Technical Report TR12-7

Colorado State University

Agricultural Experiment Station

College of Agricultural Sciences | Department of Soil and Crop Sciences | Southwestern Colorado Research Center | Colorado State University Extension

Southwestern Colorado Research Center

2011 Research Report

Colorado State University

Agricultural Experiment Station

Southwestern Colorado Research Center

2011 Field Crops Research Results

Editor: Abdel F. Berrada, Senior Research Scientist & Manager
Colorado State University
Southwestern Colorado Research Center
Yellow Jacket, Colorado

Cover photo shows the Dryland Crop Rotation Trial at the Southwestern Colorado Research Center with the Sleeping Ute Mountain in the background. Photo taken on October 4, 2010 by Abdel Berrada.

Acknowledgments

The following individuals have contributed to the 2011 research projects at the Southwestern Colorado Research Center (SWCRC):

1. Crop testing
    a. Dry bean: Dr. Mark Brick of CSU Ft. Collins
    b. Canola: Michael Stamm of KSU & Dr. Jerry Johnson of CSU Ft. Collins
    c. Camelina: Dr. Jerry Johnson of CSU-Ft. Collins
    d. Wheat: Dr. Scott Haley of CSU Ft. Collins
2. Sunflower research: Joel Schneekloth of CSU Extension at Akron, Bob Hammon of CSU Extension at Grand Junction, Rodney Sharp of CSU Extension at Grand Junction, and Daniel Fernandez, recently retired CSU Extension Director in Dolores County
3. Native plants (not included in this report): Dr. Ron Godin of CSU Extension in Delta (project sponsored by the San Juan National Forest)

Jerry Mahaffey (Research Technician), Amin Berrada (Research Associate), Daniel Cole (summer help), and Jordan Lestina (summer help) assisted with the installation and maintenance of field trials, and with data collection. Amin Berrada helped put this report together.

This report was reviewed by Dr. Gary A. Peterson and Dr. Dwayne G. Westfall, Emeritus Professors at CSU-Ft. Collins.

Disclaimer

Mention of a trademark or proprietary product does not constitute endorsement by the Colorado Agricultural Experiment Station.

Colorado State University is an equal opportunity/affirmative action institution and complies with all Federal and Colorado State laws, regulations, and executive orders regarding affirmative action requirements in all programs. The Office of Equal Opportunity is located in 101 Student Services. In order to assist Colorado State University in meeting its affirmative action responsibilities, ethnic minorities, women, and other protected class members are encouraged to apply and to so identify themselves.

Table of Contents

Table of Figures

Table of Tables

A brief history of the Southwestern Colorado Research Center*

Abdel Berrada†

Agricultural research in southwestern Colorado began at the San Juan Basin Research Center near Hesperus in 1921. The major emphasis was to identify crop species and varieties adapted to the high altitudes of southwestern Colorado under both dryland and irrigated conditions. Crops tested included grass, clovers, alfalfa, field peas, corn, potatoes, dry beans, sugar beets, small grains, and vegetables.

By the mid-1940's, southwestern Colorado became a major pinto bean-producing area. A comprehensive edible dry bean research program was initiated during this period. The pinto bean variety 'San Juan Select' was developed and released in 1946. An additional research site at Yellow Jacket (Yellow Jacket Unit of the San Juan Basin Research Center) was opened in 1962 to study management of dryland soils and crops. Major emphasis was on the production of pinto beans, winter wheat, and soil and water conservation practices. Additional crops studied at Yellow Jacket under dryland conditions included grasses, alfalfa, sunflowers, oats, barley, safflower, and sorghum.

The soil and crop sciences section of the San Juan Basin Research Center separated from animal science in 1971 and leased a farm 10 miles northwest of Cortez in the Arriola area. The need for a research facility in the Cortez area was catalyzed by plans to construct the Dolores Project, a Bureau of Reclamation irrigation, municipal, industrial, and recreation project. The Colorado Legislature, Bureau of Reclamation, Four Corners Regional Commission, and the Soil Conservation Service provided the funding to lease and operate the 300-acre farm. Surface and sprinkler irrigation systems were studied utilizing furrow, flood, gated pipe, sideroll, center pivot, end-tow, and traveling gun. The economic impact of converting from dryland farming to irrigated agriculture was assessed. An adjacent 20-acre dryland site was added in 1976 for research on plant-water relationships, erosion control, dryland cultural practices, fertilizer use, and bean root rot control. The lease on the Arriola farm expired and research at the San Juan Basin Research Center-Cortez Unit ceased in 1983.

The present 158-acre farm located 15 miles north of Cortez on County Road Z was purchased by the State Board of Agriculture (now Board of Governors of the Colorado State University System) in 1981. An office, shop, equipment shed, and later a hay storage facility were constructed. A 650 ft. length (32-acre) center pivot was donated by Valmont Industries with the assistance of Jarmon Irrigation and erected in 1986. Water from the Dolores Project was delivered to the research center for the first time in June 1987. The Dolores Water Conservancy District and the Southwestern Water Conservation District contributed funds for the development of the research center. The name 'Southwestern Colorado Research Center' (SWCRC) was officially given to this research facility in 1984. In 1988, 30 acres one-half mile northeast of the research center was leased to conduct research on dryland

---

* Mark Stack, former manager of the SWCRC, contributed to this article.

† Senior Research Scientist and Manager of the SWCRC

cropping systems. The lease was terminated in 2010 but to compensate for the change 20 acres of previously irrigated cropland on the main farm were converted to dryland production.

The SWCRC is part of the Colorado Agricultural Experiment Station whose mission is to "conduct research that addresses the economic viability, environmental sustainability, and social acceptability of activities impacting agriculture, natural resources, and consumers in Colorado" (http://www.aes.colostate.edu/). The two major research programs at the SWCRC are (1) crop testing and (2) management practices to optimize crop production. Numerous crop species, varieties and experimental lines have been tested to assess their performance and adaptation to the local soil and climatic conditions. Species tested include alfalfa, dry bean, winter wheat, spring wheat, canola, safflower, sunflower, camelina, oat, barley, triticale, chickpea, peppermint, quinoa, lentils, and edemame beans. Seeds for the field crops variety performance trials come from CSU's crop improvement programs, other land grant universities, and private companies. CSU has released crop varieties that have performed well at the SWCRC. Examples are 'Cahone' dry bean, 'Fairview' winter wheat, and 'Sylvan' spring wheat. The other major program at the SWCRC is the testing and development of best management practices to optimize crop production. These practices include planting dates, seeding rates, water and nutrient management, and crop rotations. For example, the primary objective of a recent project is to enhance sunflower seed and oil production with limited irrigation and nitrogen fertilizer. Another project examines the viability of sunflower and other oilseed crops in dryland crop rotations. The information generated through field experimentation at the SWCRC is disseminated via publications and presentations at meetings, workshops, and field days. Most of the published results can be accessed online at: http://www.colostate.edu/Depts/AES/pubs_list.html or http://www.extsoilcrop.colostate.edu/CropVar/.

A fruit tree project was initiated in 1991 to demonstrate surface drip and micro-spray irrigation. It was later expanded to include additional apple varieties, peaches, pears, wine grapes, high-density apple plantings, and grass cover plantings. The fruit tree and vineyard demonstration orchard is managed by Dolores County and Montezuma County Extension services with assistance from the Southwestern Colorado Research Center. A fruit pruning workshop is held each year. The fruit is marketed through U-PICK days with the proceeds helping fund the operation of the orchard. The orchard's performance is evaluated annually and can be accessed at: http://www.extension.colostate.edu/WR/Dolores/fruitproj.htm

The SWCRC has an advisory committee that meets annually to discuss and review current and future research and demonstration projects. The committee includes farmers and ranchers, agri-business and agency representatives, and extension personnel and gives guidance to the SWCRC project manager. It is currently chaired by David McCart.

Advisory Committee Meeting‡

January 31, 2012

Pleasant View Fire Station

David McCart, Advisory Committee Chair

The meeting started with everyone introducing themselves. Minutes from the previous meeting were accepted without modification. Officers were elected: Matt Mecham was chosen as the Vice Chairman of Steering Committee and David McCart was retained as Chairman.

Abdel Berrada, Senior Research Scientist/Manager, SWCRC.

Dr. Berrada presented the highlights of the 2011 season and plans for 2012.

Highlights of 2011 season

For the native plants seed production project about 30 species were planted in the fall of 2010 but many of them did not establish. The research center had a successful field day in August. Dr. Berrada urged the attendees to sign up for the Ag/Renewable Energy Workshop which will take place at the Lewis-Arriola Community Center on February 6, 2012. A map of the crops grown at the research center in 2011 was shown. The yields were about average and prices were good. The 2011 precipitation from rain and snow was below average most months with a few months that were above average. Precipitation for the year was 77% of normal. Proso millet 'Huntsman' was grown on approximately 3.0 acres for observation purposes. It did very well.

Several variety trials were conducted in 2011: spring camelina, winter wheat, spring wheat, dry bean, sunflower, and winter canola. Spring camelina had problems including shattering and uneven maturity. Winter wheat had very good growth until June. The kernels were a little shriveled. Grain yield averaged 51 bu/A but the test weight was low. Protein content was good. Winter canola averaged 1632 lb/A with no irrigation.

Spring camelina planted in early September winter killed. The variety 'Yellow Stone' did well when it was planted on 12-Oct. For the dryland crop rotation trial winter wheat had the highest yield, but safflower had the highest gross revenue. Sunflower after dry bean did better than sunflower after conventional -tillage summer fallow due to more available water at planting. Dry bean after summer fallow produced almost twice the seed yield of dry bean after dry bean.

Sunflower responded well to limited irrigation in 2011. Seed yield of the full irrigation treatment was similar to the treatment where most of the water was applied during the R-1 to R-6 growth stages. The second highest yield was produced when water was applied mostly during flowering (R-4 to R-6). The latter had much greater water use efficiency than the full irrigation. Seed oil content decreased when 50 or 100 lb N/A was applied to the sunflower crop compared to the check. In contrast, seed yield increased significantly with 50 lb N/A.

‡ The minutes of this meeting were taken by Amin Berrada.

An irrigated pinto bean trial had several different treatments including: single or double rows, two different seeding rates, and several varieties. There were no significant differences in yield between single and double rows or between low and high seeding rates. There were significant differences in yield between different varieties. This same study was done at several different locations and in some circumstances the double row configuration had a higher yield than single rows.

Plans for 2012

Projects planned for 2012 include continuing the dryland crop rotation trial and finishing a crop consumptive use simulation for the Dolores Water Conservancy District. Potential projects for the future include irrigation management to optimize grass/forage production in Montezuma Valley, cover crops, and possibly no-till farming. Steve Trudeau of BASIN CO-OP suggested testing short season corn with limited irrigation. The research center lacks corn harvesting equipment right now but the idea will be looked into.

Mark Stack commented that the amount of foxtail on his farm has greatly increased.

Presentation by Craig Beyrouty, Dean College of Agricultural Sciences

Craig Beyrouty gave an update on the College of Agricultural Sciences (CAS). Student numbers are up. He discussed awards achieved by students including the National Spokesperson for Ag contest winner and Boettcher Scholars. Judging teams are ranked nationally. Faculty news includes a new Equine Sciences endowed chair and a Rouse Chair in Animal Breeding/Genetics. Temple Grandin was named to the Colorado Women's Hall Of Fame.

The college is in the process of renovating the animal sciences building. For the 30th anniversary of Ag day 3,000 to 4,000 people attended. The Ag Adventure took place in Ft. Collins, Denver, and Cortez. Seventeen hundred 3rd graders and 200 adults attended. There were 200 student volunteers. Ag Adventure helps the elementary school students develop an understanding for what agriculture is about.

The College has a responsibility to contribute to the well-being of the citizens of Colorado by doing research and translating it into something that can be used by others. CSU activities take place throughout Colorado. CAS faculty toured western Colorado last year.

Chris Landry, Executive Director, Center for Snow and Avalanche Studies: Dust-on-Snow is Affecting Colorado Snowmelt Water Supplies

The study was done by the Center for Snow and Avalanche Studies which is a Nonprofit. One of the study locations was near Red Mountain Pass at Senator Beck Basin. In the spring of 2009, dust from the Colorado Plateau was deposited at the study site. Deciding that the dust came from the Colorado Plateau was based on the chemistry and size of the dust which also indicated that the dust did not come from Asia. On April 3, 2009 the wind was primarily from the Southwest which is typical for dust on snow events. These events also cause dust storms in Moab which lead to traffic accidents.

Dust on snow events have been increasing over the last decade. Lake core samples have recreated a history of dust events going back 6,000-7,000 years. The rate of deposition went up by approximately a

multiple of 10 following settlement by Caucasian people. There was a drop in dust deposition following passage of the Taylor Grazing Act. Dust deposition stabilized at 6-7 times the pre-settlement rate.

Last year was the wettest year since the study started. The snow melt was also delayed. The study utilized several different weather stations. Albedo measurements are taken at the weather stations. There is a trend toward an increasing amount of wind over the winter (over study period).

Dirty snow absorbs much more visible sunlight than clean snow. The timing of snowmelt is partly due to amount of dust on snow. With clean snow the time until the snow was all gone would have occurred 22-31 days later than with actual dirty snow conditions.

The Colorado dust-on-snow program generates a report every couple weeks throughout the spring. There were twelve dust events in 2009 generating 55 grams of dust/m^2. Over time the surface of the snow gets darker and darker as the snow melts.

Dust-on-snow events are having an effect on the ski industry. Arapahoe Basin had to close some areas in 2010 because of dust on snow. There is rapid snowmelt once dust has emerged onto the surface of the snow. This causes an early peak in river flow. Runoff at Lees Ferry, AZ peaked three weeks early. The peak at Lees Ferry was also lower because of greater evapotranspiration usage by plants at high elevations. Overall, this led to 4.9% less water at Lee's Ferry.

Dust-on-snow events are affecting the whole state, not just Southwest Colorado. Snow is all gone up to 50 days earlier than without dust. This exceeds the effects of raising temperatures up to 5^{o}C. Dust on snow has reduced Colorado River Basin flows 3-7%. What is still unknown is how much dust to allocate to different disturbances.

Presentation about Cover Crops by Lon Varnis of the Dolores Conservation District

The economic advantages of using cover crops were discussed. Some of these advantages include less tillage which reduces fuel costs and soil temperature, which in turn reduces evaporation.

Tom Hooten, Interim Extension Director, Montezuma County: Orchard Update

This year is the 150th anniversary of Morrill Act and the 100-year anniversary of Extension in Colorado. The pruning workshop was held at the orchard on March 30th, 2011. Approximately 70 people attended. Some new trees were planted in the orchard to replace trees that had been killed by herbicide drift. Last year there was a plum crop for the first time. On September 24, 2011 there was a U-Pick day at the orchard. It was very successful with an estimated 700 people attending. Approximately 17,500 pounds of fruit were sold. Volunteers are very important for the orchard project.

Kim Dillivan, Extension Director, Dolores County

Kim is new to both CSU and Colorado. He is involved in many different activities and wants to be an advocate for the people in this area.

Lee Sommers, Director of CSU Agricultural Experiment Station

Funding for the experiment stations comes from four main sources: (1) Colorado legislature through higher education funding, (2) USDA via the Farm Bill which provides for formula funding for extension and experiment stations, (3) competitive grants from USDA, which totaled $12 million in 2011 for the College of Agriculture, and (4) public and privately funded grants and contracts. When earmarks were cut out CSU lost about $1.5 million in funding.

Financially, things are looking better than they have for a while, although we are still planning for a 3% cut. The research station at Roger's Mesa was closed in 2011 and the program in invasive plants will not be continued after the current students complete their studies. The SWCRC will probably not see budget reduction this year. CSU's president Tony Frank has been very supportive of ag science.

There was a retirement at Orchard Mesa. A new person was hired. A pilot scale winery will be started. The wine will be sold via the internet. There is new office construction at the Arkansas Valley. Projects with the weighing lysimeter have been running for three years. The weighing lysimeter is basically a 50-ton cube of soil on a truck scale.

There is a new agreement between ARDEC and the Trimble Co. concerning GPS. The agreement will result in new equipment being installed at ARDEC free of charge. Feed intake measurements at ARDEC can now be taken on the scale of individual animals.

Gene Kelly, Head, Department of Soil and Crop Sciences.

Dr. Kelley is the new department head for Soils and Crop Sciences. He replaced Gary Peterson who retired. There's been a lot of change in the department over the last 8-10 years in terms of the people working there. The department has a lot of diversity in terms of specialties. Student enrollments are quite high. Dr. Kelley is preparing for program review next fall. He also met with all the faculty and staff. Lots of awards went out to the faculty.

New concentrations available for students include a Soil Ecology major and Biomass for Biofuels. Other activities include trying to upgrade some equipment, working with student organizations, and recruiting students.

David McCart

Before adjourning the meeting David McCart asked if anyone had any questions or comments.

Soil & Climate at the Southwestern Colorado Research Center

Soil

The principal soil type at the Research Center is Wetherill loam (fine-silty, mixed, superactive, mesic Aridic Haplustalfs). The Wetherill series is made up of generally deep well drained soils, located on mesas and hills. These soils were formed from sandstone material transported by wind from the Southwest. They tend to be reddish on the surface and generally have low organic matter (around 1.0%). Their water holding capacity ranges from approximately 1.8 to 2.0 inches/ft. Soil pH at the SWCRC is around 7.5. The terrain is southwestern Colorado is generally rolling. Slopes vary from 1 to 12% and the elevation from less than 6,000 ft. to above 7,000 ft. The potential exists for significant wind and water erosion on bare ground, especially in the spring.

Precipitation & temperature

The 30-year average precipitation at Yellow Jacket show is 15.9 inches. The average annual snowfall is 68.1 inches. June is the driest month. Average monthly minimum and maximum temperatures are shown in Figure 2. The frost-free period is 100 to 120 days. The Research Center lies at an elevation of 6900 ft., latitude 37°32' N and longitude 108°44' W. The yearly precipitation data is from the CoAgMet (Colorado Agricultural Meteorology) station at the SWCRC. It may not account for all the moisture from snow since the station uses a simple tipping bucket rain gauge to measure precipitation. Precipitation was below average in Nov. 2010, and Jan., Feb., June, and Aug. 2011. It was average in Oct. 2010 and July 2011 and above average in Dec. 2010 and April and May 2011 (Figure 1).

Figure 1. 2008 to 2011 and 30-yr (1971-2000) monthly precipitation at Yellow Jacket, CO

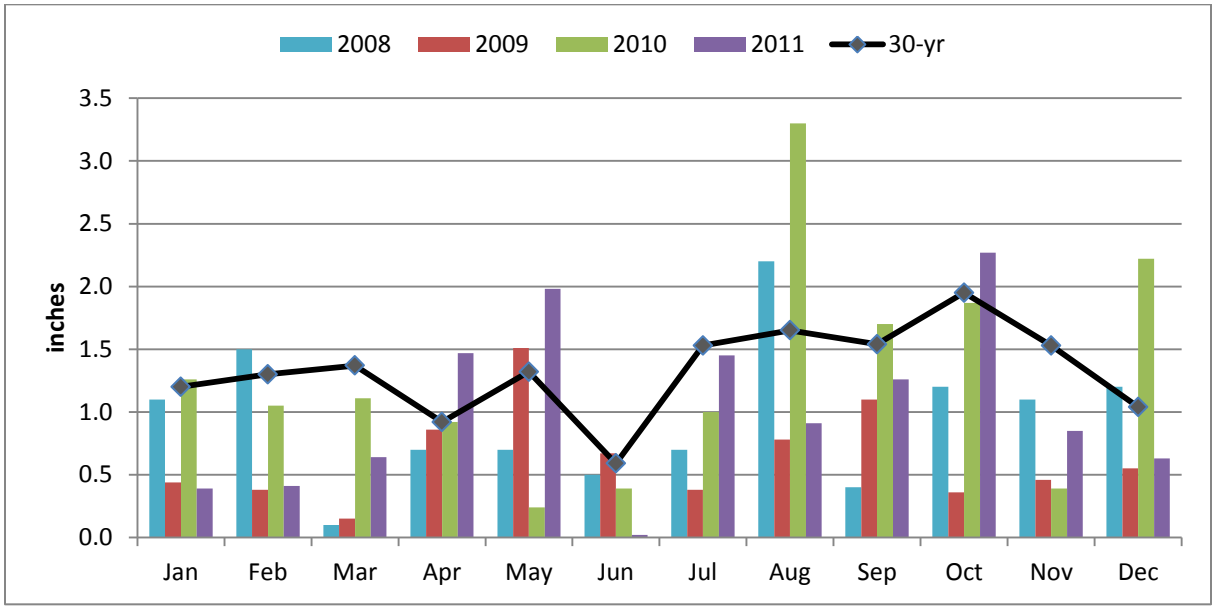
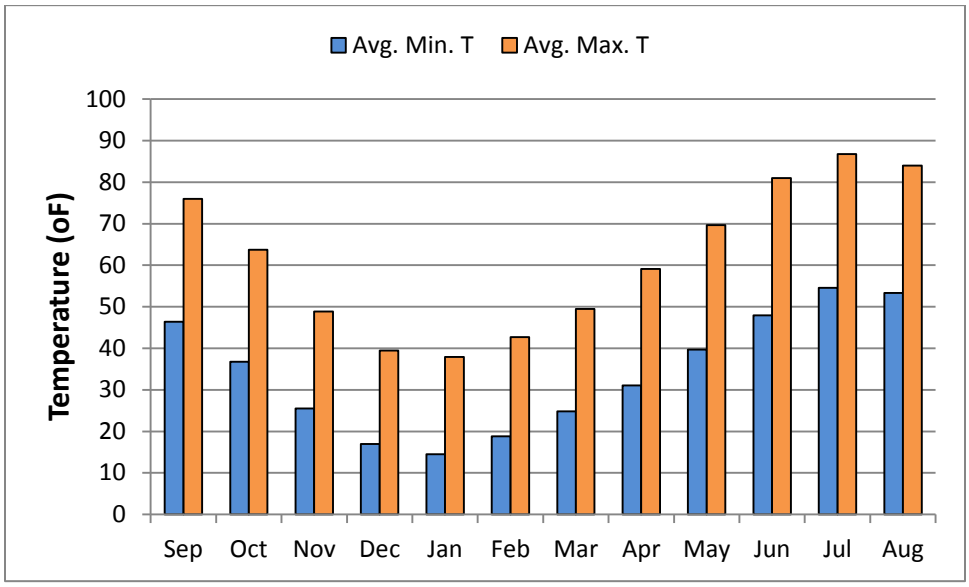


Figure 2. 1971-2000 average monthly minimum and maximum temperatures at Yellow Jacket, CO



Summary of the Main Results

Abdel Berrada†

Dryland Winter Wheat Variety Trial

Winter wheat averaged 51 bu/A due to adequate soil fertility and good water availability at planting through the fall of 2010 and in April and May of 2011. The latter part of May through 10-Jul was extremely dry, which resulted in small kernels and low test weights. Most of the entries from CSU's wheat breeding program produced above average grain yield. The two most common hard red winter wheat varieties in SW Colorado, Fairview and Deloris, averaged 46.2 bu/A. Grain protein content ranged from 14.3 to 17.5% and averaged 15.9%.

Irrigated Spring Wheat Variety Trial

The trial averaged 86 bu/A with Sylvan and several varieties and experimental lines from Idaho and Washington topping 90 bu/A. Three durum wheat varieties, Alzada, APB D1-35, and Sky were tested for the first time at the Research Center. They averaged 66.3 bu/A. The bottom two, APB D1-35 and Sky also had the lowest test weights and highest protein contents of all the entries. Colder temperatures at planting through early May and much drier conditions in June and August of 2011 may explain the lower grain yields in 2011 compared to 2010 (http://www.colostate.edu/depts/swcrc/pubs/tr11-4.pdf). A late irrigation application may have boosted production in 2011.

Dryland Dry Bean Variety Trial

Seed yields ranged from 784 to 1196 lb/A and averaged 1023 lb/A. The experimental line CO 30048 and Bill Z had the lowest yields while Fisher had the highest yield. Differences between entries were not significant due to the high variability (high CV = 20%) within the trial. The bean stand was uneven and some of the plants exhibited symptoms of abiotic stress.

Irrigated Dry Bean Row Configuration by Seeding Rate by Variety Trial

Seed and dry matter yields were not affected by row configuration (single vs. double rows) or seeding rate (70,000 vs. 84,000 seeds/A). Planting closely spaced rows and achieving the target seeding rates was a challenge with the Monosem Planter used in this trial. Montrose had the highest seed yield with 2,673 lb/A, significantly more than CO 24972, Croissant, Montrose, and Stampede, which averaged 2,227 lb/A. There was no significant response to seeding rate at ARDEC or Greeley either where a similar trial was conducted (Schwartz, Brick, Buchleiter, Ogg, & McMillan, 2011). The two spreading varieties Montrose and Othello produced 28 and 126 lb/A more with double than with single rows at ARDEC and Greely, respectively. The upright varieties Croissant and Stampede had lower mean yields with double rows in Greely (- 39 lb/A) and higher mean yields at ARDEC (+ 303 lb/A), compared to single rows. Double rows increased the seed yield of Croissant at both locations and that of Stampede at ARDEC only.

Dryland Winter Canola Variety Trial

Seed yield averaged 1632 lb/A; oil content 36.2%, and test weight 49.1 lb/bu. Most of the entries survived winter extremely well. This was the first dryland winter canola trial at Yellow Jacket, CO. The

results indicate good potential for growing winter canola in southwestern Colorado with no supplemental irrigation.

Dryland Spring Camelina Variety Trial

Spring camelina was planted on 20 April and harvested on 16 August 2011. Seed yield averaged 283 lb/A with a high of 362 and a low of 172 lb/A. Oil content averaged 37.3 % and test weight 43.7 lb/bu. Camelina has had mixed results at Yellow Jacket, CO. It averaged 531 lb/A in 2009 and 605 lb/A in 2010 with no irrigation and 2002 lb/A in 2009 with limited irrigation (http://www.colostate.edu/depts/swcrc/pubs/tr10-6.pdf). Challenges include stand establishment (dryland), limited number of varieties to choose from, pod shattering, bird damage, and marketing.

Adequate stand and fall growth were achieved when three spring camelina varieties (Celine, Ligena, and Yellow Stone) and a winter-type entry (HPX-WG3) were planted on 7 September 2010. None of the spring varieties survived the winter while HPX-WG3 averaged 767 lb/A. Yellow Stone did exceptionally well when it was planted on 12-Oct. Early April and early May spring camelina sowings did poorly partly due to pod shattering and bird feeding.

Dryland Sunflower Hybrid Trial

Seed yield averaged 1283 lb/A with the hybrid Triumph s678 topping the list with 1571 lb/A. Other short-stature hybrids also did fairly well in 2011. Seed oil content was below 40% for all entries, which may have been due to cool temperatures early in the season and relatively dry conditions during flowering.

Dryland Sunflower Planting Date x Seeding rate x Hybrid

Plant population at harvest was much lower than what might be expected based on the seeding rate. The ratio of plants at harvest/seeding rate averaged 70 to 75% in 2009 (data not shown) and only 59% in 2010. Worn out sprockets in the planter may explain the lower ratio in 2010.

There was a significant drop in seed yield, oil content, and test weight when planting was delayed from June 1 to June 15, 2010. Similarly, oil yield decreased significantly as planting was delayed from 1-Jun to 12-Jun in 2009 (Stack, Berrada, Brick, & Johnson, 2010, pp. 61-63). The 18 May and 1 June 2010 plantings produced similar seed yields, oil contents, and test weights when averaged over all four hybrids. Mycogen 8H449 and Triumph 657 had the highest seed yield at these planting dates, followed by Triumph s878. Pioneer 64H41 had the lowest yield at all three planting dates. Increasing seeding rate from 13,939 to 17,289 seeds/A increased seed yield by an average of 129 lb/A, which was significant at P=0.05. Mycogen 8H449 had the highest oil content at all three planting dates and the highest test weight and number of seeds/lb on average. Triumph s878 and Pioneer 64H41 had the lowest oil content, while Triumph 657 had the lowest test weight. Sunflower plants were tallest at the 1-Jun planting.

The 2009 and 2010 results indicate that sunflower should be planted by early June in Yellow Jacket, CO to optimize oil production. Late planting will depress yield and increase the likelihood of a killing frost before sunflower reaches physiological maturity.

Dryland Crop Rotations That Include Sunflower

Winter wheat had the highest seed yield in 2011 (2667 lb/A or 45 bu/A), followed by safflower, sunflower, and dry bean. Winter wheat benefited from above average precipitation (from rain and snow) in late summer and fall of 2010. April and May of 2011 also had above average precipitation. June through early July was extremely dry, which adversely affected grain filling (small kernels) and may explain the low test weight of 53.5 lb/bu.

Dry bean after summer fallow produced almost twice the yield as compared to dry bean after dry bean, which may have been due to more available soil water and nitrate nitrogen (NO_3-N) at planting after fallow. Sunflower after dry bean or summer fallow outperformed sunflower after spring camelina. Sunflower after dry bean had more available water at planting than sunflower after fallow, possibly due to fewer tillage operations after dry bean. In contrast, sunflower after fallow had more available NO_3-N in the top 2 ft. of soil than sunflower after dry bean or camelina. Sunflower seed oil content varied in the reverse order, i.e., oil content decreased as soil NO_3-N concentration increased. Sunflower had the highest test weight after dry bean, significantly more than when it was planted after fallow or camelina. Camelina had good growth in 2010 and 2011 but sustained severe damage from pod shattering and bird feeding. There was relatively high soil NO_3-N concentration in the treatments with one or two years of summer fallow, which may be due to residual nitrogen from several years of alfalfa cultivation (2000 through 2008).

Sunflower Irrigation Scheduling by N rate

The 2011 results indicate that sunflower yield and water use efficiency can be increased substantially with limited but well-timed irrigation applications. Applying water mostly during flowering increased seed yield by 55% compared to early-season irrigation. Water (irrigation + rain) use efficiency (lb of seeds/inch of water/A) increased by 70% compared to full irrigation. Seed yield also increased significantly with the application of 50 lb N/A. Applying water with linear-move sprinkler systems or siderolls, which are common in SW Colorado, is not an efficient way to irrigate standard-height sunflower hybrids since most of the water is applied during the vegetative growth. A short stature sunflower hybrid will be included in the 2012 field trial.

Dryland Dry Bean Variety Performance at Yellow Jacket, CO

Abdel Berrada† and Mark Brick[§]

Table 1. The 2011 Dryland Dry Bean Variety Trial Results[1]

Name	Seed yield lb/A	Plants/ac[2]	Number seeds/lb
Fisher	1196	20367	1144
CO 30047	1166	20367	1545
Croissant	1163	21252	1371
CO 30068	1143	19481	1566
CO 432	1143	21252	1492
CO 30052	1087	19481	1276
CO 34142	1026	23909	1349
CO 55646	1022	21252	1250
CO 438	1005	23909	1364
Cahone	931	20367	1306
Montrose	930	18596	1703
CO 24972	900	20980	1368
Bill Z	829	23023	1524
CO 30048	784	21252	1357
Average	**1023**	**21106**	**1401**
$LSD_{.05}$	NS	NS	214
CV (%)	20	9	7

[1] Trial conducted at the Southwestern Colorado Research in a RCBD with three replications
[2] Number of plants at harvest

[§] Bean breeder and Professor at CSU-Ft. Collins

Trial information

Previous crop:	Summer fallow
Planting date:	June 8, 2011
Seeding rate:	23,232 seeds/A (9 in. spacing on 30-in rows)
Planter:	Monosem vacuum planter
Harvest date:	Cut by hand on 9/20/11 and threshed on 10/11/11
Soil type:	Wetherill silty clay loam
Soil test (0-12 in.):	OM: 1.2%, NO3-N: 68 lb/A, Mehlich-3 P: 11 ppm, K: 147 ppm, Zn: 1.2 ppm
Fertilizer:	60 lb P_2O_5/A on 4/15/11 (2x the recommended rate due to a malfunction of the fertilizer spreader)
Row cultivation:	July 11, 2011
Bactericide:	Kocide 4.5L @ 2.0 pt/A on 8/9/11 for common bean blight prevention
Irrigation:	None
Rainfall:	3.6 in. from planting to harvest

Comments

Seed yields ranged from 784 to 1196 lb/A and averaged 1023 lb/A, despite the low rainfall during the growing season. The field was in summer fallow the previous year; hence soil moisture was adequate at planting. There were no significant differences between the yields of all entries, however, Fisher, Croissant and several experimental lines were at the top of the yield spread while Bill Z and CO 30048 were at the bottom. The bean stand was uneven and the plants of the some of the entries looked anemic and may have suffered from abiotic stresses such as wind and nutrient imbalances.

All the experimental lines outperformed Cahone when averaged over 2010 and 2011 or 2008, 2010, and 2011, with the exception of CO 30048 (Table 2). Over these years, entry CO 432 had the highest seed yield followed by CO 30068 and CO 30047. The numbered entries were developed by the CSU dryland dry bean breeding program for SW Colorado. The program lost momentum after funding from the Colorado Dry Bean Administrative Committee ceased in 2006. The goal of the breeding program at the Southwestern Colorado Research Center was to broaden the genetic base, improve disease resistance, and improve market quality (Stack, Berrada, Brick, & Johnson, 2010, p. 18). The release of Cahone was the result of a concentrated effort to develop a pinto bean with resistance to Fusarium root rot. Root rot diseases are intensified by continuous bean rotations and soil compaction. Bacterial bean blights can also be a serious problem for bean farmers if contaminated seed is planted or summer storms move bacteria in rain showers. New funding sources and renewed emphasis will be required to reinvigorate the dry bean breeding program for SW Colorado (Stack, Berrada, Brick, & Johnson, 2010, p. 18).

Table 2. Two and three year dryland dry bean variety trial yield averages. Varieties that weren't in both the 2010 and 2011 trials are not included in this table.

Variety	2010 & 2011 Average Yield (lb/A)	2008, 2010 & 2011 Average Yield (lb/A)
CO 432	1091	1037
CO 30068	923	980
CO 30047	919	954
Fisher	864	871
Croissant	851	NA
CO 30052	827	868
Montrose	823	NA
CO 438	810	850
Cahone	735	611
CO 30048	682	768
Average	**853**	**843**

The Effects of Row Configuration and Seeding Rate on Four Dry Bean Varieties

Mark Brick[§], Howard Schwartz[**], and Abdel Berrada[†]

This study was sponsored by the Colorado Dry Bean Administrative Committee and the Colorado Seed Growers Association. It compares the performance of upright type II varieties Croissant and Stampede and experimental line CO 24972 with the more prostrate type III varieties Othello and Montrose when grown in single and double rows at low and high seeding rates. Narrow row spacing has been shown to improve production efficiency in crops such as soybean (http://extension.agron.iastate.edu/soybean/documents/RowSpacing.pdf). Conversely, denser canopies of grain legumes can result in greater damage from sclerotinia disease than thinner stands Krupinsky, Bailey, McMullen, Gossen, & Turkington, 2002. Factors that influence the incidence of white mold (caused by the fungus *Sclerotinia sclerotiorum*) in dry bean include plant architecture, planting rate and row spacing, nitrogen fertilizer management, and irrigation management (http://www.ext.colostate.edu/pubs/crops/02918.html). For example, the newer, more upright dry bean varieties when planted at the optimum row spacing and seeding rate should allow for more aeration and sunlight penetration in the plant canopy than the spreading type varieties, which in turn should lead to drier conditions and less incidence of white mold.

Materials and Methods

The trial was established in a field that was in spring wheat in 2010. Sonalan HFP herbicide (active ingredient: ethalfluralin) was applied on 6-May at 2.3 pt/A and incorporated to the soil with a field cultivator. Fertilizer was applied on 3-Jun at [46 lb N + 34 lb P_2O_5 + 8.3 lb Zn + 4.1 lb S]/A. Dry bean was planted on 10-Jun with a 4-row Monosem Planter and cultivated on 1-Aug. Water was applied five times during the growing season with a wheel-line sprinkler irrigation system, commonly known as sideroll. The total amount applied was 9.8 in. In addition, 2.5 in. of rainfall was recorded from planting through harvest.

The dry bean varieties Croissant, Stampede, Othello, Montrose, and the experimental line CO 24972 were planted in single and double rows at the seeding rates shown in Table 3. The distance between single rows and between the middles of the double rows was 30 inches (Figure 3). It was not possible to plant the double rows in one pass with the Monosem Planter. Single rows were planted in one direction then the planter was shifted (offset) approximately 8 in. to the right and four more rows were planted in the opposite direction. After the number of seeds of each dry bean variety or experimental line was determined for each plot, it was divided into four lots (envelopes) for single rows and eight lots for double rows. Thus, the double rows received half of the required number of seeds in the first pass and the other half in the second pass. Matching the target seeding rates was a challenge given the number of gear ratio combinations that were available with the Monosem Planter. Seeding rates with single

** Plant pathologist and Professor at CSU-Ft. Collins

rows were closest to the target rates (Table 3). Seeding rates with double rows exceeded the target rates by 5 to 9%. Selective thinning was done after stand establishment to reduce the gap between plant population of single and double rows but as Table 3 shows the gap widened at harvest. The final plant population reflects not only the actual seeding rate but also the number of seeds that germinated and grew into plants and the number of plants that survived competition and biotic and abiotic stresses. Visual observations did not reveal any significant damage from insects or diseases.

Figure 3. Single and double row bean planting configurations

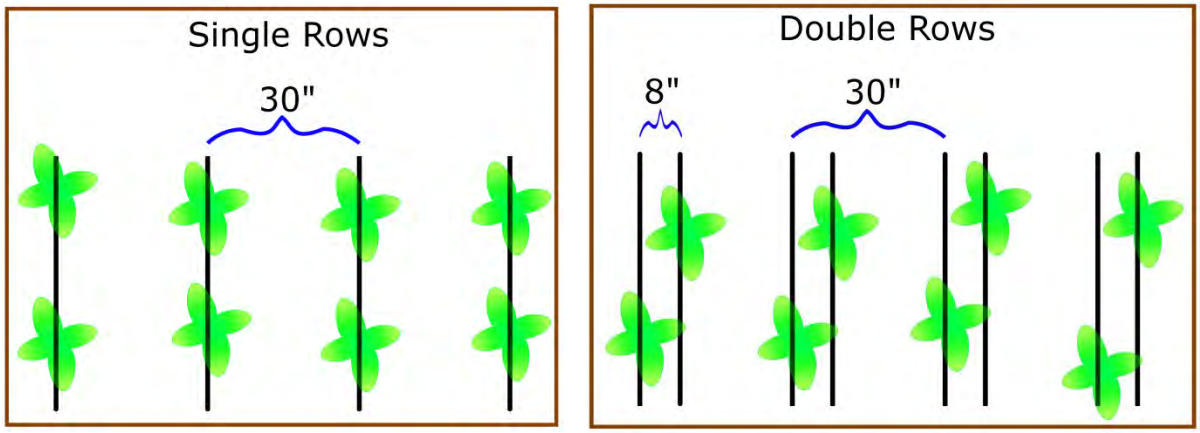


Table 3. Seeding rate vs. plant population at harvest

Rows	Seeding rate	Target Seeds/A	Monosem[1] Seeds/A	Harvest Plants/A
Double	High	84000	88328	77071
Double	Low	70000	76032	67230
Single	High	84000	83635	64351
Single	Low	70000	69156	54961

[1] The closest to target seeding rates achievable with the Monosem Planter

The fixed variables were arranged in four randomized complete blocks. Single and double rows were assigned to the main plots, which were split in half to receive the low and high seeding rates. The split plots were themselves divided into five sub-plots to accommodate the bean entries. The bean plots were 10 ft. wide by 30 ft. long.

At approximately 80% pod striping, all the bean plants in a one-meter row length were counted and cut at ground level. They were weighed and a representative subsample was weighed again, dried in a forced-air oven at 65^{0}C for 48 hours and weighed to determine its water content. Approximately three weeks later, all the plants in 3-m of row/plot were cut, put in onion sacs and left to dry for several weeks then threshed with a stationary Vogel thresher. The dry matter and seed samples were taken from a single row or both halves of a double row.

Results

Row configuration and seeding rate did not have a significant effect on seed or dry matter yields at $P \leq 0.05$ nor did the 2- and 3-way interactions (Table 4). However, there were significant differences between bean entries. Montrose had the highest seed yield with 2,673 lb/A. The other entries averaged 2,227 lb/A. Entries CO 24972, Montrose, and Stampede had the highest dry matter yields, significantly more than Croissant. Othello had the lowest dry matter yield. Croissant had the highest number of seeds/lb with single and double rows (Table 4).

In a similar study at CSU Research Farm near Ft. Collins and at the USDA/ARS Research Farm near Greeley (Schwartz, Brick, Buchleiter, Ogg, & McMillan, 2011), Montrose and Othello had higher mean seed yields with double compared to single rows in both Greely (+ 126 lb/A) and Ft. Collins (+ 28 lb/A). The upright varieties Croissant and Stampede had lower mean yields with double compared to single rows in Greely (- 39 lb/A) and higher mean yield in Ft. Collins (+ 303 lb/A). Bean yields were on average 70.5% greater in Ft. Collins than in Greely. The latter had less favorable growing conditions due to soil compaction, moderate fertility, and apparent heat stress. The double row increased the seed yield of Croissant at both locations and that of Stampede in Ft. Collins only. Double row increased the yield of Othello at both locations, whereas Montrose had no response. The entry CO 24972 was not included in the study. The authors concluded that "growers must carefully choose varieties with appropriate agronomic and disease resistance characteristics suitable for their environment, production system, and integrated pest management strategy".

Table 4. Irrigated dry bean yield at Yellow Jacket in 2011

Entry		Seed yield (lb/A)	Dry matter yield (lb/A)	Seeds/lb @ harvest	Plants/A @ harvest
CO 24972		2190b[1]	5634a[1]	1430	55050
Croissant		2222b	5015b	1577	68828
Montrose		2673a	5561a	1410	69805
Othello		2273b	4209c	1397	69938
Stampede		2222a	5537a	1364	65896
Row configuration					
Double		2353	5484	1446	72150
Single		2278	4899	1425	59656
Seeding rate					
High		2330	5236	1434	70711
Low		2302	5147	1437	61096
Row x Entry					
Double	CO 24972	2170	6209	1448b[1]	60595
Double	Croissant	2246	5129	1614a	73170
Double	Montrose	2739	5657	1413b	77319
Double	Othello	2325	4476	1430b	77367
Double	Stampede	2287	5947	1323c	72301
Single	CO 24972	2210	5058	1412B[1]	49504
Single	Croissant	2198	4902	1539A	64485
Single	Montrose	2606	5465	1407B	62291
Single	Othello	2220	3942	1363B	62509
single	Stampede	2157	5127	1406B	59491
Analysis of variance (Proc Mixed—SAS, Inc.)					
Effect		Pr > F	Pr > F	Pr > F	Pr > F
Rows		0.640	0.126	0.618	0.005
Seeding rate (SR)		0.680	0.648	0.852	0.001
Rows*SR		0.571	0.265	0.942	0.897
Entry		<.0001	<.0001	<.0001	<.0001

Entry	Seed yield (lb/A)	Dry matter yield (lb/A)	Seeds/lb @ harvest	Plants/A @ harvest
Rows*Entry	0.905	0.259	0.032	0.493
SR * Entry	0.569	0.269	0.969	0.003
Rows*SR*Entry	0.803	0.072	0.881	0.211

[1] Means followed by the same letter are not statistically different at α = 0.05.

Evaluation of Dryland Crop Rotations that Include Sunflower

Abdel Berrada[†]

This study was sponsored by the National Sunflower Association. Collaborators included Rod Sharp, Bob Hammon, and Dan Fernandez.

Sunflower has been grown commercially in SW Colorado since 2006. Another oilseed crop that has been grown in this area longer than sunflower is safflower. Tests at the Southwestern Colorado Research Center in Yellow Jacket, CO show good yield potential and adaptation of both safflower and sunflower (see "Dryland Sunflower Hybrid Trials" in this report and also http://www.colostate.edu/depts/swcrc/pubs/tr11-4.pdf). Both crops have deep root systems and thus are capable of extracting soil moisture from great depths, which allows them to withstand drought better than crops with shallower root systems. Conversely, there may not be enough water in the soil to sustain crop production in the year following sunflower or safflower. Research on this topic in the Colorado Plateau is lacking. Moreover, results from other sunflower producing areas may have limited applicability to the unique environment of SW Colorado.

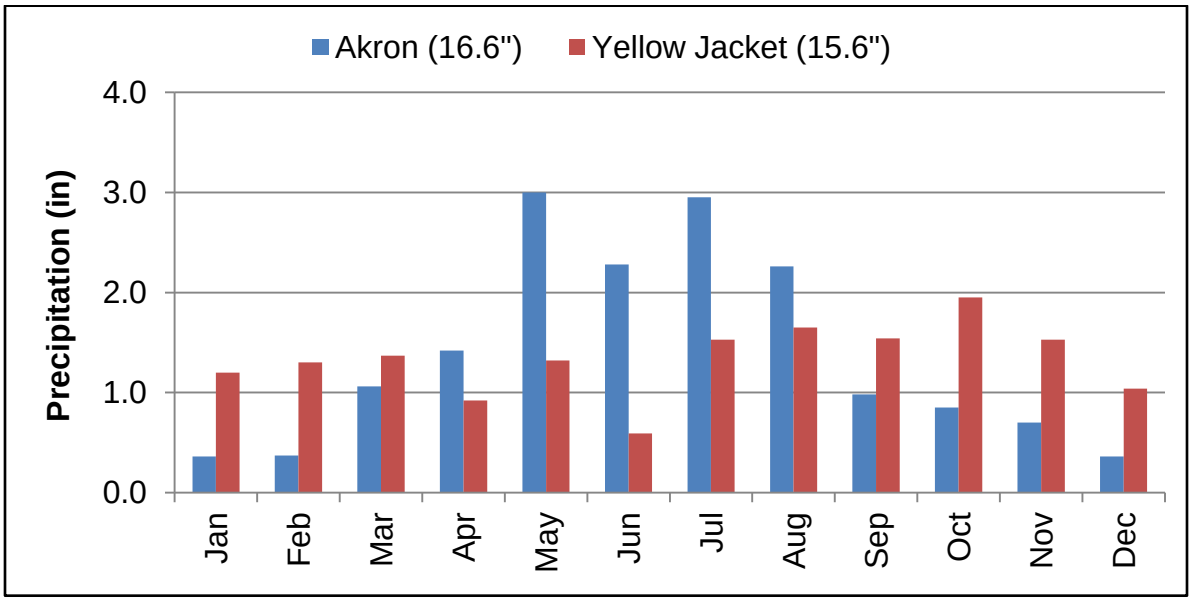
At Akron, CO for example, the available soil water at wheat planting was 4.3 inches less in wheat-sunflower-fallow than in the wheat-fallow and wheat-corn-fallow rotations, which resulted in 30% less wheat grain (Nielsen, et al., 1999). Wheat yield was reduced by 3.0 bu/A for every 1.0 inch decrease in water availability at wheat planting. Nelson et al. (1999) recommended planting sunflower only once every four years, as in wheat-corn-sunflower-fallow or wheat-millet-sunflower-fallow, to minimize the potentially negative impact on succeeding crop production. Corn and millet are not commonly grown in SW Colorado.

There are notable differences between Akron in NE Colorado and Yellow Jacket in SW Colorado. The elevation at Akron is 4540 ft compared to 6860 ft at Yellow Jacket and, even though the annual precipitation is similar (15 to 16 in. on average) at both locations, its seasonal distribution is different. Close to 80% of the annual precipitation at Akron occurs from April through September while it is more evenly distributed at Yellow Jacket with June being the driest month of the year (Figure 4). Moreover, Yellow Jacket receives twice as much snow (68.1 vs. 32.2 in.) as Akron does (Western Regional Climate Center, wrcc@dri.edu). Therefore, cropping systems that are adapted to the climatic and soil conditions in eastern Colorado may not be as adapted to southwestern Colorado.

A survey conducted in Dolores County in 2007 showed that sunflowers were planted after winter wheat in 44% (43/97) of the fields, 34% after dry bean (mostly Pintos), 6% after fallow, and 14% after alfalfa, spring wheat, oat, safflower, or sunflower combined (Daniel Fernandez, Personal Communication, August 2009). Dryland sunflower seed yields varied greatly due to differences in hybrid, planting date, seeding rate, wildlife damage, etc. but appeared to be highest when sunflower was planted after dry bean, winter wheat or summer fallow and lowest when sunflower was planted after alfalfa, sunflower, or safflower. In a dryland cropping systems study at the SWCRC, winter wheat and safflower fared better in wheat-safflower-fallow than in wheat-safflower-bean or wheat-safflower-oat rotations (Berrada, 2004). Wheat yields were highest in wheat-fallow, particularly in dry years and with

minimum- or no-till. Wheat in a wheat-bean rotation did not do as well but total seed production (wheat plus bean) was higher since a crop was produced each year. No-till during the bean year was problematic due to the difficulty of undercutting the beans (with knives or a rod cutter) in undisturbed soil and poor weed control. Most soils in SW Colorado are low in organic matter, tend to crust easily after a rain event, and are prone to compaction. Pre-plant herbicides such as Pursuit, Dual, or Treflan were not effective due to lack of incorporation or lack of moisture. Dry beans are usually planted in late May to mid-June, which is the driest period of the year in SW Colorado. They are undercut in early to mid-September, windrowed, left to dry, and threshed. Bean harvest can be delayed by rain or snow, which is why wheat after bean is not considered a good crop sequence in SW Colorado. Winter wheat yield potential is greatest if it is planted by mid-September (Hammon, Sanford, Stack, Berrada, & Peairs, 1999). Spring wheat or oats are sometimes substituted for winter wheat--for example, when bean harvest is delayed--but they generally do poorly unless winter precipitation is adequate or they receive supplemental irrigation. Other rotations practiced in SW Colorado include wheat-bean-bean-fallow and bean-wheat-bean-alfalfa.

Figure 4. 30-year monthly average precipitation at Akron and Yellow Jacket, CO



Incorporating sunflower or safflower into dryland cropping systems in SW Colorado would enhance crop diversification and provide more options to manage soil moisture and break up the cycle of weeds, diseases, and insects. However, data are lacking as to the agronomic and economic feasibility of sunflower and safflower in rotation with more traditional crops such as winter wheat and dry bean.

Measurements were made to determine the effects of sunflower in rotation with winter wheat, dry bean, and other crops on:

- Soil moisture availability
- Nutrient (N & P) availability
- Crop yields and quality (seed oil or protein concentration)
- Pest dynamics

Materials and Methods

The following crop rotations were tested:

1. Winter Wheat-Fallow
2. Winter Wheat-Safflower-Fallow
3. Winter Wheat-Sunflower-Fallow
4. Winter Wheat-Dry Bean-Sunflower-Fallow
5. Winter Wheat-Dry Bean-Dry Bean-Fallow
6. Winter wheat-Opportunity crop-Sunflower-Opportunity crop. The opportunity crop in 2010 and 2011 was camelina [Camelina sativa (L.) Crantz].

The field experiment was established in the spring of 2010 at the Southwestern Colorado Research Center at Yellow Jacket, in a randomized complete block design with three replications. Each phase of each crop rotation is present each year. Minor adjustments were made to crop rotations in 2011. Plot size is 30 ft wide by 167 ft long. Cultural practices (tillage, seeding date and rate, pest control, etc.) are based on experience and field conditions. Fertilizer rates are based on soil test results and yield goals. The plot area was in irrigated oat in 2009 and irrigated alfalfa from 2000 to 2008. It was converted to dryland farming after oat was cut for hay in August 2009. Planting and harvest dates are shown in Table 5.

Table 5. Crop information

Crop	Variety	Planting date		Planting rate	Unit	Harvest date	
		2010	2011			2010	2011
Camelina	Cheyenne	17-May	20-Apr	6	lb/A	No harvest	No harvest
Safflower	CW 99OL	17-May	20-Apr[1]	25	lb/A	19-Oct	28-Sep
Sunflower	Triumph 657	27-May	31-May	15,488[2]	seeds/A	6-Nov	2-Nov
Dry bean	Cahone	08-Jun	7-Jun	23,232	seeds/A	8-Oct[3]	29-Sep[3]
Winter wheat	Fairview	13-Sep	22-Sep	50	lb/A	No crop	20-Jul

[1] Re-seeded on 3-May
[2] Sunflower seeding rate was increased to 17,282 seeds/A in 2011.
[3] Dates on which dry beans were undercut. Beans were threshed on 10/15 in 2010 and 10/19 in 2011.

Results

In 2011, winter wheat had the highest seed yield of 2667 lb/A (45 bu/A), followed by safflower, sunflower, and dry bean (Table 6). Dry bean after fallow produced almost twice the yield of dry bean after dry bean, which may have been due to more available soil water and nitrate nitrogen (NO_3-N) at planting after fallow (Table 7).

Sunflower after dry bean or fallow out performed sunflower after camelina (Table 6). Sunflower after dry bean had more available water at planting than sunflower after fallow, possibly due to fewer tillage operations after dry bean. In contrast, sunflower after fallow had more available NO_3-N in the top 2 ft. of soil than sunflower after dry bean or camelina (Table 7). Sunflower seed oil content varied in the reverse order, i.e., oil content decreased as soil NO_3-N concentration increased. Sunflower had the highest test weight after dry bean, significantly more than when it was planted after fallow or camelina.

Camelina had good growth in 2010 and 2011 but sustained severe damage from pod shattering and bird feeding. Other opportunity crops will be tested in the future.

Table 6. Seed yield and oil content

Crop	Previous crop		Average seed yield (lb/A)[1]		Oil content (%)		Test weight (lb/bu)	
	2009-2010	2010-2011	2010	2011	2010	2011	2010	2011
Camelina	Fallow[2]	Camelina	No crop[3]	No crop[3]	-	-	-	-
Safflower	Fallow	Fallow	1761	1582	41.2	N/A	39.4	38.6
Sunflower	Fallow	Fallow	1799	1190	39.7	36.9	25.4	23.4
Sunflower	Fallow	Dry bean	-	1273	-	39.0	-	29.5
Sunflower	Fallow	Camelina		1036	-	39.8	-	23.8
Dry bean	Fallow	Fallow	893	748	-	-	-	
Dry bean	Fallow	Dry bean		383	-	-	-	
W. wheat	Fallow	Fallow	NA	2667	-	16.5[4]	-	53.5

[1] Seed yields of sunflower, safflower, and winter wheat were adjusted to 10%, 9%, and 12% moisture, respectively.
[2] Summer fallow
[3] Crop was not harvested due to shattering and bird damage
[4] Protein content

There was "plenty" of NO_3-N in the soil prior to planting winter wheat in the fall of 2010 (Table 7). The same was true in the fall of 2011, i.e., 132 lb NO_3-N/A. The relatively high NO_3-N concentration in the treatments with one or two years of summer fallow was undoubtedly due to residual nitrogen from several years of alfalfa cultivation (2000 through 2008) in the plot area.

Table 7. Soil moisture content and soil test NO_3-N prior to planting

Crop	Previous crop		Available soil moisture in 0-3 ft	lb NO_3-N/A in 0-2 ft
	2009-2010	2010-2011	2011	2011
Camelina	Fallow	Camelina	1.5	22
Safflower	Fallow	Fallow	1.6	85
Sunflower	Fallow	Fallow	1.7	101
Sunflower	Fallow	Dry bean	2.5	72
Sunflower	Fallow	Camelina	1.8	45
Dry bean	Fallow	Fallow	1.7	98
Dry bean	Fallow	Dry bean	0.8	71
Winter wheat	Fallow	Fallow	N/A	113[1]

[1] Amount of NO3-N/A in the fall of 2010

Winter wheat benefited from above average precipitation (from rain and snow) in late summer and fall of 2010. April and May of 2011 also had above average precipitation (Figure 1). June through early July was extremely dry, which adversely affected grain filling (small kernels) and may explain the low test weight of 53.5 lb/bu. In 2012 and subsequent years, the costs and returns of each crop sequence will be analyzed and more soil and crop data will be collected as the study gains momentum.

Oilseed Crops

Abdel Berrada[†]

Introduction

Oil crops gained interest in SW Colorado as part of the national drive to produce clean, renewable energy and to reduce our dependence on fossil fuels. Other incentives include crop diversification and the anticipated economic benefits from processing oilseed crops locally. A plant to mechanically extract oil from sunflower (*Helianthus annuus* L.) and safflower (*Carthamus tinctorius* L.) seeds was built in 2008 in Dove Creek, CO by San Juan Bioenergy, LLC. The company's ultimate goal was to produce biodiesel from sunflower, safflower, and eventually canola oil. The byproduct from oil extraction was marketed as animal feed meal. The sunflower seed hulls and the sunflower and safflower leaves and stems (dockage) were to be converted to syngas whose combustion was expected to provide up to 100% of the heat and 50% of the electricity needed to run the Dove Creek Plant. The biodiesel project never materialized due to unfavorable market conditions and a drop in government subsidies among other things. Instead, crude oil extracted from safflower and sunflower at the Dove Creek Plant was sold to refineries for processing as food-grade oil. The Plant ceased operation in 2010 for various reasons including difficulties to secure financing and gain growers' trust.

Oilseed crops that have been tested at the Southwestern Colorado Research Center in the last five to seven years are: sunflower, safflower, canola (*Brassica napa* L.), and camelina (*Camelina sativa* L.). Currently, only safflower and sunflower are grown commercially in southwestern Colorado.

Sunflowers are grown for use as ornamental plants, snacks (e.g., roasted seeds), bird seed, or for oil production. Only the oil type has been tested at the Southwestern Colorado Research Center. Sunflower oil is commonly divided into NuSun, linoleic, and high oleic. "NuSun® oil is the 'new' mid-oleic sunflower oil. It is lower in saturated fat (less than 10%) than linoleic sunflower oil and has higher oleic levels (55-75%) with the remainder being linoleic (15-35%). Linoleic oil is the original sunflower oil and until recently has been the most common type of sunflower oil. This type of sunflower oil is predominantly (65%) polyunsaturated. High oleic sunflower oil is usually defined as having a minimum 80 percent oleic acid." (http://www.sunflowernsa.com/)

Safflower is one of the oldest cultivated crops. It has been used for coloring and flavoring foods, for making red (carthamin) and yellow dye, and as bird seed (http://en.wikipedia.org/wiki/Safflower). In recent times, safflower has been grown mainly for edible oil production. Safflower oil is either 'oleic' or 'linoleic'. Oleic oils are high in monounsaturated fatty acids (C18:1) while linoleic oils are high in polyunsaturated fatty acids (C18:2). The predominant safflower edible oil market is for oleic oil. The results of the safflower variety performance trials can be found at: http://www.colostate.edu/depts/swcrc/pubs/tr11-4.pdf and http://www.colostate.edu/depts/swcrc/pubs/tr10-6.pdf. Safflower was included in the dryland crop rotation study but there was no safflower variety trial in 2011.

Canola is a registered trademark of the Canadian Canola Association and refers to cultivars of rapeseed with low erucic acid content. Currently, about 1.5 million acres are grown in the U.S.,

predominantly in North Dakota, but also in Oklahoma, Minnesota, Montana, Idaho, Oregon and other states. (http://www.uscanola.com/). Canola oil has 60 to 65% of monounsaturated fats (oleic), 30 to 35% of polyunsaturated fats (linoleic), and 5 to 8% of saturated fats (Raymer, 2002). Some canola hybrids contain over 70% of monounsaturated fats.

Winter and spring canola crops have performed well at the Southwestern Colorado Research Center. However, winter canola is less subject to damage by hail, insects or birds since it matures earlier. It also requires less irrigation water to maximize production since it is grown during the cooler part of the year and benefits from fall and winter precipitation. Seed yields of over 4,000 lb/A were achieved at the SWCRC with irrigation (http://www.colostate.edu/depts/swcrc/pubs/tr10-6.pdf).

Camelina is native of Europe where it has been grown for a long time. It is also known as gold-of-pleasure, false flax, wild flax, and linseed dodder. Camelina is a member of the mustard family which includes rapeseed, cabbage, cauliflower, radish, and turnip. Camelina plants are heavily branched and produce "small, pale yellow and greenish-yellow flowers with four petals". Pods are about ¼ inch long and contain numerous seeds (Putnam, Budin, Field, & Breene, 1993). Camelina seeds contain 30 to 40% oil by weight (Pilgeram, et al., 2007). More importantly, camelina oil contains 35 to 39% of omega-3 (C18:3), which is an essential fatty acid because the human body cannot make it. It reduces inflammation and may help lower risk of heart disease, cancer, and arthritis.

Camelina seeds or oil can be used as an additive in a variety of food products (bread, baked foods, spreads, etc.) to enhance their nutritional value and health benefits (McVay & Lamb, 2008). Camelina seeds are also used as bird feed or to supplement the rations of poultry, dairy goats, beef or fish. Biodiesel made from camelina oil performed similarly to biodiesel made from other oilseed crops such as soybean.

Camelina is a minor crop in the US with Montana leading the way in production. Its short growing season (85-100 days) and relatively low water and nutrient requirements makes it a good candidate as an alternative crop in dryland crop rotations in SW Colorado.

National Winter Canola Variety Performance Trial

Abdel Berrada[†], Michael Stamm[††], and Jerry Johnson[‡‡]

The objectives of the National Winter Canola Variety Trial (NWCVT) are to "evaluate the performance of released and experimental varieties, determine where these varieties are best adapted, and increase visibility of winter canola across the nation" (http://www.ksre.ksu.edu/library/crpsl2/srp1062.pdf). Seeds for the 2010-21011 NWCVT were distributed to 51 cooperators in 22 states. Several locations were not harvested due to drought, winterkill, poor establishment or too much precipitation. The NWCVT is coordinated by the Kansas Agricultural Experiment Station with funding from the National Canola Research Program of the United States Department of Agriculture - National Institute of Food and Agriculture. The results of the 2010-2011 NWCVT in Yellow Jacket, CO are reported here. Results from 25 other locations can be accessed at: http://www.ksre.ksu.edu/library/crpsl2/srp1062.pdf.

Table 8. Results of the 2010-2011 National Winter Canola Variety Trial at Yellow Jacket, CO[1]

Entry	Seed yield[2] lb/A	Seed oil content %	Seed moisture %	Test weight lb/bu	Plant height in.	Fall stand 0-10	Winter survival %	50% Bloom date	Seed shattering[3] %
Visby	2374	39.3	6.8	49.0	44.3	8.2	98.3	10-May	1.0
HPX-7228	2280	35.1	7.1	50.5	46.0	7.4	98.3	13-May	2.3
HYBRISTAR	2213	35.1	6.5	49.0	44.7	8.3	98.3	13-May	2.3
HYBRISURF	2148	37.8	7.0	49.4	46.7	8.6	96.7	15-May	3.0
Baldur	2029	36.7	6.4	50.2	45.3	7.5	96.7	10-May	2.3
Dynastie	2029	37.9	6.6	49.4	45.7	6.9	90.0	11-May	1.3
Wichita	1998	35.8	5.8	49.2	45.0	8.1	96.7	15-May	2.3

[††] Canola breeder, Kansas State University
[‡‡] CSU Crops Testing Coordinator

Entry	Seed yield[2] lb/A	Seed oil content %	Seed moisture %	Test weight lb/bu	Plant height in.	Fall stand 0-10	Winter survival %	50% Bloom date	Seed shattering[3] %
HPX-7341	1982	37.4	6.1	49.1	45.3	7.8	100.0	14-May	4.0
Athena	1949	37.2	6.1	50.2	44.3	8.3	96.7	13-May	3.3
Sitro	1809	37.1	6.6	48.0	45.3	6.3	93.3	15-May	2.0
Kiowa	1795	35.4	5.9	48.7	49.0	7.7	100.0	16-May	3.3
Durola	1792	39.8	6.2	47.9	45.0	7.6	93.3	16-May	4.7
Riley	1769	36.6	5.8	48.7	45.7	7.3	96.7	14-May	1.0
CHROME	1753	37.8	6.3	50.5	44.3	6.7	98.3	18-May	2.0
Amanda	1693	36.0	6.1	51.3	44.0	7.6	98.3	16-May	2.7
Safran	1684	34.9	8.0	48.4	45.0	4.7	95.0	17-May	3.0
HPX-501[4]	1648	35.5	6.4	49.7	46.3	7.9	98.3	19-May	1.3
KS4428	1601	37.0	6.3	50.2	45.7	7.5	93.3	15-May	2.7
Virginia	1571	34.6	6.3	48.6	41.0	7.1	96.7	16-May	2.0
KS4083	1513	35.4	6.4	48.7	46.3	7.1	98.3	17-May	12.7
Flash	1449	36.2	9.3	49.0	49.3	6.6	98.3	17-May	1.3
Hornet	1376	35.4	7.2	50.5	49.0	4.7	96.7	17-May	2.3
KADORE	1364	35.6	6.9	49.4	38.7	5.2	93.3	18-May	2.3
VSX-3	1275	35.0	6.4	49.9	39.0	6.1	96.7	17-May	14.3
KS4426	1200	36.5	6.5	49.1	45.0	6.8	96.7	17-May	8.3
Dimension	1176	37.6	7.8	50.1	43.7	4.9	93.3	19-May	6.3
Sumner	1157	35.3	6.0	49.8	44.7	5.3	91.7	16-May	13.3

Entry	Seed yield[2] lb/A	Seed oil content %	Seed moisture %	Test weight lb/bu	Plant height in.	Fall stand 0-10	Winter survival %	50% Bloom date	Seed shattering[3] %
HYBRILUX	1019	35.9	6.9	47.5	44.7	6.8	91.7	18-May	14.0
JJJ1	770	N/A	5.8	45.2	33.0	6.3	83.3	16-May	1.3
JJJ2	532	N/A	6.7	45.8	32.7	5.6	75.0	17-May	5.7
Mean	**1632**		**6.6**	**49.1**	**44.2**	**6.9**	**95.0**	**15-May**	**4.3**
CV (%)	22		9.7	2.5	4.2	13.4	6.0		
$LSD_{.05}$	586		1.0	2.0	3.0	1.5	9.2		

[1] This trial was conducted at CSU's Southwestern Colorado Research Center.
[2] Seed yield adjusted to 9% moisture
[3] Shattering was mostly due to bird feeding.
[4] "Clarence CL"

Trial information

Planted: 9/2/2010 @ 5.0 lb/A
Harvested: 7/22/2011
Pesticide: Sonalan@ 2.3 pt/A on 6/2/2010
Fertilizer application: 60 lb N + 40 lb P_2O_5/A on 6/2/2010
Irrigation application: None
Precipitation amount (from rain & snow) from planting through mid-July: 11.6" (winter precipitation measurements may not be accurate)

Comments

Soil moisture at planting was adequate. Fall stand was uneven due to windy conditions at planting, which caused uneven seed distribution. The entries labeled 'JJJ1' and 'JJJ2" exhibited below average winter survival, plant height, and seed yield. Seed shattering was caused mostly by bird feeding. No lodging was observed. This was the first truly dryland winter canola trial at Yellow Jacket, CO. The results indicate good potential for growing winter canola in southwestern Colorado with no supplemental irrigation. Results from previous years at Yellow Jacket are available at: http://www.colostate.edu/depts/swcrc/pubs/tr11-4.pdf and http://www.colostate.edu/depts/swcrc/pubs/tr10-6.pdf

Evaluation of Spring Camelina

Abdel Berrada[†], Jerry Johnson[‡‡], and Garrett Jewett[§§]

Table 9. The 2011 Camelina Variety Performance Trial at Yellow Jacket, CO[1]

Entry	Source	Seed yield (lb/A)[2,3]	Seed oil (%)	Seed moisture (%)[4]	Test weight (lb/bu)	Plant height (in)	1000-seed weight (g)	Number seeds per pod	% Green pods on 8/10/11
BSX G22	Blue Sun Biodiesel	362	38.2	7.1	44.6	17.8	1.32	8.7	14.3
Yellowstone	Great Plain Oil	360	37.4	7.0	44.6	18.2	1.37	7.6	20.3
SO-40	Sustainable Oils	346	38.4	7.1	46.4	20.5	1.69	8.6	19.7
C10-BZ-SB7_5	Sustainable Oils	324	38.1	7.2	45.3	17.8	1.36	11.4	25.0
Ligena	Europe	320	36.3	7.1	42.8	18.7	1.45	10.2	41.7
SSD 177	Germany[5]	318	38.2	7.2	45.2	18.2	1.51	8.7	20.3
SSD 10	Germany[5]	317	37.3	6.9	47.0	19.2	1.55	7.3	14.3
SSD 186	Germany[5]	310	37.7	7.2	42.5	18.5	1.13	7.0	24.3
Blaine Creek	MSU	292	38.7	7.1	42.8	18.0	1.13	10.4	20.0
Cheyenne	Blue Sun Biodiesel	290	36.6	7.0	39.9	19.3	1.20	11.1	25.0
Celine	Europe	287	38.1	6.9	44.7	18.7	0.99	10.2	13.3
Lindo	Germany[5]	283	37.0	7.0	45.3	17.3	0.95	9.6	11.7
Suneson	MSU	267	34.4	7.1	38.1	18.7	0.81	4.5	35.0
SO-60	Sustainable Oils	258	37.2	7.2	40.9	21.2	1.28	6.9	21.7

[§§] Graduate student at CSU

Entry	Source	Seed yield (lb/A)[2,3]	Seed oil (%)	Seed moisture (%)[4]	Test weight (lb/bu)	Plant height (in)	1000-seed weight (g)	Number seeds per pod	% Green pods on 8/10/11
C10-BZ-SB7_7	Sustainable Oils	257	38.3	7.0	44.2	18.5	1.10	16.1	16.3
SO-50	Sustainable Oils	253	37.8	7.1	45.4	19.0	1.05	11.3	10.7
BSX G24	Blue Sun Biodiesel	236	37.9	7.1	45.9	19.3	0.87	8.2	22.3
SSD 87	Germany[5]	222	35.2	7.0	40.9	18.5	1.33	8.5	31.7
Licalla	Germany[5]	187	36.7	6.9	42.3	19.8	1.27	11.6	11.7
SSD 138	Germany[5]	172	37.3	6.7	42.5	18.8	1.11	7.7	27.3
Mean		**283**	**37.3**	**7.0**	**43.7**	**18.8**	**1.22**	**9.3**	**21.3**
$LSD_{.05}$		79	-			1.5	0.23	-	7.5
$LSD_{.30}$		41	1.2			0.8	0.45	-	3.9
P-value		0.00	0.12			0.00	0.01	0.62	0.00

[1] This trial was conducted at CSU's Southwestern Colorado Research Center in a randomized complete block design with three replications.
[2] Adjusted to 8.5% moisture
[3] Several plots where the combine got plugged were removed from the results.
[4] The seed from all plots of this variety were combined so that the grain analysis computer had enough seed to make measurements.
[5] University of Giessen

Trial information

Previous crop: Summer fallow

Plot size: 6 ft. by 20 ft.

Fertilizer: 60 lbs of P_2O_5 + 13 lb N/A on 4/15/2011

Herbicide: Sonalan sprayed @ 2.4 pt/A on 4/19/2011

Planting date: 4/20/2011 @ 5 lb/A. The seeds were packaged in Ft. Collins

Irrigation: none

Rainfall from planting to harvest: 4.8 in.
Insect pest observations: No noticeable/significant pest infestation
Harvest date: 8/16/2011

Comments

Seed yield averaged 283 lb/A with a high of 362 and a low of 172 lb/A. Approximately one fifth of the pods were still green one week before harvest. Some of the mature pods had no seeds as a result of shattering or bird feeding. Greater seed losses would have occurred had harvest been delayed. Oil content averaged 37.3 % and test weight 43.7 lb/bu.

Dryland Camelina Planting Date Study

Abdel Berrada[†]

Table 10. Results of the 2010-2011 Dryland Camelina Planting Date Study at Yellow Jacket, CO

Planting date	Harvest date	Variety	Seed yield (lb/A)	Comments
9/7/2010	NA	Celine	0	Winter-killed
9/7/2010	NA	Ligena	0	Winter-killed
9/7/2010	NA	Yellow Stone	0	Winter-killed
		Average	**0**	
10/12/2010	7/11/11	Celine	320	
10/12/2010	7/11/11	Ligena	79	Severe frost damage in rep. 1
10/12/2010	7/11/11	Yellow Stone	1043	
		Average	**481**	
4/4/2011	8/5/11	Celine	294	
4/4/2011	8/5/11	Ligena	225	
4/4/2011	8/5/11	Yellow Stone	140	
		Average	**220**	
5/4/2011	8/16/11	Celine	191	
5/4/2011	8/16/11	Ligena	182	
5/4/2011	8/16/11	Yellow Stone	117	
		Average	**171**	
9/7/2010		HPX-WG3	767	Winter camelina line from USDA-ARS, Washington

Trial information

Plot size: 6 ft. by 50 ft.
Seeding rate: 6.0 lb/A
Number of replications: 2

Comments

The early planted camelina had good stand and growth in the fall of 2010 but did not survive the winter. The October planting averaged 481 lb/A due in large part to the exceptional performance of Yellow Stone. The early April and May plantings did poorly partly due to pod shattering and bird feeding. The winter canola HPX-WG3 averaged 767 lb/A, which far exceeds the performance the spring camelina varieties tested in 2011 (Table 9), with the exception of Yellow Stone (Table 10).

Boosting Sunflower Production in SW Colorado with Supplemental Irrigation: 2011 Result Summary

Abdel Berrada[†]

This study was sponsored by the National Sunflower Association. Abdel Berrada was the principal investigator. Joel Schneekloth, CSU Irrigation Extension Specialist at Akron, CO provided valuable input during the design phase of the study.

Sunflower was grown commercially in SW Colorado in the 1970s but was abandoned partly because of the long distance from markets and processing facilities. It was reintroduced in 2006 after a biodiesel cooperative was formed and in 2008, a plant was built in Dove Creek, CO to mechanically extract oil from sunflower and safflower grown in the area. Twenty five hundred acres were planted to sunflower in Dolores and Montezuma counties, CO in 2006; 10,000 acres in 2007; and 11,500 in 2008. Sunflower acreage declined in 2010 after the Dove Creek plant ceased operation due to financial and other difficulties. Nonetheless, there is still strong demand for sunflower and safflower grown in SW Colorado and SW Utah, most of which is rain-fed.

Contrary to popular belief, sunflower may use as much or more water than other field crops such as corn to produce maximum yields (Meyer, Belshe, O'Brien, & Darling, 2009). This misconception comes from the fact that sunflower can extract water from deep soil layers and thus may not require as much rain or irrigation water, providing there is adequate soil moisture.

The following equation depicts the response of sunflower to irrigation in Akron, CO (Nielsen D. C., 2007):

Yield (lb/A) = 150.6*(inches water use – 6.88)

It took 6.9 in. of water consumption before sunflower started producing seeds. Each additional inch of water produced 151 lb/A.

Long-term average precipitation from May through September in Yellow Jacket is 6.6 in., thus, using the above equation, 5.6 in. of additional water would be required to produce 800 lb/Aof sunflower seeds, which was about the average dryland yield in SW Colorado in 2006-2008. It would take another 5.3 in. to double the yield. Assuming 6.0 inches of effective rainfall during the growing season and 5.0 inches of available soil moisture at planting, the net amount of water that would need to be supplied with irrigation to produce 1600 lb/A is 6.5 in. At 80% irrigation efficiency, the gross irrigation amount would be 8.1 in.

Sunflower is most sensitive to water stress "just before flowering through seed development" (Meyer, Belshe, O'Brien, & Darling, 2009). Schneekloth, 2007, achieved a 60% water saving compared to full irrigation when he applied water at the R-4 to R-5 stage. Seed and oil yields were equal or higher to those obtained with full irrigation in two (2003 and 2005) out of the four-year period (2002-2005) of the study. However, there was plenty soil moisture (field capacity in 0- to 6-ft) at planting in 2002 and 2003. When there was less water available at planting or during the growing season, full irrigation outperformed the limited irrigation treatments. Withholding irrigation until R-6 to R-7 increased oil

concentration significantly compared to full irrigation. Conversely, applying water at R-1 to R-3 (bud stage) only reduced seed oil concentration.

The study reported therein was conducted at the Southwestern Colorado Research Center, located in the Dolores Irrigation Project service area. The Dolores Project provides irrigation water to approximately 62,000 acres of crop land in Dolores and Montezuma counties. Approximately half of this acreage receives 100% of its irrigation water from the Dolores Project and is referred to as the Full Service Area (FSA). Pressurized water of excellent quality is delivered to each farm in underground pipes. Most FSA farmers irrigate their land with wheel-line sprinkler systems (siderolls) but more and more are switching to center pivots to replace aging siderolls or to reduce labor costs. Each farmer is allocated an average of 22.6 inches of water per acre and per season. The total FSA annual water allocation was reached or exceeded several times since the start of the irrigation project in 1987. Reasons for this include frequent droughts and the predominance of alfalfa (> 80% of the irrigated acreage).

Alfalfa net consumptive use is estimated at around 28 inches in SW Colorado, which exceeds the average allocation for FSA. Furthermore, the price FSA irrigators pay for water has been on the rise due to increases in energy (pumping) and maintenance costs. Thus conserving water and enhancing its efficiency is paramount to the long-term sustainability of the FSA. When alfalfa ground is plowed, it is usually planted to dry bean, oat or spring wheat for one to two years before reseeding it to alfalfa. Sunflower would be a good crop to plant after alfalfa to mine the residual water and nitrogen that may be beyond the reach of dry bean or spring cereals.

There are conflicting reports about the response of sunflower to N fertilizer. In general, increasing N rates tend to increase seed yield (up to a point) and decrease oil concentration, although the final oil yield may be enhanced with N application. The response to N may vary with application rate and timing, water management, and other factors. The current recommendation is 65 lb N/A per 1000 lb/A of sunflower seed. In 2010, there was no response to 120 lb N/A compared to 60 lb N/A at the Research Center even though only 27 lb of residual NO_3-N/A were available in the top 2 feet of soil prior to fertilizer application.

The objectives of this study were to determine the response of sunflower to irrigation scheduling, N rate and N by Irrigation interaction.

Materials and Methods

An experiment was established that included five irrigation scheduling treatments and two N rates plus a check (Table 11). Approximately 0.8 in. of water was applied pre-plant and 2.5 in. after planting to enhance seed germination and seedling emergence. Water for I-2, I-3, and I-4 was applied to meet crop ET during the treatment period (Table 11). It was delivered through a subsurface drip irrigation system.

The irrigation and N treatments were arranged in a RCB split-plot design with four replications. Irrigation treatments were assigned to the main plots and N rates to the split-plots. Nitrogen plot size was 10 ft wide by 50 ft long.

Thirty four pounds per acre of P_2O_5 was applied to the whole plot area on 4-May and on 5-May, Sonalan was applied at 2.3 pt/A to control pigweeds, Russian thistle and other weeds. The fertilizer and herbicide were incorporated to the soil with a field cultivator shortly after application. The high-oleic sunflower hybrid Mycogen 8H449 DM was planted on 1-Jun at 22,082 seeds/A in 30-in rows with a 4-row Monosem Planter. It was cultivated between the rows on 29-Jun. Urea was dissolved in warm water and injected through the drip tape on July 8, 11, 19, and 25 to achieve the N rates of 50 and 100 lb/A.

After physiological maturity was reached, all the heads of sunflower in three 8.0-ft of (middle) rows were counted, cut, dried and threshed with a Vogel thresher. Plant height was also measured.

Table 11. Irrigation treatments and N rate

Irrigation treatment	Description	N rate[1]
I-1	Irrigation for stand establishment only	Check (0 N) 50 lb N/A 100 lb N/A
I-2	Full irrigation to meet crop ET[2]	
I-3	Irrigation at R-1 to R-6[3]	
I-4	Irrigation at R-4 to R-6[3]	
I-5	Mimics irrigation with sideroll[4]	

[1] Each irrigation treatment received the same N rates. Liquid nitrogen (Urea dissolved in water) was injected through the drip tape in three applications.
[2] Irrigation to meet crop ET from planting through physiological maturity (R-9). Fifty percent R-9 was reached on 10/10/11.
[3] Irrigation to meet crop ET from R-1 through R-6 (I-3) or R-4 through R-6 (I-4).Fifty percent R-1 was reached on 7/18, 50% R-4 on 8/8, and 50% R-6 on 8/21/11.
[4] I-5 consists of applying water until the sunflower is too tall to irrigate with a sideroll.

Table 12. Precipitation amounts and crop ET (in)

Irrigation Treatment	Pre-plant irrigation amount (net)	Total irrigation amount (net)[1]	Rainfall amount[2]	Reference ET[2]	Crop ET[2]
	inches				
I-1	0.8	2.5	4.2	34.4	13.0
I-2	0.8	18.1	4.2	34.4	21.9
I-3	0.8	11.7	4.2	34.4	20.9
I-4	0.8	7.2	4.2	34.4	17.0
I-5	0.8	4.9	4.2	34.4	15.5

[1] Includes two light applications early in the season to enhance seed germination and seedling emergence

[2] From planting through 4-Oct.

Results

Irrigation application at R-1 (start of the reproductive growth stage) through flowering (R-6) produced as much seeds/acre as the full irrigation treatment (I-2) and was similar to I-4 (irrigation during flowering). Similarly, seed oil content was in the order (highest to lowest): I-2 ≥ I-3 ≡ I-4 > I-5 > I-1 (Table 13). Sunflower plants averaged 45.7 in. in height with the treatment that received the least amount of irrigation water (I-1) and with I-4, and 51.4 in. with I-2, I-3, and I-5. Thus, restricting irrigation mostly to the flowering period (I-4) reduced plant growth but it did not negatively impact seed yield or oil content compared to I-3. Treatment I-4 produced more seeds/inch of irrigation water plus rain than I-2, I-3, and I-5 (Figure 5). The addition of 50 lb N/A increased seed yield and oil content significantly compared to the check (Table 13). Seed oil content decreased as N rate was increased from 50 to 100 lb N/A (Table 13). The irrigation by N rate interaction had no significant effect on seed yield or oil content at $\alpha = 0.05$, although there was a large increase (352 lb/A) in seed yield with 100 lb N/A compared to 0 and 50 lb N/A at I-3.

Table 13. Seed yield, plants/acre, and plant height

Irrigation treatment	N rate lb/A	Seed yield lb/A[1]	Seed oil content (%)	Number plants/A[2]	Plant height in.
I-1	0	1807	38.1	18113	45.8
I-1	50	1909	37.5	16538	46.0
I-1	100	1845	36.9	16144	45.5
I-2	0	2846	42.1	17129	52.9
I-2	50	3222	40.7	16144	51.1
I-2	100	3287	41.1	17129	51.1
I-3	0	2985	41.0	18310	51.5
I-3	50	2927	40.7	16735	50.1
I-3	100	3308	40.4	16932	51.6
I-4	0	2656	41.1	17522	45.5
I-4	50	3065	40.7	17129	45.7
I-4	100	2914	38.9	16144	45.6
I-5	0	1956	39.4	17129	51.8
I-5	50	2233	38.8	17129	52.8
I-5	100	1852	38.1	18310	49.9
Treatment averages					
I-1		1854d[3]	37.5d	16932	45.8b
I-2		3119a	41.3a	16801	51.7a
I-3		3073ab	40.7ab	17326	51.1a
I-4		2878b	40.2b	16932	45.6b
I-5		2014c	38.7c	17522	51.5a
Mean		**2588**	**39.7**	**17102**	**49.1**
	0	2450b	40.3a	17641	49.5
	50	2671a	39.7b	16735	49.1
	100	2641a	39.1c	16932	48.7
Analysis of variance[4]					
Source		Pr> F	Pr> F	Pr> F	Pr> F
Irrigation		<0.00	<0.00	0.91	<0.00
N rate		0.02	<0.00	0.14	0.14
I * N		0.12	0.21	0.53	0.07

[1] Seed yield adjusted to 10% moisture. Number of plants at harvest was used as covariate.
[2] Based on the number of harvested heads; thus plant population is likely higher.
[3] Averages within the same column that are followed by the same letter are not significantly different from each other at α = 0.05.
[4] In most published work, a treatment effect is considered non-significant when the probability (Pr> F or α) of falsely rejecting the null hypothesis is> 0.05. However, in many instances, α values > 0.05 may be acceptable.

The 2011 results indicate that sunflower yield and use efficiency can be increased substantially with limited but well targeted irrigation application. Applying water mostly during flowering increased seed yield by 55% compared to early-season irrigation. Water (irrigation+rain) use efficiency (lb of seeds/inch of water/acre) increased by 70% compared to full irrigation. Seed yield also increased significantly with the application of 50 lb N/acre.

These results also show that applying water with linear-move sprinkler systems or siderolls, which are common in SW Colorado, is not an efficient way to irrigate standard-height sunflower hybrids since most of the water is applied during the vegetative growth (I-5).

Figure 5. Sunflower seed yield and precipitation use efficiency (seed yield/amount of irrigation + rain).

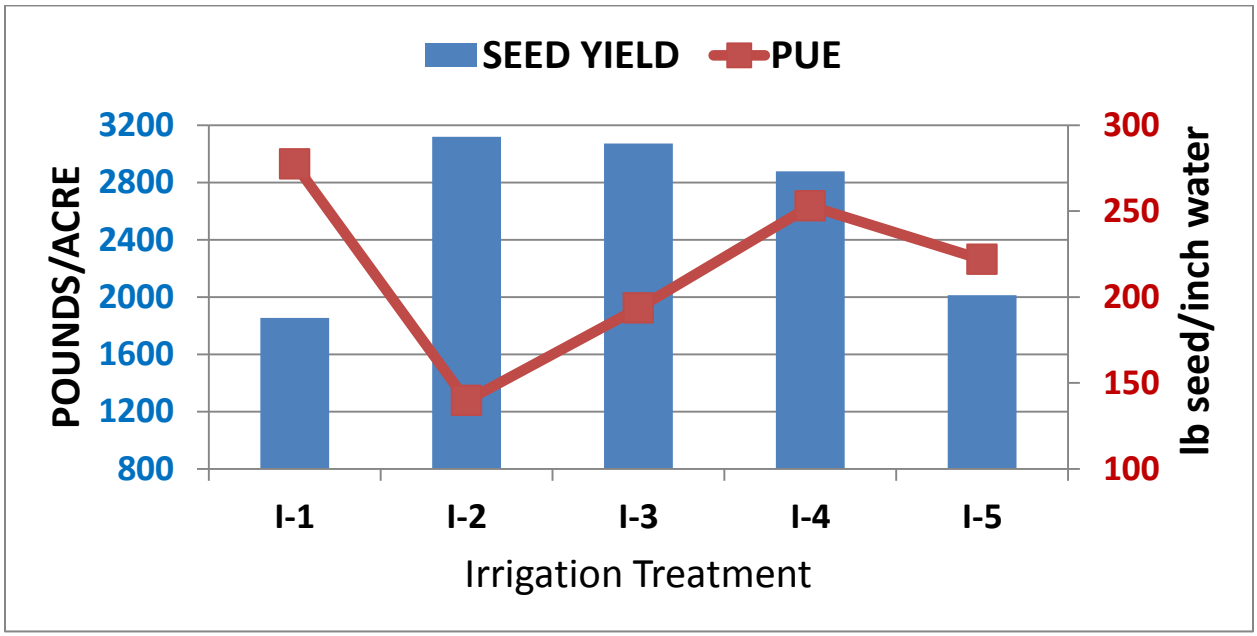
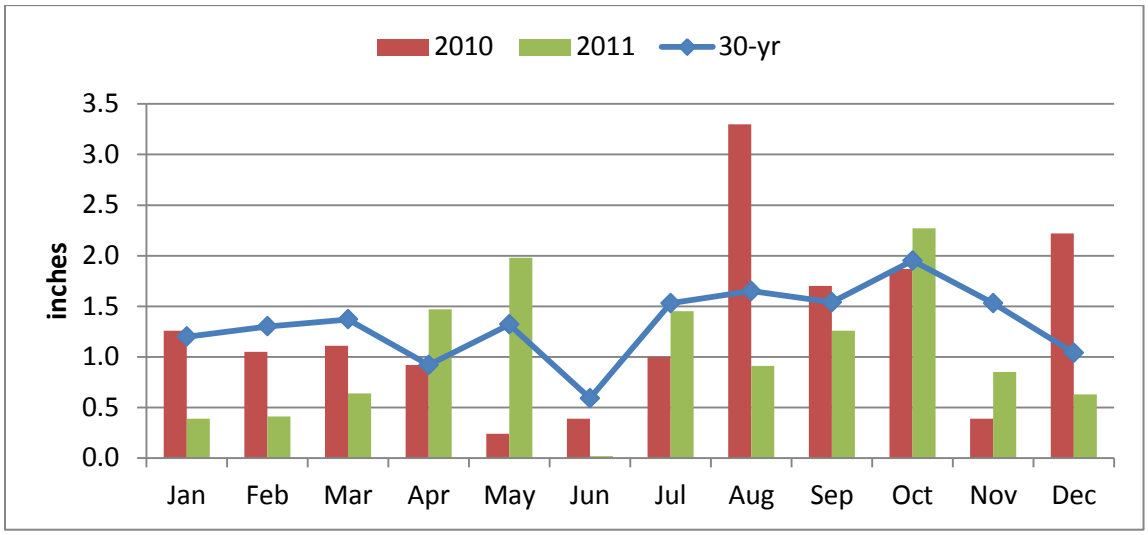


Figure 6. Monthly precipitation at Yellow Jacket, CO



The banded sunflower moth (*Cochylishospes*) and the sunflower moth (*Cochylishospes*) were monitored in August 2011 in several fields, with the use of pheromone traps (Table 14). No insecticides were applied as a result of this monitoring.

Table 14. 2011 Moth Counts in Sunflower Fields.

Date	Moth Type	Sunflower field (number of moths in one wing trap)			
		Limited Irrigation	Variety Trial	Dryland Crop Rotation	Southwest
15-Aug	Banded Sunflower Moth	2	0	5	7
	Sunflower Moth	1	0	2	0
18-Aug	Banded Sunflower Moth	4	0	7	9
	Sunflower Moth	1	0	2	0
22-Aug	Banded Sunflower Moth	4	2	7	10
	Sunflower Moth	2	0	2	0

Dryland Sunflower Planting Date x Seeding Rate x Hybrid Trial at Yellow Jacket, CO***

Abdel Berrada†

The objective of this study was to determine the optimum planting date of four sunflower hybrids planted at two seeding rates. Planting dates were: 18-May, 1-Jun, and 15-Jun. Seeding rates were: 13,939 and 17,289 seeds/A in 30-in row spacing. Sunflower hybrids were: Triumph 657 NS, Triumph s878 HO, Mycogen 8H449 HO, and Pioneer 64H41 HO. The trial was arranged in a split-split plot RCB design with three replications. Planting was assigned to the main plots, seeding rate to split plots, and hybrids to split-split plots. Split-split plot size was 10 ft (four sunflower rows) by 100 ft. Sunflower was harvested on 6-Nov.

Results

Stand establishment

Table 15. Sunflower plant population at harvest[1]

Planting date	Target seeds/A	Harvest plants/A	Success rate
18-May	13939	8971	64%
18-May	17289	10711	62%
1-Jun	13939	9635	69%
1-Jun	17289	11195	65%
15-Jun	13939	6759	48%
15-Jun	17289	8184	47%
Average	**13939**	**8455**	**61%**
	17289	**10030**	**58%**

[1] All the plants with heads in the two middle rows were counted.

*** Jordan Lestina assisted with harvest and presented the results at the San Juan Science Fair in Durango, CO on March 2011.

Plant population at harvest was substantially lower than what might be expected based on the seeding rate (Table 15). Lodging was minimal; thus the low plant population may be attributed to low germination and/or emergence. There were also problems with the Monosem planter, i.e., worn out sprockets, which may have caused gaps in the 2010 sunflower stand. The ratio of number plants at harvest/seeding rate averaged 70 to 75% in 2009. Achieving a uniform stand has been a concern since the Research Center started growing sunflowers in 2006. Several factors can influence stand uniformity including seed size and shape, tractor speed, fan speed, planting depth, and soil water content at planting. For example, if the narrow soil trench created by the disk openers is not closed or firmly pressed, seeds may not germinate due to insufficient moisture/imbibition. Good soil-seed contact is particularly important for sunflowers given the barrier (seed hull) that separates the soil and therefore moisture from the pericarp. Furthermore, the "walls" created by the disk openers harden as the soil dries, making it difficult for the seedling to poke through.

In 2010, the Monosem press wheels were replaced with the 'Posi Close Planter Wheels' (http://www.schlagel.net/pw.html). These attachments have 'fingers' that churn the soil, which helps break the walls created by disk openers and fill the space around the seeds. However, these attachments may not press the soil firmly enough against the seeds, which would limit the seeds' exposure to soil moisture and thus hinder germination. This may have contributed to the low plants-to- seeds ratio in 2010 (Table 15). Soil moisture content at planting was not measured but was deemed adequate (feel method) for germination and emergence. Winter precipitation was above average but that of May and June was below average, which may have impacted stand establishment, particularly at the 15-Jun planting.

Seedling emergence can further be hampered by deep seed placement (e.g., more than 2 to 3 inches below the soil surface), compaction, and crusting. The predominant soil (silty-clay texture and low organic matter) at Yellow Jacket and surrounding areas tends to form a crust after a rain or irrigation event, which may not only slow down seedling emergence but also promotes water erosion. Gaps in the sunflower stand can also be caused by insects (e.g., cut worms, wireworms, etc.), rodents, or birds which damage seeds or seedlings; although this was not observed to any great extent in 2010.

Seed yield and plant height

Seed yield, oil content, and test weight decreased significantly as planting was delayed from 1-Jun to 15-Jun (Table 16). The 18-May and 1-Jun plantings produced similar seed yields, oil contents, and test weights when averaged over all four hybrids. Mycogen 8H449 HO produced the highest seed yield at the 18-May planting and both Mycogen 8H449 HO and Triumph 657 NS produced the highest yields at the 1-Jun and 15-Jun plantings. Triumph s878 HO and Pioneer 64H41 HO had the lowest yield at the second and third planting dates. Pioneer 64H41 HO also performed poorly at the 18-May planting.

Increasing seeding rate from 13,939 to 17,289 seeds/A increased seed yield by an average of 129 lb/A, which was significant at P=0.05. Mycogen 8H449 HO had the highest oil content at all three planting dates and the highest test weight and number of seeds/lb on average. Triumph s878 HO and Pioneer 64H41 HO had the lowest oil contents, while Triumph 657 NS had the lowest test weight.

Plant height varied significantly with planting date and hybrid. Pioneer 64H41 HO and Triumph 657 NS produced the tallest plants at the 1-Jun planting date followed by Mycogen 8H449 HO. Pioneer 64H41 HO also had the tallest plants at the 15-Jun and 18-May planting dates. As would be expected, Triumph s878 HO had the shortest plants, regardless of the planting date. Overall, the 1-Jun planting produced the tallest plants followed by the 15-Jun planting.

A similar trial in 2009 showed a significant decline in oil yield as planting was delayed from 1-Jun to 12-Jun (Stack, Berrada, Brick, & Johnson, 2010, pp. 61-63).

Conclusion

Based on the 2009 and 2010 results and the climatic conditions at Yellow Jacket, CO, it is safe to conclude that sunflower should be planted by early June to optimize oil production. Late planting will depress yield and increase the likelihood that sunflower may not mature completely before the occurrence of the first killing frost in the fall, which usually takes place in late September or early October. The 2010 season was unusual in this regard since the first killing frost did not occur until late October.

How early can sunflower be planted in SW Colorado without negatively impacting oil production? According to the High Plains Sunflower Production Handbook, not before soil temperature reaches 50°F. This occurs at Yellow Jacket around 20-May and seems to confirm the 2009 and 2010 results whereas sunflower was planted on 18 May 2010 or 19 May 2009 without a significant reduction in seed or oil yield, compared to the 1-Jun planting. Growers have reported earlier planting dates (e.g., mid-May) but this has not been tested at Yellow Jacket. Planting date by seeding rate did not impact sunflower seed yield or oil concentration significantly in 2010, which may have been due to the large disparity between seeding rate and final plant population. More research is needed to determine the optimum sunflower seeding rates (target plant populations) in SW Colorado.

Table 16. Sunflower performance in 2010 as affected by planting date, seeding rate, and hybrid

	Seed Yield[1] (lb/A)	Oil[1] (%)	Seeds/lb	Test Weight (lb/bu)	Plant Height[2] (in)
Planting date					
18-May	1669	37.5	5936a[3]	30.3a	41.5
1-Jun	1637	37.0	6107a	29.8a	47.3
15-Jun	1330	34.7	5581b	27.6b	44.2
Seeding rate					

		Seed Yield[1] (lb/A)	Oil[1] (%)	Seeds/lb	Test Weight (lb/bu)	Plant Height[2] (in)
13939 seeds/acre		1481b	36.2a	5777b	29.1b	44.4a
17289 seeds/acre		1610a	36.6a	5972a	29.4a	44.3a
Hybrid[4]						
Triumph 657 NS		1707	36.7	5160d	25.6d	45.3
Triumph s878 HO		1430	34.7	6075b	29.1c	38.7
Mycogen 8H449 HO		1796	39.3	6782a	32.6a	45.9
Pioneer 64H41 HO		1248	34.8	5481c	29.7b	47.4
Planting date	Hybrid					
18-May	Triumph 657 NS	1753b	37.8b	5133	26.6	40.9b
18-May	Triumph s878 HO	1654b	35.8c	6141	30.2	38.6c
18-May	Mycogen 8H449 HO	1986a	40.7a	6893	33.4	42.3ab
18-May	Pioneer 64H41 HO	1283c	35.8c	5577	31.0	44.4a
1-Jun	Triumph 657 NS	1843a	37.5b	5299	26.2	50.6a
1-Jun	Triumph s878 HO	1453b	35.0c	6441	29.5	40.6c
1-Jun	Mycogen 8H449 HO	1966a	40.3a	7066	33.2	47.6b
1-Jun	Pioneer 64H41 HO	1286b	35.2c	5622	30.1	50.3a
15-Jun	Triumph 657 NS	1525a	35.0b	5047	23.9	44.3b
15-Jun	Triumph s878 HO	1182b	33.4c	5645	27.5	37.1c
15-Jun	Mycogen 8H449 HO	1437a	36.8a	6387	31.1	47.8a
15-Jun	Pioneer 64H41 HO	1175b	33.3c	5245	27.9	47.3a
Effect		Pr> F	Pr> F	Pr> F	Pr> F	Pr> F
Planting date (pdate)		0.001	<.0001	0.000	0.000	0.005
Seeding rate (srate)		0.032	<.0001	0.025	0.043	0.900
pdate*srate		0.350	0.912	0.654	0.611	0.767
Hybrid (hyb)		<.0001	<.0001	<.0001	<.0001	<.0001

	Seed Yield[1] (lb/A)	Oil[1] (%)	Seeds/lb	Test Weight (lb/bu)	Plant Height[2] (in)
pdate*hyb	0.028	<.0001	0.066	0.792	0.000
srate*hyb	0.662	0.167	0.057	0.413	0.025
pdate*srate*hyb	0.148	0.355	0.882	0.740	0.672

[1] Adjusted to 10% moisture

[2] Height at the highest point of the plant. The height of bent plants may not reflect their true height

[3] Averages followed by the same letter are not significantly different at P = 0.05.

[4] NS: NuSun (mid-oleic), HO: High Oleic.

Trial information

Harvest date:	11/6/2010
Previous crop:	Irrigated oats
Soil type:	Wetherill silty clay loam
Fertilizer:	48 lb N/A + 24 lb P_2O_5/A on 5/20/2010
Soil test (0-10”):	Nitrate-N: 21 lb/A, Mehlich-3 P: 15 ppm, pH: 7.1, OM: 1.4%
Herbicide:	Sonalan@ 2.5 pt/A PPI on 5/14/2010
Rain (Jun-Oct):	8.28 in (gross amount) or 114% of normal

Dryland Sunflower Variety Trials

Abdel Berrada[†] and Jerry Johnson[‡‡]

Table 17. Results of the 2011 Sunflower Variety Trial at Yellow Jacket, CO

Hybrid	Company	Oil type	Adjusted Yield[1] lb/A	Plants at harvest plants/ac[2]	Seed Oil Content (%)	Seed Moisture (%)	Test Weight (lb/bu)	Plant Height (in)
s678	Triumph Seed Co., Inc.	Nusun	1571	10541	37.3	7.8	28.9	34.8
4596 HO/DM	Syngenta Seed	High Oleic	1483	9439	35.7	7.1	29.5	46.6
P63ME80	Pioneer Hi-Bred Intl', Inc.	Nusun	1463	9402	37.7	6.9	28.5	45.2
3733 NS/DM	Syngenta Seed	Nusun	1456	10171	37.3	6.5	29.3	35.7
s673	Triumph Seed Co., Inc.	Nusun	1449	9635	38.9	6.8	29.3	31.7
8H449CLDM	Mycogen Seeds	High Oleic	1386	8988	38.2	6.7	31.2	41.4
s671	Triumph Seed Co., Inc.	Nusun	1386	11179	37.2	6.9	29.5	29.7
P63HE60	Pioneer Hi-Bred Intl', Inc.	High Oleic	1324	10241	35.6	6.6	27.6	40.9
TRXs10429H	Triumph Seed Co., Inc.	High Oleic	1303	10033	37.5	6.8	29.6	31.2
3845 HO	Syngenta Seed	High Oleic	1301	7869	38.2	6.4	28.9	35.1
s870HCL	Triumph Seed Co., Inc.	High Oleic	1221	9663	37.4	6.8	29.1	29.6
s668	Triumph Seed Co., Inc.	Nusun	1196	10495	35.7	7.1	27.8	29.3
859HCL	Triumph Seed Co., Inc.	High Oleic	1173	8607	34.9	7.3	27.2	43.3
P63ME70	Pioneer Hi-Bred Intl', Inc.	Nusun	1158	9395	35.2	6.7	25.9	44.2
8H288CLDM	Mycogen Seeds	High Oleic	1105	10715	39.5	6.2	30.1	38.9
63M91	Pioneer Hi-Bred Intl', Inc.	Nusun	1090	8435	38.5	6.5	29.6	47.1
3495	Syngenta Seed	Nusun	1083	9744	36.2	6.8	29.2	43.0

Hybrid	Company	Oil type	Adjusted Yield[1] lb/A	Plants at harvest plants/ac[2]	Seed Oil Content (%)	Seed Moisture (%)	Test Weight (lb/bu)	Plant Height (in)
NS/CL/DM								
3995 NS/SU	Syngenta Seed	Nusun	941	10131	36.2	6.5	29.2	36.1
AVERAGE			**1283**	**9705**	**37.1**	**6.8**	**28.9**	**38.0**
CV (%)			12	13	3.0	5.5	3.2	3.0
$LSD_{0.05}$			258	NS	1.6	0.6	1.5	1.9
$LSD_{0.30}$			133.76	1110.50	0.94	0.32	0.79	0.97

[1] Seed yield was adjusted to 10% moisture.
[2] Number of plants with harvestable heads

Trial Information

Planting date: 5/31/2011
Harvest: 11/3/2011
Planting equipment: Monosem Pneumatic Planter
Seeding rate (seeds/A): 17,289 (Seed spacing: 12.1", Row spacing: 30")
Tillage: the field cultivator was used on 4/15 and 4/20/2011
Fertilizer: 60 lb P_2O_5/A on 4/15/2011 based on soil test results and a yield goal of 1500 lb/A
Herbicide: Sonalan at 2.4 pt/A on 4/19/2011
Hoeing: 5/26/11 and 7/29/2011
Row cultivation: 7/5/2011
Irrigation: none
Rainfall from June through October: 5.9 in.

Comments

Seed yield averaged 1283 lb/A with hybrid s678 topping the list with 1571 lb/A. Other short-stature hybrids also did fairly well. Seed oil content was below 40% for all entries, which may have been due to cool temperatures early in the season and relatively dry conditions during bloom. The results of this and other 2011 sunflower hybrid performance trials in Colorado are available at: http://www.extsoilcrop.colostate.edu/CropVar/documents/sunflowers/sunflowerreport_2011.pdf

Table 18. 2005-2011 Dryland Sunflower Hybrid Performance Multi-year Summary[1]

Brand	Hybrid[2]	Oil Type	Seed Yield (lb/A)[3]	Years of Yield Data	Seed Oil Content (%)[4]	Test Weight (lb/bu)	Plant Height (in)	50% Bloom Date
Triumph	657	NuSun	1741	3	41.8	27.7	49.3	8/8
Syngenta	3845 HO	High Oleic	1609	2	39.0	29.2	39.1	8/3
Mycogen	8H449 DM	High Oleic	1602	3	42.3	33.0	49.3	8/7
Mycogen	8N453 DM	NuSun	1533	3	43.5	33.9	46.2	8/6
Triumph	664	NuSun	1525	2	40.1	28.2	45.8	8/6
Pioneer	63N82	NuSun	1505	2	37.2	30.0	52.4	8/5
Pioneer	63M91	NuSun	1462	4	41.0	30.7	51.7	8/6
Triumph	s878	High Oleic	1400	2	40.0	30.4	39.3	8/8
Pioneer	P63ME70	NuSun	1394	2	35.7	25.3	46.6	8/4
Triumph	s671	NuSun	1382	3	39.8	30.9	31.5	8/9
Monsanto	MH6640	NuSun	1337	2	42.0	31.6	45.2	8/11
Mycogen	8N510	NuSun	1329	2	39.5	30.4	43.8	8/12
Triumph	845HO	High Oleic	1235	3	40.8	27.8	44.5	8/7
Triumph	820HO	High Oleic	1152	4	40.8	31.9	42.9	8/2
Triumph	s655	NuSun	1152	2	40.3	30.3	32.5	8/7

Brand	Hybrid[2]	Oil Type	Seed Yield (lb/A)[3]	Years of Yield Data	Seed Oil Content (%)[4]	Test Weight (lb/bu)	Plant Height (in)	50% Bloom Date
Dekalb	DKF37-31 NS	NuSun	1098	3	40.2	32.2	42.1	8/10
Garst	4651 NS/DM	NuSun	1077	3	36.2	28.3	45.1	8/7
Pioneer	64H41	High Oleic	1068	2	39.4	31.5	53.4	8/11
Mycogen	8H288CLDM	High Oleic	1029	2	42.2	30.6	41.1	8/5
Croplan	378 DMR, HO	High Oleic	853	2	35.3	28.5	41.8	8/11
Triumph	636	NuSun	832	2	40.2	29.7	39.5	8/11
Garst	4704 NS	NuSun	696	2	35.0	29.4	39.5	8/7
Garst	4668 NS/CL	NuSun	619	2	35.4	30.3	42.8	8/11
Average			**1245**	**2**	**39.4**	**30.1**	**43.7**	**8/7**

[1] Only sunflower hybrids that were tested for two or more years are shown.
[2] NS = NuSun (mid-oleic); CL = Clearfield; DM or DMR = Downy mildew resistant; HO = High-oleic.
[3] Includes only data that was adjusted to 10% seed moisture
[4] Some data may have been adjusted to 10% seed moisture and other data may not have been adjusted or may have been adjusted to a different moisture level.

Irrigated Spring Wheat Variety Performance Trials

Abdel Berrada[†], Scott Haley[†††], and Jerry Johnson[‡‡]

Table 19. The 2011 Irrigated Spring Wheat Variety Performance Trial at Yellow Jacket, CO[1]

Entry	Type[2]	Source[3]	Grain yield (bu/A)[4]	Grain protein (%)	Grain moisture (%)	Test weight (lb/bu)	Plant height (in)	50% heading date
Sylvan	HRS	CSU-SWCRC	97.9	11.3	11.0	61.0	27.0	5-Jul
WA8123	HWS	WSU	95.1	12.9	10.8	59.7	25.0	29-Jun
IDO 686	SWS	UI	94.2	12.1	11.5	61.2	25.9	1-Jul
IDO 599	SWS	UI	93.6	11.4	11.5	60.4	25.1	29-Jun
WB-Idamax	HWS	Westbred	92.3	14.1	10.3	59.1	24.6	29-Jun
IDO 644	SWS	UI	91.3	12.2	11.3	58.3	24.9	28-Jun
Kelse	HRS	WSU	90.7	14.2	10.5	59.6	27.9	5-Jul
WB-Paloma	HWS	Westbred	90.4	15.3	10.6	59.5	23.8	29-Jun
WA8074	HRS	WSU	89.6	13.6	11.0	60.7	25.6	28-Jun
IDO377S	HWS	UI	89.1	13.0	10.9	60.8	24.1	29-Jun
IDO 671	SWS	UI	88.4	11.2	11.6	58.8	24.8	30-Jun
SY Soren	HRS	Agripro	87.5	14.0	10.7	60.4	26.3	30-Jun
WA8133	HWS	WSU	87.5	13.3	10.4	60.6	26.0	29-Jun
Jefferson	HRS	UI	87.4	13.8	10.8	60.6	26.0	29-Jun

[†††] Wheat breeder and Professor at CSU-Ft. Collins

Entry	Type[2]	Source[3]	Grain yield (bu/A)[4]	Grain protein (%)	Grain moisture (%)	Test weight (lb/bu)	Plant height (in)	50% heading date
02S0178-1	HRS	Agripro	86.8	13.2	11.3	60.7	26.4	30-Jun
03S0253-7	HRS	Agripro	86.6	13.4	11.3	58.8	23.9	30-Jun
WB-Fuzion	HRS	Westbred	86.6	14.6	10.6	61.2	27.3	30-Jun
UI Winchester	HRS	UI	84.3	13.5	11.0	60.5	23.5	30-Jun
UI Cataldo	SWS	UI	80.1	12.9	10.9	58.0	23.6	27-Jun
Jerome	HRS	UI	79.9	13.9	11.3	60.4	24.3	29-Jun
Westbred 936	HRS	Westbred	78.4	13.1	10.6	59.5	23.8	29-Jun
Alzada	Durum	Westbred	76.0	14.5	11.1	58.8	20.6	29-Jun
APB D1-35	Durum	Arizona Grain	66.3	15.5	10.2	50.2	21.9	30-Jun
SKY	Durum	Arizona Grain	56.6	16.3	10.9	52.7	22.6	29-Jun
Average			**85.7**	**13.5**	**10.9**	**59.2**	**24.8**	**29-Jun**
LSD.05			10.1	1.7	0.5	0.9	1.4	
CV (%)			8.4	6.2	3.0	1.0	4.0	

[1] The trial is conducted at CSU's Southwestern Colorado Research Center (CSU-SWCRC).

[2] HRS: Hard Red Spring wheat; HWS: Hard White Spring wheat; SWS: Soft White Spring wheat

[3] WSU: Washington State University, UI: University of Idaho

[4] Grain yield adjusted to 12% moisture and 60 lb/bu test weight

Trial information

Previous crop: Sunflower in 2010, spring wheat in 2009

Seeded on 4/21/2011 @ 1,200,000 seeds/A and harvested on 8/31/2011

Soil temperature at seeding: 47.8F
Fertilizer: 80 N + 58 lb P_2O_5/A on 4/13/2011 & 48 lb N/A on 6/11/2011
Pesticide: 2,4-D Amine on 6/8/2011 @ 1.4 pt/A
Rainfall (planting – Aug.): 5.3 in.
Irrigation: Five irrigation applications with the sideroll for a total of approximately 13 in. gross water amount

Comments

The trial averaged 86 bu/A with Sylvan and several varieties and experimental lines from Idaho and Washington topping 90 bu/A. Three durum wheat varieties were tested for the first time at the Research Center. They had the lowest grain yields. The two varieties, APB D1-35 and Sky, with the lowest grain yields also had the lowest test weights but had the highest protein contents. Grain yields of comparable hard red and soft white entries were 8 to 20 bu/A lower in 2011 compared to 2010, possibly due to colder weather at planting through early May and much drier conditions in June and August of 2011. A late irrigation application in 2011 may have boosted grain yield.

Table 20. Irrigated Spring Wheat Variety Performance Trial at Yellow Jacket, CO. Averages for 2010 and 2011. Only varieties for which there is two years of data are included.

Entry	Type[1]	Source[2]	Grain yield (bu/A)[3]	Grain protein (%)	Grain moisture (%)	Test weight (lb/bu)	Plant height (in)	50% heading date
Sylvan	HRS	CSU-SWCRC	101.6	11.4	10.7	61.0	29.5	7/6
Kelse	HRS	WSU	94.8	14.7	9.9	59.2	30.6	7/3
Jerome	HRS	UI	89.3	13.4	10.5	60.2	26.8	6/30
UI Winchester	HRS	UI	87.0	13.8	10.3	60.1	25.1	6/30
Average			**93.2**	**13.3**	**10.3**	**60.1**	**28.0**	**7/2**

[1] HRS: Hard Red Spring wheat; HWS: Hard White Spring wheat; SWS: Soft White Spring wheat

[2] WSU: Washington State University, UI: University of Idaho

[3] Grain yield adjusted to 12% moisture and 60 lb/bu test weight

Wheat Variety Trials

Abdel Berrada[†], Scott Haley[†††], and Jerry Johnson[‡‡]

Winter wheat is the second largest field crop (in acreage) in southwestern Colorado, after alfalfa. The hard red winter wheat variety 'Fairview' which was released in 1991 (Quick, Souza, & Sunderman, 1993) based on testing at the Southwestern Colorado Research Center (SWCRC) is the most widely grown variety in this area. It has good yield potential and excellent bread making quality. Certified seed of 'Fairview' has been in short supply in recent years. Another commonly grown winter wheat variety is 'Deloris', developed by the Utah Agricultural Experiment Station and released in 2002 (Hole, Roche, Clawson, & Young, 2004). It has performed similarly to Fairview in the variety trials at Yellow Jacket. Both Deloris and Fairview possess resistance to dwarf bunt (*Tilletia controversa* Kuhn), which is a soil born, seed head fungal disease. Dwarf bunt is "limited to areas with prolonged snow cover on unfrozen ground" (Cook & Veseth, 1991). It has not been observed in the variety trials to any significant extent for several years, except in 2007, which had very low yields due to water stress. Several of the top-performing varieties in 2008 and 2009, such as 'Ripper' and 'Bill Brown', do not have dwarf bunt resistance since they were developed for eastern Colorado where dwarf bunt is not a concern.

Another pest of importance to wheat production in Colorado is Russian wheat aphid (RWA) (*Diuraphis noxia* (Mordvilko). It became established in SW Colorado in the late 1980's (Stack, Berrada, Brick, & Johnson, 2010, p. 18). Russian wheat aphid infestation appears to be greatest when winter wheat is planted early (Hammon, Sanford, Stack, Berrada, & Peairs, 1999). Russian wheat aphid has been more prevalent in spring wheat than in winter wheat at the SWCRC and usually requires an insecticide application. An attempt by Colorado State University's (CSU's) wheat breeding program to develop a winter wheat variety that has resistance to both dwarf bunt and RWA, using selections from a single three-way cross, was not successful (Stack, Berrada, Brick, & Johnson, 2010, p. 18) and Burd, Porter, Puterka, Haley, & Peairs, 2006).

Spring wheat or oat is sometimes planted under rainfed conditions, for example when winter moisture is adequate, or when late bean harvest or other factors (time, weather, etc.) result in winter wheat not being planted. However, these two spring crops are more commonly grown under irrigation, especially after alfalfa, for example to take advantage of residual nitrogen or to control broadleaf weeds, including volunteer alfalfa. In 2008, a total of 5,100 acres of oat (only 1,600 acres were harvested) and 3,400 acres of spring wheat were planted in SW Colorado (http://www.nass.usda.gov/Statistics_by_State/Colorado). Most of the oat grown under irrigation is harvested for hay.

Table 21. The 2010-2011 Dryland Winter Wheat Variety Trial at Yellow Jacket, CO[1]

Variety	Type[2]	Grain Yield[3] bu/A	Grain Protein %	Grain Moisture %	Grain Test Weight lb/bu	Plant Height in.	50% Heading date
CO050173	HRW	62.7	16.2	10.3	55.8	30.2	6/4
CO06052	HRW-C	61.8	16.3	10.1	56.5	29.3	6/3
Hatcher	HRW	58.3	15.0	9.3	52.3	26.5	6/4
TAM 112	HRW	57.5	15.5	10.1	55.3	27.8	6/3
Ripper	HRW	56.8	15.7	9.5	53.3	26.8	6/3
Winterhawk	HRW	56.3	14.5	10.3	55.7	27.8	6/6
Snowmass	HWW	55.6	14.8	10.1	54.2	28.7	6/4
Above	HRW-C	55.4	14.3	10.0	54.2	27.5	6/3
CO050303-2	HRW	54.4	16.2	9.9	53.9	28.3	6/8
CO050233-2	HRW	54.1	16.8	9.3	52.3	28.0	6/8
CO050322	HRW	53.3	16.1	10.0	52.9	25.5	6/8
Thunder CL	HWW-C	52.9	14.3	9.5	55.2	26.3	6/10
UI Darwin	HWW	52.7	16.3	10.2	56.0	30.5	6/10
CO05W111	HWW	52.0	16.6	10.1	55.0	28.5	6/8
Bill Brown	HRW	51.5	15.9	10.1	52.2	26.7	6/4
IDO658	HWW	50.4	15.9	10.1	54.8	28.2	6/14
IDO656	HRW	50.1	17.1	9.2	50.2	31.2	6/10
Curlew	HRW	49.0	16.9	9.3	51.1	29.7	6/10
IDO835	HWW	48.9	16.1	10.5	52.3	26.3	6/15
IDO816	HRW	48.4	16.0	11.5	51.2	28.0	6/17
CO06424	HRW	48.3	14.3	10.3	53.0	27.7	6/3

Variety	Type[2]	Grain Yield[3] bu/A	Grain Protein %	Grain Moisture %	Grain Test Weight lb/bu	Plant Height in.	50% Heading date
CO050337-2	HRW	47.0	17.1	9.8	52.4	26.8	6/8
Deloris	HWW	46.3	17.2	9.6	53.0	29.3	6/10
Fairview	HRW	46.0	15.9	9.6	51.8	28.2	6/10
JC108	HWW	45.9	15.8	9.8	52.6	26.5	6/10
IDO821	HRW	44.7	16.0	9.6	54.1	26.8	6/13
Bond CL	HRW-C	44.2	14.6	9.7	52.2	29.8	6/3
Lucin CL	HRW-C	42.1	17.1	10.2	52.9	32.3	6/10
JC109	HRW	35.4	17.5	10.3	45.5	23.7	6/17
Average		**51.1**	**15.9**	**9.9**	**53.2**	**28.0**	**6/8**
CV (%)		11.2	3.3	5.9	2.5	4.1	
$LSD_{.05}$		9.4	1.1	1.0	2.2	1.9	

[1] The trial was conducted at CSU's Southwestern Colorado Research Center.
[2] HRW: Hard Red Wheat; HWW: Hard White Wheat; C: Clearfield (resistant to 'Beyond' herbicide)
[3] Grain yield adjusted to 12% moisture and 60 lb/bu test weight

Trial information

Seeded on 9/30/2010 and harvested on 7/20/2011

Fertilizer: 15 lb N + 73lb P_2O_5/A on 9/2/2010

Previous crop: Summer fallow in 2010, Irrigated oat in 2009, irrigated alfalfa in 2000-2008

Rainfall (Oct. - June): 9.4 in. (Precipitation from snow may not be accurate)

Comments

Soil moisture at wheat seeding was adequate. Fall precipitation was above average. January through March precipitation was well below average. Wheat stand and vegetative growth were excellent. However, dry conditions (0.1" from 21 May through 10 July) during the

reproductive growth stages, especially flowering and grain filling, reduced seed size, test weight, and yield. Still, the mean yield of51 bu/A was above the area's average. Summer fallowing in 2010 and fertilizer application in early September 2011 probably contributed to these yields.

Several experimental lines from Colorado State University's wheat breeding program performed in the top tier as did Hatcher, TAM 112, Ripper, Winterhawk, Snowmass (HWW), and Above. These and other winter wheat varieties grown in eastern Colorado lack resistance to dwarf bunt (*Tilletia controversa* Kuhn), which may be a concern in southwestern Colorado in some years. Winter wheat recommendations for eastern Colorado are available at: http://www.extsoilcrop.colostate.edu/CropVar/documents/winterwheat/wheatreport_2011.pdf.

Table 22. Dryland Winter Wheat Variety Trials at Yellow Jacket, CO--Multi-year averages. Varieties that were only in trials for one year are excluded.

Entry	Grain yield (bu/A)	Grain protein (%)	Test weight (lb/bu)	Plant Height (in.)	Ending year	# of years
Ripper	49.9	12.6	55.3	25.5	2008-2011	4.0
IDO653	49.1	15.7	56.2	34.6	2008-2009	2.0
Winterhawk	46.7	12.5	58.2	26.0	2009-2011	3.0
Thunder CL	46.0	12.2	57.4	25.4	2009-2011	3.0
Curlew	45.7	13.6	56.2	29.0	2008-2011	4.0
TAM 112	45.1	13.4	57.2	25.2	2008-2011	4.0
SRG	44.5	14.2	55.0	30.0	2009-2011	3.0
NuDakota	44.5	12.7	55.3	23.0	2008-2010	3.0
Bill Brown	44.4	12.6	56.2	24.6	2008-2011	4.0
Snowmass	44.1	12.6	56.2	27.4	2009-2011	3.0
Above	43.9	12.3	56.0	25.3	2008-2011	4.0
Hatcher	43.8	12.6	55.9	23.6	2008-2011	4.0
UI Silver	43.6	13.0	58.1	27.3	2009-2011	3.0
Keota	43.0	12.7	58.8	27.0	2008-2010	3.0
UI Darwin	42.6	14.1	58.9	29.4	2008-2011	4.0
Deloris	42.6	13.7	56.7	29.2	2008-2011	4.0
Fairview	42.4	13.2	55.8	27.7	2008-2011	4.0
Jagalene	42.0	14.0	59.1	25.8	2008-2010	3.0
Hawken	40.6	13.7	56.9	23.5	2008-2010	3.0

Entry	Grain yield (bu/A)	Grain protein (%)	Test weight (lb/bu)	Plant Height (in.)	Ending year	# of years
Bond CL	40.4	12.6	55.3	26.7	2008-2011	4.0
UICF Grace	39.0	13.7	55.3	33.5	2008-2010	3.0
Danby	38.9	13.9	60.0	25.0	2008-2010	3.0
IDO660	37.8	14.3	57.0	23.4	2009-2010	2.0
Avalanche	37.3	12.9	57.7	25.0	2008-2010	3.0
Golden Spike	36.9	13.6	57.7	26.8	2009-2010	2.0
JC109	35.4		45.5	23.7	2011	2.0
Gary	34.7	13.4	58.0	26.3	2008-2010	3.0
Hayden	33.4	14.5	59.9	31.6	2009-2010	2.0
Grand Total	**42.7**	**13.3**	**56.5**	**26.8**		

Bibliography

Berrada, A. (2004). *Developing Sustainable Dryland Cropping Systems in SW Colorado and SE Utah Using Conservation Tillage and Crop Diversification - 2002 and 2003 Results.* Ft. Collins, CO: Colorado State University.

Burd, J. D., Porter, D. R., Puterka, G. J., Haley, S. D., & Peairs, F. B. (2006). Biotypic Variation Among North American Russian Wheat Aphid (Homoptera: Aphididae) Populations. *Journal of Economic Entomology, 99*(5), 1862-1866.

Cook, R. J., & Veseth, R. J. (1991). *Wheat Health Management.* St. Paul, Minn: APS Press.

Hammon, R., Sanford, D., Stack, M., Berrada, A., & Peairs, F. (1999). *Dryland Winter Wheat Planting Date and Russian Wheat Aphid Studies in Southwestern Colorado, 1990-1998.* Fort Collins, CO: Colorado State University.

Hole, D., Roche, D., Clawson, S., & Young, S. (2004). Registration of 'Deloris' Wheat. *Crop Science, 44*(2), 695-696.

Krupinsky, J., Bailey, K., McMullen, M., Gossen, B., & Turkington, T. (2002). Managing Plant Disease Risk in Diversified Cropping Systems. *Agron. J., 94*, 198–209.

McVay, K., & Lamb, P. (2008). *Camelina Production in Montana.* Montana State University Extension.

Meyer, R., Belshe, D., O'Brien, D., & Darling, R. (2009). *High Plains Sunflower Production Handbook.* Kansas State University.

Nielsen, D. C. (2007, April). Estimated Yield of Some Alternative Crops Under Varying Irrigation in Northeast Colorado. *Agronomy News, 26*(1), 8-9.

Nielsen, D. C., Anderson, R. L., Bowman, R. A., Aiken, R. M., Vigil, M. F., & Benjamin, J. G. (1999). Winter wheat and Proso millet yield reduction due to sunflower in rotation. *J. Prod. Agric., 12*(2), 129-197.

Pilgeram, A., Sands, D., Boss, D., Dale, N., Wichman, D., Lamb, P., . . . Johnson, D. (2007). Camelina sativa, A Montana Omega-3 and fuel crop. In J. Janick, & A. Whipkey, *Issues in new crops and new uses* (pp. 129-131). Alexandria, VA: ASHS Press.

Putnam, D., Budin, J., Field, L., & Breene, W. (1993). Camelina: A promising low-input oilseed. In J. Janick, & J. Simon, *New crops* (pp. 314-322). New York, NY: Wiley.

Quick, J., Souza, E., & Sunderman, D. (1993). Registration of 'Fairview' wheat. *Crop Science, 33*(878).

Raymer, P. (2002). Canola: An Emerging Oilseed Crop. In J. Janick, & A. Whipkey, *Trends in new crops and new uses* (pp. 122-126). Alexandria, VA: ASHS Press.

Schneekloth, J. (2007, April). Yield impact of growth stage irrigation of sunflowers. *Agronomy News, 26*(1), 10-11.

Schwartz, H. F., Brick, M. A., Buchleiter, G., Ogg, J. B., & McMillan, M. S. (2011). Plant Arrangement Enhances Dry Bean Production for Some Varieties. *2011 Bean Improvement Cooperative Conference, October 30 - Nov 2.* San Juan, Puerto Rico.

Stack, M., Berrada, A., Brick, M., & Johnson, J. (2010). Dry Bean Research at the Southwestern Colorado Research Center Yellow Jacket, Colorado. In A. F. Berrada, & M. W. Stack, *Southwestern Colorado - Research Report (2005-2009 Results)* (pp. 87-89). Fort Collins, CO: Colorado State University.