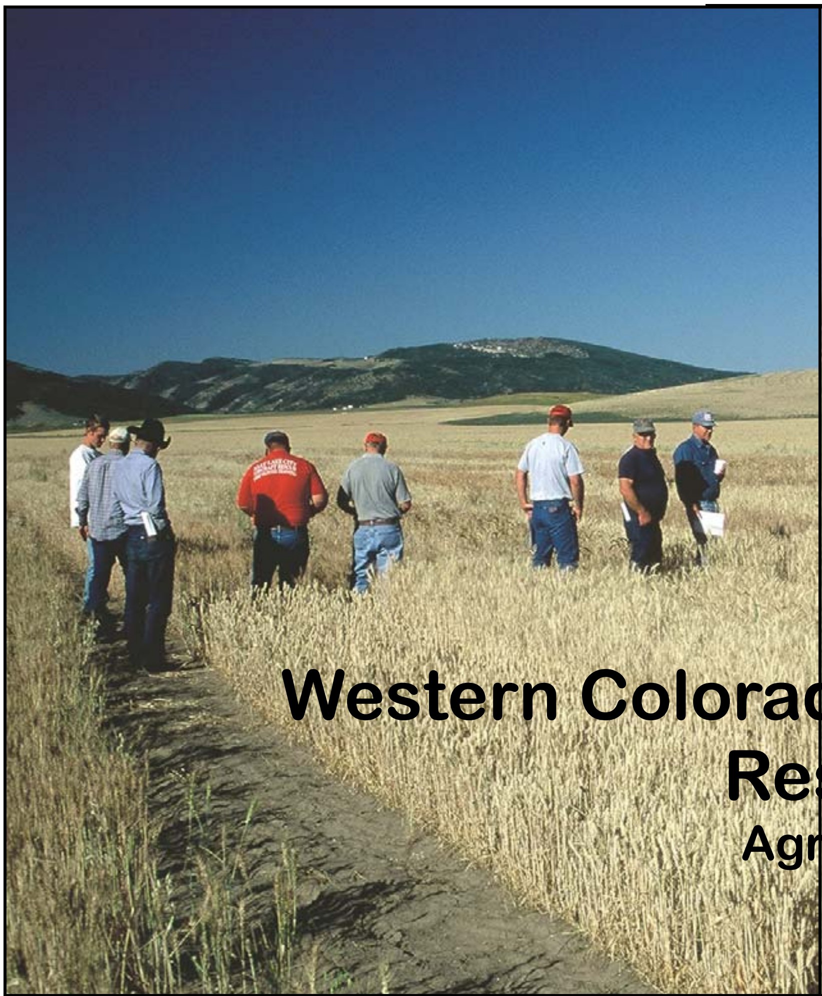

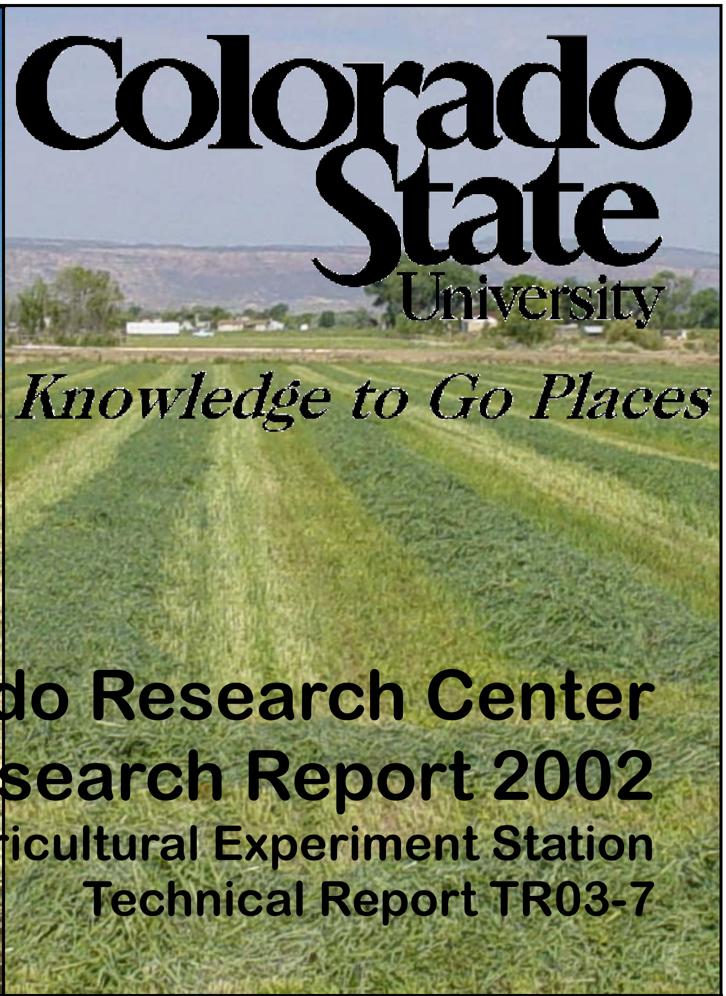

Colorado State University

Knowledge to Go Places

Western Colorado Research Center
Research Report 2002

Agricultural Experiment Station
Technical Report TR03-7

Front Cover Photos (clockwise from upper left):

"Touring of Winter Wheat Plots", Photo by Calvin H. Pearson
"1st Cutting of Oat Hay", Photo by D. Frank Kelsey
"Pest Monitoring in Cherries", Photo by D. Frank Kelsey
"Simulated Hail Damage to grape cv. Chardonnay", Photo by Harold J. Larsen

Technical Report TR03-7

Agricultural Experiment Station	Cooperative Extension	Western Colorado Research Center: Fruita Orchard Mesa Rogers Mesa	June 2003

Western Colorado Research Center 2002 Research Report

Horst W. Caspari
Ron E. Godin
Robert W. Hammon
Harold J. Larsen
Calvin H. Pearson

Colorado State University
Knowledge to Go Places

Table of Contents

Introduction

Agriculture on the Western Slope continues to face changes. Low commodity prices and raising land values push farmers to consider new ideas in farm management, types of crops grown, and how to better market their crops to maximize farm-gate returns. The Western Colorado Research Center (WCRC) is well aware of these issues and continues to work within its areas of expertise to meet its mission statement in planning, implementing, and conducting research and outreach programs to address the needs of farmers in the region.

Like the farming community around us, we also face and encounter change. A major one for us was the departure of our former station Manager, Shane Max. His replacement, Frank Kelsey, joined the WCRC staff in February, 2003. We look forward to the new perspectives he brings to the mix as we continue to focus our resources in areas where we can generate the most benefit. Investment in our new program areas of Improving Established Crop Systems, Sustainable/Organic Agriculture, New Crops, Viticulture and Ornamental Nursery Production is having significant payoffs. Faculty have been very active, successfully developing new joint projects with eight out-of-state research institutions, six on-campus faculty, and local Cooperative Extension agents. Significant new external funding was received from a number of these projects. Funding agencies included the Dept of Energy, SARE, Washington Tree Fruit Commission, Colorado Division of Wildlife, Bureau of Reclamation, and the Organic Farm Research Foundation. You can look forward to reading the outcome of this work in this and future annual reports.

To improve our outreach programs we are making much greater use of the internet. As more and more farmers adopt computers as a management tool, they have access to a wealth of free information from the worldwide web. We have updated our web page and now make use of the Tri County Cooperative Extension web page, as well as "Agfacts" and the new "FruitFacts" listserves to post pertinent information for farmers in the region.

I gratefully acknowledge the effort that support staff and faculty have made in ensuring the successful completion of this years' projects. Much of the redirection of WCRCs' objectives would not have been possible without their cooperation or the support of the Colorado Agricultural Experiment Station and the department heads associated with this center.

Individual researchers acknowledge sponsors and cooperators in their own reports. Additional support has been provided by a number of others, including Van Well Nursery, Colorado Organic Crop Management Association, Rohm and Haas, and members of the Western Colorado Horticultural Society.

This publication marks the 5th year of the formation of the Western Colorado Research Center. The reports enclosed in this publication give an indication of the breadth of research conducted at our three locations in 2002. A comprehensive list of 2002 findings will be available on our web site in mid-2003. I trust you will enjoy this report and contact the authors with any questions.

Harold Larsen
Chairman, Western Colorado Research Center Research Committee

Western Colorado Research Center Station Descriptions

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

The Fruita site 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, and a dry bean conditioning facility/storage building. A comprehensive range of agronomic equipment is based at the site.

Orchard Mesa Location: 3168 B 1/2 Road
Grand Junction, CO 81503
(970) 434-3264
(970) 434-1035 *fax*

The Orchard Mesa site is located seven miles east and south of Grand Junction on B 1/2 Road and south of Clifton. It lies at an elevation of 4,750 feet with Mesa clay loam and Hinman clay loam soil types. High temperatures average 92/ F in July and 37/ F in January. Lows average between 63/ F in July and 16/ F in January. Readings of 100/ F or higher are infrequent, and about one-third of the winters have no readings below 0/ F. Relative humidity is very low during the summer. 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 and propane orchard heaters. Irrigation is by mini-sprinkler and gated pipe systems supplied by ditch water from the Colorado River. Facilities at the Orchard Mesa Center include the regional office, conference room and several labs. Other buildings include a workshop and greenhouse. Approximately 20 of the center's 80 acres are devoted to experimental orchards, principally apples, peaches and grapes. Smaller plantings of pears and cherries are also grown.

Rogers Mesa Location: 3060 Highway 92
Hotchkiss, CO 81419
(970) 872-3387
(970) 872-3397 *fax*

Rogers Mesa Research Center 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 and propane orchard heaters. Irrigation methods used include drip, mini-sprinklers, gated pipe and open ditch, all supplied from the Fire Mountain canal water. Facilities at the Rogers Mesa Research Center include offices, several laboratories and a conference room. Other buildings include workshop, machine shed, barn, and greenhouse. Approximately 20 of the 80 acres are planted with experimental orchards. Apples and peaches are the main crops. A small acreage is also devoted to sweet cherries and vegetable production. An arboretum was planted in 2001.

Personnel Listing

Ms. Susan Baker, Accounting Technician susan.baker@colostate.edu	3168 B 1/2 Road Grand Junction, CO 81503 (970) 434-3264 ext. 201 fax (970) 434-1035
Mr. Bryan Braddy, Support Staff bryan.braddy@colostate.edu	3060 Highway 92 Hotchkiss, CO 81419 (970) 872-3387 ext. 3 fax (970) 872-3397
Dr. Horst Caspari, Viticulturist horst.caspari@colostate.edu	3168 B 1/2 Road Grand Junction, CO 81503 (970) 434-3264 ext. 204 fax (970) 434-1035
Mr. Todd Einhorn, Graduate Student teinhorn@lamar.colostate.edu	3168 B 1/2 Road Grand Junction, CO 81503 (970) 434-3264 ext. 208 fax (970) 434-1035
Dr. Ron Godin, Agronomist/Soil Scientist rgodin@lamar.colostate.edu	3060 Highway 92 Hotchkiss, CO 81419 (970) 872-3387 ext. 5 fax (970) 872-3397
Mr. Robert (Bob) Hammon, Entomologist bob.hammon@colostate.edu (Transferred to Coop. Ext. in April, 2003)	1910 "L" Road Fruita, CO 81521 (970) 858-3629 ext. 3 fax (970) 858-0461
Mr. Fred Judson, Support Staff/Foundation Bean Manager fred.judson@colostate.edu	1910 "L" Road Fruita, CO 81521 (970) 858-3629 ext. 4 fax (970) 858-0461
Mr. Frank Kelsey, WCRC Manager frank.kelsey@colostate.edu (Replaced Shane Max, Feb., 2003)	3168 B 1/2 Road Grand Junction, CO 81503 (970) 434-3264 ext. 203 fax (970) 434-1035
Dr. Harold Larsen, Pathologist harold.larsen@colostate.edu	3168 B 1/2 Road Grand Junction, CO 81503 (970) 434-3264 ext. 205 fax (970) 434-1035
Mr. George Osborn, Support Staff george.osborn@colostate.edu	3060 Highway 92 Hotchkiss, CO 81419 (970) 872-3387 ext. 3 fax (970) 872-3397
Dr. Calvin Pearson, Research Agronomist calvin.pearson@colostate.edu	1910 "L" Road Fruita, CO 81521 (970) 858-3629 ext. 2 fax (970) 858-0461
Mr. Lot Robinson, Support Staff lot.robinson@colostate.edu	1910 "L" Road Fruita, CO 81521 (970) 858-3629 ext. 5 fax (970) 858-0461
Dr. Matt Rogoyski, Horticulturist rogoyski@lamar.colostate.edu	3168 B 1/2 Road Grand Junction, CO 81503 (970) 434-3264 ext. 202 fax (970) 434-1035
Mr. John Wilhelm, Support Staff wilhelm@gj.net	3168 B 1/2 Road Grand Junction, CO 81503 (970) 434-3264 ext. 221 fax (970) 434-1035
Dr. Rick Zimmerman, Entomologist rick.zimmerman@colostate.edu	3060 Highway 92 Hotchkiss, CO 81419 (970) 872-3387 ext. 1 fax (970) 872-3397

ADVISORY COMMITTEE

We would like to sincerely thank all the members of our Advisory Committee for their time and input into our planning processes. Maylon Peters, the committee chairman, in particular has put a lot of time and commitment into ensuring the group had an active voice in our programmatic decisions. Betsy Hale and Laurie Felix resigned in late 2002 - early 2003; we regret the loss of their input.

The committee's role is to suggest, provide input, promote, and influence research planning that is conducted at WCRC centers. The outreach role is to work in conjunction with other committee members, research scientists and Experiment Station administrators to promote the interest of agriculture and the Agricultural Experiment Station within the region and to inform politicians, service groups, and the general public of current research being conducted at WCRC centers.

Present members of the committee are listed below. Should you have any questions or comments about WCRCs' programs please feel free to contact them.

Peters, Maylon - Farm and Ranch Mgmt Lecturer
62757 Jeremy Road Montrose, CO 81401
Fax: 970-248-1923
Tel: 970-248-1109, 240-4104
e-mail: mpeters@mesastate.edu

Proctor, Larry - Agronomic Farmer
269 State Hwy 348 Delta, CO 81416
Fax: 970-874-9859
Tel: 970-874-7488
e-mail: redbeard@gj.net

Talbot, Bruce - Orchardist
497 - 34 3/4 Road Palisade, CO 81526
Fax: 970-464-7821
Tel: 970-464-7392
e-mail: bruce@talbottfarms.com

Baughman, Jim - County Commissioner
750 Main Street Grand Junction, CO 81501
Tel: 970-244-1605
e-mail: jbaughma@co.mesa.co.us

Hill, Dennis - Nurseryman
755 - 26 Road Grand Junction, CO 81505
Fax: 970-242-0941
Tel: 970-242-7766
e-mail: dennis@bookcliffgardens.com

Steve Ela - Organic Grower
3075 L Road Hotchkiss, CO 81419
Tel: 970-872-3488
e-mail: sela@co.tds.net

Brew, Wayne - Agronomic Farmer
53055 Carnation Road Olathe, CO 81425
Fax: 970-874-8814
Tel: 970-874-8814
e-mail: wbrew@tds.net

Roles, Greg - Realtor/Small Acreage Farmer
963 Laura Street Fruita, CO 81521
Fax: 970-245-6495
Tel: 970-858-7838
e-mail: gr@mbgj.com

Bradley, Leland - Orchardist
1612 - 4175 Drive Paonia, CO 81428
Fax: 970-527-6838
Tel: 970-527-3005
e-mail: Lkbradley@aol.com

Moreng,Nathan - Regional Director/Cooperative Ext.
2764 Compass Drive, Suite 236
Grand Junction, CO 81506-8706
Fax: 970-241-3643
Tel: 970-241-3346
e-mail: nmoreng@coop.ext.colostate.edu

Traubel, Larry- Orchardist/Farm Supply Rep.
2269 S50 Rd
Cedaredge CO 81413
Tel: 970-856-3424
e-mail: ltraubel@hotmail.com

Performance of Hybrid Poplar in Western Colorado, 2000-2002

Calvin H. Pearson, Professor, Western Colorado Research Center (WCRC) at Fruita, 1910 L Road, Fruita, CO 81521, ph: 970-858-3629, fax: 970-858-0461, calvin.pearson@colostate.edu; **Matthew Rogoyski**, Assistant Professor, WCRC at Orchard Mesa, 3168 B ½ Road, Grand Junction, CO 81503, ph: 970-434-3264, fax: 970-434-1035, matthew.rogoyski@colostate.edu; **Ron Godin**, Research Scientist, WCRC at Rogers Mesa, 3060 Hwy. 92, Hotchkiss, CO 81419, ph: 970-872-3387, fax: 970-872-3387, ronald.godin@colostate.edu; **Bob Hammon**, Research Associate, WCRC at Fruita, 1910 L Road, Fruita, CO 81521, ph: 970-858-3629, fax: 970-858-0461, robert.hammon@colostate.edu; and **Randy Moench**, Manager, Colorado State University Forest Service Nursery, CSU Foothills Campus, Fort Collins, CO 80523, ph: 970-491-8429, rmoench@lamar.colstate.edu.

Summary

Hybrid poplars are suitable for a number of uses including pulp, dimension lumber, oriented strand board (OSB), plywood, and fuel, as well as conservation and ornamental plantings. A hybrid poplar clone evaluation study consisting of eight hybrid clones was initiated in 2000 at the Western Colorado Research Center (WCRC) at Fruita and at Hotchkiss. Growth of hybrid poplars in 2002 after three years of production has been noteworthy. In 2002 at Fruita, OP367, 52225, and Raverdeau maintained the largest tree diameters ranging from 4.0 to 4.3 inches when measured at a meter height up the tree trunk. Tree height at the end of the 2001 growing season following two years of growth, averaged across all hybrids, at Fruita was 22.1 feet. Poplar Hybrids NM6, 52225, and OP367 were taller than other hybrids with average heights of 24.5, 26.5, and 25.9 feet, respectively. Tree height, averaged across all hybrids at Hotchkiss after three years of growth, was 19.8 feet. Poplar Hybrids OP367 at 23.5 feet and 5225 at 22.7 feet were taller than other poplar cultivars. Hybrid 14274 had the lowest average tree height at 15.8 feet at Hotchkiss. A tree density is also being conducted at WCRC at Orchard Mesa. Tree density did not affect tree trunk diameter at the end of the 2002 growing season after three years of growth. All of these studies are ongoing and will continue for another three years.

Introduction

Hybrid poplars are suitable for a number of uses (Blatner, et al., 2000) including pulp, dimension lumber, oriented strand board (OSB), plywood, and fuel, as well as conservation and ornamental plantings (Heilman, et. al.,1995). Hybrid poplar has also shown potential for use in various phytoremediation applications (Pilon-Smits, et al., 1998) and land reclamation projects (Bjugstad, 1986). Wildlife can benefit from the rich habitats created by hybrid poplar plantations (Allen, 2000), and although hybrid poplar plantations affect avian and small mammal abundance and species diversity this can create both positive and negative impacts (Christian, et al., 1997). These negative impacts are experienced by the grower when tree damage by some animal species occurs at an economic level and to animal species given the short term rotation and the effect of harvest on habitat.

Hybrid poplar plantings have other potential limitations in certain applications. This plant species appears to be of limited value for remediating soils and water contaminated with explosive materials (HMX) (Yoon, et al., 2002), primarily because explosive compounds, although taken up by hybrid poplar are not metabolized or transformed in plant tissues; thus, the contaminants are transported from confined soil environments to plant tissues such as leaves that once abscised from the tree are subject to wind transport or other dispersals that carry contaminants to other areas.

Numerous hybrid poplar clones are commercially available and have been shown to differ in various growth performance characteristics, such as response to carbon dioxide level (Ceulemans, et al., 1996), root growth differences (Friend, et al., 2000), and water use (Gochis, et al., 2000). Hybrid clones have also been evaluated for their resistance to deer browse damage (Moser, 2000), which would be of value in plantings that are subject to considerable deer browsing.

The initial focus of the agroforestry research in western Colorado was to produce hybrid poplar for use in manufacturing OSB at the Louisiana-Pacific (L-P) facility in Olathe, Colorado. This initial interest in hybrid poplar under agroforestry was the result of decreased access to timber resources on public lands in western Colorado and surrounding areas, and increased hauling costs to transport logs over long distances from harvest sites to manufacturing facilities. With the permanent closure of the L-P facility in May 2002, other markets are needed for hybrid poplar that may be grown in western Colorado. The impressive growth of the poplars that has occurred to date at WCRC (Figs. 1, 2, 3, and 4) has created substantial interest from the public for growing hybrid poplar for various applications beyond our initial interest for using poplars to make OSB.

Materials and Methods

A hybrid poplar clone evaluation study was initiated in 2000 at the Western Colorado Research Center at Fruita and Hotchkiss. The eight hybrid poplar clones included in the two studies are:

1. NM6 - used in the Minnesota program. *Populus nigra x P. maximowiczii.*
2. 52225 - a *P. trichocarpa x P. deltoides* cross. Cold tolerance may be an issue.
3. OP367 - a successful hybrid used in the northwest. Originally developed by a timber company in Maine.
4. Norway - an older male hybrid, common in the plains. *P. deltoides x P. nigra.*
5. Noreaster (NE237) - a sterile female, common in the plains, has good disease resistance. Developed at the University of Nebraska, released in 1979. Primary hybrid cottonwood seedling produced at the Colorado State Forest Service in Fort Collins. *P. deltoides x P. nigra.*
6. Raverdeau - a standard Euroamericana clone. Used in the Lake States.
7. 14274 - a ‘newer’ Euroamericana from the Morden Experimental Station, Manitoba, Canada.
8. 14272 - ‘Prairie Sky,’ also from Morden, one that is being developed for production at the Colorado State Forest Service in Fort Collins. Drought tolerant. *P. deltoides x P. nigra* ‘Thevestin.’ Good canker resistance.

The experiment is a randomized complete block with four replications. At Fruita, each plot consists of 36 trees planted on an 8x8-foot spacing, totaling 2,304 square feet per plot. One row of trees surrounds the experiment area. All hybrids were planted from 10-inch cuttings, except Norway and Noreaster. Norway and Noreaster were planted as rooted whips. At Rogers Mesa, each plot consists of 40 trees (4 rows of 10 trees each).

At Fruita, the seedbed was prepared by moldboard plowing in the fall. In the spring, the field was tilled using an S-tine harrow and a roller harrow. The field was marked in perpendicular directions on an 8x8-foot spacing using a tractor and toolbar mounted with a furrow opener. The intersection of the marks determined where trees were to be planted.

Planting at Fruita occurred on April 13, 2000 and at Hotchkiss during May 2000. Cuttings within and among hybrid clones varied somewhat, but in other research the cutting

Fig. 1. Hybrid poplars at Fruita, Colorado. June12, 2002. Trees are 26 months old. Photo by Daniel Dawson.

diameter was shown not to be of major importance (Robison and Raffa, 1996). On the same day as planting at Fruita, Goal (oxyfluofen) herbicide was applied at a rate of 4 pints/acre in 22 gallons of water/acre at 20 psi. Care was taken not to spray the herbicide onto the cuttings and whips. During the 2000 growing season the field was cultivated three times using a Roto-Lely. Hand labor was used twice during the summer 2000 to weed next to the trees where equipment could not be safely used.

Roundup (glyphosate) herbicide was applied twice at Fruita during 2000, once on July 6, 2000 and again on August 10, 2000 using a backpack sprayer. These applications were made to control summer weed flushes. Roundup was applied twice during 2001 at Fruita on May 14, 2001 and again on June 6, 2001 using a backpack sprayer. These applications controlled early summer weed flushes. After that time poplar trees were large enough and provided sufficient shading that weeds were not a concern. At Hotchkiss, Goal and Roundup herbicides have also been used each spring for weed control.

At Fruita on June 25, 2001 and June 3, 2002 ammonium nitrate was hand-applied at a rate of 100 lbs N/acre by placing a measured amount of fertilizer in the furrow next to each tree This nitrogen fertilizer rate was similar to those recommended by Hansen, 1993. On June 21, 2002 furrows were reshaped using Acra-Plant trash tillers and a small Kubota tractor that would fit between the rows of trees.

At Fruita, poplars were irrigated liberally during the establishment year to minimize plant mortality and promote good growth. Poplars were irrigated 16 times during the 2000 growing season, averaging an irrigation every 11 days. In 2001, the poplar field was irrigated seven times during the growing season, averaging 11.8 hours per irrigation set. During 2002, poplars were irrigated seven times during the growing season at approximately 22-day intervals with an average of 11 hours per irrigation set.

Of the 36 trees in each plot, the interior 16 trees were used for data collection at Fruita. At Hotchkiss, the two center rows of trees were used for data collection (20 trees for each plot). Mortality of the sixteen trees were determined in fall 2000 at Fruita. Tree height was measured from the soil surface to the top of the tree (leaves not included) using a surveyor's measuring rod (Fig 4). Trees were measured during late fall after leaves had fallen. Depending on the location, trunk diameters or trunk circumferences (girth) were measured at the base of the tree and at a one meter height or at breast height using calipers.

Fig. 2. Hybrid poplars at Fruita, Colorado. October 15, 2001. Photo by Calvin Pearson.

The planting density study was established at WCRC at Orchard Mesa on April 21, and 24, 2000. Two hybrid poplar clones are used in the experiment: Noreaster and Norway. Four hybrid poplar tree densities are being tested: [1.8m x 2.4m (6' x 8'), 2.4m x 2.4m (8' x 8'), 3.0m x 2.4m (10' x 8'), and 3.6m x 2.4m (12' x 8')]. The clones are planted separately in adjoining fields. Within each field, the density trial is arranged as a randomized complete block design.

Weeds in the planting density experiment were controlled through cultivation during the first growing season. During the following growing seasons, weeds were spot-treated with Roundup as needed. Microsprinklers were used during the second year and drip irrigation was used during the third growing season. It is likely the tree roots reached a capillary fringe sometime later during the second growing season as ground water at the site is known to be present at less than 10 feet below the soil surface.

Results and Discussion

Most hybrid poplar clones at Fruita established well with low mortalities (< 2% mortality), with the exception of 14274 (31% mortality), Raverdeau (9% mortality), and 14272 (8% mortality) (Table 1).

Tree height during the first year of growth in 2000 at Fruita, averaged across all eight hybrid poplar clones, was 8.1 feet (Table 1). Poplar Hybrid OP367 was the tallest with an average height of 10.2 feet (n = 64) and a 1.7-inch trunk diameter at the base of the tree and a 1.0-inch diameter taken at a one-meter (3.3 ft) tree height. Tree height of NM6 averaged 9.6 feet and was not statistically significantly different from that of OP367. Hybrid 52225 was shorter than OP367 but had a similar trunk diameter to OP367 both at the base of the tree and at a one-meter (3.3 ft) height. Tree heights of Norway, Noreaster, and Raverdeau were statistically similar, but were shorter than OP367 and NM6. The shortest poplar clones were 14274 (5.9 feet tall) and 14272 (6.9 feet).

Overall, the first year of growth of the hybrid poplars at Fruita was very impressive (Figs. 1, 2, 3, and 4), and on the basis of on-site observations from people who are experienced with poplars on other areas, the growth of poplars at Fruita was similar if not superior to poplars grown in many other locations around the country.

Tree diameter at the base of tree was greatest for Norway at Fruita in 2000 (Table 1). Tree diameters of Noreaster, 52225, and OP367 were similar but smaller than Norway. 14274 and 14272 had the smallest tree diameters, averaging nearly 0.8 inches smaller than Norway. NM6 and Raverdeau had similar trunk diameters, which were somewhat larger than 14274 and 14272, but smaller than other hybrids. Trunk diameters were also measured at a one meter height on the trunk. OP367 and 52225 had the largest trunk diameters, averaging 1.0 inches. 14274 had the smallest trunk diameter at 0.4 inches. Trunk diameters of others clones measured at a meter height ranged from 0.5 to 0.8 inches.

Of the total number of trees measured at Fruita in 2001, most hybrid clones had only one or two missing trees (Table 2). The exception to this was 14274 which had 20 trees missing or that were not suitable for measurements. Poplar Hybrid 14272 had five missing trees, while all 64 trees were present and measured for OP367 and Noreaster.

Tree height, averaged across all hybrids after two years of production at Fruita was 22.1 feet (Table 2). Poplar Hybrids NM6, 52225, and OP367 were taller than the other five poplar cultivars with heights of 24.5, 26.5, and 25.9 feet, respectively. Hybrid 14274 had the lowest tree height at 17.0 feet. Hybrid 14272 also had a low tree height of 19.1 feet, compared to other poplar hybrids.

At Fruita in 2001, Poplar Hybrids 52225, OP367, Norway, and Noreaster had tree diameters at the base of 3.8 to 4.0 inches (Table 2). Poplar hybrids with the smallest diameters at the base of the trunk were NM6 and 14272 at 3.4 and 3.3 inches, respectively.

In 2001 at Fruita, both 52225 and OP367 maintained the largest tree diameters at 3.2 inches when measured at a meter height (Table 2). Hybrids 14274 and 14272 had the smallest tree diameters at a meter height at 2.4 and 2.5

Fig. 3. Dr. Calvin Pearson assessing poplar growth at Fruita, Colorado. November 7, 2001. Photo taken by Daniel Dawson.

inches, respectively. Other hybrids were intermediate for trunk diameter at a meter height.

In 2002 at Fruita, Poplar Hybrids OP367, 5225, and Norway had the largest tree diameters at the base of the trunk, ranging from 4.8 to 5.0 inches (Table 3). Poplar hybrids with the smallest diameters at the base of the trunk in 2002 were NM6 and 14272.

In 2002 at Fruita, OP367, 52225, and Raverdeau maintained the largest tree diameters ranging from 4.0 to 4.3 inches at a meter height (Table 3). The other poplar hybrids (14272, 14274, Noreaster, Norway, and NM6) had smaller diameter trunks at a meter height.

There was some variability among the poplar hybrids for range in measurements for tree height, trunk diameter at the soil surface, and at a one-meter height at Fruita in 2000, 2001, and 2002 (Tables 1, 2, and 3). The variability among trees for tree diameter

Fig. 4. Fred Judson and Daniel Dawson measuring poplar tree height at Fruita, Colorado on November 14, 2001. Photo by Calvin Pearson.

measured at both the soil surface and at a one meter height in 2001 compared to 2002 was similar. This would indicate that the trees within each hybrid are growing at the same rate.

At Hotchkiss, Norway and Noreaster had the highest number of total trees measured (Table 4). Poplar hybrids 14274 and 14272 had the fewest number of total trees available for measurement. The number of trees for NM6, 52225, OP367, and Raverdeau were somewhat intermediate between poplar hybrids that had high and low numbers of trees.

Tree height, averaged across all hybrids at Hotchkiss after the first two years of growth in 2001 was 12.4 feet (Table 4). Poplar Hybrid OP367 at 16.3 feet was taller than other poplar cultivars. Hybrid 14274 had the lowest average tree height at 9.8 feet. Poplar Hybrids NM6, 52225, Noreaster, and 14272 were also shorter than OP367. Norway and Raverdeau had intermediate tree heights when compared to other hybrids in the study.

At Hotchkiss in 2001, tree circumference at breast height averaged 3.8 inches (Table 4). OP367 had the largest tree trunk with a 6.0-inch circumference, while NM6 and 14274 had the smallest tree trunks each averaging 2.3 inches (Table 4.).

At Hotchkiss in 2002, tree height after three years of growth averaged 19.8 ft (604.5 cm) (Table 5.). Poplar Hybrids OP367 and 52225 were the tallest at 23.5 and 22.7 feet, respectively. Poplar Hybrids 14274 and NM6 were the shortest at 15.8 and 17.9 feet.

Tree circumference at breast height averaged 7.6 inches (19.2 cm) at Hotchkiss in 2002 (Table 5). Poplar Hybrids OP367 and 52225 had the largest trunk circumference at 9.2 inches (23.4 cm). Poplar Hybrid NM6 had the smallest circumference at 5.9 inches (15.0 cm).

Four hybrid poplar tree densities [1.8m x 2.4m (6' x 8'), 2.4m x 2.4m (8' x 8'), 3.0m x 2.4m (10' x 8'), 3.6m x 2.4m (12' x 8')] for two cultivars [Noreaster (planted 24 Apr. 2000) and Norway (planted 21 Apr. 200)] were evaluated at WCRC at Orchard Mesa. Tree height, tree width, and trunk circumference taken near ground level and at 1-m height from the soil surface were obtained at the end of the second growing season for both hybrid poplar clones. The only significant effect that tree density had was on trunk circumference at the 3-cm height

Fig. 5. Larva of cottonwood leaf beetle skeletonizing leaves and causing damage to hybrid poplar. Photo by Bob Hammon 2002.

(Table 6). Trees in the highest density had a smaller trunk circumference than trees in the other density treatments. Poplar trees at the lowest density tended to have a somewhat larger tree width.

Tree density did not affect tree trunk diameter at the end of the 2002 growing season after three years of growth (Table 7). Both poplar cultivars, Norway and Noreaster, responded similarly to tree density. These data obtained after three years of growth indicate that hybrid poplar is not sensitive to planting density at least during the first few years of growth. Subsequent years of growth may reveal more about the response of hybrid poplar to these tree densities.

Notes and observations about spring and fall growth for each of the eight hybrid poplar clones at Fruita are presented in Table 8.

The poplar plantings at Fruita and Rogers Mesa have been visually inspected during the growing seasons for the presence of insect pests. Pheromone traps for poplar twig borer, *Paranthrene tabaniformis* (Rottemburg), and western poplar clearwing, *Paranthrene robiniae* (Hy. Edwards), were set in the Fruita planting in 2002 and checked weekly. All pest insects were collected and identified to species (Cranshaw, et al., not dated). Specimens are stored in the collection at the Western Colorado Research Center at Fruita.

Cottonwood leaf beetle, *Chrysomela scripta* (F.) has been the most serious insect pest to date (Fig. 5). They appeared in moderate numbers in 2001 at Hotchkiss, and in low numbers at Fruita the same year. Beetle numbers were significant at Fruita on 12 April 2002, when many adults were observed feeding and laying eggs on newly emerged leaves. The beetles were concentrated on NM6 and 52225, which had flushed leaves before other varieties. A decision was taken at that time to treat the entire planting with insecticide to eliminate any differential early season damage from cottonwood leaf beetle caused by concentration of beetles on the early flushing clones. Pounce insecticide was applied aerially at 6 oz/acre on April 17, 2002. Larval damage from cottonwood leaf beetle was significant enough at Hotchkiss to justify an insecticide application during late July 2002. Egg mass density has been found to be the most useful indicator for determining economic injury levels (Fang and Hart, 2000) and the economic injury level on 2-year-old poplar trees was found to range from 0.2 to 0.9 egg masses per growing terminal (Fang, et al., 2002).

Two-spotted spider mites, *Tetranychus urticae* Koch, were abundant on the lower portion of the trees at Fruita during August 2001. The populations were reduced by beneficial predators. This mite species have the potential to be flared by inappropriate insecticide use when they are present.

Fall webworm, *Hyphantria cunea* (Drury), is present during the late summer at Fruita. This defoliator is highly conspicuous due to its large silken nest, but does little actual damage to the trees. Parasitism of larvae by beneficial wasps and flies is typically significant.

The cottonwood catkingall mite, *Eriophyes neoessigi* (Keifer), has distorted growth on some trees at Hotchkiss. Long, distorted catkin-like growths are produced when this microscopic mite is present, but its impact on growth is probably minimal.

A total of 10 western poplar clearwing moths were captured in pheromone traps in July, and on one date in September 2002. The peak flight appears to be in July. Four poplar twig borer moths were captured, in mid to late July. No clearwing larvae were found in the trees. An unidentified borer has done significant damage to several trees at Hotchkiss. Borers have the potential to become one of the more serious pests of poplar plantings over time.

Hybrid poplar studies at the WCRC will continue for three more years when marketable trees are expected to be achieved.

References

Allen, Mark. 2000. Fiber farming produces record growth. Tree Farmer (Mar/Apr.) 14-17.

Bjugstad, Ardell J. 1986. Hybrid poplar cultivars for maximizing phytomass production on gold mine tailings in the Black Hills. National Symposium on Mining, Hydrology, Sedimentology, and Reclamation. University of Kentucky, Lexington, Kentucky. December 8-11, 1986.

Blatner, Keith, Jon D. Johnson, and David M. Baumgartner (eds.). 2000. *Hybrid poplars in the Pacific Northwest: culture, commerce, and capability*. Washington State University Cooperative Extension, MISCO272. Pullman, Washington.

Cranshaw, W., D. Leatherman, L. Mannix, W. Jacobi, C. Rodriguez and D. Weitzel. *Insects and Diseases of Woody Plants of the Central Rockies.* Colorado State University Cooperative Extension Bulletin 506A. Fort Collins CO.

Christian, Donald P., Patrick T. Collins, Joann M. Hanowski, and Gerald J. Niemi. 1997. Bird and small mammal use of short-rotation hybrid poplar plantations. J. Wildl. Manage. 61:171-182.

Ceulemans, R., B.Y. Shao, X. N. Jiang, and J. Kalina. 1996. First- and second-year aboveground growth and productivity of two *Populus* hybrids grown at ambient and elevated CO_2. Tree Physiology 16:61-68.

Fang, Ying, and Elwood R. Hart. 2000. Effect of cottonwood leaf beetle (Coleoptera: Chrysomelidae) larval population levels on *Populus* terminal damage. Environ. Entomol. 29:43-48.

Fang, Ying, Larry P. Pedigo, Joe P. Colletti, and Elwood R. Hart. 2002. Economic injury level for second-generation cottonwood leaf beetle (Coleoptera: Chrysomelidae) in two-year-old *Populus*. J. Econ. Entomol. 95:313-316.

Friend, Alexander L., Juanita A. Mobley, Elizabeth A. Ryan, and H.D. Bradshaw, Jr. 2000. Root growth plasticity of hybrid poplar in response to soil nutrient gradients. J. Sust. Forestry 10:133-140.

Gochis, David J. and Richard H. Cuenca. 2000. Plant water use and crop curves for hybrid poplars. J. of Irrigation and Drainage Engr. 126 (4):206-214.

Hansen, Edward A. 1993. A guide for determining when to fertilizer hybrid poplar plantations. USDA/Forest Service. North Central Forest Experiment Station. Research Paper NC-319.

Heilman, Paul E., R.F. Stettler, Donald P. Hanley, and Richard W. Carkner. 1995 (revised). *High Yield Hybrid Poplar Plantations in the Pacific Northwest*. Pacific Northwest Regional Extension Bulletin - Washington, Oregon, Idaho. PNW 356.

Moser, Brian W. 2000. A comparison of physical, chemical, and genetic controls to reduce deer browse damage to hybrid poplar seedlings. Vertebrate Pest Conference Proceedings 19:88-92.

Pilon-Smits, E.A.H., M.P. de Souza, C.M. Lytle, C. Shang, and N Terry. 1998. Selenium volatilization and assimilation by hybrid poplar (Populus tremula x alba). J. Exp. Bot. 49:1889-1892.

Robison, Daniel J. and Kenneth F. Raffa. 1996. Importance of cutting diameter and method of production on early growth of hybrid poplar. Tree Planters' Notes 47:76-80.

Yoon, Jong Moon, Byung-Taek Oh, Craig L. Just, and Jerald L. Schnoor. 2002. Uptake and leaching of Octahydo-1,3,5,7-tetranitro-1,3,5,7-tetrazocine by hybrid poplar trees. Environ. Sci. Technol. 36:4649-4655.

Useful Web Sites

Hybrid Poplar Research at the Klamath Experiment Station
http://extension.oregonstate.edu/klamath/poplar/klamath.html

Hybrid Poplar Profits
http://www.extension.umn.edu/distribution/naturalresources/DD7279.html

Growing Hybrid Poplars as a Crop
http://www.hybridpoplar.org/

Minnesota Department of Agriculture - Hybrid Poplar
http://www.mda.state.mn.us/mgo/crops/hybrid_poplar.htm

Hybrid Poplar Research Program - Washington State University
http://www.puyallup.wsu.edu/poplar/hybridpoplar/poplar.htm

Management of Irrigated Hybrid Poplar Plantations in the Pacific Northwest
http://www.woodycrops.org/mechconf/wierman.html

Acknowledgments

Appreciation is expressed to Shane Max (formerly WCRC manager); Lot Robinson, Fred Judson, John Wilhelm, Bryan Brady, and George Osborn (WCRC support staff), and Daniel Dawson (part-time hourly employee) who assisted with this research. We express special appreciation to Randy Moench (Greenhouse Manager, Colorado State Forest Service, Fort Collins, CO) who provided technical assistance, helped with planting the trees, and for his support and involvement in this project. Thanks to Carroll Bennett for digitizing and manipulating the pictures used in this report.

Table 1. Plant performance of eight hybrid poplar clones during the first year of establishment at Western Colorado Research Center at Fruita, Colorado 2000.

Hybrid Clone	Mortality	Tree Height	Range (max-min) of tree ht	Tree dia. at soil surface	Range of tree dia. at soil surface	Tree dia. at 1 m (3.3 ft)	Range of tree dia. at 1 m
	%	----------- feet	-----------	--------------------	inches	--------------------	----
NM6	2	9.6	4.3	1.3	0.9	0.8	0.6
52225	2	9.4	4.1	1.7	0.9	1.0	0.7
OP367	0	10.2	4.1	1.7	1.0	1.0	0.7
Norway	2	7.8	2.7	1.9	0.6	0.6	0.4
Noreaster	0	7.5	3.4	1.7	1.0	0.6	0.4
Raverdeau	9	7.5	3.9	1.3	0.8	0.7	0.6
14274	31	5.9	2.1	1.0	0.5	0.4	0.3
14272	8	6.9	3.0	1.1	0.6	0.5	0.4
Ave.	6	8.1	3.4	1.5	0.8	0.7	0.5
LSD (0.05)		0.7		0.2		0.1	
CV (%)		5.8		7.0		9.3	

Table 2. Plant performance of eight hybrid poplar clones during the second year of growth at the Western Colorado Research Center at Fruita, Colorado 2001.

Hybrid Clone	Total trees measured	Tree Height	Range (max-min) of tree ht	Tree dia. at soil surface	Range of tree dia. at soil surface	Tree dia. at 1 m (3.3 ft)	Range of tree dia. at 1 m
	no.	--------- feet ----------		------------------ inches ------------------------			
NM6	63	24.5	4.1	3.4	1.1	2.9	1.4
52225	62	26.5	4.7	3.8	1.1	3.2	0.9
OP367	64	25.9	4.1	4.0	1.4	3.2	1.3
Norway	63	21.0	4.0	4.0	1.2	2.6	1.1
Noreaster	64	20.9	4.5	4.0	1.4	2.7	1.2
Raverdeau	62	21.9	3.7	3.7	1.4	2.9	1.3
14274	44	17.0	4.5	3.5	1.3	2.4	1.1
14272	59	19.1	6.8	3.3	2.1	2.5	1.9
Ave.	60	22.1	4.6	3.7	1.4	2.8	1.3
LSD (0.05)		1.2	2.7	0.2		0.2	
CV (%)		3.7		2.9		4.6	

Table 3. Plant performance of eight hybrid poplar clones during the second year of growth at the Western Colorado Research Center at Fruita, Colorado 2002.

Hybrid Clone	Total trees measured	Tree dia. at soil surface	Range of tree dia. at soil surface	Tree dia. at 1 m (3.3 ft)	Range of tree dia. at 1 m
	no.	--------------------------- inches ----------------------------			
NM6	63	4.2	1.4	3.6	1.6
52225	62	4.8	1.4	4.2	1.0
OP367	64	5.0	1.7	4.3	1.6
Norway	63	4.8	1.2	3.6	1.3
Noreaster	64	4.7	1.3	3.6	1.5
Raverdeau	62	4.7	1.4	4.0	1.6
14274	45	4.5	1.3	3.5	1.2
14272	57	4.1	2.8	3.4	1.5
Ave.	60	4.6	1.4	3.8	1.4
LSD (0.05)		0.3		0.3	
CV (%)		4.4		5.6	

Table 4. Plant performance of eight hybrid poplar clones during the second year of growth at the Western Colorado Research Center Rogers Mesa at Hotchkiss, Colorado 2001.

Hybrid Clone	Total trees measured	Tree Height	Tree height	Tree circumference at breast height	Tree circumference at breast height
	No.	feet	meters	inches	cm
NM6	47	10.3	3.1	2.3	5.9
52225	57	12.4	3.8	3.9	10.0
OP367	58	16.3	5.0	6.0	15.3
Norway	77	13.1	4.0	4.4	11.2
Noreaster	76	12.1	3.7	3.9	9.8
Raverdeau	50	12.8	3.9	4.1	10.4
14274	32	9.8	3.0	2.3	5.8
14272	35	12.4	3.8	3.3	8.3
Ave.		12.4	3.8	3.8	9.6
LSD (0.05)		2.7	0.8	1.4	3.6
CV (%)		15.1	15.1	25.8	25.8

Table 5. Plant performance of eight hybrid poplar clones during the second year of growth at the Western Colorado Research Center Rogers Mesa at Hotchkiss, Colorado 2002.

Hybrid Clone	Total trees measured	Tree height	Tree Height	Tree circumference at breast height	Tree circumference at breast height
	No.	ft	cm	in	cm
NM6	27	17.9	545.7	5.9	15.0
52225	45	22.7	690.9	9.2	23.3
OP367	69	23.5	716.8	9.2	23.5
Norway	77	20.3	617.7	7.9	20.0
Noreaster	73	19.4	590.8	7.3	18.6
Raverdeau	53	19.8	602.8	7.9	20.0
14274	36	15.8	482.9	6.5	16.6
14272	39	19.3	588.7	6.7	17.0
Ave.		19.8	604.5	7.6	19.2
LSD (0.05)		4.2	73.8	1.7	2.4
CV (%)		8.3	8.3	15.0	15.0

Table 6. Effect of planting density on tree height, tree width, and trunk circumference for two poplar cultivars (Noreaster and Norway) at the Western Colorado Research Center at Orchard Mesa for the first two years of growth from 2000-2001.

Tree Density	Tree height	Tree width	Trunk circumference at 3-cm height	Trunk circumference at 1-m height
	m	m	mm	mm
1.8 m x 2.4 m (6 x 8 ft)	5.5	1.9	273	179
2.4 m x 2.4 m (8 x8 ft)	5.8	1.9	320	184
3.0 m x 2.4 m (10 x 8 ft)	5.7	1.9	318	181
3.6 m x 2.4 m (12 x 8 ft)	5.7	2.1	333	186
Ave.	5.7	1.9	311	182
LSD 0.05	0.5	0.2	32	22

Table 7. Effect of planting density on tree trunk diameter for two poplar cultivars (Noreaster and Norway) at the Western Colorado Research Center at Orchard Mesa after three years of growth at the end of the 2002 growing season. Data are averaged across both poplar cultivars.

Tree Density	Trunk diameter at 3-cm height	Trunk diameter at 1-m height
	cm	cm
1.8 m x 2.4 m (6 x 8 ft)	12.7	8.5
2.4 m x 2.4 m (8 x8 ft)	13.4	8.5
3.0 m x 2.4 m (10 x 8 ft)	11.9	7.9
3.6 m x 2.4 m (12 x 8 ft)	12.1	8.3
Ave.	12.5	8.3
LSD 0.05	NS[†]	NS[†]

[†] NS, not significant at the 5% level of probability.

Table 8. Notes and observations on hybrid poplar clones at Fruita, Colorado taken on November 7, 2001 at the end of the second year of growth.

Hybrid Clone	Notes and Observations
NM6	Began spring growth March 26, 2001 and April 3, 2002. Trunks are somewhat wavy. Some secondary trunk development has occurred. Compared to other hybrids, bark is quite green.
52225	Began spring growth April 4, 2001 and April 9, 2002. Main trunk is somewhat wavy. Some trees have horizontal basal branching.
OP367	Began spring growth April 17, 2001 and April 16, 2002. Trees are very erect and plant architecture is columnar. Trees are uniform with regard to shape and growth. Pleasing yellow fall leaf color more so than other hybrids. Some late fall leaf retention.
Norway	Began spring growth April 11, 2001 and April 13, 2002. Many large branches with a sprawling plant architecture.
Noreaster	Began spring growth April 13, 2001 and April 14, 2002. Many large branches with a sprawling plant architecture.
Raverdeau	Began spring growth April 14, 2001 and April 12, 2002. Trees are erect and plant architecture is columnar. Some trees have basal branching.
14274	Began spring growth April 3, 2001 and April 12, 2002. Architecture is good for high populations in agroforestry. Tree growth is variable for this hybrid. Some trees have secondary trunk development and basal branching.
14272	Began spring growth April 9, 2001 and April 12, 2002. Architecture is good for high populations in agroforestry. Tree growth is variable for this hybrid. Some trees have secondary trunk development.

Evaluation of the Effect of Hail Damage on Chardonnay Grape Production

Horst W. Caspari, **Harold J. Larsen**, and **Shane Max**, Colorado State University, Western Colorado Research Center at Orchard Mesa, 3168 B½ Rd., Grand Junction, CO 81503; and **Mark Zarnstorff**, National Crop Insurance Services, 7201 West 129th Street, Suite 200, Overland Park, KS 66213

Summary

The effect of simulated hail on Chardonnay grape production was evaluated from 1999 to 2002 at the Western Colorado Research Center near Grand Junction, CO. In the first year, the applicability of a hail device supplied by the National Crop Insurance Services to inflict "hail" damage was evaluated. Natural hail damage could be successfully replicated. Damage severity could be manipulated by varying the distance of the hail device from the treated vine. The closer the hail device, the greater the damage. Distances of 10 to 15 feet caused damages similar to that experienced with natural hail events. Damage due to early (pre-veraison) hail treatments did not differ significantly from those caused by late (post-veraison) hail treatments in two out of three years. Differences in 2002 were mainly due to a lack of berry shriveling in the late hail treatment. Simulated hail damaged clusters only on the side of hail application. Hail did not penetrate through the canopy and did not damage clusters on the other side. Hail-affected bunches sustained close to 50 % berry damage. Theoretical yield reductions from hail are around 25 %. This is based on the assumption that clusters are evenly distributed on a vine and a 50 % berry damage on the hail-affected side. Actual yield reductions caused by hail were in the order of 6 to 30 %. Yield reductions were due to desiccation of damaged berries, as well as from berries, cluster parts and whole clusters being knocked off by hail. Damaged, desiccated berries accounted for 10-15 % of the total yield. As those shriveled, dried berries are of zero value from a winemaking perspective, juice yield from a load of hail-affected grapes at the press can be expected to be 10-15 % less than from a load of grapes without such damage. The yield reduction due to hail thus is greater than that predicted simply from harvest data. Under climatic conditions that favor bunch rots such as *Botrytis cinerea*, actual yield losses could be much higher than those found in the dry climate of Colorado.

Introduction

Hail storms are an annually recurring event in Western Colorado. These storms generally have a brief duration and are rather localized. Nevertheless, even short hail events can cause significant damage to many fruit crops due to the market demand for blemish-free fruit. For example, small skin ruptures and blemishes on fresh-market peaches or apples will reduce the market quality, and often the price received by the grower. The impact of hail on wine grapes is somewhat less than for fresh-market fruit such as peaches and apples because a) appearance is less important in a processed crop such as wine grapes; b) trellis systems with upward shoot positioning appear to provide more protection to the bunches from leaves above compared to the open tree canopies used for tree crops; and c) even when some berries on a bunch get damaged, the remaining undamaged berries retain full market value.

The severity of hail damage depends on many factors. First and foremost, damage depends on the intensity and duration of the hail event. Sustained events that produce only small hail pellets may be as damaging as short, intense events with big hailstones. Second, damage from similar hail events may differ due to the stage of crop development. For example, a hail event during tree or vine dormancy is likely to cause no or little damage while a similar event close to harvest may result in significant crop losses. And third, damage depends on the type of crop and its intended end use (e.g. fresh market or processed). Growers use different approaches to manage the risk of crop losses due to hail. Some orchardists in Western Colorado use overhead hail nets to protect their tree fruit. Those nets can also be used as shade nets to reduce sunburn of fruit. Other growers purchase hail insurance for parts or all of their crops, while some growers use neither approach. We started a series of experiments in 1999 to provide the National Crop Insurance Services with scientifically-based data on hail damage for wine grapes. The project objective was to quantify the effect of hail damage at different times of the season on wine grape production.

Material and Methods

Experimental setup

The experimental setup differed between years. From 1999 to 2001 we used own-rooted Chardonnay vines planted in 1991 at a spacing of 5’ x 10’. Due to significant vine damage in the original block during the winter 2001/02, we used own-rooted Chardonnay vines planted in 1984 at a spacing of 8’ x 12’ in the final year. The row orientation was North-South, and all vines were trained to a bilateral cordon and spur-pruned. From 1999-2001, we used 2-vine plots, while in 2002 treatments were applied to single-vine plots. There were five replications per treatment in 1999 and 2000, six in 2001, and seven in 2002.

Treatments

In 1999, hail was applied on 10 August (seven weeks prior to harvest) using a hail device supplied by National Crop Insurance Services. There were three hail treatments; hail was applied from a distance of 5’, 10’ or 15’ to the vine row.

In 2000 and 2001, treatments were arranged in a split-plot design with time (Early or Late) as the main plot, and distance [Close (10’) or Far (15’)] as sub-plot. In 2002, hail was applied either early or late from a distance of 12’ from the vine row. In all years, Early and Late treatments were applied approximately three weeks prior to or after veraison, respectively. In each year, damage caused by hail was compared to an untreated Control. A treatment summary is provided in Table 1.

Hail application

In 1999, the hail device was positioned on a pallet on the back of a tractor so that the device's delivery tube went through a 90º bend. The device was positioned at 5', 10' or 15’ distances from the vines. Only vines on the outside row could be used, as the vine row spacing is 10' leaving insufficient room to operate the device inside the block. In the final three years, the hail device was positioned on a pallet at the front of a tractor located in the inter-row adjacent to the treatment rows. The machine was lifted to a height of about 6’6” so that the hail was delivered to the treatment vines at about 50-70º angles from above. As the delivery tube was flexible, the distance from the tube outlet to the treatment row could be altered.

From 1999 to 2001, 40 lb of solid tubed ice was applied to each 2-vine plot. In the 2002 season, 20 lb of solid tubed ice was applied to each single-vine plot. The operator applied the ice in approximately six sweeps of the vines taking about ten seconds per plot. In all years, hail was applied to the western side of the canopy, and plastic sheeting was used to protect adjacent vines both within the row and in adjacent rows.

Table 1. Summary of hail treatments applied to own-rooted Chardonnay vines growing at the Western Colorado Research Center near Grand Junction, CO.

Year	Vine spacing	pre-veraison			post-veraison				
		10’	12’	15’	5’	10’	12’	15’	n
1999	5 x 10				x	x		x	5
2000		x		x		x		x	5
2001		x		x		x		x	6
2002	8 x 12		x				x		7

Damage evaluation

In 1999 and 2000, damage caused by the hail application was evaluated at harvest only. Total cluster number and total cluster weight was determined separately for each plot. In 2001 and 2002, damage was evaluated two weeks after the early hail application and at harvest. For the early evaluation, six clusters per plot were harvested at random from the treated (west) side of the Early vines. Likewise, six clusters per plot were collected at random from the western side of three Control plots. Clusters were taken back to the laboratory to determine total cluster weight. Berries were then cut off and classified as either damaged or undamaged, and total number and total weight was recorded separately for each class.

At commercial harvest (24 September, 2001 and 9 September 2002), six clusters per plot were harvested at random from the Late treatment plots on the treated (west) side of the vines. Likewise, six clusters per plot were collected at random from the western side of three (2001) or four (2002) Control plots not used for the early evaluation (see above). These clusters were evaluated as described previously.

Statistical analysis

All data were analyzed by the general linear model procedure (SAS Institute, Cary, N.C.). Significance was determined at the p>0.05% level.

Results

1999 season

The severity of damage differed between the three hail treatments. Very severe damage was inflicted with a spacing of 5' from the row: berry skins were ruptured, leaves were severely shredded to the point of defoliation, and some damage to wood occurred. With 10' spacing, damage was severe with some berry skin rupture and shredding of leaves. At the furthest distance of 15', damage was classified as moderate with minimal rupture of berry skins and holes in the leaves. In all cases, damage only occurred to the side of the vine that was being treated. While the "hail" generated from the machine may have been larger than natural hail, the damage, especially with 10' and 15' distance, appeared similar to that experienced in nature.

As expected, the closer the distance the hail machine was positioned to the vines the greater the yield decrease (Table 2). However no statistical significance was found between any of the treatments.

Table 2. Effect of spacing of the hail device on yield of Chardonnay. Hail was applied about one week after veraison (10 August, 1999).

Treatment	Yield per vine (lb)
Control	3.08
Hail 15'	2.51
Hail 10'	2.40
Hail 5'	1.97

2000 season

Two changes were made compared to the 1999 season. First, the damage observed with 5' spacing in 1999 was found to be too severe and this treatment was not repeated. Second, a platform was built to secure the hail device so that the device could be lifted above the vine rows using a tractor-mounted forklift. Thus, hail could be applied to the treatment vines from above at an angle of about 50-70º

Although yields were reduced by hail applications before or after veraison compared to the Control, the differences were not significant (Table 3). Further, there was no significant effect of timing (Early or Late) or spacing (Close or Far).

Table 3. Effect of timing (Early or Late) and spacing (Close or Far) of hail application on yield of Chardonnay. Hail was applied about five weeks prior to (Early) or three weeks after veraison (Late) from a distance of either 10' (Close) or 15' (Far) from the row.

Treatment	Yield per vine (kg)
Control	8.32
Early Close (EC)	7.68
Early Far (EF)	8.14
Late Close (LC)	7.80
Late Far (LF)	7.30

Table 4. Effect of early hail application on cluster and berry characteristics of Chardonnay. Hail was applied about four weeks prior to veraison, and clusters were evaluated two weeks after the hail application (2001).

	Undamaged berries			Damaged berries			Cluster weight (g)
	Number	Weight (g)		Number	Weight (g)		
		Total	Mean		Total	Mean	
Control	121.7 A	73.3 A	0.59	0 C	0		77.8
Early close	74.1 B	42.4 B	0.56	42.5 A	6.8	0.19 B	54.4
Early far	95.5 AB	52.5 AB	0.56	26.8 B	6.4	0.25 A	64.3

[1]Numbers with differing letters differ at the $P<0.05$ level. Not significant where not shown.

2001 season

Early damage evaluation

Application of hail approximately four weeks prior to veraison reduced the weight of clusters sampled two weeks later from the hail-affected side of the vine by about 30 % and 20 % in the close and far treatment, respectively (Table 4; Fig. 1). However, the differences in cluster weights were significant at the 10 % level only (P=0.0516). Further evaluation of the clusters showed that significantly more berries were damaged in Early Close (EC) than Early Far (EF) (36 % versus 23 %, respectively). Damaged berries accounted for 14 % and 11 % of total berry weight in the EC and EF treatments. There was no significant difference in the total number of berries per cluster between treatments

.

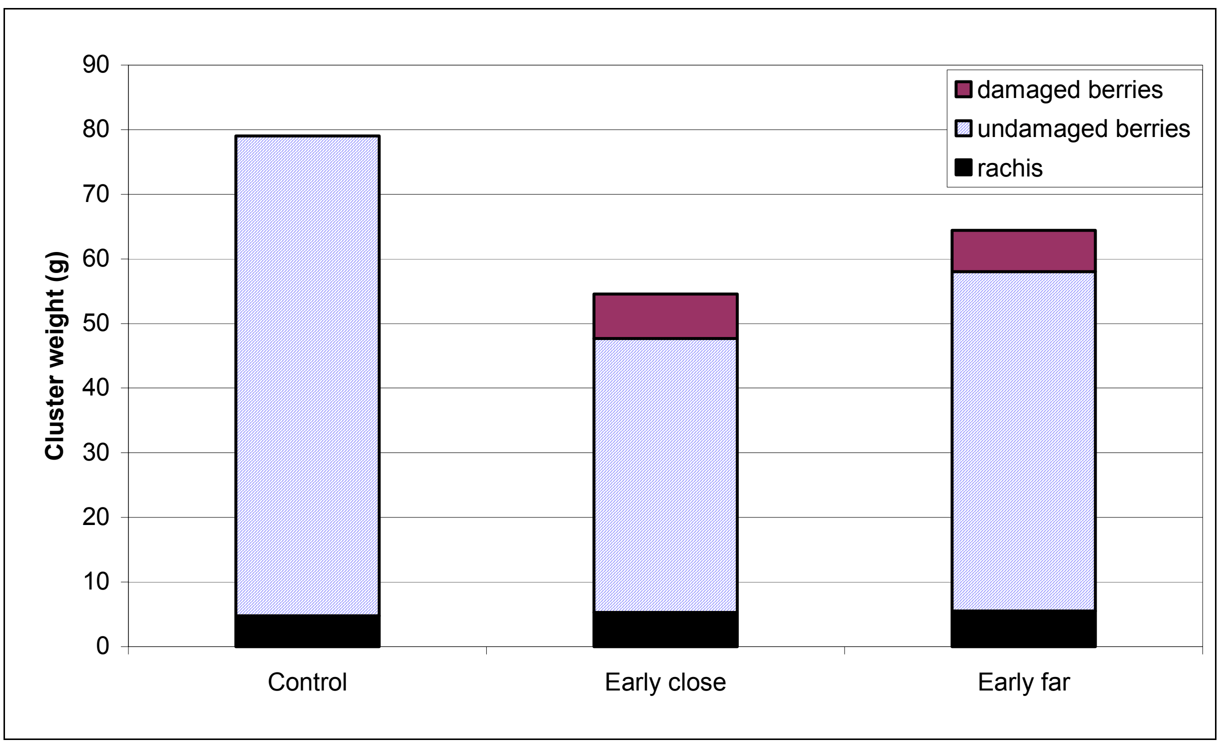

Fig. 1. Effect of an early hail application on mean cluster weight of Chardonnay two weeks after the hail application in 2001.

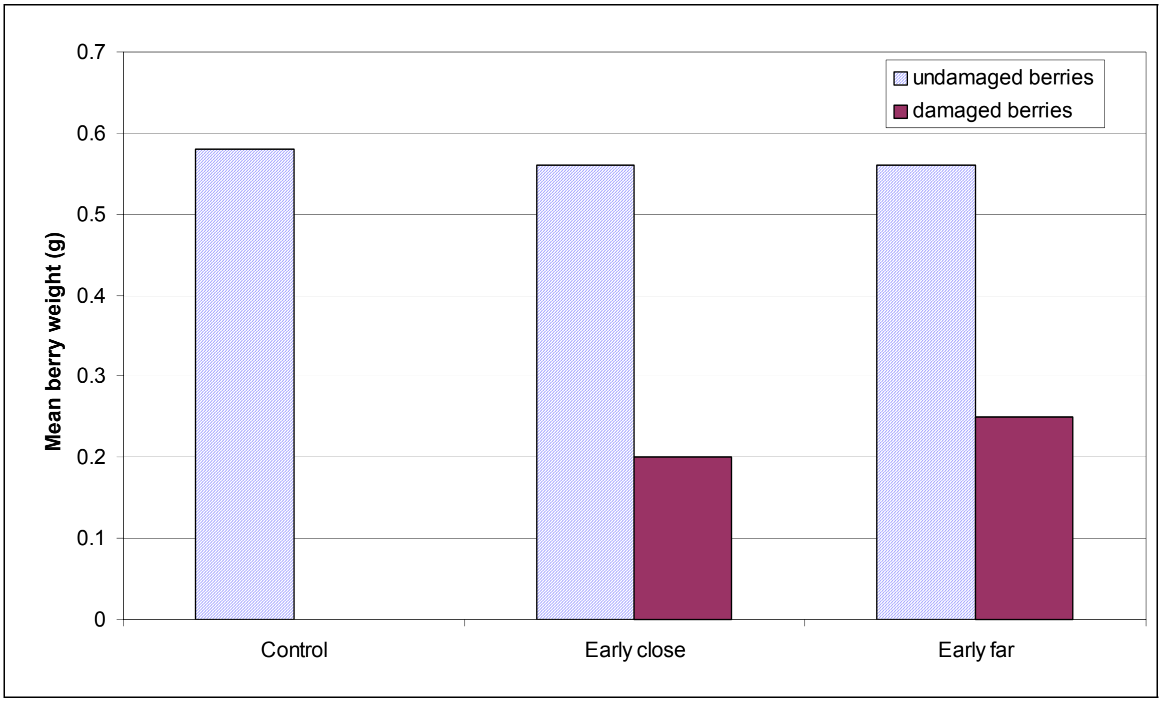

Fig. 2. Effect of early hail application on the average weight of undamaged and damaged berries of Chardonnay two weeks after the hail application in 2001.

The hail application significantly reduced the overall mean berry weight from 0.58 g for the control to 0.43 g and 0.48 g for EC and EF. However, the mean weight of undamaged berries was very similar between treatments (Fig. 2).

Late damage evaluation

Application of hail approximately four weeks after veraison resulted in a larger reduction of cluster weight than a similar application prior to veraison. Compared to the control, hail reduced the weight of clusters sampled at commercial harvest from the hail-affected side of the late-treatment vines by about 40 % and 30 % in the close and far treatment, respectively (Table 5; Fig. 3). Unlike the early evaluation, the differences in cluster weights were highly significant (P=0.0023).

About 36 % and 23 % of the berries were damaged in Late Close (LC) and Late Far (LF) clusters, respectively, and accounted for 15 % and 10 % of total cluster weight. It should be noted that we also found about 2 % damaged berries accounting for 1 % of cluster weight in control clusters. This damage is likely due to physical injury from wind or shoot rubbing, insect damage, or damage caused during canopy management or harvesting operations.

Table 5. Effect of late hail application on cluster and berry characteristics of Chardonnay. Hail was applied about four weeks after veraison, and clusters were evaluated five weeks later at the time of commercial harvest (2001).

	Undamaged berries			Damaged berries			Cluster weight (g)
	Number	Weight (g)		Number	Weight (g)		
		Total	Mean		Total	Mean	
Control	135.5 A	138.2 A	1.00	3.0 C	1.9 B	0.63 A	147.7 A
Late close	65.8 B	68.8 B	1.04	34.4 A	11.7 A	0.34 B	86.2 B
Late far	80.1 B	84.9 B	1.07	23.4 B	9.1 A	0.37 B	97.9 B

[1]Numbers with differing letters differ at the P<0.05 level. Not significant where not shown.

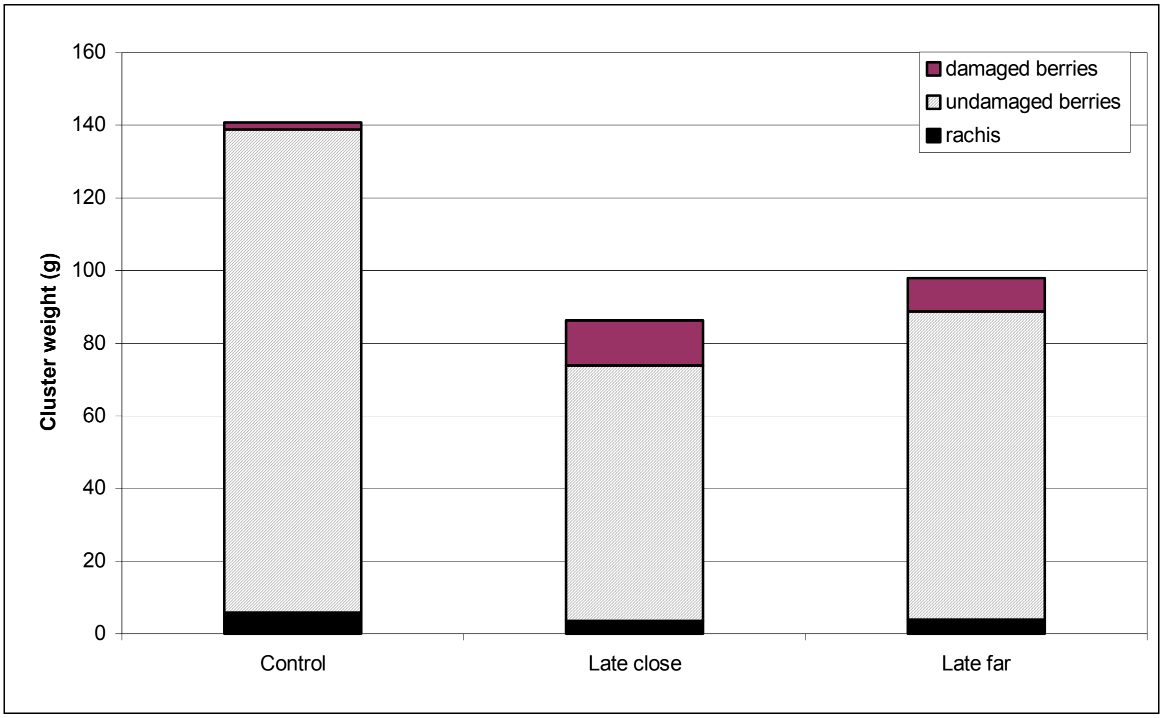

Fig. 3. Effect of a late hail application on the mean cluster weight of Chardonnay at commercial harvest in 2001 (five weeks after the hail application).

The mean berry weight of 0.99 g in the control treatment was significantly higher than the 0.80 g and 0.90 g for LC and LF. Again, the mean berry weight of undamaged berries did not differ between treatments, but damaged berries in the control were heavier than those of LC and LF (Table 5; Fig. 4).

<u>Effect on yield</u>

Yield reductions due to hail ranged from about 12 % in the LF regime to 22 % in LC (Table 6), but the differences were not significant. The number of clusters per vine was slightly less in the early treatments. The control had significantly more clusters with no damage than any of the hail treatments. There was no difference in the number of clusters with or without damage between the hail treatments. Compared to the control, the mean cluster weight was reduced by about 10 % by the early and about 20 % by the late hail treatments.

Table 6. Effect of early and late hail applications on yield characteristics of Chardonnay. Hail was applied about four weeks prior to and after veraison, and clusters were evaluated at the time of commercial harvest (2001).

	Cluster number/vine	Yield (kg/vine)	Undamaged clusters		Damaged clusters		
			Number/vine	Weight (kg/vine)	Number/vine	Weight (kg/vine)	%
Control	79	7.23	67 A[1]	5.77 A	13 B	1.46 B	16 C
Early close	73	6.02	20 B	1.63 B	53 A	4.39 A	75 AB
Early far	71	6.06	14 B	0.81 B	58 A	5.26 A	82 A
Late close	81	5.71	18 B	0.97 B	63 A	4.74 A	79 AB
Late far	84	6.39	26 B	1.67 B	58 A	4.72 A	70 B

[1]Numbers with differing letters differ at the P<0.05 level. Not significant where not shown.

Table 7. Effect of early hail application on cluster and berry characteristics of Chardonnay. Hail was applied about four weeks prior to veraison, and clusters were evaluated two weeks after the hail application (2002).

	Undamaged berries			Damaged berries			Cluster weight (g)
	Number	Weight (g)		Number	Weight (g)		
		Total	Mean		Total	Mean	
Control	114.7 A	52.0 A	0.46 A	0.1 B	<0.01 B	<0.01 B	56.2 A
Early	47.3 B	18.9 B	0.38 B	39.9 A	4.13 A	0.12 A	26.4 B

[1]Numbers with differing letters differ at the P<0.05 level. Not significant where not shown.

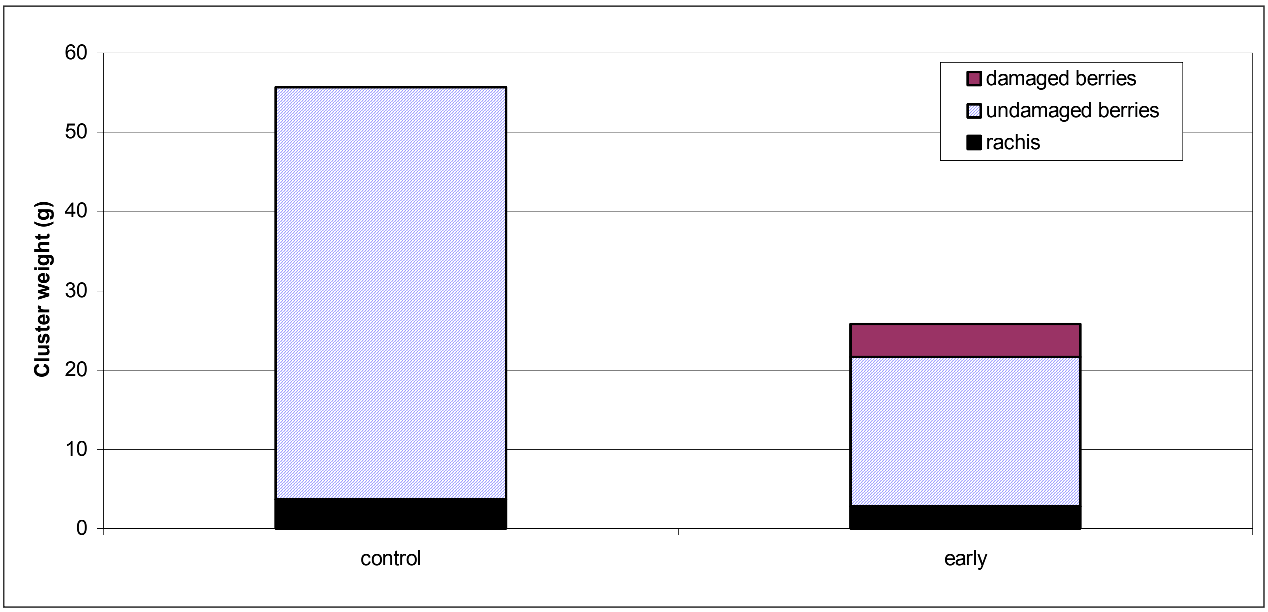

Fig. 4. Effect of an early hail application on mean cluster weight of Chardonnay two weeks after the hail application in 2002.

2002 season

Application of hail approximately four weeks prior to veraison reduced the weight of clusters sampled two weeks later from the hail-affected side of the vine by about 53 % (Table 7; Fig. 4). Damaged berries accounted for 18% of total berry weight in the early treatment.

The hail application significantly reduced the overall mean berry weight from 0.46 g for the control to 0.24 g for the early treatment, representing a 49 % decrease. In contrast to previous years, the mean weight of undamaged berries was significantly lower in the early treatment than the control (Fig. 5). The mean weight of undamaged berries in the Early treatment was about 17 % lower than in Control.

Late damage evaluation

In contrast to the previous year, a hail application approximately four weeks after veraison caused less reduction of cluster weight than a similar application prior to veraison. Compared to the control, hail reduced the weight of clusters sampled at commercial harvest from the hail-affected side of the late treatment vines by about 25 %, but differences in cluster weight were not significant (Table 8; Fig. 6).

About 47 % of the berries were damaged in late treatment clusters, and accounted for 35 % of total cluster weight. It should be noted that we also found about 11 % damaged berries accounting for 12 % of cluster weight in control clusters. This damage is likely due to physical

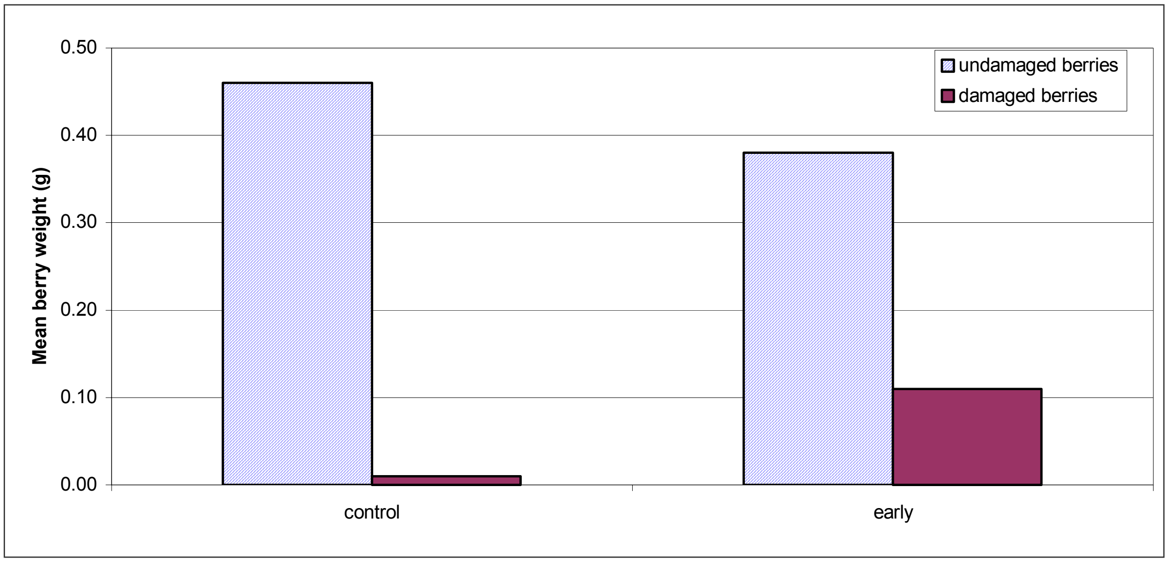

Fig. 5. Effect of hail application on the average weight of undamaged and damaged berries of Chardonnay two weeks after the hail application in 2002.

injury from wind or shoot rubbing, insect damage, or damage caused during canopy management or harvesting operations.

The mean berry weight of 0.84 g in the control treatment was significantly higher than the 0.70 g for the late treatment. The mean berry weight of undamaged berries did not differ significantly between treatments (3 % difference), but damaged berries in the control were 80 % heavier than those in the late treatment clusters (Table 8; Fig. 7).

Effect on yield

Yield reduction due to hail was about 30 % in the early treatment and 6 % in the late application regime (Table 9). Compared to the control, the mean cluster weight was reduced by about 35 % by the early and about 15 % by the late hail treatments.

Table 8. Effect of late hail application on cluster and berry characteristics of Chardonnay. Hail was applied about four weeks after veraison, and clusters were evaluated three weeks later at the time of commercial harvest (2002).

	Undamaged berries			Damaged berries			Cluster weight (g)
	Number	Weight (g)		Number	Weight (g)		
		Total	Mean		Total	Mean	
Control	84.4 A	67.3 A	0.84	10.9 A	9.8 A	0.85 A	81.7
Late	47.1 B	41.5 B	0.88	41.6 B	22.0 B	0.52 B	68.1

[1]Numbers with differing letters differ at the P<0.05 level. Not significant where not shown.

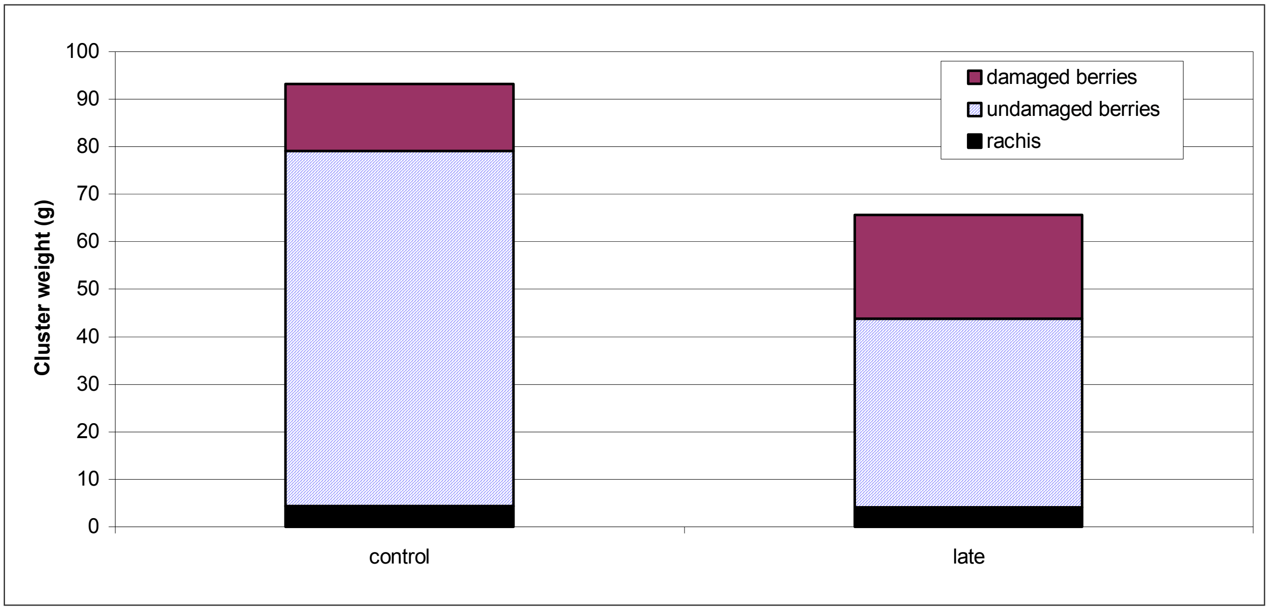

Fig. 6. Effect of a late hail application on the mean cluster weight of Chardonnay at commercial harvest in 2002 (three weeks after the hail application).

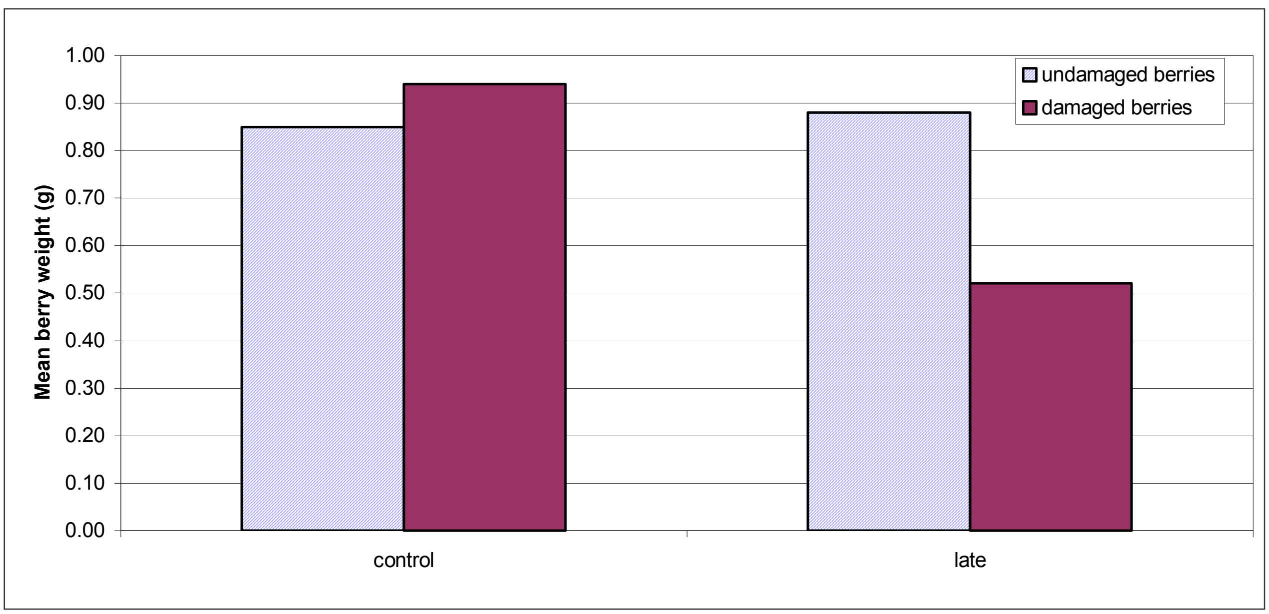

Fig. 7. Effect of a late hail application on the mean weight of undamaged and damaged berries of Chardonnay at commercial harvest (three weeks after the hail application).

Table 9: Effect of hail applications on total yield of Chardonnay. During both the early and late hail treatments, hail was applied at a distance of approximately 12 feet from the vines.

Treatment	Total yield (kg/vine)
Control	3.88 (100)[1]
Early	2.74 (71)
Late	3.66 (94)

[1] Number in parentheses shows the percentage relative to the control.

Discussion

Although a hail application reduced yields by up to 30 %, these differences were not significant statistically. The main reason for the lack of significance is a large variation between treatment replicates. However, the type and extent of damage is specified by the evaluation of clusters from the hail-affected side of the vine. At harvest, the mean cluster weight in the hail treatments was 7 % to 35 % less than that of the control. The difference is less than the damage found when evaluating individual clusters from the hail-affected side. Such lower overall effect is to be expected as the hail did not penetrate the entire canopy and thus only affected clusters on the treated side. As it is reasonable to assume that the clusters are evenly distributed along the two sides of the canopy, it follows that the overall damage should be about half the level found when evaluating the treated side.

The close treatments caused more damage than the far treatments. However, evaluation of damaged clusters showed a very similar level of cluster damage between the early and late applications. In 2002, the impact of this percentage damage on the average berry and cluster weight was much more in the early than the late treatment. In previous years, both the weight of damaged and undamaged berries did not differ between the early and late treatments. While the weight of undamaged berries in the late application was similar to those of control vines, the berries were smaller for early-treated vines. Likewise, the mean cluster weight was more reduced in early- than in late-treated vines. The main reason for the difference between early and late treatment in 2002 appears to be the extent of drying of damaged berries. Damaged berries from the early treatment were completely desiccated. Berries desiccated quickly after the early hail application as maximum temperatures were close to or exceeded 100 F during much of July. At the time of evaluation, the mean weight of damaged berries was 0.12 g for the early hail, but 0.52 g for the late hail. Berries from the late hail treatment did not desiccate to the same extent as from the early treatment, or as found in previous years. This lack of desiccation was likely due to lower temperatures combined with several rainfall events that happened between hail application and harvest. Damaged berries turned brown but remained soft and somewhat turgid. It is very likely that rot organisms such as *Botrytis cinerea* would have infected these berries if harvest had been delayed.

Damaged, desiccated berries accounted for 10-15 % of the total yield. Those shriveled, dried berries are of zero value from a winemaking perspective. Juice yield from a load of hail-affected grapes at the press can be expected to be 10-15 % less than from a load of grapes without such damage. As juice can only be gained from undamaged berries, the yield reduction due to hail is greater than that predicted simply from harvest data.

Acknowledgements

We wish to thank John Wilhelm, Gary Valpando, Richard Gonzalez, Todd Einhorn and Jeff Beddow for their help with the hail application and harvest. We also like to acknowledge the help from Ainsley and Sophia Max, Jackie Harris, Lacey Byers and Cate Hight in harvesting and evaluating cluster damage.

Application of Crop Modeling for Sustainable Grape Production

Horst W. Caspari and **Harold J. Larsen**, Colorado State University Western Colorado Research Center at Orchard Mesa 3168 B1/2 Rd., Grand Junction, CO 81503

Summary

Results from three separate studies to control powdery mildew, *Uncinula necator,* in the dry Colorado climate indicated that no fungicide applications were required until late July under the dry conditions of 2001. Those results also suggested that significant cost savings might be achieved by changing current spray practices. In 2002, two trial sites were established within commercial Chardonnay vineyards, weather stations set up in both vineyards, and meteorological data relayed back to a central computer server once every 15 minutes. Weather data was used to run two, commercially available powdery mildew models (Gubler-Thomas, Kast). In each vineyard, two spray programs were compared: the grower's standard and a reduced (model) program. In the grower standard, sprays were applied on a calendar basis so as to provide continuous protection from fungicide coverage. In the model program, the decision to apply a fungicide was based on a) output from the models, and b) actual field data of incidence and severity of powdery mildew. Field data were gathered at least once per week.

First season experience with the available Gubler-Thomas and Kast powdery mildew models found that neither model tracked powdery mildew disease development in the study vineyards very closely. The Kast model was the closest, but it is likely that adjustment of the models may be required to obtain a close fit with actual disease observations through the season. However, the reduction of number of control sprays from six in the grower standard program to only three in the model-driven program demonstrated the potential value of the concept for control of powdery mildew in Colorado vineyards.

Introduction

Powdery mildew , caused by the fungus *Uncinula necator*, is the most severe disease problem faced by grape producers in Colorado. Historically, as many as seven to eight protective sprays have been applied within a single season to insure that the crop and the vines sustain minimal damage. Studies done in 2001 in Colorado showed that, under the dry conditions experienced that year, no fungicide applications were required until significant rainfall and wetting periods occurred in mid-July. This suggested that significant cost savings might be achieved by changing current spray practices through use of meteorological monitoring stations and computer models to evaluate the collected data. Such a meteorological network was initiated in 2002 and the data used to run two commercially available powdery mildew models, Gubler-Thomas and Kast. The results were then verified via field scouting and spray programs prescribed. The results of the model + scout spray program were then compared with the results in the standard spray program blocks.

Materials and Methods

One-acre blocks of Chardonnay (the "model" treatment) were set aside at two vineyards in Palisade, Colorado (Vineyard A and Vineyard B). Apart from a single sulfur application at bud break, no further powdery mildew sprays were applied to the model treatment unless requested by the technical advisors. The decisions to spray or not spray were based on (i) the powdery mildew models (Gubler-Thomas and Kast), (ii) accurate, site-specific weather and leaf wetness data, and (iii) field scouting. At each vineyard site, a similar-sized block of Chardonnay served as the control in which powdery mildew was managed according to the growers' previous practices (the "standard" treatment).

Incidence and severity of powdery mildew infections on shoots and leaves were recorded by a field scout one to three times per week throughout the 2002 season up to and slightly beyond harvest.

Adcon Telemetry Inc. weather stations were set up at each grower cooperator site and weather data (temperature, humidity, wind speed & direction, rainfall, leaf wetness, solar radiation, etc.) was radio-transmitted back to the base station at the W. Colo. Res. Center at Orchard Mesa site. The weather data was used in the powdery mildew models to calculate a "Risk Index". The Risk Index provided an assessment of the need for any treatment applications to the model blocks.

The computer model assessments were then compared to the field infection data as gathered by the scout. After reviewing the model output and the field data, the technical advisors forwarded recommendations to the cooperators as to whether to apply mildew control sprays in the model block and what type of spray materials to use. In the standard block, mildew was controlled by way of the grower's typical spray program. At the end of the season, the inputs and disease ratings were compared for the two treatments.

Results

Powdery mildew infections were not observed in the study blocks until after July 15, 2002. Infection incidence and severity increased steadily at the end of July in both the standard program blocks and the model program blocks through and beyond harvest (Fig. 1). The timing of this increase corresponded closely with a significant rainfall event in late July at both

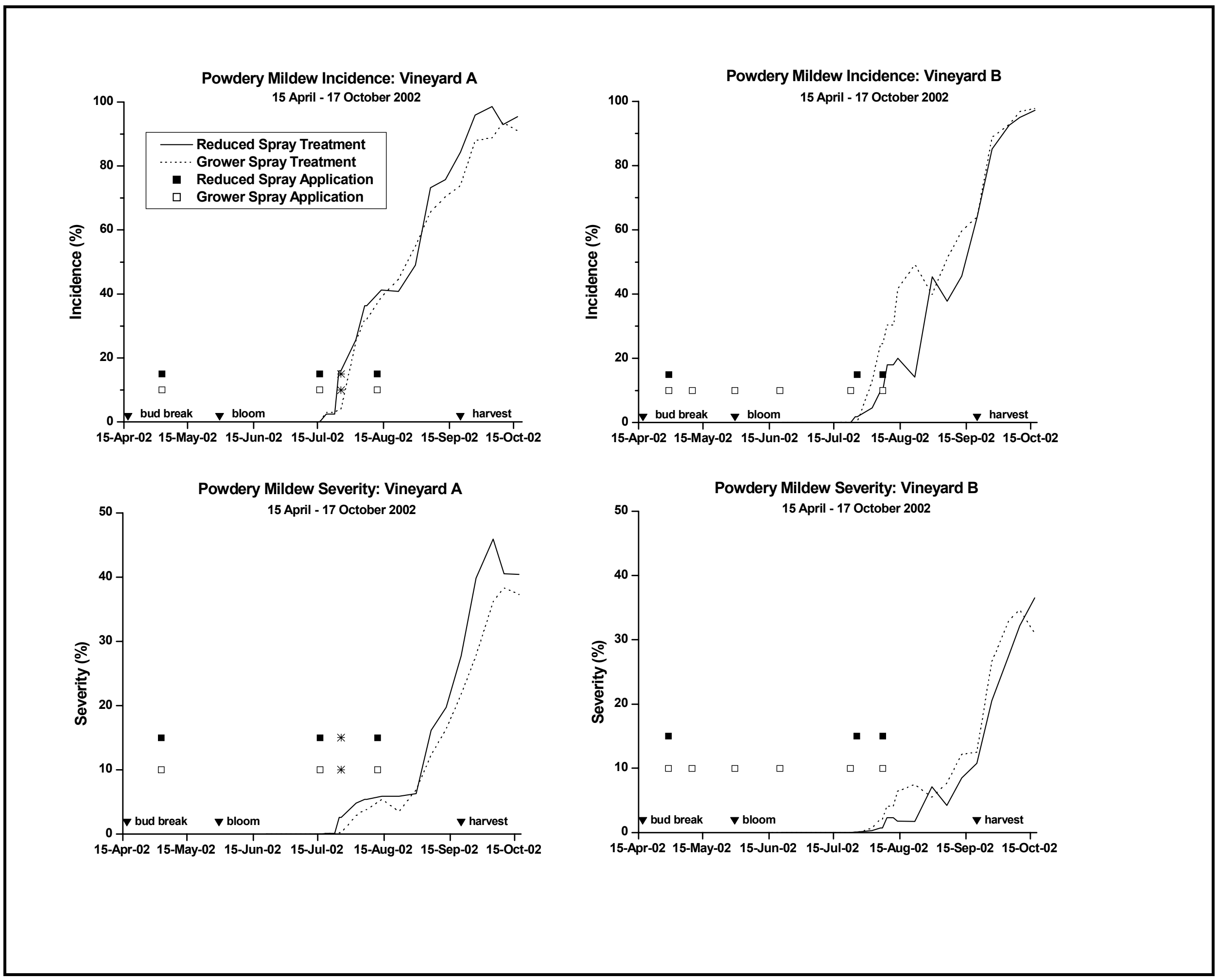

Fig. 1. Incidence (top) and severity (bottom) of grape powdery mildew on Chardonnay leaves at two Colorado vineyards in 2002. At each site, the grower's standard spray program was compared to a reduced (model) spray program. Spray applications are indicated by a "☐" (grower program) and a "■" (reduced program). An "*" indicates an insecticide application with a material that was also active against powdery mildew. Left: Vineyard A; right: Vineyard B.

study sites. Figure 2 shows the precipitation and leaf wetness data for Vineyard B; this data was similar at Vineyard A.

The comparative spray programs differed at the two grower cooperator sites. At one site (Vineyard B), the grower applied to the standard block a mildew control program similar to one he used in previous years. This resulted in six protective spray applications in the standard block compared to three in the model block (Fig. 1). At the other site (Vineyard A), the grower did not apply his standard program as was originally intended. Instead, he decided not to apply any further mildewcide sprays after the first application at bud-break until precipitation events occurred or powdery mildew infections were observed. Thus, the grower used the information gathered by the scout in his standard program. This resulted in the standard and the model program being virtually identical with three sprays each (Fig. 1). It should be noted that the grower applied one insecticide application using Stylet oil at 1.5 % vol/vol. At that rate Stylet oil also has efficacy against powdery mildew.

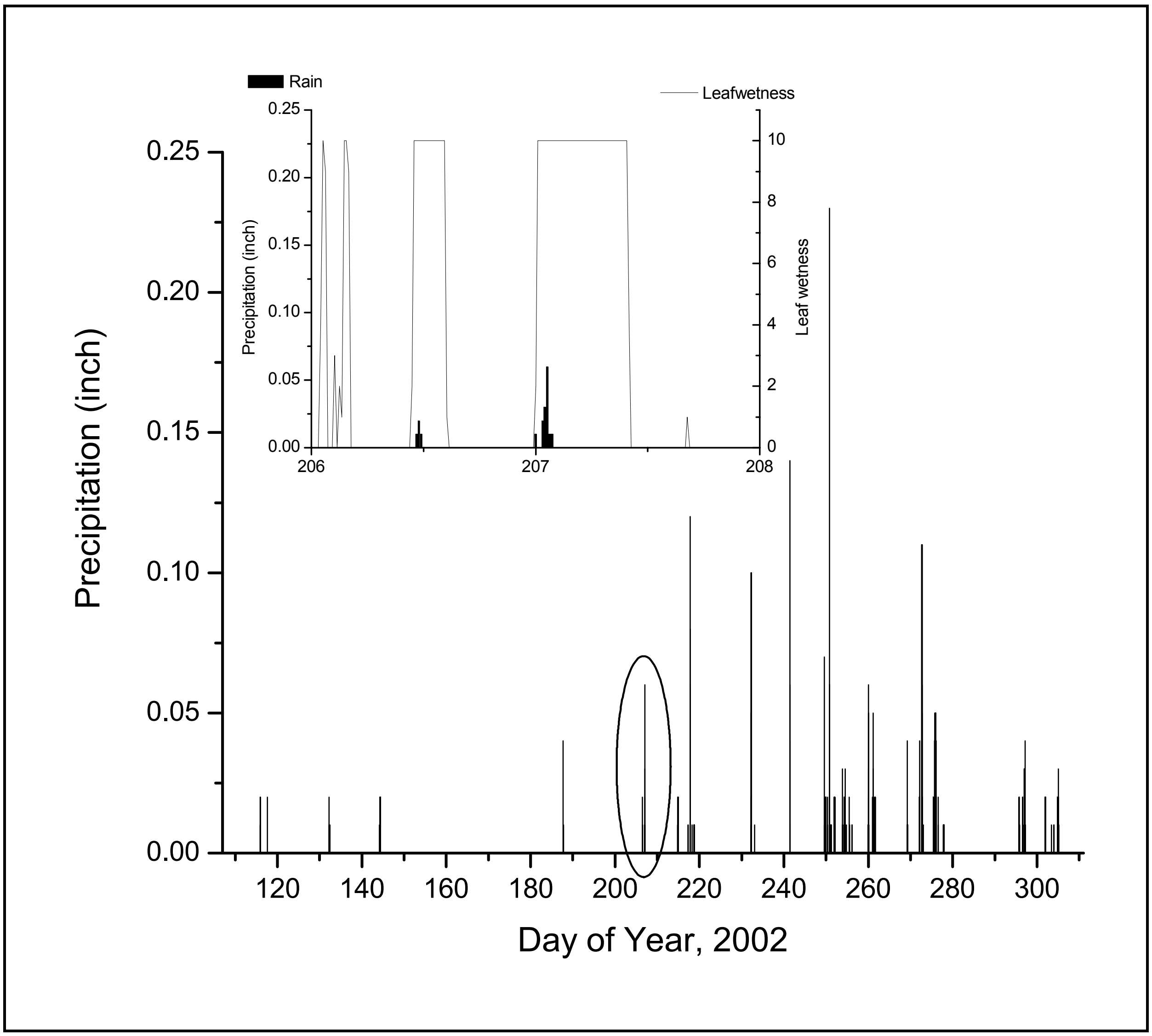

Fig. 2. Precipitation at Vineyard B near Grand Junction, CO during 2002. Insert: Close-up of the precipitation and leaf wetness data for July 25 and 26 (DOY 206 and 207).

Discussion and Conclusions

The first season data demonstrate the potential benefit of using computer models driven by remotely gathered weather data and validated by scout observations. At the Vineyard B cooperator site, the model program used ½ of the number of spray applications used by the standard program. The standard program used at Vineyard B is very representative of the type of program used within the industry prior to the start of the study. In fact, Vineyard A used a spray program very similar to that of Vineyard B prior to the start of our study. However, due to the change in the standard program used at Vineyard A, the number and timing of the control sprays did not differ from the model treatment and so do not reflect a very accurate comparison.

It is worth noting that the model program at Vineyard B had a slight offset from the standard program spray in late July. In the standard program, a spray was applied on July 23 because the efficacy of the previous spray (applied on June 20) had ceased. In the model program, the same fungicide spray was applied on July 26 in response to significant rainfall and extended leaf wetness periods on July 25, 26. Following those applications, a major difference was noted in incidence and severity levels for several observations thereafter (Fig. 2). This reduction in incidence and severity of infections is very likely due to the difference in timing.

There was obviously no difference in the costs for the control programs at Vineyard A. However, at Vineyard B the approximate costs (materials only) for the grower treatment was $98 per acre versus $46 per acre for the model program. The actual cost savings are likely to be higher when one considers the additional costs of labor and equipment.

It was noted that the Gubler-Thomas model incorporated within the computer software called for protective sprays many additional times early in the season. Conversely, the Kast model from Germany was more conservative in its assessment of infection periods, and did a better job during the early season when the Gubler-Thomas model was calling for infection periods driven primarily by temperature data (no significant rainfall during that period). It appears that additional experience with these models is needed, and best results may require adjustment of the models to better track Colorado conditions.

It should also be noted that the Gubler-Thomas model was developed for California growing conditions. In California, powdery mildew can overwinter in infected buds (so-called bud perennation) that can lead to powdery mildew infections of shoots emerging from infected buds. Infected shoots, called flag shoots, are covered in white mycelium and are easily identified. The main reason for a fungicide application at bud break is to target over-wintering powdery mildew such as on flag shoots. We have not found any evidence for bud perennation of grape powdery mildew under Colorado growing conditions, which suggests that a primary infection (from over-wintering cleistothecia) is required to start the powdery mildew disease. This in turn raises the question if the common practice of a fungicide application at bud break is needed.

The objectives of phase 1 of the study were achieved. Phase II will expand the number of vineyards within the study by two additional vineyards, with addition of two more telemetry weather stations that will be tied in with the existing computer server. An additional season of data will provide further indication on whether (and how) the models may need adjustment for Colorado's conditions..

Acknowledgments

We gratefully acknowledge partial funding of this project by the Rocky Mountain Association of Vintners and Viticulturists (RMAVV), via a grant from the Specialty Crops Program awarded to RMAVV, and via a grant from the Environmental Protection Agency – Region 8 (EPA). We also like to thank the grower-cooperators for allowing us to use their vineyards, and their help and support during the season.

2002 Observations for 1994 Dwarf Apple Rootstock Trial (NC-140 Regional Project)

Ron Godin, Research Scientist / Sustainable Agriculture, WCRC – Rogers Mesa

Summary and Recommendations

At the end of nine years of growth, none of the trees are growing vigorously at this site. Terminal growth is not excessive and leaf size is small. For 2002, fruit was harvested prior to maturity due to severe drought conditions. Early harvest was done in order to reduce evapotranspiration and save the trees (Table 1). To date, Pajam2 has produced the greatest cumulative yield, but this is based on only 6 years worth of yield. The trees with the largest trunk diameter are V.1 and M.26 EMLA; however, several rootstocks are very similar in size. Average fruit weight this year is not indicative of rootstock performance due to premature harvest. It is too early for conclusions, and no recommendations should be made at this time.

Introductions and Objectives

Choice of a suitable rootstock could make the difference between an economically viable orchard and one that loses money for the orchardist. This trial was initiated in the NC-140 committee (NC-140 is composed of tree fruit researchers across the U.S. and Canada that do research on tree fruit rootstocks) to see how several dwarfing (M.9 size) rootstocks would perform over a range of climates. The objectives of this trial were to determine the adaptability of differing dwarfing apple rootstocks to Western Colorado and to determine if any of these rootstocks perform better than existing rootstocks.

Materials and Methods

This trial was planted in Block 11D at the Western Colorado Research Center – Rogers Mesa site in 1994. The trial consisted of 16 rootstock clones from the semi-dwarf M.26 EMLA to the very dwarfing M.27 EMLA. The scion variety chosen was Gala (Treco Red Gala #42). It was planted in a randomized complete block design with 10 replications. Trees were supported and trained to a modified vertical axe training system. The site chosen was a replant-site with no fumigation. Trees were watered by microsprinkler irrigation. Similar plantings are replicated at 21 other sites across the U.S.

Results and Discussion

The results for the 2002 growing season are presented in Table 1. Recommendation on rootstock choice will not be made this year due to adverse, severe drought conditions even with 9 years worth of data. The rootstock Mark was highly promoted after the preliminary 5-year report; it looked like the best rootstock. It had size control, lots of fruiting, and no staking needed. However, after 10 years, a soil-line swelling similar to crown gall made this rootstock unacceptable. With that stated, it appears that the largest trees were on V.1 and M.26 EMLA; the smallest trees were on P.22 and M.27 EMLA. The most suckering was on PAJAM 2 and M.9 RN29 as has been typical for the past few years. Greatest cumulative yield occurred on PAJAM 2 and M.9 RN 29. The least cumulative yield occurred with M.27 EMLA and P.22 which correlates with the small size of the trees.

Acknowledgments

Colorado Agricultural Experiment Station provided funding that supported data collection and analysis. Special thanks to George Osborn, Bryan Braddy and Kim Schultz for data collection.

Table 1. Several growth parameters for the 2002 growing season in the 1994 NC-140 dwarf apple rootstock planting at the WCRC - Rogers Mesa site (Block 11D).

Rootstock	Average Trunk Circumference (in)	Average Rootsuckers (number/tree)	Yield/tree (lbs)	Cumulative Yield (lbs)	Average Fruit Wt. (oz)[1]
M.9 EMLA	6.9	8.9	7.1	72.4	3.4
M.26 EMLA	8.0	3.2	10.0	76.7	3.7
M.27 EMLA	4.3	5.8	11.6	30.5	3.5
M.9 RN29	7.5	16.9	20.6	108.7	3.7
PAJAM 1	6.7	11.1	23.4	84.9	3.5
PAJAM 2	7.8	19.7	25.1	116.4	3.6
B.9	7.4	8.2	14.4	81.9	3.4
B.491	4.7	9.9	14.5	48.0	3.6
O.3	6.6	11.4	26.0	84.6	3.5
V.1	8.4	10.0	29.7	93.2	3.5
P.2	6.2	1.6	30.4	87.6	3.0
P.16	6.9	8.7	25.3	56.5	3.3
MARK	5.5	15.4	27.5	70.2	3.6
P.22	3.8	2.6	28.5	42.8	3.3
B.469	6.9	7.0	30.7	82.1	3.5
NAKBT 337	6.2	12.8	37.9	92.3	3.4

[1] An average fruit weight of 4.4 ounces is the equivalent of a 150 count size.

2002 Observations for 1998 Sweet Cherry Rootstock Trial (NC-140 Regional Project)

Ron Godin, Research Scientist / Sustainable Agriculture, WCRC – Rogers Mesa

Summary and Recommendations

This is the end of the fifth year of the planting. The trees are still too young to draw conclusions and no recommendations should be made at this time.

Introductions and Objectives

Until a few years ago, there had not been a good dwarfing rootstock for cherry. Several Prunus species and crosses have been made that have resulted in potential dwarfing rootstocks for sweet cherry. The Gisela® series is one such example. This trial was initiated in the NC-140 committee (NC-140 is composed of tree fruit researchers across the U.S. and Canada that do research on tree fruit rootstocks) to see how these relatively new Prunus rootstocks would perform over a range of climates. The objectives of this trial were to determine the adaptability of differing Prunus rootstocks to western Colorado, to determine if these rootstocks induce dwarfing, and to determine if any of these rootstocks perform better than existing rootstocks. Similar plantings are under evaluation at several other sites across the U.S.

Materials and Methods

This trial was planted in Block 31 at the Western Colorado Research Center – Rogers Mesa site in 1998. The trial consisted of 13 *Prunus* rootstocks with a Bing scion. It was planted in a randomized complete block design with seven replications. Trees were trained to a central leader. Trees were watered by furrow irrigation until 1999 when microsprinklers were installed. On 14th of November, trunk circumference and the number of rootsuckers were counted. There was no yield this year due to late frost.

Results and Discussion

Most of the tree loss in this planting is due to late fall/early winter damage in the first year of the planting. It is unclear why more loss has occurred in the Mazzard rootstock. The possibility is that they were weaker trees from the nursery. The results for tree growth parameters are presented in Table 1. Making recommendations after only 5 years worth of data is not wise. However, it is apparent that some trees are inducing dwarfing in this planting as seen in trunk diameter. Whether those particular rootstocks will be productive is yet to be determined. The tree height parameter is included this year because of the 5 year benchmark. The largest trees in circumference are also the tallest and include Mahaleb, 148/1, 195/20, W10 and W13. The W13 continues to be the rootstock with the greatest number of suckers.

Acknowledgments

Colorado Agricultural Experiment Station provided funds that supported data collection and analysis. Special thanks to George Osborn, Bryan Braddy and Kim Schultz for data collection.

Table 1. Several growth parameters for the 2002 growing season in the 1998 NC-140 sweet cherry rootstock planting at the WCRC - Rogers Mesa site (Block 31).

Rootstock	No. still alive[1]	Average Trunk Circumference (inches)	Average Tree Ht. (ft)	Average Fruit Wt. (lbs/tree)	Cumulative Yield (lbs)	Average no. rootsuckers (no./tree)
Mazzard	4	7.2	10.3	0.0	3	4.0
Mahaleb	6	11.1	11.4	0.0	2.5	0.0
148/1	6	11.5	10.1	0.0	1.8	0.0
148/2	7	8.7	8.2	0.0	2.2	0.3
148/8	7	9.9	8.9	0.0	1.5	11.9
195/20	7	10.6	10.3	0.0	2.6	5.0
209/1	5	6.6	6.0	0.0	1	1.2
Edabriz	6	8.2	9.2	0.0	1.7	4.1
W10	7	10.8	11.8	0.0	2.3	18.0
W13	7	11.3	12.0	0.0	1.9	48.6
W53	6	8.6	8.9	0.0	2.7	13.3
W72	6	8.4	8.9	0.0	1.7	8.6
W158	7	9.5	9.8	0.0	3.5	8.7

[1] Out of seven originally planted trees.

Management of Sap Beetles in Commercial Sweet Corn

Robert Hammon, Research Entomologist, Western Colorado Research Center at Fruita, Fruita, CO

Summary

A three-phased sweet corn sap beetle research project was conducted in western Colorado in 2002. Field biology observations showed that adult beetles entered sweet corn fields any time after silking. Egg laying did not begin until about one week before sweet corn maturity, as kernel size was increasing. Eggs were laid on or between developing kernels or between husks at the tip of the ear. Chemical control trials showed only minor differences in insecticide efficacy. Pyrethroid insecticides applied every other day during the two weeks prior to harvest reduced, but did not eliminate larval infestations. Petri dish assays showed differences in insecticide performance when sap beetles were exposed for ten minutes and then placed in an untreated environment, with 90% mortality at 24 hours with three of four insecticides but only 50% mortality from a fourth insecticide. They demonstrated no differences between insecticides when adult beetles were exposed continuously for 24 hours. Results of the 2002 research project were used during the season in the development of a modified spray program in which insecticide applications were made on four consecutive days beginning one week prior to harvest. Once the modified spray program was initiated, sap beetle contamination of sweet corn was reduced, and there were no further rejections of sweet corn fields due to their presence.

Introduction

Dusky sap beetle, *Carpophilus lugubris*, is a primary pest of sweet corn grown in western Colorado. Adult beetles lay eggs in the tips of sweet corn, and emergent larvae contaminate the harvested crop. When the percentage of infested ears within a field exceeds threshold levels, the crop is not harvested, and the grower takes a significant financial loss. Sap beetle infestation caused significant acreage in Montrose and Delta counties to be rejected in 2001. A research program directed at sap beetles management was initiated in 2002 with these objectives:

1) Determine how sap beetle field biology affects control efforts.

2) Evaluate insecticides and application schedules for sap beetle control.

3) Gain experience in using sap beetle pheromone traps to monitor populations.

4) Use experimental and observational research results to develop an IPM program for sap beetles in sweet corn.

Sap Beetle Field Biology

Sap beetle biology was observed in sweet corn planted at WCRC@Fruita, and in a commercial field at Olathe. Sap beetle adults were caged on ears of mature sweet corn planted at Fruita to observe egg laying behavior. Several ears were picked and inspected each day after beetles were caged. Eggs could be found one day after beetles were placed on ears. Eggs were not attached to anything, but dropped among kernels or between layers of husk at the tip of the ears. The eggs, which are barely visible to the unaided eye, are about 0.1 mm in length, creamy white and elongate (Figure 1). Eggs

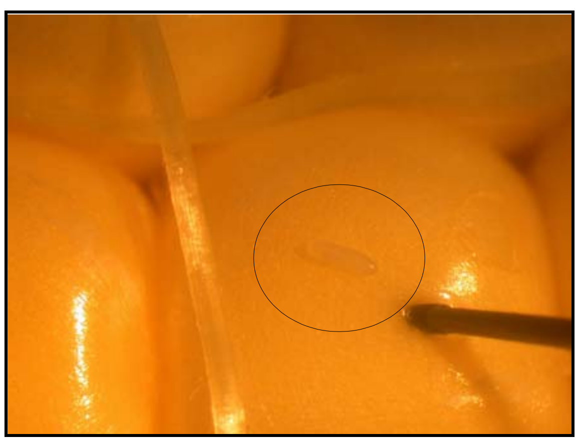

Figure 1. Sap beetle egg on sweet corn kernel.

hatch within 24 to 48 hours after being laid, and larvae molt from first to second instar in about the same length of time.

Egg laying observations were made during early July, when daily temperatures were near 100 degrees F. At these temperatures, sap beetle larvae could be seen with the naked eye three days after beetles were introduced onto plants. We assumed these larvae were second instar, as first instar larvae are small enough that they are barely visible to the naked eye.

Adult sap beetles were observed feeding on kernels near the tip where they hollowed them out. These damaged kernels then made excellent feeding sites for newly hatched larvae, which could by found feeding within them. Larvae could also be found feeding on the surface of kernels, directly damaging the pericarp. Larval feeding damage was typically minor compared with that from adult beetles.

Other important observations came from sampling of commercial field plots near Olathe. Adult sap beetles could be found in the field from shortly after pollen shed until harvest, with numbers generally increasing as the corn matured (Figure 2). The first sap beetle larvae were not found until shortly before harvest, suggesting that egg laying did not occur until about a week before harvest. When sap beetle larvae appeared, all were the same size, implying that egg laying was initiated over a short time period. We are speculating that there

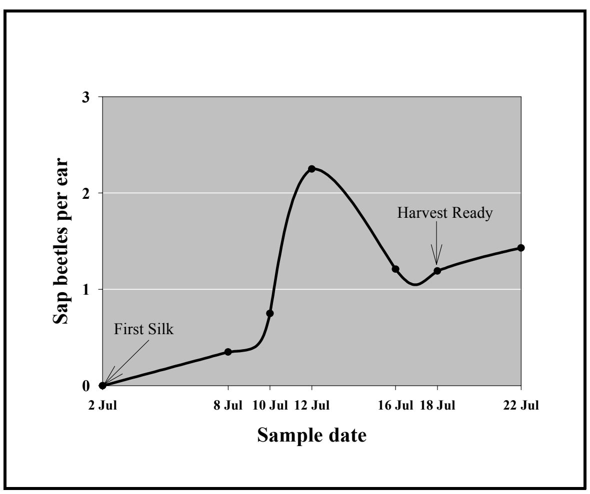

Figure 2. Sap beetle adults taken from sampling of untreated plots within commercial sweet corn at Olathe, CO.

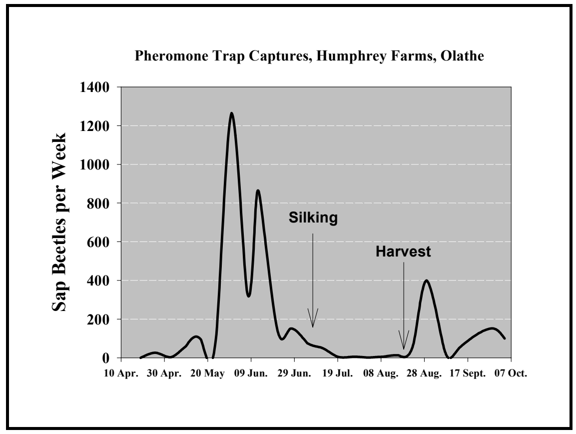

Figure 3. A sap beetle pheromone trap was baited with fermented apple juice coattractant and placed next to the chemical control trial at Olathe. There were significant captures of dusky sap beetles before and after the silking to maturity growth stage. The sweet corn field was more attractive to the beetles than the trap during the critical time period.

is a chemical cue related to a physiological change in the kernels, which triggers egg laying. The timing of egg laying coincides with kernel filling and sugar production within ears. Sap beetles are typically attracted to fermentation byproducts, so the timing of beetle attraction to sweet corn ears while sugars are being produced is not surprising.

Chemical Control Plots

Aerially applied chemical control plots were conducted in a sweet corn field located approximately 2 mi west of Olathe. The field was planted in mid-April with 'Chief Ouray' sweet corn and managed as a commercial field. Ninety foot wide strips were marked perpendicular to the rows for aerial application of spray treatments, which were arranged in a randomized complete block design with two replications. All treatments were applied by Olathe Spray Service, using commercial application equipment which covered a swath of 74 feet. Three insecticides were tested, each on two different spray schedules. Experimental treatments are outlined in Table 1.

Sampling was initiated at pollen shed. Twenty ears were sampled from the center of each plot on the first four sample dates, 40 on

Figure 4. Application of insecticides by Olathe Spray Service to experimental plots near Olathe, CO.

the next two, and 60 on the final date. The ears were inspected on-site, and the number of sap beetle adults, ears with sap beetle larvae, and ears with corn earworm damage were recorded. The field was harvest ready on July 18, but a final sample was taken July 22, seven days after the final spray.

Sap beetle adults appeared in the field shortly after pollen shed and increased in numbers as the corn matured (Figure 2). All sprays were effective in reducing sap beetle numbers when compared with the untreated control, but differences between insecticides were not statistically significant (Table 2). The first larvae were not found in any ear until July 16, two days before the field was harvest ready. At that time, the untreated had 11.25% of ears infested, which was more than any other treatment (Table 3). Differences among insecticides in percent infested ears on July 16 were not statistically significant, with the exception of Mustang (2 day throughout),which had slightly greater infestation.

All sap beetle larvae were of uniform small size, implying that egg laying had only begun three or four days prior to sampling. The sap beetle larval infestation data followed the same trend on the July 18 (harvest ready) sample. Sap beetle larvae counts were lowest in the Warrior (2 day throughout) treatment on all sample dates. There were no consistent differences between insecticide treatments in corn earworm control, but all had lower infestation than the untreated control (Table 4).

Sap Beetle Laboratory Assays

A series of assays was conducted in the laboratory at WCRC@Fruita to determine insecticide toxicity to sap beetle adults in a controlled environment. Four-inch diameter petri dishes were sprayed with insecticide, using a CO_2-pressured plot sprayer calibrated to deliver 18 gal/acre of spray material. The sprays were allowed to dry, then ten adult sap beetles were placed in each dish. Each treatment was replicated three times. Sap beetle behavior was observed over time, and analysis of variance was performed on mortality data. Beetle behavior was observed in the untreated dishes. Mortality in the treated dishes was determined by comparing beetle behavior in treated dished to that in untreated. Beetles were counted as dead if they were not moving, were on their back, or did not respond to movement of the dish. The experiment was repeated several times over the summer to refine techniques. A larger trial, reported here was conducted on September 11 and 12, 2002.

Field observation on adult sap beetle behavior has led to the belief that they enter the sweet corn field and move directly to the green silk, which plants produce constantly until harvest. Presumably, this behavior minimizes exposure to insecticides, as beetles encounter no residue once they enter the ear husk. Another treatment was added to the petri dish assays to mimic this situation. Beetles were placed into treated dishes for ten minutes, after which they were transferred to untreated dishes.

All insecticides were applied at the rate and schedule listed in Table 1. Additionally, Bathroid was applied at a rate of 2.8 fl oz/A (0.044 lb a.i./A). All insecticides impacted sap beetle behavior in a matter of minutes. Beetles in treated dishes scattered from each other, became lethargic, and many laid on their backs. Those in the untreated dishes grouped together, and many were on the lid of the dishes. All remained upright and moved around. After removal from the insecticide treated dishes, a percentage of beetles in each treatment recovered. Mortality was at 100% in all of the constant exposure treatments by four hours. By contrast, those with ten minute exposure never reached 100% mortality, although mortality increased over time. Mortality among treatments did not differ

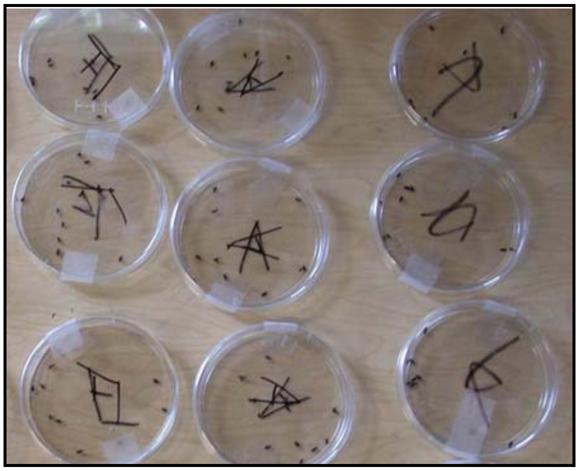

Figure 5. Sap beetles were placed in insecticide treated petri dishes, and behavior monitored.

statistically at 24 hours, with the exception of Asana 10 minute exposure and the untreated control (Figure 5).

Conclusions/Recommendations

1) Sap beetle adults invade sweet corn shortly after pollen shed, but do not begin to lay eggs until about one week before the field is harvest ready.

2) The time from egg laying until larvae can be seen with the naked eye can be as short as 3 days at temperatures in the high 90 degrees F.

3) Early season spray schedules play no role in preventing sap beetle larval infestations.

4) Differences in field performance between insecticides tested were not great enough to be identified by this experiment.

5) All four pyrethroids worked well in petri dish tests when exposure was constant. Mortality at 24 hours after 10 minute exposure to insecticide was less in the Asana treatment than any other.

6) Pyrethroid insecticides work quickly in knocking down sap beetle adults, but death does not occur for at least 24 hours. This is true for both short term and constant exposure.

The data and conclusions from these experiments were incorporated into a spray program which was used by Olathe Spray Service during late July and August in Montrose and Delta County sweet corn fields. Spraying every other day in the two weeks before harvest reduced sap beetle larval infestations, but did not eliminate them entirely. The data showed that sap beetles did not begin to lay eggs until about one week before harvest. Females enter the ears through the tips. Since the silk on sweet corn plants continues to grow until harvest, this is the only plant part having no insecticide residue. It made sense to concentrate sap beetle treatments into the seven days before harvest, using daily sprays for four days to cover the newly emerged silk with insecticide residue. Spraying could be terminated three days before harvest, as it takes that long for newly laid eggs to hatch and larvae grow to a detectable size. This program was successfully used on several fields, and became a standard treatment during mid and late August, with no failures. Data to show that the success of the treatment is due to the spray schedule and not to other factors are still lacking, but the schedule looks promising in managing sap beetle populations in sweet corn.

Acknowledgments

This research was funded by the Colorado Specialty Crops Grower Grant Program, Syngenta, FMC and DuPont, and Olathe Spray Service. Seed was donated by Mesa Maize, herbicide and fertilizer by Tuxedo Sweet Corn. Humphrey Farms grew the sweet corn. The staff of Olathe Spray Service assisted in setting up the field plots. Melissa Foley coordinated the sampling, and several volunteers with the Cooperative Extension Master Gardener Program assisted with sampling. Jason Bishop provided a valuable review of the manuscript.

Table 1. Experimental treatments.

Treatment	Rate	Schedule	# applications
Warrior ZT 3/2d	3.84 fl oz/A; 0.03 lb a.i./A	3 day early, fb 2 day	9
Warrior ZT 2d	3.84 fl oz/A; 0.03 lb a.i./A	2 day throughout	11
Asana XL 3/2d	9.6 fl oz/A; 0.05 lb a.i./A	3 day early, fb 2 day	9
Asana XL 2d	9.6 fl oz/A; 0.05 lb a.i./A	2 day throughout	11
Mustang 1.5 EW 3/2d	4.26 fl oz/A; 0.05 lb a.i./A	3 day early, fb 2 day	9
Mustang 1.5 EW 2d	4.26 fl oz/A; 0.05 lb a.i./A	2 day throughout	11
Untreated			0

Table 2. Sap beetle adults per ear.

	Jul-02 Pollen shed	Jul-08	Jul-10	Jul-12	Jul-16	Jul-18 Harvest	Jul-22	Average
Warrior 3/2d	0.00	0.03	0.13	0.05	0.04	0.31	0.11	0.096 A
Warrior 2d	0.00	0.00	0.00	0.00	0.30	0.10	0.30	0.100 A
Asana 3/2d	0.00	0.00	0.00	0.05	0.05	0.15	0.48	0.104 A
Asana 2d	0.00	0.00	0.00	0.22	0.01	0.05	0.11	0.056 A
Mustang 3/2d	0.00	0.05	0.00	0.15	0.06	0.08	0.31	0.093 A
Mustang 2d	0.00	0.00	0.08	0.00	0.14	0.35	0.70	0.181 A
Untreated	0.00	0.35	0.75	2.25	1.21	1.19	1.43	1.026 B
Average	0.00	0.06	0.24	0.39	0.26	0.32	0.49	

Means within the insecticide average column followed by the same upper case letter are not significantly different (P=0.0004, LSD=0.44).

Table 3. Percent sap beetle larvae infested ears

	Jul-02	Jul-08	Jul-10	Jul-12	Jul-16	Jul-18	Jul-22	Average
Warrior 3/2d	0.00a	0.00a	0.00a	0.00a	1.25a,AB	5.00ab,AB	5.83b,BC	1.73 *AB*
Warrior 2d	0.00a	0.00a	0.00a	0.00a	0.00a,A	0.00a,A	0.83a,AB	0.12 *A*
Asana 3/2d	0.00a	0.00a	0.00a	0.00a	0.00a,A	2.50a,AB	9.17b,CD	1.67 *AB*
Asana 2d	0.00a	0.00a	0.00a	0.00a	1.25a,AB	5.00a,AB	10.83b,CD	2.44 *AB*
Mustang 3/2d	0.00a	0.00a	0.00a	0.00a	3.75a,AB	3.75ab,AB	6.67b,C	2.02 *AB*
Mustang 2d	0.00a	0.00a	0.00a	0.00a	6.25b,BC	6.25b,B	10.83b,CD	3.33 *B*
Untreated	0.00a	0.00a	0.00a	0.00a	11.25b,CD	20.00c,C	12.50b,D	6.25 *C*
Average	0.00 *a*	0.00 *a*	0.00 *a*	0.00 *a*	3.39 *b*	6.07 *c*	8.09 *c*	

Means within a row followed by the same lower case, non-italicized letter; and means within a column followed by the same upper case, non-italicized letter are not significantly different (insecticide x sample date *P*=0.094, LSD=5.30). Means within the insecticide average column followed by the same italicized, upper case letter are not significantly different (*P*=0.0008, LSD=2.40). Means within the sample date average row followed by the same lower case italicized letter are not significantly different (P<0.0001, LSD=2.40).

Table 4. Percent corn earworm infested ears.

	Jul-02	Jul-08	Jul-10	Jul-12	Jul-16	Jul-18	Jul-22	Average
Warrior 3/2d	0.00a	0.00a,A	2.50b,B	2.50b,B	0.00a	0.00a,A	0.00a,A	0.71 *AB*
Warrior 2d	0.00a	0.00a,A	0.00a,A	0.00a,A	0.00a	0.00a,A	0.08a,A	0.01 *A*
Asana 3/2d	0.00a	5.00b,B	0.00a,A	0.00a,A	0.00a	1.25ab,A	0.00a,A	0.89 *B*
Asana 2d	0.00a	0.00a,A	2.50b,B	0.00a,A	1.25a	0.00a,A	0.00a,A	0.54 *AB*
Mustang 3/2d	0.00a	0.00a,A	0.00a,A	0.00a,A	0.00a	1.25ab,A	2.50b,B	0.54 *AB*
Mustang 2d	0.00a	0.00a,A	0.00a,A	2.50b,B	1.25a	1.25ab,A	0.00a,A	0.71 *AB*
Untreated	0.01a	0.00a,A	0.00a,A	12.50c,C	0.00a	6.25b,B	1.67a,AB	2.92 *C*
Average	0.00 *a*	0.71 *b*	0.71 *b*	2.50 *d*	0.36 *ab*	1.43 *c*	0.71 *b*	

Means within a row followed by the same lower case, non-italicized letter; and means within a column followed by the same upper case, non-italicized letter are not significantly different (insecticide x sample date *P*=0.014, LSD=2.01). Means within the insecticide average column followed by the same italicized, upper case letter are not significantly different (*P*=0.0.028, LSD=0.76). Means within the sample date average row followed by the same lower case italicized letter are not significantly different (P=0.069, LSD=0.634).

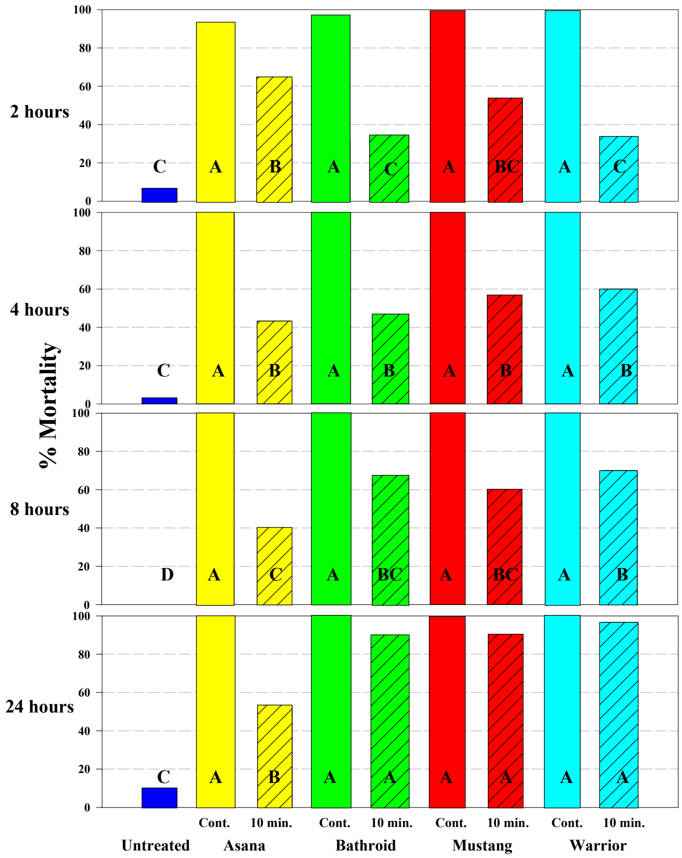

Figure 6. Sap beetle mortality in petri dish assay tests at 2,4,8 and 24 hours. Values within solid colored bars are for beetles with constant exposure to insecticide; those within shaded bars are for beetles with 10 minute exposure to insecticide. Values within a single graph with the same letter are not significantly different (LSD, P=0.05).

Onion Thrips Biology and Management

Robert Hammon, Western Colorado Research Center

Summary

Several research projects regarding the biology and management of onion thrips were conducted at WCRC@Fruita during 2002. Thirty onion varieties were evaluated to determine their relative tolerance to thrips feeding. The results were variable, but in general supported 2001 results in which the greatest tolerance was found in the most vigorous growing full Spanish varieties. Surveys of flowering plants in the vicinity of Fruita showed that only whitetop supported onion thrips populations early in the season. Thrips populations appeared in onions in early June, and peaked at about 600 per plant in mid July before collapsing to less than ten per plant in early August. Predators such as minute pirate bugs and lady beetles were responsible in part for the population collapse. Western flower thrips constituted about 10% of adult thrips in the onions until nearby alfalfa was cut, at which time the proportion increased to 33%. Spray schedules in insecticide trials consisted of two sprays, five days apart, followed by furrow irrigation. Lannate LV and Vydate L, either alone or in combination with other insecticides reduced onion thrips numbers in both trials conducted. Differences in performance were noted when comparing Colorado Front Range and West Slope insecticide trial results.

Introduction and Objectives

Onion thrips (OT), *Thrips tabaci* Lindeman, is a major pest of onion production in western Colorado. Thrips can significantly reduce bulb size, which can have major impacts on economic return. Economic thresholds vary, but in general it takes more than 25 thrips per plant during bulbing to reduce yield. Resistance to pyrethroid insecticides developed during the late 1990's, and control has been a challenge to producers since that time. Growers need non-chemical techniques to add to an integrated management program. This report describes research conducted at the Western Colorado Research Center at Fruita during 2002 to address several aspects of thrips management in onions. The objectives of this work were:

1) Identify early season non-crop host plants of onion thrips.
2) Monitor population trends of thrips in onions.
3) Evaluate insecticides and timing schedules for effectiveness against onion thrips.

Early Season Host Plants of Onion Thrips

Flowering weeds in the vicinity of Fruita were collected in April and May 2002, and insects extracted in Berlese funnels. Specimens of adult thrips were mounted on microscope slides and identified under a compound microscope.

Plant species sampled during 2002 are listed in Table 1. Western flower thrips (WFT), *Frankliniella occidentalis* (Pergande), were found on all plants sampled. Thrips other than OT and WFT were not identified, but were present on several plant species. Onion thrips were found in all collections of whitetop, but not in any other plant collection.

Table 1. Plant species sampled for thrips during 2002. * Onion thrips were found only on whitetop; western flower thrips were found on all species.

Common Name	Botanical Name
Russian knapweed	*Centaurea repens*
Hairy golden aster	*Heterotheca villosa*
Dandelion	*Taraxacum officinale*
Whitetop*	*Cardaria draba*
Field bindweed	*Convolvulus arvensis*
Alfalfa	*Medicago sativa*
Utah sweet vetch	*Hedysarum boreale*
Yellow sweet clover	*Metilotus officinalis*
Iris	*Iris* sp.
Four o'clock	*Mirabalis multiflora*
Peony	*Paeonia*
Apricot	*Prunus*
Peach	*Prunus*

Population Trend of Thrips in Onions

Twenty onion plants (cv 'Gladstone') were collected from unsprayed plots at Fruita on a weekly basis beginning mid May and continuing though early September. Thrips were sorted into mature and immature classifications, and the mature thrips were further separated by species (OT or WFT). The results from that sampling are presented in Figures 1& 2.

Onion thrips appeared in the field in late May, before bulbing was initiated. Populations increased rapidly, until there were almost 600

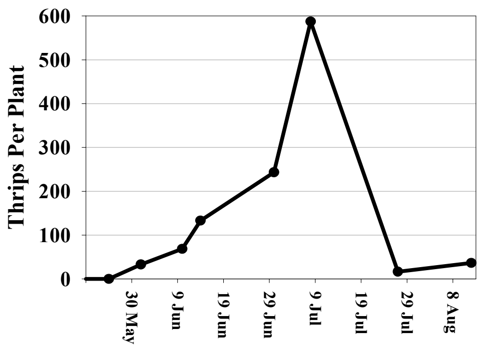

Figure 1. Onion thrips population during the 2002 growing season in unsprayed plots at Fruita CO. Data points are average number of thrips per plant, in 20 plant sample.

thrips per plant in mid July, at early bulbing. Thrips populations then fell to near zero in the next three weeks. The population reduction was largely due to predation by several insects. Minute pirate bugs, lady beetles, lacewings, predatory mites, and other beneficial insects were present in the field. Predation in the research plots was very great due to the small field size (~1 acre) and the presence of unsprayed alfalfa or sweet corn on either side of the field. Predators built up on aphids and mites in the adjacent crops, and moved as the alfalfa was cut and the sweet corn matured.

Early season sampling showed that 90% of adult thrips in the field were OT, with the remainder being WFT. When the second cutting of adjacent alfalfa, which was heavily infested with WFT was taken on July 2, the percentage of WFT increased to 33.4% (Figure 2). It is unknown if WFT reproduce in onion fields. The alfalfa cutting was taken within one week of the

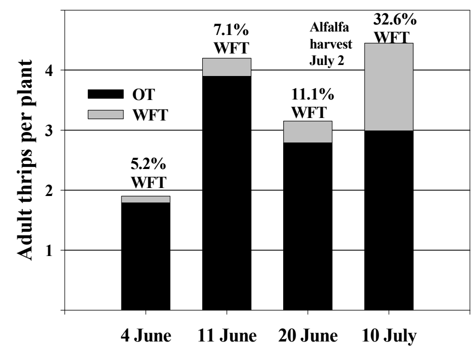

Figure 2. Species composition of adult thrips in onions on four sample dates at Fruita. The percentage of WFT increased after alfalfa harvest.

thrips population peak, so it is apparent that the influx of adult thrips from alfalfa played no more than a minor role in the overall thrips population trend.

Chemical Control

Two insecticide trials were conducted in 'Varsity' onions at Fruita in 2002. Sprays in both trials were applied with a hand held CO_2 pressured sprayer calibrated to apply 18 gal/acre of material. Plots were 7.5 ft (three 30" beds, with two seed rows per bed) by 25 ft, arranged in a randomized complete block design with four replications. All data was subjected to analysis of variance and means separated with LSD (*P*=0.05).

<u>Trial # 1</u>

This experiment was designed to evaluate onion thrips control using currently labeled insecticides and combinations. Non-ionic surfactant (Activator 90, Loveland Industries) was added to all materials at a concentration of 1% by volume. Insecticides were applied four times (June 19 and 24, July 9 and 12). The field was furrow irrigated immediately after the second and fourth sprays. Plots were sampled twice, after the field had dried following the two irrigations. Three plants were randomly chosen from the center of each plot, and thrips extracted in Berlese funnels for 24 hours. Thrips were separated by growth stage (adult and immature) in the counting process.

Trial # 2

This trial evaluated both labeled insecticide combinations and unlabeled materials. Methods were the same as used in trial #1, with the exception of the first sample. Insecticides were applied on July 8 and again on July 12. Crop oil (Clean Crop 83% A.I. Paraffin Base Petroleum Oil) was added to Lannate, Vydate, and Penncap-M treatments and combinations The plots were sampled on July 15 (3 DAT) by counting the thrips in the field on three plants from the center of each plot. A second sample was taken on July 18, using the same methods as in trial # 1. Count data from the July 18 sample was $(X + 0.5)^{½}$ transformed before statistical analysis.

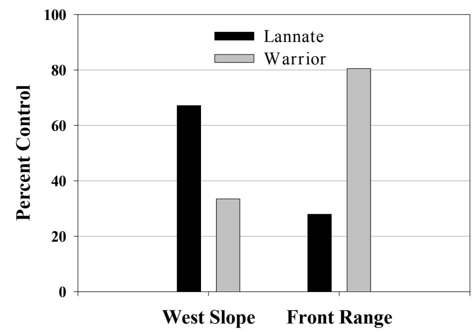

Figure 3. Onion thrips control comparison of eastern and western Colorado insecticide trials. The data is the average of multiple trials in each location.

Results

Results are presented in Tables 2 & 3. Lannate LV and Vydate L reduced thrips numbers in both trials, either alone or in combination with other insecticides. Both of these are carbamate insecticides. The two pyrethroid insecticides tested, Warrior ZT and Bathroid 2, were not effective in reducing thrips numbers. The addition of sulfur did not increase the efficacy of any insecticide.

The results of these trials are different than those of eastern Colorado trials at Fort Collins and Rocky Ford in which different formulations of Warrior are still effective against onion thrips, and Lannate LV is relatively ineffective. Figure 3 shows the average control from insecticide trials on the Front Range (7 Warrior, 2 Lannate trials) and West Slope (5 trials each insecticide). The differences in efficacy are the result of resistance acquired by thrips from past exposure to insecticides.

Efficacy of insecticides in the 2002 Fruita trials may have been increased by the 2 spray schedule. Thrips hatch from eggs and then spend two larval stages feeding actively on leaves before spending two quiescent stages in the soil. At summertime temperatures, the active and quiescent stages can last five days to a week. By applying two sprays, five days apart, most immature thrips will be exposed to insecticide residue.

Conclusions and Recommendations

- Early season flowering weeds, especially whitetop, provide a source of onion thrips for infesting of fields.
- The harvest or senescence of surrounding crops, especially alfalfa, can contribute significant numbers of western flower thrips to onion fields.
- Natural enemies can be very effective in reducing thrips numbers in onions. Control by natural enemies may not occur until thrips have reached damaging levels.
- There is considerable geographic variation in the response of onion thrips to insecticides. Growers should be aware of which insecticides are effective in their region. Thrips management should not rely exclusively on chemical methods.

Table 2. Results from insecticide trial #1.

Treatment	Rate	Thrips per plant					
		July 2			July 17		
	lb a.i./A	Adu	Immature	Total	Adult	Immatur	Total
Lannate LV	0.6	10.4	23.2a	33.6a	16.8a	22.3ab	39.0ab
Lannate LV + Sulfur	0.6 + 1.5	6.3	28.4ab	3.48a	13.5a	35.3ab	48.8ab
Vydate L	1.0	6.8	29.1ab	35.8a	10.0a	24.3ab	34.3a
Vydate L	0.5	5.2	34.9ab	40.1a	12.3a	22.3ab	34.5a
Vydate L + Sulfur	0.5 + 1.5	4.3	39.8abcd	44.1a	20.8ab	52.3abc	73.0abc
Warrior ZT + Lannate	0.03 +0.6	5.8	43.2abcd	49.0 ab	10.8a	18.3a	29.0a
Warrior ZT	0.03	4.4	54.0bcd	58.4ab	28.0ab	193.5d	221.5d
Sulfur	1.5	4.1	55.6cd	59.7ab	24.3ab	147.5cd	171.8cd
Warrior ZT + Sulfur	0.03 + 1.5	7.8	67.2cde	74.9bc	28.8ab	167.5d	196.3d
Actara	0.0625	5.3	68.7de	74.0bc	39.3bc	97.0abc	136.3abc
Warrior ZT + Actara	0.03 +	8.1	85.9e	94.0c	47.8c	148.8cd	196.5d
Untreated		4.2	54.8bcd	59.0ab	26.5ab	12.08bc	147.3bcd

Means within a column followed by the same letter are not significantly different (*P*=0.05).

Table 3. Results from insecticide trial # 3.

Treatment	Rate	Thrips per plant			
	lb a.i./A	15 July	18 July		
		Total	Adult	Immature	Total
Lannate LV	0.9	14.2 a	17.8	60.3 ab	78.0 a
Lannate LV + Penncap-M	0.6 + 0.5	14.6 a	25.8	45.3 a	71.0 a
Vydate L + Penncap-M	0.5 + 0.5	21.2 a	24.5	80.3 abc	104.8 ab
Penncap-M	0.5	76.7 b	31.8	217.0 bcd	248.8 bc
Provado 1.6 P	0.11	94.6 b	28.3	168.5 abcd	196.8 abc
Bathroid 2	0.04	124.2 cd	24.3	239.8 cd	264.0 c
Leverage 2.7 SE	0.063	137.1 d	32.3	274.0 d	306.3 c
Untreated		101.7 bc	28.3	266.0 d	294.3 c

Means within a column followed by the same letter are not significantly different (*P*=0.05).

Acknowledgments

This project was funded in part by a grant from the Colorado Onion Association. E.I. DuPont De Nemours and Company, Syngenta, and Bayer Corporation assisted with donations of material and funding. Melissa Foley assisted in all phases of fieldwork and sampling. Fred Judson and Lot Robinson assisted with fieldwork and irrigation.

Results of the Cooperative Dry Bean Nursery and State Uniform Dry Bean Variety Performance Test at Fruita, Colorado 2002

Calvin H. Pearson, Professor/Research Agronomist, Agricultural Experiment Station, Western Colorado Research Center at Fruita; **Mark A. Brick**, Professor, Plant Breeding, Fort Collins; **Jerry J. Johnson**, Extension Specialist Crop Production, Fort Collins; **J. Barry Ogg**, Research Associate, Fort Collins; **Cynthia L. Johnson**, Research Associate, Fort Collins. All authors are in the Department of Soil & Crop Sciences, Colorado State University.

Summary

Dry bean cultivar performance tests conducted in the dry bean producing areas of the state are important to provide farmers with information that has been obtained under local conditions. Such information can be used by farmers when selecting varieties to plant on their farms, to seedsmen in knowing which varieties to grow for seed production, to companies to determine which varieties to market and in which locations varieties are best adapted, and to university personnel in developing new dry bean varieties and to educate people about them. The Cooperative Dry Bean Nursery and the State Uniform Dry Bean Variety Performance Test were conducted at the Western Colorado Research Center at Fruita during the 2002 growing season. Yields in the Cooperative Dry Bean Nursery averaged 3160 lbs/acre and ranged from a high of 3734 lbs/acre for 93:208G, a Great Northern, to a low of 2465 lbs/acre for CPC 99814, a cranberry variety. Seventeen of the twenty-nine dry bean entries were high yielding. Yields in the State Uniform Dry Bean Variety Performance Test averaged 2011 lbs/acre and ranged from a high of 2468 lbs/acre for USPT-73 to a low of 1513 lbs/acre for CO75563. Nine of the twenty-four dry bean entries were high yielding.

Introduction

The Western Colorado Research Center at Fruita is an 80-acre property located 15 miles northwest of Grand Junction and 2 miles northeast of the city of Fruita. The elevation is 4510 feet with an average precipitation of slightly more than 8 inches. With an annual frost-free growing season of up to 175 days the growing season at Fruita is long compared to many other locations in Colorado. 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 loam. Irrigation is accomplished with gated pipe and furrows using a canal delivery system with water from the Colorado River. The long growing season, good irrigation water availability, the production of seed in the region, and a favorable environment for growing dry beans are important reasons for evaluating dry bean cultivars in western Colorado.

During 2002, we participated in the Cooperative Dry Bean Nursery in which the same varieties and advanced breeding lines of several market classes of dry beans were cooperatively evaluated in many locations across the U.S. and Canada. We also participated in the State Uniform Dry Bean Variety Performance Test in which the same entries were evaluated at six locations across Colorado. The State Uniform Dry Bean Variety Performance Test serves for screening new Colorado lines developed by CSU's dry bean breeding program. The State Uniform Dry Bean Variety Performance Test also allows for the

Fred Judson cutting the field in the pinto bean cultivar performance test, September 25, 2001 at the Western Colorado Research Center at Fruita. Photo by Calvin Pearson.

selection of promising new, high yielding and disease resistant lines, and also allows us to collect data from several locations and several environments in just one year, which provides considerable information about the performance of dry bean lines and varieties in diverse environments.

Materials and Methods

Cooperative Dry Bean Nursery

The Cooperative Dry Bean Nursery was conducted at the Western Colorado Research Center at Fruita in 2002. The experiment was a randomized complete block with four replications. Twenty-nine varieties and advanced breeding lines were included in the 2002 trial. The soil type was a Youngston clay loam. The previous crop was corn in 2001 and the previous crop in 2000 was alfalfa. Plot size was 5-feet wide by 25-feet long (2, 30-inch plant rows per plot). The field was irrigated prior to planting and herbicide application. Outlook herbicide (6.0 lb/gal. formulation) at 16 oz/acre and Eptam (7E) at 2 pts/acre as a tank mix were applied preplant broadcast on 10 June 2002 and incorporated by rollerharrowing once, followed by spike tooth harrowing. Planting occurred on 11 June 2002 with an air planter modified for planting plots. Plots were irrigated nine times averaging 13.4 hours per set during the growing season. Plots were cut on 27 September 2002 with a Pickett One-Step™ rod cutter windrower and threshed on 8 October 2002 using a Hege small plot combine equipped to harvest dry beans. Flowering date was recorded when 50% of the plants were showing the first flower.

State Uniform Dry Bean Variety Performance Test

The State Uniform Dry Bean Variety Performance Test was conducted at the Western Colorado Research Center at Fruita in 2002. The experiment was a randomized complete block with three replications. Twenty-four varieties and advanced breeding lines were included in the 2002 trial. The soil type was a Glenton very fine sandy loam. Plot size was 10-feet wide by 35-feet long (4, 30-inch rows). The field was irrigated prior to planting and herbicide application. Frontier herbicide (6.0 lb/gal. formulation) at 24 oz/acre and Eptam (7E) at 2 pts/acre as a tank mix were applied preplant broadcast on 5 June 2001 and incorporated by rollerharrowing once, followed by spiketooth harrowing. Planting occurred on 12 June 2002 with an air planter modified for planting plots. Seeding rate was approximately 85,120 seeds per acre. Plots were irrigated nine times averaging 13.0 hours per set during the growing season. Plots were cut on 24 September 2002 with a Pickett One-Step™ rod cutter windrower and threshed on 9 October 2002 using a Hege small plot combine equipped to harvest dry beans.

Results and Discussion

Weed control was good in the dry bean fields where these two studies were located. The 2002 cropping season in western Colorado was very dry and hot. Adequate irrigation water was available during the growing season and water was not a limiting input to the dry bean crop.

Cooperative Dry Bean Nursery

Data were collected in the Cooperative Dry Bean Nursery for seed yield, seed size (seeds/lb and weight per 200 seeds), and days to flowering (Table 1). Yield in the Cooperative Dry Bean Nursery averaged 3160 lbs/acre and ranged from a high of 3734 lbs/acre for 93:208G, a Great Northern, to a low of 2465 lbs/acre for CPC 99814, a cranberry variety. Seventeen of the twenty-nine dry bean entries were high yielding. Average number of seeds/lb was 1469 (68.39 g/200 seeds). Seeds/lb ranged from a large seed size of 916 seeds/lb (99.33 g/200 seeds) for CPC 99814 to a small seed size of 2608 seeds/lb (34.95 g/200seeds) for T-39, a black variety. Average number of days to flowering was 44. Two varieties (98:209G and Othello) flowered the earliest at 39 days after planting and B00136 took the longest time to flower at 52 days after planting.

State Uniform Dry Bean Variety Performance Test

Yield in the State Uniform Dry Bean Variety Performance Test averaged 2011 lbs/acre and ranged from a high of 2468 lbs/acre for USPT-73 to a low of 1513 lbs/acre for CO75563. Nine of the twenty-four dry bean entries were high yielding. Average number of seeds/lb was 1365. Seeds/lb ranged from a large seed size of 1147 seeds/lb for CO96753 to a small seed size of 1636 seeds/lb for CO84975. For more information and results on dry bean testing in Colorado visit the web site at:

http:www.colostate.edu/Depts/SoilCrop/extension/CropVar/index.html

Acknowledgments

Appreciation is expressed to Lot Robinson and Fred Judson (Western Colorado Research Center staff), and Daniel Dawson (part-time hourly employee) who assisted with this research. We express appreciation to the Colorado Dry Bean Administrative Committee for funding this research. Thanks to Carroll Bennett for digitizing and manipulating the picture used in this report.

Table 1. Performance of twenty-nine dry bean entries in the Cooperative Dry Bean Nursery at Fruita, Colorado in 2002.

Dry bean entry	Market Class	Yield	Seeds/lb	Seed weight	Days to flowering
		lbs/acre	no.	g/200 seed	no.
93:208G	Great Northern	3734	1295	70.20	40
USPT-72	Pinto	3602	1219	74.53	43
H9673-87	Black	3582	2405	37.90	49
PR95-055-2-1-16	Pink	3481	1254	72.40	42
RC-105	Pinto	3469	1370	66.43	40
R93-365	Small red	3455	1254	72.50	40
N97774	Small white	3449	2129	42.75	46
H 9659-23-1	Light red kidney	3428	1082	84.03	46
Flor 9623	Flor de Mayo	3398	1303	69.70	40
B00136	Black	3396	2517	36.10	52
USPT-CBB-1	Pinto	3360	1284	70.75	41
T-39	Black	3340	2608	34.95	51
Canario 107	Canario	3324	974	93.35	49
L95F025	Black	3251	2411	37.73	50
USPT-73	Pinto	3214	1155	78.98	40
Othello	Pinto	3184	1192	76.30	39
USWA-27	Anasazi	3139	1544	58.83	49
USPT-74	Pinto	3065	1259	72.25	41
Matterhorn	Great Northern	3063	1474	61.65	44
Grand Mesa	Pinto	2962	1441	63.08	45
H 9659-37-2	Dark red kidney	2952	953	95.45	44
USWA-33	Light red kidney	2952	1009	91.03	43
B98306	Black	2936	2356	38.68	49
USWA-39	Dard red kidney	2903	950	95.85	41
98:209G	Great Northern	2891	1280	71.03	39
LeBaron	Small red	2642	1332	68.18	40
CPC 00125	Small white	2552	1663	55.10	45
Nichols	Dark red kidney	2467	964	94.43	45
CPC 99814	Cranberry	2465	916	99.33	41
Average		3160	1469	68.39	44
LSD (0.05)		645	115	5	2
CV (%)		14.5	6	5.2	3.3

Table 2. Seed yield and seeds per pound of twenty-four dry bean varieties in the State Uniform Dry Bean Variety Performance Test conducted at Fruita, Colorado[1] in 2002.

Variety	Yield[2]	Seed/lb
	lb/acre	No.
USPT-73	2468	1257
CO83783	2387	1308
USPT-72	2350	1417
CO83778	2259	1317
Grand Mesa + Myconate +	2214	1374
Buckskin	2211	1344
CO96753	2192	1147
Bill Z	2190	1502
Montrose	2148	1328
CO96731	2112	1257
CO75619	2099	1532
CO75495	2062	1368
Grand Mesa	2053	1543
CO83777	1973	1191
CO75965	1919	1328
Poncho	1859	1335
Grand Mesa + Myconate +	1817	1248
CO84975	1782	1636
Rally	1770	1464
CO96737	1758	1315
USPT-74	1753	1459
GTS-900	1732	1192
CO96775	1656	1492
CO75563	1513	1415
Average	2011	1365
LSD (0.30)	340	

[1]Trial conducted on the Western Colorado Research Center; seeded 6/12 and harvested 10/9.
[2]Some yield variation resulted from herbicide damage in parts of the trial with sandy soil.
*Myconate® is a trademark product of VAMTech, L.L.C., commercially available for enhancing mycorrhizal colonization.

Small Grain Variety Performance Tests at Hayden, Colorado 2002

Calvin H. Pearson, Professor/Research Agronomist, Agricultural Experiment Station, Western Colorado Research Center at Fruita; **Scott Haley**, Wheat Breeder; **Jerry J. Johnson**, Extension Crop Production; **Cynthia Johnson**, Crops Testing Program; all Dept. of Soil & Crop Sciences, CSU Fort Collins

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. Three small grain variety performance tests (winter wheat, spring wheat, and spring barley) were conducted at Hayden in 2002. The 2002 growing season was very dry and overall yields in the trials were low. The 2002 results provide information about the performance of wheat and barley varieties under severe stress conditions. Grain yield in the winter wheat variety performance test averaged 1886 lbs/acre (31.4 bu/acre). The highest yielding variety in the winter wheat test was UT910422 at 2186 lbs/acre (36.4 bu/acre) with twelve varieties outyielding the other eight. Grain yield in the spring wheat variety performance test averaged 721 lbs/acre (12.0 bu/acre). The highest yielding variety in the spring wheat test was Dirkwin at 1092 lbs/acre (18.2 bu/acre) with five varieties outyielding the other six. Grain yield in the spring barley variety performance test averaged 884 lbs/acre (18.4 bu/acre). The highest yielding variety in the spring barley test was Hector at 1370 lbs/acre (28.5 bu/acre) with eight outyielding the other fourteen.

Introduction

Growers in northwest Colorado are limited to only a few crops to grow because of constraints created by dryland production conditions, a short growing season, limited precipitation, and isolation to markets. Growers in this region of Colorado are supportive of agronomic research that provides them with science-based information and when adapted to their farms can lead to increased crop yields and profits. Alternative crops are also of interest to growers in northwest Colorado. The principal cash crop grown in northwest Colorado is wheat. Alternative small grains, such as malting barley, triticale, and specialty wheats (i.e., hard white wheats) are of interest to growers because these crops are often sold into specialty markets which demand a premium selling price. Alternative crops, such as these specialty small grains, are also of interest because they can be grown with production practices and equipment already owned by farmers. During 2002, we conducted winter and spring small grain variety tests that included not only traditional small grains but also some of these specialty small grains.

Tour of winter wheat variety test plots at Hayden, Colorado. July 30, 2001. Photo by Calvin Pearson.

Materials and Methods

Winter Wheat Variety Performance Test

Twenty winter wheat varieties and lines were evaluated during the 2002 growing season at the Mike and Dutch Williams Farm near Hayden, Colorado. The experiment design was a randomized complete block with four replications. Plot size was 4-feet wide x 40-feet long with six seed rows per plot. The seeding rate was 56 lbs/acre and planting occurred on October 3, 2001. An application of 2,4-D at 0.50 lb/acre was made on May 15, 2002. No insecticides or fertilizer were applied. Harvest occurred on July 31, 2002 using a Hege small plot combine.

Spring Small Grain Variety Performance Tests

Eleven spring wheat and twenty-two spring barley entries were evaluated during the 2002 growing season at the Dutch and Mike Williams Farm near Hayden, Colorado. The experiment design was a randomized complete block with four replications. Plot size was 4-feet wide x 40-feet long with six seed rows per plot. Planting occurred on May 6, 2002. Spring wheat was planted at 60 lbs seed/acre and spring barley was planted at 56 lbs seed/acre. No fertilizer, herbicides, or insecticides were applied to the spring wheat or barley plots. Spring wheat plots and spring barley plots were harvested on September 4, 2002 using a Hege small plot combine.

Spring wheat variety test plots at Hayden, Colorado. June 12, 1998. Photo by Calvin Pearson.

Results and Discussion

Precipitation during the 2002 growing season for the months of April, May, June, July, August, September, and October was 1.57, 0.23, 0.35, 0.74, 1.90, 1.26, and 1.61 inches, respectively. Precipitation in the Craig/Hayden area varies considerably from month to month and year to year and is the most limiting factor for dryland small grain production.

Winter Wheat Variety Performance Test

Grain moisture in the winter wheat variety performance test at Hayden averaged 8.8% (Table 1). Grain moisture content ranged from a high of 9.2% for IDO571 to a low of 8.5% for IDO574. Grain yields of the winter wheat varieties averaged 1886 lbs/acre (31.4 bu/acre). Grain yield ranged from a high of 2186 lbs/acre (36.4 bu/acre) for UT910422 to a low of 1486 lbs/acre (24.7 bu/acre) for IDO517. Twelve of the twenty winter varieties outyielded the other eight varieties. Test weights averaged 55.1 lbs/bushel. Test weights ranged from a high of 57.6 lbs/bushel for Trego to a low of 52.1 lbs/bushel for Presto. Planted height averaged 22.6 inches. Plant heights ranged from a high of 30.8 inches for Presto to a low of 18.7 inches for Trego. There was no lodging in the winter wheat variety performance test in 2002. Protein concentration averaged 15.7%. Protein concentration ranged from a high of 17.7% for IDO517 to a low of 12.9% for Presto triticale.

Spring wheat variety test plots at Hayden, Colorado, June 19, 2001. Photo by Calvin Pearson.

Spring Wheat Variety Performance Test

Grain moisture in the spring wheat variety performance test averaged 9.9% (Table 2). Grain yields averaged 721 lbs/acre (12.0 bu/acre). Grain yield ranged from a high of 1092 lbs/acre (18.2 bu/acre) for Dirkwin to a low of 415 lbs/acre (6.9 bu/acre) for Walworth. Test weight averaged 56.5 lbs/bushel. Plant height averaged 13.8 inches. Plant height ranged from a high of 15.5 inches for IDO566 to a low of 12.5 inches for Eden. There was no lodging in the spring wheat variety performance test in 2002.

Spring Barley Variety Performance Test

Grain moisture in the spring barley variety performance test averaged 13.1% (Table 3). Grain yield averaged across all varieties was 884 lbs/acre (18.4 bu/acre). Grain yield ranged from a high of 1370 lbs/acre (28.5 bu/acre) for Hector to a low of 403 lbs/acre (8.4 bu/acre) for Provena, a naked-seeded oat. Test weight averaged 44.5 lbs/bushel. Plant height averaged 15.0 inches. Plant height ranged from a high of 17.6 inches for Conlon to a low of 11.0 inches for Ajay oats. There was no lodging in the spring wheat variety performance test in 2002.

Acknowledgments

Farmer-cooperators for the winter wheat, spring wheat, and barley variety performance tests were Dutch and Mike Williams. We thank Dutch and Mike for their willingness to participate with us in conducting this research. We also thank C.J. Mucklow, CSU Cooperative Extension, for his assistance with our small grain research in northwest Colorado. Appreciation is also expressed to Lot Robinson, Fred Judson (Western Colorado Research Center staff), and Daniel Dawson (part-time hourly employee) who assisted with this research. Special appreciation is extended to the Colorado Wheat Administrative Committee for funding this research. Thanks to Carroll Bennett for digitizing and manipulating the pictures used in this report.

Table 1. Winter wheat variety performance at Hayden, Colorado in 2002. Farmer-Cooperators: Mike and Dutch Williams.

Variety	Grain moisture	Grain yield		Test weight	Plant height	Protein
	(%)	lbs/acre	bu/acre	lbs/bu	inches	%
UT910422	8.7	2186	36.4	55.3	24.8	16.5
Lakin	8.7	2154	35.9	56.8	22.1	14.6
Above	8.7	2135	35.6	55.6	20.5	14.7
Golden Spike	8.8	2116	35.3	54.6	24.1	15.1
CO99534	8.9	2068	34.5	55.9	20.4	16.4
UT203032	8.6	1992	33.2	54.9	23.1	16.1
IDO574	8.5	1969	32.8	57.1	26.5	15.1
IDO550	9.1	1946	32.4	54.1	22.4	17.1
UT910320	8.6	1928	32.1	53.6	22.7	16.1
CO99508	8.9	1897	31.6	54.6	21.7	16.3
Avalanche	8.6	1853	30.9	56.8	20.9	15.7
IDO575	8.9	1852	30.9	54.8	22.8	14.1
IDO573	8.6	1845	30.8	56.3	22.9	16.9
Trego	8.8	1829	30.5	57.6	18.7	15.3
Fairview	8.8	1768	29.5	54.0	22.7	16.9
Presto (triticale)	9.1	1730	28.8	52.1	30.8	12.9
IDO571	9.2	1719	28.7	53.1	21.5	17.0
CO970547	8.9	1654	27.6	55.2	20.5	14.7
Hayden	8.5	1587	26.5	57.5	24.3	15.6
IDO517	8.9	1486	24.7	52.2	19.2	17.7
Ave.	8.8	1886	31.4	55.1	22.6	15.7
LSD (0.05)	0.3	336	5.6	1.4	1.8	
CV (%)	2.1	10.8	10.8	1.6	4.8	

Table 2. Spring wheat variety performance test at Hayden, Colorado 2002. Farmer-Cooperators: Mike and Dutch Williams.

Barley variety	Grain moisture	Grain yield		Test weight	Plant height
	(%)	lbs/acre	bu/acre	lbs/bu	inches
Dirkwin	10.2	1092	18.2	53.4	14.5
IDO566	9.8	971	16.2	57.2	15.5
ID377S	9.7	845	14.1	57.9	14.7
Forge	9.7	814	13.6	58.4	13.9
IDO577	10.1	812	13.6	57.1	14.4
Oxen	9.7	702	11.7	56.5	12.6
Eden	9.7	701	11.7	57.8	12.5
Winsome	9.8	585	9.7	55.7	13.2
Grandin	9.9	500	8.3	57.1	13.4
Briggs	9.5	484	8.1	56.7	13.8
Walworth	10.9	415	6.9	53.6	13.0
Ave.	9.9	721	12.0	56.5	13.8
LSD (0.05)		342	5.7		1.8
CV(%)		33	32.8		9.2


Seed of ‘Hayden’ hard red winter wheat.

Table 3. Spring barley variety performance test at Hayden, Colorado 2002. Farmer-Cooperators: Mike and Dutch Williams.

Wheat variety	Grain moisture	Grain yield		Test weight	Plant height
	(%)	lbs/acre	bu/acre	lbs/bu	inches
Hector	13.0	1370	28.5	48.2	17.4
Targhee	15.0	1349	28.1	45.6	15.7
Powell (oat)	-	1272	26.5	-	12.3
Monida (oat)	16.1	1199	25.0	32.8	16.4
C40	10.0	1166	24.3	48.8	15.2
Harrington	11.8	1065	22.2	48.0	15.4
Steptoe	10.1	1050	21.9	44.0	14.1
85Ab2323	16.0	1028	21.4	47.3	14.8
Camas	13.2	978	20.4	47.9	14.6
Griton	15.1	926	19.3	44.9	16.9
C37	10.7	904	18.8	48.2	15.0
98Ab12362	10.4	896	18.7	45.8	13.4
94Ab13449	11.3	808	16.8	45.0	13.2
98Ab11865	19.5	790	16.5	44.1	15.8
Ajay (oat)	14.0	782	16.3	33.6	11.0
93Ab688	11.7	737	15.4	42.1	14.6
Conlon	10.7	718	15.0	45.9	17.6
Xena	11.8	596	12.4	45.3	16.3
Garnet	13.8	532	11.1	44.1	14.8
Lamont (oat)	13.0	450	9.4	43.4	16.0
97Ab8333	14.7	439	9.2	42.4	13.8
Provena (oat)	12.6	403	8.4	47.5	15.0
Ave.	13.1	884	18.4	44.5	15.0
LSD (0.05)		384	8.0		2.1
CV (%)		30.7	30.7		9.7

Dr. Horst W. Caspari

2002 Research Projects:

Viticulture & Enology Programs for the Colorado Wine Industry.
Partial Root Zone Drying (Wash. Tree Fruit Research Commission funded; P. Andrews, B. Leib, T. Auvil, & J. McFerson; + T. Einhorn)
Soft Control Options for Grape Powdery Mildew (H. Larsen)
Application of Weather-Data Driven Computer Models to Grape Powdery Mildew Control in Colorado (Colorado Specialty Crops Program, RMAVV, & EPA funded; H. Larsen)
Potential Use of Tydeid Mites for Biological Control of Grape Powdery Mildew (WRIPM funded; A. Norton -- CSU Dept. of Bioag. Sci. & Pest Mgmt., & H. Larsen)

2002 Publications:

<u>Conference papers:</u>

Larsen, H.J. and H.W. Caspari. 2002. Delaying bud break of grapevines. Proc. 21. New Mexico Grape Growers & Winemakers Conference, 1 – 2 February 2002, Albuquerque, NM, USA, pp. 96-98.
Larsen, H.J. and H.W. Caspari. 2002. Developing alternative control strategies for grape powdery mildew in Colorado. Proc. 21. New Mexico Grape Growers & Winemakers Conference, 1 – 2 February 2002, Albuquerque, NM, USA, pp. 99-105.
Caspari, H. 2002. The fruit industry in Western Colorado. 2002 PPFA Annual Conference, 30 July – 1 August 2002, Grand Junction, CO, USA.
Caspari, H.W., T.C. Einhorn, S.M. Neal, P. Alspach, B. Leib, L. Lombardini, T.D. Auvil and J.R. McFerson. 2002. Irrigation volumes rather than placement determine response of apple trees to deficit irrigation. XXVI International Horticultural Congress, 11 - 17 August 2002, Toronto, Canada.
Lombardini, L., H.W. Caspari, D.C. Elfving, T.D. Auvil, and J.R. McFerson. 2002. Gas exchange and water relations in ‘Fuji’ apple trees grown under deficit irrigation. XXVI International Horticultural Congress, 11 - 17 August 2002, Toronto, Canada.
Leib, B., P. Andrews, C. Redulla, and H. Caspari. 2002. Deficit irrigation and Partial Rootzone Drying compared in Fuji apples. Proc. 23rd Annual International Irrigation Show & Conference, 24 – 26 October 2002, New Orleans, LA, USA, 8 pp.
Caspari, H.W., B. Leib, P.K. Andrews, T.D. Auvil, and J.R. McFerson. 2002. Growing apples in Washington State with only 12 inches of irrigation water – fact or fiction? Proc. Washington State Horticultural Association Annual Meeting, 2 – 4 December 2002, Yakima, WA, USA, 5 pp.

<u>Book chapters:</u>

Green, S., B. Clothier, H. Caspari, and S. Neal. 2002. Rootzone processes, tree water-use and the equitable allocation of irrigation water to olives. In: Raats, P.A.C., D.E. Smiles, and A. Warrick (Eds.). Environmental Mechanics: Water, Mass and Energy Transfer in the Biosphere. Geophysical Monograph Series Vol. 129, pp. 337-345. American Geophysical Union, Washington, DC, USA.

<u>Client Reports</u>

Max, S., H.W. Caspari, and H.J. Larsen. 2002. Evaluation of the effect of hail on Chardonnay grape production. Annual Report 2001, National Crop Insurance Service, 10 pp.
Caspari, H., P. Andrews, and B. Leib. 2002. Partial Rootzone Drying – A new deficit irrigation strategy for apples and pears. Annual Report, Washington Tree Fruit Research Commission, 8 pp.

<u>Technical Reports</u>

Sharp, R., H. Caspari, and D. Hoag. 2002. The cost of growing wine grapes in Western Colorado, 20 pp. www.coopext.colostate.edu/WR/costofgrowinggrapes.pdf.

Robert W. Hammon

2002 Research Projects

Extending Irrigated Alfalfa Stand Life by Alteration of Late-Season Harvest Schedules
Management of Onion Thrips in Commercial Onions
Biology and Management of Sap Beetles in Sweet Corn
Cooperative Agricultural Pest Survey
Biological Control of Cereal Leaf Beetle
Factors Influencing the Establishment of Seeded Bitterbrush at Maybell Colorado
Insects Impacting the Production of *Penstemon* Seed
Development of Russian Wheat Aphid Resistant Spring and Winter Barleys
Evaluation of YieldGard Corn for Corn Earworm Control

2002 Publications

Hammon, R.W and M. Foley. 2002. Bean (Pinto), Western Flower Thrips Control, 2001. Arthropod Management Tests 27:E2

Hammon, R.W and M. Foley. 2002. Alfalfa, Western Flower Thrips Control, 2001. Arthropod Management Tests 27:F2

Hammon, R.W and M. Foley. 2002. Onion, Onion Thrips Control, 2001. Arthropod Management Tests 27:E53

Hammon, R.W. and G. Noller. 2002. Fate of Fall-planted Bitterbrush Seed at Maybell Colorado. *In*: Proceedings of the 2002 High Altitude Reclamation Workshop.

Hammon R.W and M. O'Neill. 2002. Evaluation of YieldGard Corn for Corn Earworm Control. *In:* 2001 Annual Progress Report, NMSU Farmington Science Center. NMSU Agric. Exp. Sta. Las Cruces NM.

Berrada. A. et al. 2002. Developing sustainable dryland cropping systems in SW Colorado and SE Utah using conservation tillage andcrop diversification. Colo. Agric. Exp. Sta. Tech. Bull. TB 02-02.

Hammon. R. 2002. Onion Variety Tolerance to Thrips Feeding. *In*: Onion Research Reports, M. Bartolo ed. Arkansas Valley Research Center Report to Industry.

Dr. Calvin H. Pearson

2002 Research Projects

Water-use efficiency of cool-season turf grass species in western Colorado - Fruita (City of Grand Junction, Bureau of Reclamation, Arkansas Valley Seed Solutions, and Barenbrug)

Grain Crops:
Winter wheat cultivar performance test - Hayden (Mike and Dutch Williams, Dr. Scott Haley, C.J. Mucklow)
Spring wheat and spring barley cultivar performance tests - Hayden (Mike and Dutch Williams, Dr. Scott Haley, C.J. Mucklow)
Long season corn grain hybrid performance test - Fruita (Dr. Jerry Johnson, seed companies)
Short season corn grain hybrid performance tests - Fruita, Delta (Wayne Brew, Dr. Jerry Johnson, seed companies)
Corn forage hybrid performance tests - Fruita, Olathe (Earl Seymour, Dr. Jerry Johnson, seed companies)

Forage Crops:
Alfalfa variety performance test (2002-2004) - Fruita (Dr. Jerry Johnson, seed companies, breeding companies, private industry)
Alfalfa germplasm evaluations, 2000-2002 and 2002-2004 tests - Fruita (Dr. Peter Reisen of Forage Genetics)

Other:
Field evaluation of baler liner in alfalfa hay - Fruita (Leland Driggs of L.D. Ag Machinery, L.L.C.)
Cooperative dry bean nursery test - Fruita [Colorado Dry Bean Administrative Committee (CDBAC), Dr. Mark Brick and Barry Ogg, Dry Bean Breeding Project]
State pinto bean cultivar performance test - Fruita (CDBAC, Dr. Jerry Johnson)
Evaluation of Golden Harvest corn hybrids for BES - Fruita (Wayne Fithian of J.C. Robinson Company)
Hybrid poplar performance tests - Fruita, Orchard Mesa, and Hotchkiss (Dr. Matt Rogoyski, Dr. Ron Godin, Shane Max)
Container-grown production of native plant species - Orchard Mesa (Dr. Matt Rogoyski)
Development of sunflower as an industrial, natural rubber-producing crop (Dr. Katrina Cornish, USDA-ARS, Albany, CA; Dr. Jay Keasling, U.C. Berkeley; Dr. Dennis Ray, University of Arizona; Dr. John Vederas, University of Edmonton)

*Cooperators/collaborators/sponsors are noted in parentheses.

2002 Publications

Brick, M.A., H.F Schwartz, J.B. Ogg, J.J. Johnson, F. Judson, and C. H. Pearson. 2002. Registration of ‘Shiny Crow’ Black Bean. Crop. Sci. 42:1751-1752.
Pearson, Calvin H. 2002. Letter From The Editor. Agron. J. 94:171.
Brummer, J.E., and C.H. Pearson (eds.). 2002. Proceedings of the Intermountain Forage Symposium. Colorado State University. Agricultural Experiment Station and Cooperative Extension. Technical Bulletin LTB 02-1. 136 p.
Max, Shane and Calvin Pearson. 2002. Operating Protocol for Growing Transgenic Plants at the Western Colorado Research Center. Colorado State University, Agricultural Experiment Station. Grand Junction, Colorado. Updated January 2003. 6p.
Berrada, Abdel, Merlin Dillon, Scott Haley, Jerry Johnson, Calvin Pearson, Jim Quick, and Mark Stack. 2002. Making Better Decisions: 2001 Colorado Spring Wheat, Barley, and Oats Performance Trials.

Colorado State University, Agricultural Experiment Station and Cooperative Extension, Technical Report TR02-3. Fort Collins, Colorado.
Johnson, Jerry J., Frank C. Schweissing, Calvin H. Pearson, James P. Hain, Cynthia L. Johnson, and Steve Norberg. 2002. 2002 Colorado Corn, Soybean, and Sunflower Performance Trials. Colorado State University, Agricultural Experiment Station and Cooperative Extension, Technical Report TR02-10. Fort Collins, Colorado.
Pearson, Calvin H., Charles A. Holcomb, A. Wayne Cooley, and John E. Murray. 2002. Guidelines for Using Conservation Tillage Under Furrow Irrigation. Colorado State University, Agricultural Experiment Station and Cooperative Extension, Technical Report TR02-6. Fort Collins, Colorado.
Berrada, A., Bruce Bosley, Bill Brown, ... Calvin Pearson, ... , and Cris Woodward (25 authors listed alphabetically). 20202. Making Better Decision: 2001 Colorado Wheat Variety Performance Trials. Colorado State University, Agricultural Experiment Station and Cooperative Extension, Technical Report TR02-7. Fort Collins, Colorado.

Website developed to inform/educate people regarding our research project entitled, "Commercial and Strategic Rubber from Crop Plants and Bioreactors." The website address is:
www.naturalrubber.info.