropicrin and the metam sodium are still available to growers as production of the methyl isothiocyanate has been discontinued and use of methyl bromide is being phased out (due to ozone depletion concerns and the Kyoto treaty); thus methyl bromide is currently unavailable. Identification of alternative materials for use to treat orchard replant problems and evaluation of their efficacy in different production areas with different edaphic and climatic conditions is needed. Methyl iodide (iodomethane) is one potential

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alternative that is being developed to replace methyl bromide. It is intermediate between methyl bromide and chloropicrin in its boiling point and vapor pressures. The lower boiling point and higher vapor pressure of methyl bromide allowed self pre-pressurization of the delivery containers and minimized the need for supplemental pressurization of the tanks in order to deliver the fumigant in the fumigation process. Chloropicrin's higher boiling point and lower vapor pressure necessitate use of supplemental pressurization of the fumigant tanks at time of application. However, both were shown to be equally efficacious in control of stone fruit replant disorders for peach and cherry (Larsen, 1990). New materials blending chloropicrin and methyl iodide in different ratios have been formulated as pesticides and are expected to work more effectively than either chloropicrin or methyl iodide. MIDAS is such a blend of methyl iodide and chloropicrin recommended for control of soil-borne pathogens of wheat and barley, but its efficacy for fruit replant problems is undocumented.

Recently, terpene-based materials have been found to have wide efficacy against bacteria, fungi, and nematodes. Proprietary blends of terpenses under development by Eden Research, including a product named Mevalone, have shown promise in soil applications for nematode control and may have efficacy for control of stone fruit replant disorders. Mevalone is emulsifiable in water and breaks down to produce H_2O and CO_2 within 2 weeks of application. Its constituents currently are all on the EPA's 25-B Exempt list and the material therefore has potential for organic certification. In addition, according to the manufacturer, it has very low plant phytotoxicity and can be applied directly to plants as either foliar treatments (for foliar diseases) or via soil drench (for soil-borne diseases). This study examined the potential of soil treatment with methyl iodide/chloropicrin blend (MIDAS materials) and the new terpene-blend material to alleviate stone fruit replant problems in western Colorado and compared their efficacy with that of chloropicrin.

Materials and Methods

Studies were established at seven grower-cooperator orchards in Mesa Co. of western Colorado (Table 1). Each orchard had previously been planted to peaches except one orchard previously planted to nectarines; the trees were pushed out in September, 2004 or 2005 and the sites prepared for soil fumigation. Site preparation varied from orchard to orchard: plots either were excavated by backhoe or trencher (3 ft x 3ft x 3 ft deep) with soil pushed back into the excavated hole or trench or the orchard block was sub-soiled, plowed, and then leveled or the soil loosened to 12 inches depth via a rotary hoe (Weed Badger). The soil type and methods of soil preparation in each orchard are given in Table 1. All locations except one had moist soils at the time of treatment application, either from precipitation or from irrigation after site preparation but prior to treatment.

Materials used in the studies for soil fumigation were chloropicrin (Arysta Corp.), methyl iodide/chloropicrin blends MIDAS 98 (98% MI : 2 % Pic) and MIDAS 33 (33% MI : 67% Pic) (Arysta Corp.) and a terpene-blend material Mevalone (Eden Research). Three types of studies were carried out using individual tree plots: study 1 compared the efficacies of three rates of chloropicrin (0.25, 0.5 and 1.0 lb/tree) and of MIDAS 98 (0.25, 0.5 and 1.0 lb/tree) and of two or three rates (1,000, 500 and 250 ppm) of the terpene material. Study 2 compared the efficacies of three rates of chloropicrin as in set 1 but with three or four levels (1.0, 0.5, 0.25, 0.125 lb/tree) of both MIDAS 98 (98% methyl iodide : 2% chloropicrin), and MIDAS 33 (33% methyl iodide : 67% chloropicrin). Study 3 examined efficacies of five rates of the terpene-blend material. The experiments in the first and third studies were conducted in 2004 and the second in 2005. All studies used a randomized complete block experimental design with various replications which are given in parenthesis in Table 1.

Soil treatments were applied in October and November, 2004 for studies 1 and 2. The chloropicrin and MIDAS were injected at 18 inches depth via soil hand probe between 10/13 and 10/21/2004 while soil temperatures ranged between 61^o and 65 ^{o} F at 18 inches soil depth. The terpene material was applied between 10/16 and 11/11/2004 in 30 - 60 gallons of water dilutions per tree (based on soil texture and associated calculated field capacity) to soil basins approximately 3 ft x 3 ft x 6 - 12 inches deep. Soil temperatures were all above 40° F in the top 18 inches soil profile during and immediately following application. The blocks were planted back to stone fruit in April, 2005. Similarly, for set 2 studies, trees were pushed in September, 2005. Chloropicrin was applied on 10/17 at a soil temperature of 63 F° in orchard G and on 10/6 at 66 F at orchard C, MIDAS (98% MI : 2% Pic) were applied on 10/17 -18 at soil temperature of 63 ° F in orchard G and 10/11-12 at 62 and 63 ° F soil temperatures at orchard C. At orchard C, the site was plowed and labeled before fumigation treatments were applied in fall 2005. In orchard G, the site was ripped to 14 inches down the row before fumigations were applied. Soils were plowed to the sub-surface level and trees were planted in fall of 2005. Trees were planted at both orchards in spring 2006. Grafted trees were planted in all the experiments except the peach trees in 2005 at orchard C and these trees were obtained from tissue culture. All of these orchards were maintained by growers as per their standard production practices.

Trunk circumferences were measured at 12 inches above the graft union at planting and at the end of the first or second growing season. The trunk circumferences were converted into trunk cross-sectional area (TCA) by multiplying the trunk circumferences by a constant factor. Tree survival was recorded after each tree growing seasons. Data were analyzed via SAS statistical software with means separation at the $p < 0.05$ level.

Table 1. Studies, chemical used, orchards, soil types and preparation methods and replant crop for the reported studies.

	Chemicals	Orchards	Soil types	Soil Preparation	Replant Crop	No of treatments[z]
Study 1	Chloropicrin MI 98:2 Mevalone	A	Sandy-loam	Back-hoed	Peach	10 (10)
		B	Silty-clay loam	Subsoil, plowed	Peach	9 (10)
		C	Silty-clay loam	Subsoil, plowed	Swt. Cherry	10 (9)
		D	Silty-clay loam	Trenched	Peach	9 (8)
Study 2	Chloropicrin MIDAS 98 MIDAS 33	B	Silty-clay loam	Subsoil, plowed	Peach	10 (10)
		C	Silty-clay loam	Subsoil, plowed	Swt. Cherry	11 (5)
		G	Silty-clay loam	Ditch-ripped	Peach	11 (9)
Study 3	Mevalone	B	Silty-clay loam	Subsoil, plowed	Peach	6 (10)
		D	Silty-clay loam	Trenched	Peach	6 (10)
		E	Silty-clay	Subsoil, plowed	Swt. cherry	6 (10)
		F	Silty-clay loam	Rotary hoed	Apricot	6 (10)

Note: Study 1 and 3 were started in 2004 and study 2 in 2005.
[z]Number of replications are in parenthesis.

Results and Discussion

Effect of chloropicrin, methyl iodide (MIDAS 98) and Mevalone

The TCA measurements were highly variable as observed among and within sites. In peach, treatment response was best in orchard A in which tree holes were back-hoed but not irrigated prior to treatments. Orchard D also had tree holes excavated (trenched) prior to treatments, but it was irrigated and soils were very wet at treatment. Trees treated with MIDAS 98 (0.25, 0.5 and 1.0 lb) at orchard A and chloropicrin (1.0 lb) had significantly higher

TCA as compared to rest of the treatments. However, TCA in all the treatments except Mevalone were significantly larger than the control (Table 2) whereas in orchards B and D, none of the treatments differed from the control. Similarly, in cherry at orchard E, no significant differences were observed between treatments (Table 3). This further supports the importance of proper pre-fumigation soil preparation (Larsen unpublished and Caprile and McKenry, 2006). Furthermore, it supports the premise that MI (MIDAS) is promising as a replacement for chloropicrin, despite its current lack of registration for use in stone fruit replant control. Tree survival was highly variable across sites, but less variable across treatments. Orchards A and B had 100% tree survival for most except some treatments, but this was not consistent across treatments and sites. Tree survival in the other two orchards was low, but not consistent to treatments except in orchard E, where none of the trees survived in plots treated with the highest rate of MIDAS 98 (1.0 lb/tree). Generally, low tree survival in the latter two orchards might be related to pre-fumigation site preparation and high incidence of cytospora canker infection; they are organic blocks and no organically approved control measure is available for this disease. Wet soil conditions at the time of fumigation (especially in heavy soils) probably greatly reduced fumigation response. Caprile and McKenry, (2006) reported that the soil moisture should not be higher than 12.5 % in sandy soils at the time of soil fumigation because soil moisture above that decreases the efficiency of soil fumigation and requires a higher dose of fumigants to get the same results. In orchard E, in sweet cherry, in addition to the treatment linked to death of all trees in plots treated with the highest rates of methyl iodide, tree survival likely was affected by severe deer feeding and lack of adequate weed management (Table 3). These results demonstrate the importance of good site preparation and attention to insuring proper soil conditions for fumigation in order to obtain optimal results. In addition, there appears to be a differential sensitivity to the high rate (1.0 lb/plot) of methyl iodide for peach and sweet cherry since the mortality in sweet cherry trees was higher but not in peaches.

Table 2. The effect of Chloropicrin (Pic), Methyl iodide (MI) and Mevalone (Mev) on trunk cross sectional area (TCA) and tree survival of peaches after second growing season in different grower's sites in Western Colorado

	Orchard A		Orchard B		Orchard D	
Treatments	TCA (cm^2)	Survival %	TCA (cm^2)	Survival %	TCA (cm^2)	Survival %
Non-treated check	3.50de[a]	100	4.30abc	100	3.13 ab	60
Pic, 1.0 lb/tree	4.82ab	100	4.10bc	88	3.34 ab	60
Pic, 0.5 lb/tree	4.43bc	90	4.38abc	100	3.93 a	60
Pic, 0.25 lb/tree	4.62b	100	4.35abc	100	2.73 ab	78
MI, 1.0 lb/tree	5.23a	100	4.69a	100	2.7 ab	75
MI, 0.5 lb/tree	5.47a	100	4.57ab	100	2.47 b	100
MI, 0.25 lb/tree	4.92ab	100	4.28abc	100	3.64 ab	100
Mev, 1000 ppm	3.86cd	100	3.96c	100	3.39 ab	90
Mev, 500 ppm	3.04e	100	3.83c	100	3.68 ab	80
Mev, 250 ppm	3.59de	80	-	-	4.02 a	70

[a]Means with the same letter in a column are not significantly different by LSD (P= 0.05 level)

The impact of treatments on TCA increase was more pronounced in the first growing season than in the second growing season. However, the response in average growth (TCA) for the different treatments and experiments was also variable with the sites and within sites. In orchard A, soil fumigation produced 124-157% higher average tree growth over control (Fig. 1). Higher crop growth responses were observed with methyl iodide treatments. On average, MI (0.5 and 1.0 lb per tree) had higher than 150% TCA growth response over control (data not shown). Except for Mevalone at 1,000 ppm, the rest of the treatments could be cost effective as compared to control if TCA growth is considered only for the first year. The same results were not observed in other orchards. That could be due to several causes, but some that we observed were pre-fumigation soil preparation, soil moisture at the time of fumigation, orchard management (weed, diseases and deer), difference in the trees (health and roots) during planting.

Table 3. The effect of chloropicrin, methyl iodide and Mevalone on TCA of sweet cherry after second growing season.

Treatments	Year 2	
	TCA[a]	Survival %
Non-trtd ck	1.79 a	63
Pic, 1.0 lb/tree	2.52 a	50
Pic, 0.5 lb/tree	2.05 a	63
Pic, 0.25 lb/tree	1.94 a	100
MI, 1.0 lb/tree	0	0
MI, 0.5 lb/tree	2.13 a	88
MI, 0.25 lb/tree	2.10 a	88
Mev.,1,000 ppm	1.94 a	100
Mev.,500 ppm	2.25 a	63

[a]Trunk cross-sectional area (cm^2) in second year of growth. Means with the same letter in a column are not significantly different by LSD (P= 0.05 level)

Effect of Chloropicrin (Pic) and MIDAS 98 (MI 98 : Pic 2) and MIDAS 33 (MI 33 : Pic 67.

The results from three experiments comparing Pic and MIDAS are presented in Table 4. These experiments were initiated only in 2005, so only the first year data are available.

In orchard C, Pic (0.5 and 1.0 lb) and MIDAS 33 (0.25, 0.5 and 1.0 lb/tree), MIDAS 98 (0.5 lb/tree) were not significantly different to each other but were significantly higher than control in TCA measurements. Whereas in orchard G, MIDAS 98 at 0.5 lb/tree and Pic at 0.25 lb/tree were not significantly different to each other but were significantly higher than control (Table 4). The remaining treatments in both sets of experiments did not differ significantly. Tree survival percentage in these orchards was very high, 100% survival in both the orchards. However, tree growth varied with crop (peach to cherry) and orchard (orchard B to E). The maximum peach tree growth increase in plots treated with Pic (1.0 lb/tree) was at par with that of trees treated with MIDAS 33 (1.0 lb/plot)in orchard C, but the maximum growth increase in the plots treated with MIDAS 33 (0.5 lb/plot) in orchard G (Table 4).

Table 4. The effect of chloropicrin, MIDAS 98 and MIDAS 33 on TCA of peaches and sweet cherry after the first growing season.

Chemicals treated (lb/tree)	Crop / orchards		
	Peach		Cherry
	Orchard C	Orchard G	Orchard C
	TCA[a]	TCA	TCA
No-chemical (0)	1.22 c	2.36 b	6.92 b
Pic, 1.0	1.65 a	2.52 ab	7.78 a
Pic, 0.5	1.43 abc	2.57 ab	7.18 ab
Pic, 0.25	1.25 c	2.60 a	7.80 a
MIDAS 98, 0.5	1.49 abc	2.59 a	7.36 ab
MIDAS 98, 0.25	1.32 bc	2.38 ab	7.58 ab
MIDAS 33, 1.0	1.56 ab	2.54 ab.	7.84 a
MIDAS 33, 0.5	1.41 abc	2.56 ab	7.64 ab
MIDAS 33, 0.25	1.43 abc	2.32 ab	6.90 b
MIDAS 33, 0.125	1.31 bc	2.42 ab	7.36 ab
MIDAS 98, 1.0		2.50 ab	-

[a]Trunk cross-sectional area (cm^2) in second year of growth. Means with the same letter in a column are not significantly different by LSD (P= 0.05 level).

The smaller size of peach trees in orchard C was due to smaller sizes of trees obtained from tissue culture were planted as oppose to grafted trees planted in all other experiments. None of the treatments as such may be cost effective. However, Pic, which is known to work in other sites, also had low response, indicating a problem as in above experiments, but MIDAS (especially MIDAS 33) seems to be as effective as Pic in all 3 experiments. However, in cherry the TCA measurement in the plots treated with Mevalone 500 ppm was significantly higher than the control. No significant differences were observed among the rest of the treatments (Table 5).

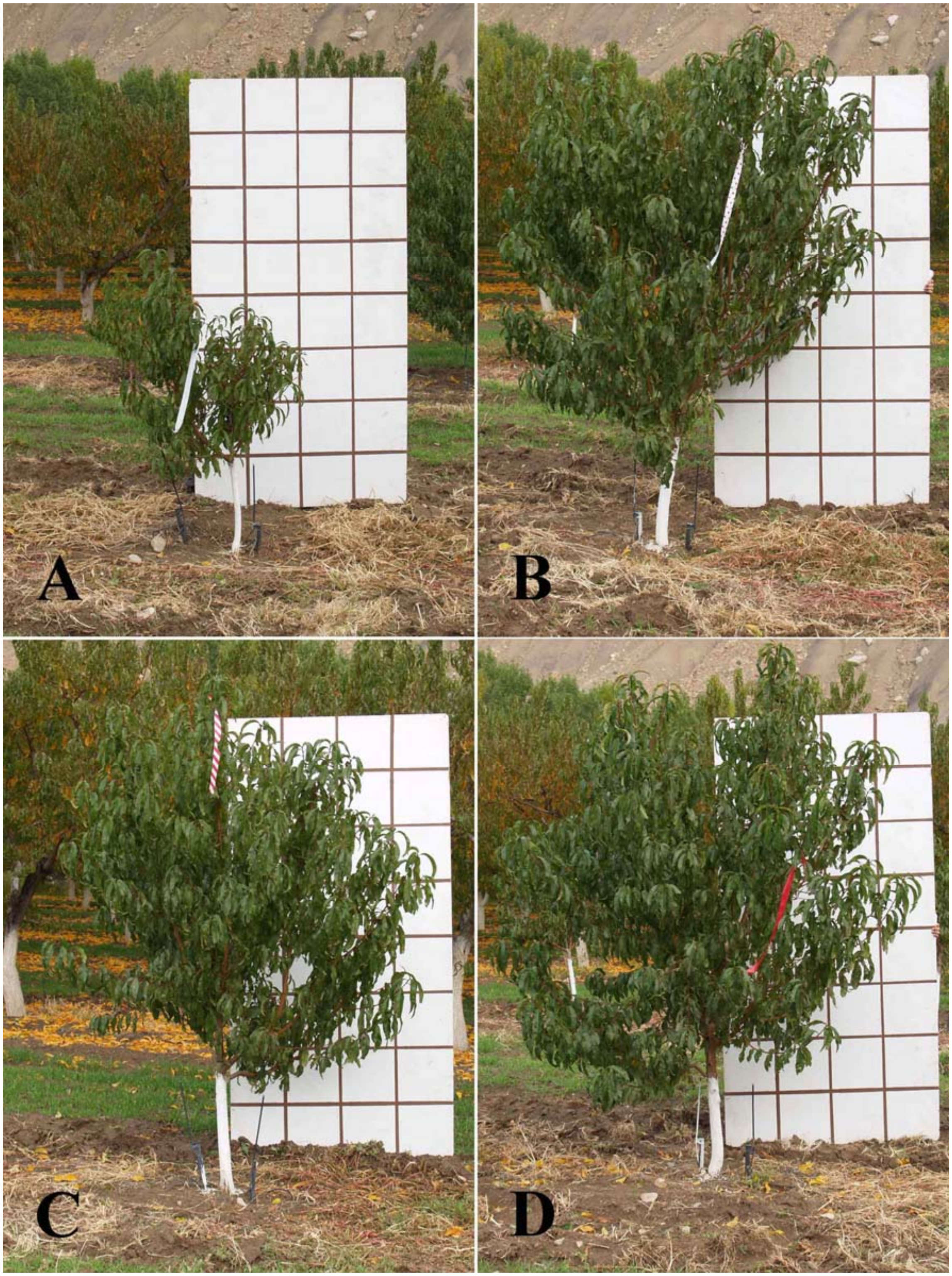

Fig. 1: Comparative second year growth of PF-25 peach replanted into old peach orchard soil in spring of 2005. A. Non-treated soil; B-D, soils fumigated in fall 2004 with 0.25, 0.5 and 1.0 lb/tree, respectively of 98:2 % mixture of methyl iodide: chloropicrin. One square on white board at the back of tree is equal to one sq foot.

Table 5. The effect of different concentrations of Mevalone on trunk cross-sectional area of peach and sweet cherry after second growing season in growers' fields.

	Peach		Cherry	Apricot
Orchards	B	D	E	F
Mevalone in ppm	TCA[a]	TCA	TCA	TCA
1,000	3.50a	2.95 a	2.09 ab	8.23 ab
500	3.46 a	3.07 a	2.37 a	9.42 a
250	3.56 a	2.97 a	1.86 b	7.96 ab
125	3.58 a	3.18 a	1.81 b	7.37 b
65	3.58 a	2.94 a	1.77 b	8.93 ab
0	3.36 a	2.96 a	1.85 b	8.80 ab

[a]Trunk cross-sectional area (cm^2) in second year of growth. Means with the same letter in a column are not significantly different by LSD (P= 0.05 level).

Effect of different concentrations of Mevalone

In peach and apricot, no significant differences among treatments were observed in all three experiments conducted in different orchards. However, for cherry, only tree growth for 500 ppm. Mevalone treatment differed from the control; tree growth for that rate also differed from 1,000 ppm rate (Table 5).

Variability in growth response in peaches to Mevalone with different concentrations in different orchards was observed (Table 5). In peach, orchard D had better growth response than orchard B where the maximum growth increase in orchard B was in the plots treated with 65 ppm and in orchard D at 125 ppm. In apricot the only positive growth increased was observed in the plots treated with 500 ppm. In cherry and apricot higher concentration (500 ppm) might be better option whereas in peaches a lower concentration might be the better option (Table 5). Since, Mevalone could be an option for the organic grower and may be effective to cope with replant problems in cherry, further investigation would seem to be warranted especially testing appropriately.

Conclusion

Strong growth response of soil fumigation by Pic., MIDAS 98 and MIDAS 33 on peach and cherry could be obtained, if fumigation is done properly; with proper soil moisture (at low soil moisture), high soil temperature and well loosened soil with back-hoe. Higher concentration of MI at 1.0 lb/tree seem to have phytotoxicity, which need further studies. Methyl iodide (MIDAS) could replace chloropicrin, provided fumigation is done in a proper manner. Mevalone might be an option to mitigate cherry replant problem especially for organic growers.

Acknowledgement

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Performance of Selected Peach Rootstocks in Western Colorado

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Summary

Peach rootstock trials were planted in 2001 and in 2002 at two locations in western Colorado as part of the NC-140 research program. The 2001 study consisted of Cresthaven peach on 12 different rootstocks. The 2002 study consisted of Cresthaven peach on nine different rootstocks. In the 2001 trial, SLAP and Cadaman rootstocks performed best over three years. In the 2002 trial, Lovell, Pumiselect and Cadaman rootstocks had significantly higher fruit yield in 2006 with Pumiselect producing a significantly lower trunk cross-sectional area (TCA) than the other two. But for the period of 2004-2006, Lovell, Cadaman, MRS 2/5 and Adesoto 101 rootstocks had the highest yield, TCA and survival rates; they also had the lowest number of suckers. Although Pumiselect performed best in 2006, it did not do so in previous years. Unfortunately, both trials had to be removed in the fall of 2006 due to a virus contamination of the rootstocks.

Introduction

Peaches are an important crop to western Colorado, the hub of fruit production in Colorado. Peaches lead all Colorado fruit crops in acreage with 2,300 acres in the ground as of 2006 and had the highest crop valuation, over $17 million in 2006 (USDA, 2007). Important issues facing growers include tree productivity and longevity, fruit size and quality, and labor availability and costs. Rootstocks and rootstock selection affect each of these issues, and rootstocks differ in their interaction with local climates, soils, and cultivars grafted to them.

Rootstock evaluation is conducted in the different agro-climatic zones of the US as part of the NC-140 Research Coordinating Committee through a series of cooperative studies. Colorado State University's Western Colorado Research Center (WCRC) has participated in both the 2001 and the 2002 peach rootstock plantings as part of those trials.

The results presented here will be the final report of the studies. Due to virus contamination of one rootstock that was included in both studies, both rootstock evaluation trials had to be destroyed following the 2006 growing season, their 5th years and 4th years after planting. This report provides results on tree growth (trunk cross-sectional area, or TCA), tree survival, number of rootsuckers, fruit yield (weight and number), and yield efficiency (wt/unit TCA).

Materials and Methods

The 2001 peach rootstock trial, consisting of Cresthaven peach on twelve different rootstocks, was planted at the WCRC – Orchard Mesa location (elevation 4,700 ft) near Grand Junction, CO. The 2002 peach rootstock trial, consisting of Cresthaven peach on nine rootstocks, was planted at the WCRC – Rogers Mesa location (elevation 5,600 ft) near Hotchkiss, CO. Both trials used a randomized complete block (RCB) design with 8 replications. Tree growth (trunk circumference) was measured and tree survival data was taken following the onset of dormancy late each fall; trunk cross-sectional area (TCA) was calculated for each tree from trunk circumference data. Fruit production data (number of fruit and weight /tree) were recorded at each harvest. The orchards were maintained per standard commercial practices. Weather data was recorded at both locations with automatic weather stations. Data was analyzed using SAS system software (SAS, 1990).

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Results and Discussion

2001 Peach Rootstock Trial: Data for 2006 (sixth year) are summarized in Table 1; due to similarity in data trends in years prior to 2006, no data for previous years except fruit yield are presented. SLAP was superior in fruit production with the highest total fruit yield/tree, and Cadaman was second in fruit production over the years (Fig. 1). In 2006, SLAP also had the highest mean fruit yield/tree, crop density and yield efficiency. In contrast, Jaspi had no fruit at all. K146-44 had the lowest fruit yield/tree and mean fruit yield; it also had the second lowest crop density and yield efficiency (Table 1). P30-135 had the lowest crop density and yield efficiency. Cadaman had the highest TCA over the years while P 30-135 had the lowest TCA. Bailey, Cadaman, Julio and SLAP had the highest survival rate (100 %) whereas Lovell had the lowest survival rate (< 50%). Bailey and K 146-44 had the least number of suckers whereas Julio, followed by SC 17, had the most suckers (Table 1). The 3-year production trend, TCA measurements and survival rate was same as for 2006 (no data are presented).

2002 Rootstock Trial: Data for 2006 (5th year) are summarized in Table 2. In 2006, Lovell, Pumiselect, and Cadaman shared the highest fruit yield. Pumiselect was among the four smallest trees (TCA values); this enabled it to have the highest crop density and yield efficiency. The other trees with the smallest TCA values (Adesoto 101, VSV-1, and VVA-1) performed the poorest with respect to fruit yield, crop density, and yield efficiency in 2006; this would be expected because of their lower TCA measurements.

Pumiselect and K146-43 had the fewest rootsuckers per tree (<2 per tree) both for 2006 and over the 3-year period of 2004-2006 while VSV-1 and VVA-1 were much more prone to rootsucker production (> 20 per tree). Pumiselect also had the lowest survival / highest mortality (37.5%) while Cadaman, MRS 2/5, and Penta had no tree loss. Lovell and Cadaman were consistent in average fruit yield over the years.

Table 1. Effect of 12 peach rootstocks on tree growth, survival, rootsucker production, fruit production, and fruit yield efficiency for Cresthaven peach in the 2001 NC-140 peach rootstock trial at the Western Colorado Research Center – Orchard Mesa, Grand Junction, CO during the 2006 growing season.[z]

Rootstock	Fall 2006 TCA[y] (cm^2)	Fall 2006 Survival (%)	No. root-suckers Fall 2006	Mean Fruit wt. (g)	Number fruit/ tree	Fruit yield/ tree (kg)	Crop Density (No fruit/ cm^2 TCA)	Yield Efficiency (kg fruit/ cm^2 TCA)
Bailey	73.5 ab	100 a	0.0 f	270 a	72.3 ab	13.6 b	2.4 b	0.46 bcd
BH-4	100.2 a	67 bc	1.0 d	240 a	55.7 bc	13.6 b	2.0 c	0.49 b
Cadaman	97.7 a	100 a	0.5 d	250 a	69.4 b	15.9 c	2.3 bc	0.51 b
Hiawatha	52.6 c	50 c	0.4 d	260 a	13.3 d	3.5 d	1.6 d	0.40 d
Jaspi	60.9 bc	84 b	14.8 c	0 d	0.0 e	0.0 e	0.0 f	0.00 f
Julio	74.9 b	100 a	69.8 a	240 bc	61.2 b	15.0 ab	2.0 cd	0.48 bc
K146-44	26.8 cd	50 c	0.0 f	190 c	17.8 d	3.3 d	1.5 d	0.27 de
Lovell	72.8 b	48 c	0.0 f	230 bc	38.0 cd	8.9 c	2.5 b	0.58 ab
P30-135	22.7 d	88 ab	7.0 cd	230 bc	16.3 d	3.3 d	1.1 e	0.22 e
SC17	70.3 b	88 ab	28.5 b	230 bc	47.7 c	11.0 bc	1.9 cd	0.44 c
SLAP	85.1 ab	100 a	5.7 cd	250 a	91.0 a	22.6 a	2.8 a	0.70 a
VVA-1	54.0 c	50 c	2.5 d	270 a	36.7 cd	11.6 bc	1.9 cd	0.50 bc

[z]Each value is the mean of 3 – 8 trees. Means within a column with no letters in common are significantly different at α=0.05 according to Tukey's HSD.
[y]TCA = trunk cross-sectional area.

Table 2. Effect of nine peach rootstocks on tree growth, survival, rootsucker production, fruit production, and fruit yield efficiency for Cresthaven peach in the 2002 NC-140 peach rootstock trial at the Western Colorado Research Center – Rogers Mesa, Hotchkiss, CO during the 2006 growing season.[z]

Rootstock	Fall 2006 TCA[y] (cm^2)	Fall 2006 Survival (%)	No. root-suckers Fall 2006	Mean Fruit wt (g)	Number fruit/ tree	Fruit yield/tree (kg)	Crop Density (No fruit/ cm^2 TCA)	Yield Efficiency (kg fruit/ cm^2 TCA)
Adesoto 101	35.0 a	100 a	1.9 b	280 c	9.4 cd	2.8 b	0.5 d	0.13 d
Cadaman	31.4 a	100 a	5.4 bc	280 c	20.6 a	4.7 a	1.0 ab	0.24 bc
K146-43	12.1 b	75 b	0.0 d	200 d	9.5 cd	2.1 c	0.7 cd	0.15 cd
MRS 2/5	35.3 a	100 a	3.9 b	280 c	12.5 b	3.4 ab	0.6 c	0.16 cd
Penta	25.2 ab	100 a	2.4 bc	260 cd	11.8 bc	2.9 b	0.7 cd	0.17 c
Pumiselect	11.4 bc	38 c	0.0 d	249 cd	20.5 a	5.1 a	1.5 a	0.38 a
VSV-1	11.5 bc	75 b	23.0 a	220 d	9.5 cd	1.6 d	0.8 bc	0.14 cd
Lovell	39.4 a	75 b	0.5 c	337 a	17.2 ab	5.8 a	0.8 bc	0.26 b
VVA-1	8.7 c	75 b	20.47a	230 d	7.5 d	1.8 d	0.7 bcd	0.17 c

[z]Each value is the mean of 3 – 8 trees. Means within a column with no letters in common are significantly different at α =0.05 according to Tukey's HSD.
[y]TCA = trunk cross-sectional area.

Although Pumiselect had good fruit yield in 2006, it had very poor yield in previous years (Fig. 2).

Severe spring frost just after full bloom on peaches at the site on April 19 & 20, 2006 (temperatures down to (–4 and –3 ^{o}C, respectively) killed some blossoms and impacted fruit production in 2006. Thus Pumiselect's performance in 2006 might be related to spring frost tolerance through a delay in bloom. However, Pumiselect's very high mortality reduces any production potential that might be realized from the later bloom time. Cadaman and Lovell rootstocks, with higher yields over the three year period and with their higher survival rates, appear to be better choices for the Rogers Mesa area from this data.

Over both studies, Cadaman, SLAP, and Lovell all did well. Cadaman and SLAP did best at the higher elevation Rogers Mesa location, and Lovell and Cadaman did best at the lower elevation Orchard Mesa location. However, Lovell had slightly higher mortality but better yield and TCA at Orchard Mesa; it had higher mortality and lower yield at Roger Mesa. SLAP was not included in Orchard Mesa, but Cadaman performed well in both the locations. Cadaman had both better yields and higher survival (100%). Thus, Cadman might be the best choice for western Colorado.

However, these findings do need further investigation because of the short duration of this study. Since these orchards are already removed because of danger of the spread of the virus, further follow-up studies are needed as only six years of data were analyzed.

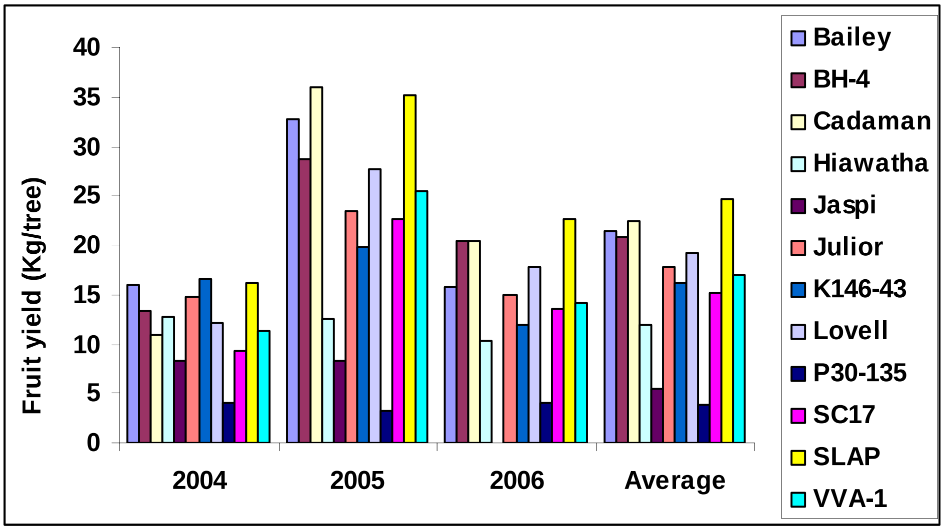

Fig 1. Effect of rootstock on fruit yield of Cresthaven peach planted in 2001 at the Western Colorado Research Center – Orchard Mesa near Grand Junction, CO.

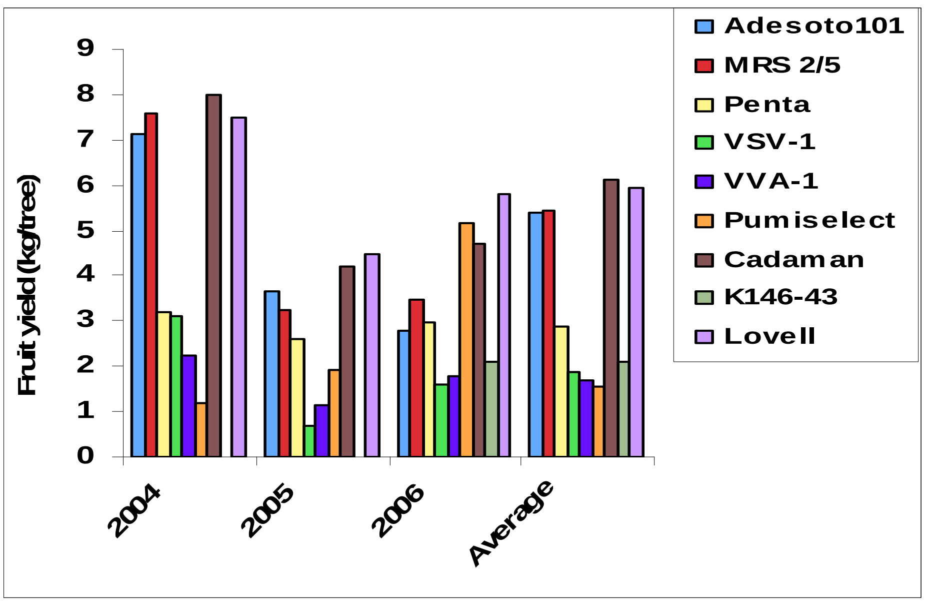

Fig 2. Effect of rootstock on fruit yield of Cresthaven peach planted in 2002 at the Western Colorado Research Center – Roger Mesa near Hotchkiss, CO. Trees on rootstock K-146-43 produced no fruits in 2004-2005.

Acknowledgments

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Western Colorado Alfalfa Variety Performance Test at Fruita 2006

Calvin H. Pearson[1]

Summary

The 2006 results of Colorado State University's alfalfa variety performance test at Fruita are presented in this report (Table 1). Plots were planted fall 2004 and the data for 2006 are for the second year of a three-year testing period. Alfalfa stands are excellent and plots were weed-free during the growing season. The field was furrow-irrigated using gated pipe. Summer 2006 in western Colorado was favorable for crop production and alfalfa yields were excellent. In 2006, there were 14 days during the summer when temperatures reached 100°F. In 2005, there were 10 ten days during the summer when temperatures reached 100°F. The average growing season for Fruita is 181 days. The 2006 growing season was 184 days.

Table 1. Forage yields of 11 alfalfa varieties at the Western Colorado Research Center at Fruita in 2006.[1]

Variety	Source/Brand	1st Cut May 25	2nd Cut July 13	3rd Cut Aug 29	4th Cut Oct 4	2006 Total[2]	2-yr Total
				tons/acre[3]			
Mountaineer 2.0	Croplan Genetics	3.82	3.02	2.12	1.31	10.27	19.91
WL 357 HQ	W-L Research	3.73	3.08	2.12	1.29	10.22	19.60
Garst 6530	Garst	3.84	2.99	2.14	1.19	10.16	19.38
4542	Forage Genetics Intl	3.60	3.08	2.13	1.28	10.10	19.74
FSG 351	Allied Seed, L.L.C.	3.48	3.16	2.17	1.18	10.00	19.85
CW 15030	Cal/West Seeds	3.55	2.97	2.20	1.26	9.98	19.44
FSG 408DP	Allied Seed, L.L.C.	3.42	3.09	2.15	1.19	9.85	19.11
FSG 505	Allied Seed, L.L.C.	3.62	2.90	2.08	1.22	9.81	19.42
Bullseye	Target Seed	3.57	2.75	2.25	1.23	9.80	18.58
CW 13014	Cal/West Seeds	3.46	2.83	2.08	1.23	9.60	19.17
FSG 406	Allied Seed, L.L.C.	3.54	2.84	1.97	1.16	9.50	18.90
Ave.		3.60	2.97	2.13	1.23	9.94	19.37
CV (%)		8.29	5.99	4.33	6.16	3.94	3.48
LSD (0.05)		NS	0.26	0.13	NS	NS	NS

[1]Seeded 26 August 2004 at 15 lbs/acre.
[2]Table is arranged by decreasing 2006 total yield.
[3]Yields were calculated on an air-dry basis.

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Last spring frost – April 21, 2006; first fall frost October 22, 2006. Frost-free days for 2006 - 184 days (28°F base). Fertilizer: 276 lbs P_2O_5/ acre and 108 lbs N/acre broadcast as 18-46-0 on August 16, 2004 and plowed down prior to planting. Applied Pursuit DG at 1.44 oz/ acre plus Select at 10 oz/acre (added 1 qt. of UAN plus 1 qt. crop oil concentrate in 100 gallons of water) using 22 gals water/acre at 25 psi for weed control on 3 Mar 2006.

Producing Oilseed Sunflower Under Irrigation in Western Colorado

Calvin H. Pearson[1]

Summary

The high cost of petroleum diesel has increased interest in alternative fuels such as biodiesel. There are a number of biodiesel production facilities currently under construction and many of the existing facilities are undergoing expansion. The potential of agriculture to produce vegetable oil to use as feedstocks to operate biodiesel manufacturing facilities in the United States appears promising. An oilseed sunflower cultivar performance test was conducted at the Western Colorado Research Center at Fruita, Colorado during 2006 to evaluate thirty-two sunflower varieties for seed and oil yield and related agronomic characteristics to assess the potential for commercial production of sunflower under irrigation in western Colorado. Seed yields averaged 2420 lbs/acre and ranged from a high of 3500 lbs/acre for HySun 454 to a low of 701 lbs/acre for Croplan Genetics 3080 DMR. Seed oil content averaged 44.3%, which is typical for many sunflower varieties. Oil contents ranged from a high of 47.0% to a low of 42.0%. Oil yield averaged 1072 lbs/acre. Oil yields among the sunflower varieties ranged from a high of 1530 lbs/acre to a low of 310 lbs/acre. The variety with the highest seed yield did not have the highest oil yield. Additional years of field research will be needed to determine the long-term potential for producing sunflower for vegetable oil under irrigation in western Colorado.

Introduction

In the Rocky Mountain region of the United States the price of petroleum diesel during January 2007 was approximately $2.55 per gallon (U.S. Dept. of Energy, 2007). The price of diesel fuel reached record highs during October-November 2005 at more than $3.00 per gallon.

Biodiesel has recently become popular primarily because of the high cost of petroleum diesel but also because of its performance characteristics and environmental benefits. Comparison characteristics of biodiesel with petroleum diesel have been summarized previously (Pearson, 2006). Ma et al. (1999) presented detailed information on direct use, blending, and the manufacturing chemistry for biodiesel.

The high cost of petroleum diesel has prompted the construction of numerous biodiesel production facilities in the United States. Currently, there are 87 biodiesel production facilities around the country with another 65 under construction along with thirteen of the existing biodiesel facilities undergoing expansion (National Biodiesel Board, 2007a; National Biodiesel Board, 2007b).

Feedstocks for biodiesel production facilities are tri-glyceride seed oils, found in crop plants such as canola, mustards, sunflower, cotton, safflower, soybean, corn, and also used cooking oils, fats, and tallows (Eidman, 2005). Many of the biodiesel facilities use multiple feedstocks while some facilities use a sole source such as soybean oil.

The potential of agriculture to produce

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vegetable oil as a feedstock to operate biodiesel manufacturing facilities in the United States appears promising (Tickell, 2003). Using vegetable oils for a diversity of applications, particularly in the energy industry, will require large quantities of feedstocks and will likely increase commodity prices in the short and long-term (Eidman, 2005).

With a yield of 3000 lbs/acre and a seed oil content of 44%, an acre of sunflower will produce 1320 lbs of oil. Sunflower oil weighs 7.5 pounds per gallon, and a gallon of vegetable oil will produce about 1 gallon of biodiesel (Hofman, 2003). Under these conditions, an acre of sunflower will produce approximately 176 gallons of biodiesel.

Currently, a biodiesel production facility in southwest Colorado is proposed for construction by the San Juan Biodiesel Cooperative in mid-2007. The main crops targeted for use in this

facility are sunflower and canola. Production of biodiesel in western Colorado will open the possibility of growing alternative crops such as sunflower in western Colorado to supply vegetable oil for the biodiesel facility.

The objective of this research was to evaluate thirty-two sunflower varieties for seed and oil yield and other agronomic characteristics to determine the potential for commercial production of sunflower under irrigation in western Colorado.

Materials and Methods

An oilseed sunflower cultivar performance test was conducted at the Western Colorado Research Center at Fruita, Colorado during 2006. The experiment was a randomized, complete block with four replications. Thirty-two oilseed sunflower cultivars were included in the trial. Plot size was 10-feet wide by 50-feet long (4, 30-inch rows). The previous crop was oats.

Prowl herbicide was applied just prior to planting at a rate of 2.5 pts at 25 psi in 20 gals water per acre and incorporated twice with a roller harrow on 11 May 2006. Planting occurred on 15 May 2006 with a White air planter modified for plot research.

Fertilizer was applied broadcast during seedbed preparation (22 lbs N/acre and 104 lbs P2O5/acre) on May 10, 2006. Nitrogen fertilizer was side-dressed (80 lbs N/acre as 32-0-0 in a split application of 40 lbs N/acre on each side of the plant row) on 15 June 2006.

The experiment was furrow-irrigated using gated pipe. A germination irrigation was applied on 16 May 2006 in a 24-hour irrigation set. Sunflower was irrigated four times during the 2006 growing season and averaged 18 hours per irrigation.

The two middle rows of the four-row plot were harvested 1 Nov. 2006 using an International 1440 commercial combine and a portable electronic weighing system positioned in the grain tank. Data was collected for plant population, flowering date, plant height, plant lodging, seed moisture at harvest, test weight, and seed yield. Seed moisture and test weight were obtained using a Dickey-John GAC2100b seed moisture tester.

Results and Discussion

The 2006 cropping season in western Colorado was mild. In 2006, there were 14 days during the summer when temperatures reached 100°F. The average growing season for Fruita is 181 days. The 2006 growing season was 184 days.

Adequate irrigation water was available during the growing season for crop production and water was not a limiting factor for sunflower production.

Seed moisture content averaged across all entries was 6.1% (Table 1). Seed moisture ranged from a high of 6.4% for Croplan Genetics 343 DMR to a low of 5.8% for Croplan Genetics 308 NS. Twenty-four of the thirty-two varieties had seed moisture contents higher than

6.0%, and eight varieties had moisture contents below 6.0%.

Seed yield for the sunflower varieties averaged 2420 lbs/acre (Table 1). There were significant and a wide range of differences among entries for seed yield. Seed yields ranged from a high of 3500 lbs/acre for HySun 454 to a low of 701 lbs/acre for Croplan Genetics 3080 DMR. Three of the thirty-two sunflower varieties (HySun 454, Producers Hybrids 7203, Garst 454) were high yielding and two varieties (Croplan Genetics 308 NS and Croplan Genetics 3080 DMR) had particularly low yields.

Seed oil content averaged 44.3%, which is typical for many sunflower varieties. Oil contents ranged from a high of 47.0% for Mycogen 8N453DM to a low of 42.0% for Dyna-Gro 93N05 #2.

Oil yield averaged 1072 lbs/acre. Oil yields among the sunflower varieties ranged from a high of 1530 lbs/acre for Mycogen 8N462DM to a low of 310 lbs/acre of Croplan Genetics 3080 DMR. The variety with the highest seed yield did not have the highest oil yield.

The standard test weight value for sunflower is 24 lbs/bu. The average test weight for the varieties evaluated in this trial was 33.6 lbs/bu (Table 2). The four varieties with the highest test weights were Pioneer brand 63M91 (34.7 lbs/bu), Mycogen 8N462DM (34.9 lbs/bu), Mycogen 8N453DM (35.5 lbs.bu), and Seeds 2000 Blazer (35.2 lbs/bu). Seven varieties had test weights that were lower than 33.0 lbs/bu., however, the lowest test weight value for all varieties was still substantially greater than the standard test weight value of 25 lbs/bu.

Plant height of sunflower varieties averaged 78.1 inches, the tallest cultivars were 7203 (88.5 inches), 8N453DM (86.4 inches), and Croplan Genetics 378 DMR (86.0 inches) (Table 2). The shortest variety, as expected, was a dwarf sunflower variety, Triumph s672, with a plant height of 57.8 inches.

Plant population, averaged across all varieties, was 31,364 plants/acre (Table 2). Plant populations ranged from a high of 35,504 plants/acre for Triumph 645 to a low of 26,930 plants/acre for Croplan Genetics 356. Plant populations among the sunflower varieties differed significantly. Eleven varieties had plant populations greater than other varieties exceeding 33,000 plants/acre and eight varieties had plant populations lower than other varieties, which were less than 29,500 plants/acre.

The average number of days to flowering was 63 days from planting (Table 2). Seven sunflower varieties were the first to flower in 60

to 62 days from planting. Three varieties (Triumph s678, Triumph s672, Sierra) took the most time to reach the flowering stage at 66.5 to 68 days. Other sunflower varieties were intermediate in the number of days they needed to reach flowering.

Plant lodging among sunflower varieties varied significantly and there was a wide range in the response of sunflower varieties to lodging (Table 2). The two sunflower varieties with the most lodging were Croplan Genetics 3080 DMR and Croplan Genetics 308 NS. The low seed yields of these two varieties were likely affected by the high amount of lodging they experienced. Three varieties had less than 1% lodging. They were Mycogen 8N453DM, Producers Hybrids 7203, and Dyna-Gro 93N05 #2.

In summary, most sunflower varieties established well and exhibited good growth during the growing season. Many sunflower varieties produced good seed yields, had low seed moisture contents at harvest, and had good seed oil contents and thus oil yields. We experienced considerable rain during the fall that delayed harvest. This provided birds with more time to forage in the sunflower field. Our seed yields, while good, would likely have been somewhat higher if we could have harvested the plots sooner and reduced seed loss due to bird damage.

Oilseed sunflower production in western Colorado appears promising based on one year of agronomic data obtained at Fruita in 2006. Weed control in the sunflower field was excellent.

Additional years of field research are needed to determine the long-term potential for producing sunflower for vegetable oil under irrigation in western Colorado.

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

Cultivar	Source	Seed moisture	Seed yield	Oil content	Oil yield
		%	lb/ac	%	lbs/acre
HySun 454	HySun	6.3	3500	43.1	1509
7203	Producers Hybrids	6.0	3388	44.1	1494
Garst 454	Garst	6.3	3377	43.6	1472
8N462DM	Mycogen	6.0	3269	46.8	1530
8N453DM	Mycogen	6.1	3166	47.0	1488
8N386CL	Mycogen	6.1	3120	42.4	1323
DKF 37-31NS	DEKALB	6.1	3046	45.7	1392
8H419CL	Mycogen	6.1	3024	43.1	1303
63M91	Pioneer brand	6.2	2996	46.2	1384
Croplan Genetics 378 DMR	Croplan Genetics	6.2	2898	44.3	1284
Croplan Genetics 356	Croplan Genetics	6.1	2756	46.2	1273
63M80	Pioneer brand	6.1	2756	46.1	1271
Triumph 645	Triumph	6.0	2736	43.8	1198
8N520DM	Mycogen	5.9	2642	45.0	1189
Sierra	Seeds 2000	6.2	2632	43.8	1153
Blazer	Seeds 2000	6.0	2374	45.5	1080
Croplan Genetics 343 DMR	Croplan Genetics	6.4	2363	41.6	983
Garst 450	Garst	6.2	2342	45.1	1056
7303	Producers Hybrids	6.0	2298	44.5	1023
Garst 4668 ns/cl	Garst	6.1	2249	42.8	963
HySun 450	HySun	6.1	2248	44.8	1007
DKF 35-10 NS	DEKALB	6.2	2126	43.4	923
Garst 521	Garst	6.1	2079	42.6	886
Croplan Genetics 305 DMR	Croplan Genetics	6.0	2010	43.0	864
SF7105NS	Producers Hybrids	6.1	1983	44.0	873
Triumph s672	Triumph	5.9	1963	42.7	838
93N05 #2	Dyna-Gro	6.0	1743	42.0	732
Triumph 820 HO	Triumph	5.9	1697	45.3	769
93C05 #4	Dyna-Gro	6.0	1645	44.1	725
Triumph s678	Triumph	6.2	1401	44.6	625
Croplan Genetics 308 NS	Croplan Genetics	5.8	899	45.8	412
Croplan Genetics 3080 DMR	Croplan Genetics	6.1	701	44.2	310
Ave.		6.1	2420	44.3	1072
LSD (0.05)		0.4	610		

[1]Table is arranged by decreasing seed yield.

Table 2. Test weight, plant height, plant population, flowering, and lodging of thirty-two sunflower varieties evaluated in the Grand Valley of western Colorado at the Western Colorado Research Center at Fruita during 2006.

Cultivar	Source	Test weight.	Plant height	Plant population	Flower	Lodging
		lb/bu	in.	Plants/ac	days	%
HySun 454	HySun	33.6	83.7	30869	63	3.2
7203	Producers Hybrids	33.4	88.5	33326	65	0.7
Garst 454	Garst	33.6	82.8	30406	64	4.3
8N462DM	Mycogen	34.9	83.7	29294	64	5.5
8N453DM	Mycogen	35.5	86.4	32167	64	0.8
8N386CL	Mycogen	32.2	83.7	30359	64	2.3
DKF 37-31NS	DEKALB	33.8	75.3	28459	63	8.2
8H419CL	Mycogen	32.8	84.0	32862	65	3.4
63M91	Pioneer brand	34.7	80.8	32352	62	1.7
Croplan Genetics 378 DMR	Croplan Genetics	33.9	86.0	30545	64	2.1
Croplan Genetics 356	Croplan Genetics	34.0	71.7	26930	63	4.9
63M80	Pioneer brand	34.1	74.5	33511	62	3.8
Triumph 645	Triumph	32.4	83.7	35504	63	7.9
8N520DM	Mycogen	33.3	80.0	33233	65	16.6
Sierra	Seeds 2000	32.0	83.6	32353	67	16.4
Blazer	Seeds 2000	35.2	71.5	27810	63	32.3
Croplan Genetics 343 DMR	Croplan Genetics	32.9	81.5	30128	63	2.6
Garst 450	Garst	32.8	79.1	28459	65	9.1
7303	Producers Hybrids	33.1	76.6	29803	65	9.1
Garst 4668 ns/cl	Garst	32.8	82.8	33789	64	14.9
HySun 450	HySun	33.6	81.1	31796	65	14.1
DKF 35-10 NS	DEKALB	33.2	79.7	31240	62	3.2
Garst 521	Garst	33.4	72.5	34021	60	4.3
Croplan Genetics 305 DMR	Croplan Genetics	34.1	77.1	33326	64	4.2
SF7105NS	Producers Hybrids	34.0	74.2	34160	61	5.8
Triumph s672	Triumph	33.7	57.8	35087	67	16.9
93N05 #2	Dyna-Gro	32.7	69.9	27903	61	0.6
Triumph 820 HO	Triumph	33.8	74.6	34438	60	10.1
93C05 #4	Dyna-Gro	34.0	81.1	30776	66	6.2
Triumph s678	Triumph	34.4	66.3	27161	68	6.2
Croplan Genetics 308 NS	Croplan Genetics	34.0	70.8	28505	62	58.6
Croplan Genetics 3080 DMR	Croplan Genetics	33.0	73.0	33094	60	57.6
Ave.		33.6	78.1	31364	63	10.5
LSD (0.05)		1.0	4.2	2595	1.9	12.4

Dr. Horst W. Caspari

2006 Research Projects

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

Application of crop modeling for sustainable grape production (United States Environmental Protection Agency; H. Larsen)

*Sponsors/Cooperators are noted in parentheses.

2006 Publications

Refereed Publications

Leib, B.G, H.W. Caspari, C.A. Redulla, P.K. Andrews, J.D. Jabro. 2006. Partial rootzone drying and deficit irrigation of 'Fuji' apples in a semi-arid climate. Irrig. Sci. 24:85-99.

Conference papers

Caspari, H. 2006. Irrigation scheduling and vine water requirements. Proc. 25th Southwest Regional Vine & Wine Conference, 24 – 25 February 2006, Albuquerque, NM, USA, pp. 1-9.

Caspari, H., C. Hawke, S. Hammelman, and B. Musgnung. 2006. Crop load management in wine grapes. Proc. 25th Southwest Regional Vine & Wine Conference, 24 – 25 February 2006, Albuquerque, NM, USA, pp. 75-79.

Client Reports

Caspari, H. and M. Whiting. 2006. Short- and long-term effects of Partial Rootzone Drying on tree physiology, fruit quality and yield of apples. Final Report, Washington Tree Fruit Research Commission, 10 pp.

Caspari, H.W. and H.J. Larsen. 2006. Application of crop modeling for sustainable grape production. Annual Report 2005, Pesticide Special Study X8-98871201-1, US-Environmental Protection Agency, 9 pp.

Technical Reports

Caspari, H.W. and H.J. Larsen. 2006. Application of crop modeling for sustainable grape production. In: Western Colorado Research Center Research Report 2006, pp. 7-14. Colorado State University Agricultural Experiment Station Technical Report TR06-06. Fort Collins, Colorado.

Outreach/Extension Reports

Numerous articles updated or added to the Viticulture web page. For details visit www.colostate.edu/programs/wcrc/Vithome.htm

Dr. Ron Godin

2006 Research Projects

Native seed production for crop diversification (Western Sustainable Agriculture Research and Education; Uncompahgre Plateau Project, USFS, BLM, CDOW, Public Lands Partnership, CSU Cooperative Extension, Carl and Cindy Roberts, Dave and Pam Herz, Kenny Hines)*

Irrigation research and demonstration project comparing furrow, sprinkler and drip irrigation on irrigation use efficiency and yield and quality of alfalfa (Delta Conservation District)

*Sponsors/Cooperators are noted in parentheses.

2006 Publications

Godin, R., S. Ela, S. Max, K. Schultz, and J. Rohde. 2006. Organic Alternatives for Weed Control and Ground Cover Management: Effects on Tree Fruit Growth, Development and Production. Colorado State University Agricultural Experiment Station Technical Bulletin TB06-03, Fort Collins, Colorado.

Dr. Harold J. Larsen

2006 Research Projects

Viticulture and enology programs for the Colorado wine industry (Colorado Wine Industry Development Board; H. Caspari, R. Zimmerman)*
Application of crop modeling for sustainable grape production (Environmental Protection Agency; H. Caspari)
Remediation of stone fruit replant problems in Colorado Orchards (Arysta Corp., Eden Research)
Nematode control materials (Eden Research, Valent Corp.)
Resistance to cherry rasp leaf virus infection in Bing sweet cherry on Zee interstem on Citation rootstock (3-yr pot-in-pot study at WCRC-OM; Dave Wilson Nursery / Talbott Farms, Inc.)

*Sponsors / Cooperators are noted in parentheses.

Technical Reports / Other Publications / Written Works

Caspari, H.W. and H.J. Larsen, 2006. Application of crop modeling for sustainable grape production. pp. 7 – 14 in Western Colorado Research Center 2005 Annual Report. TR06-06. Colo. Agric. Exp. Sta. 38 p. (on the web at: http://www.colostate.edu/programs/wcrc/annrpt/06/Caspari&Larsen.pdf)
Larsen, H. 2006. Fruit industry outlook -- 2006-2007. Colo. Ag-Forum. 1 p + abstract. in: Weitzel, D. (Ed.) 2006. 2006 Colorado Agricultural Outlook Forum.

Non-Refereed WEB Publications

Caspari, H., C. Hawk, A. Montano, and H. Larsen, Fruit (and grape) bud cold hardiness, western Colorado, 2006. http://www.colostate.edu/programs/wcrc/infopages/fruitcoldhardiness06.pdf
Larsen, H. 2006. Bloom Dates at WCRC – Orchard Mesa http://www.colostate.edu/programs/wcrc/infopages/ombloomdates.pdf
Larsen, H. 2006. Crop phenology program output data report for WCRC-Rogers Mesa, Hotchkiss, CO. (Weekly update during spring) http://www.colostate.edu/programs/wcrc/infopages/budswcrcRM.pdf
Larsen, H. 2006. Grape Pest Management Guide (2006). http://www.colostate.edu/programs/wcrc/Viticulture/grapepestmgmtguide06.pdf
Larsen, H. 2006. Western Colorado temperature records (for WCRC-Orchard Mesa & WCRC-Rogers Mesa). (updated quarterly). http://www.colostate.edu/programs/wcrc/infopages/temperaturerecords.htm

Dr. Calvin H. Pearson

2006 Research Projects

Winter wheat cultivar performance test – Hayden (Mike Williams, Dr. Scott Haley)*
Corn grain hybrid performance test – Fruita (Dr. Jerry Johnson, seed companies)
Short season corn grain hybrid performance test – Delta (Wayne Brew, Dr. Jerry Johnson, seed companies)
Corn forage hybrid performance tests – Fruita, Olathe (Earl Seymour, Dr. Jerry Johnson, seed companies)
Evaluation of corn hybrids for blunt ear syndrome – Fruita (Wayne Fithian, Golden Harvest)
Alfalfa variety performance test (2005-2007) – Fruita (Dr. Jerry Johnson, seed companies, breeding companies, private industry)
Alfalfa germplasm evaluation, 2004-2006 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of roundup-ready alfalfa, 2005-2007 – Fruita (Forage Genetics and Monsanto)
Canola cultivar performance test – Fruita (Dr. Jerry Johnson, Kansas State Univ.)
Nuna advanced breeding line seed increase and yield trial – Fruita (Dr. Mark Brick and Barry Ogg)
Sunflower cultivar performance test – Fruita (seed companies)
Volunteer sunflower seed longevity study – Fruita (Dr. Allison Snow, Ohio State University)
Development of sunflower as an industrial, natural rubber-producing crop (Drs. Katrina Cornish and Colleen McMahan, USDA-ARS, Albany, CA; Dr. Jay Keasling, U.C. Berkeley; Dr. Dennis Ray, University of Arizona; Dr. John Vederas, University of Edmonton, USDA-CSREES)

*Cooperators / collaborators/sponsors are noted in parentheses.

2006 Publications

Pearson, Calvin H. 2006. Winter Wheat Variety Performance Test at Hayden, Colorado 2005. p. 20-23. In: Making Better Decisions: 2005 Colorado Winter Wheat Variety Performance Trials. Colorado State University, Agricultural Experiment Station and Cooperative Extension, Technical Report TR06-09. Fort Collins, Colorado.

Pearson, Calvin H. 2006. Letter from the Editor. Agron. J. 96:319-320.

Pearson, C.H., R.W. Mullen, W.E. Thomason, and S.B. Phillips. 2006. Associate editor's role in helping authors and upholding journal standards. Agron. J. 98:417-422.

Pearson, C.H. 2006. Little or no-cost management practices increase hay profits. The Progressive Hay Grower 7:11-14.

McMahan, C.M., K. Cornish, J.L. Brichta, C.H. Pearson, D.K. Shintani, Xie Wenshuang, and M. Whalen. 2006. Natural rubber from plants: Interspecific comparisons and metabolic engineering strategies. Paper presented at an international workshop entitled, "Biotechnology for the Production of Industrial Materials," September 14, 2006, Osaka University, Osaka, Japan.

Cornish, K., C. Pearson, D.J. Rath, N. Dong, C.M. McMahan, and M. Whalen. 2006. The Potential for Sunflower as a Rubber-Producing Crop for the United States. Invited presentation at The First Annual Symposium on Industrial Uses of Sunflower. Udine University, Udine Province Friuli Venezia Giulia Region, Italy. September 13, 2006.

Pearson, C.H., K. Cornish, C.M. McMahan, N. Dong, D.J. Rath, S. Wong, and M Whalen. 2006. Transforming sunflower into a rubber-producing crop. Sixth National Symposium, "Creating Markets for Economic Development of New Crops and New Uses. San Diego, California. October 14-18, 2006. abst., page 49.

Dr. Ramesh Pokharel

Research Projects in 2006:

Efficiency of some new chemical pesticides on replant problem of stone fruits on Western Colorado. (H.J. Larsen)*
Survey of phytoparasitic nematodes in western Colorado fruit orchard
Seasonal variability in nematodes and effect of plastic materials on the survival of PPN in fruit orchards
Evaluation of rootstocks for peaches (2001 and 2002) and cherry (1998) for NC 140 trial

* Cooperators / collaborators / sponsors are noted in parenthesis.