Technical Report 14-13

Agricultural Experiment Station

Colorado State University

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Southwestern Colorado Research Center 2013 Results

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2013 Results

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Southwestern Colorado Research Center
Yellow Jacket, Colorado

Cover photo shows winter wheat in the dryland crop rotation trial at the Southwestern Colorado Research Center. Jerry Mahaffey is operating the mini-combine. Photo taken on July 11, 2013 by Abdel Berrada.

Acknowledgments

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This report was compiled and formatted by Amin Berrada and reviewed by Dr. Gary Peterson and Dr. Jerry Johnson.

Disclaimer

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Soil & Climate at the Southwestern Colorado Research Center

Abdel Berrada

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 in 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 (1981-2010, NOAA) average annual precipitation at Yellow Jacket is 15.9 inches of water (Figure 1). Annual precipitation at the CoAgMet (Colorado Agricultural Meteorology) weather station in Yellow Jacket averaged only 12 inches from 1992 when the station became operational through 2013. This may not account for all the moisture from snow, since CoAgMet uses a simple tipping bucket rain gauge. The average annual snowfall is 68.1 inches (30-year average from 1971-2000). June is the driest month and August is the wettest 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 2012-2013 growing season started with a dry fall followed by a "wet" January and an extremely dry spring. Precipitation in August and September was substantially above normal, which boosted the total for 2013 to 16.4 inches (Figure 1).

Figure 1: Monthly precipitation at Yellow Jacket, CO in 2012, 2013, 1992-2013 (CoAgMet), and 1981-2010

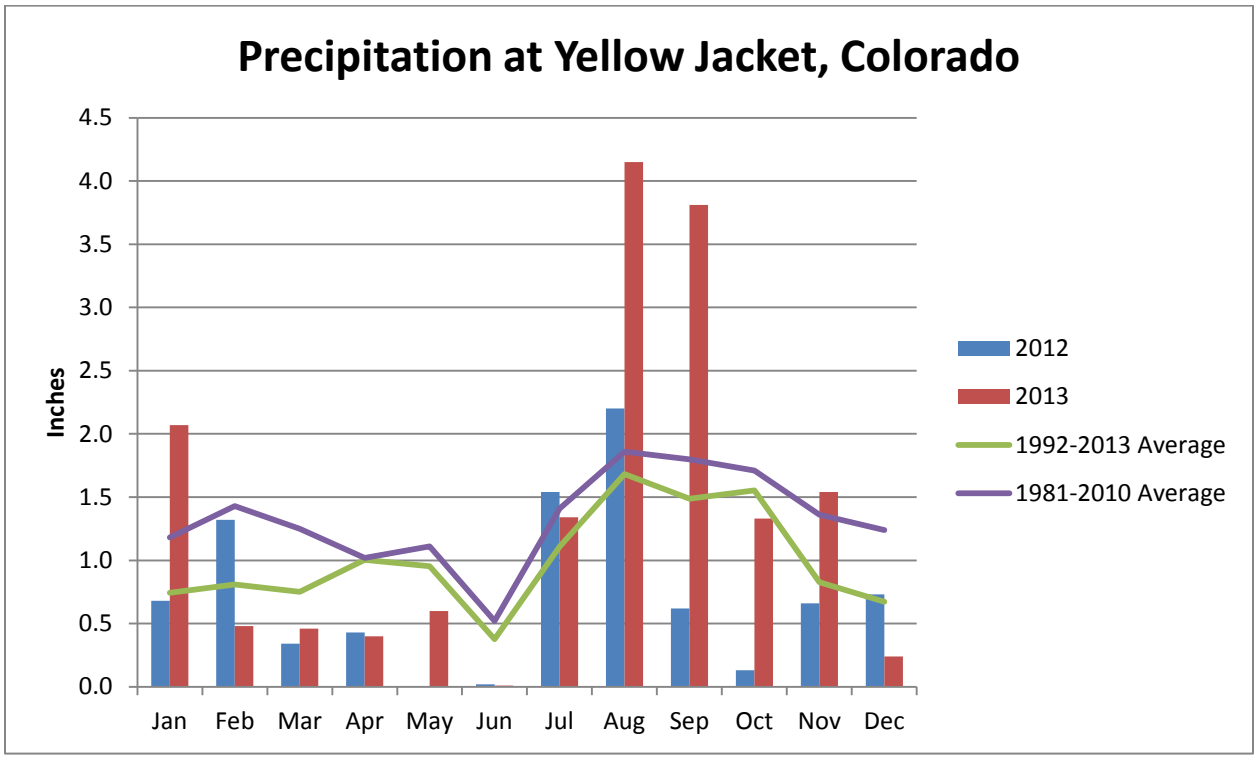
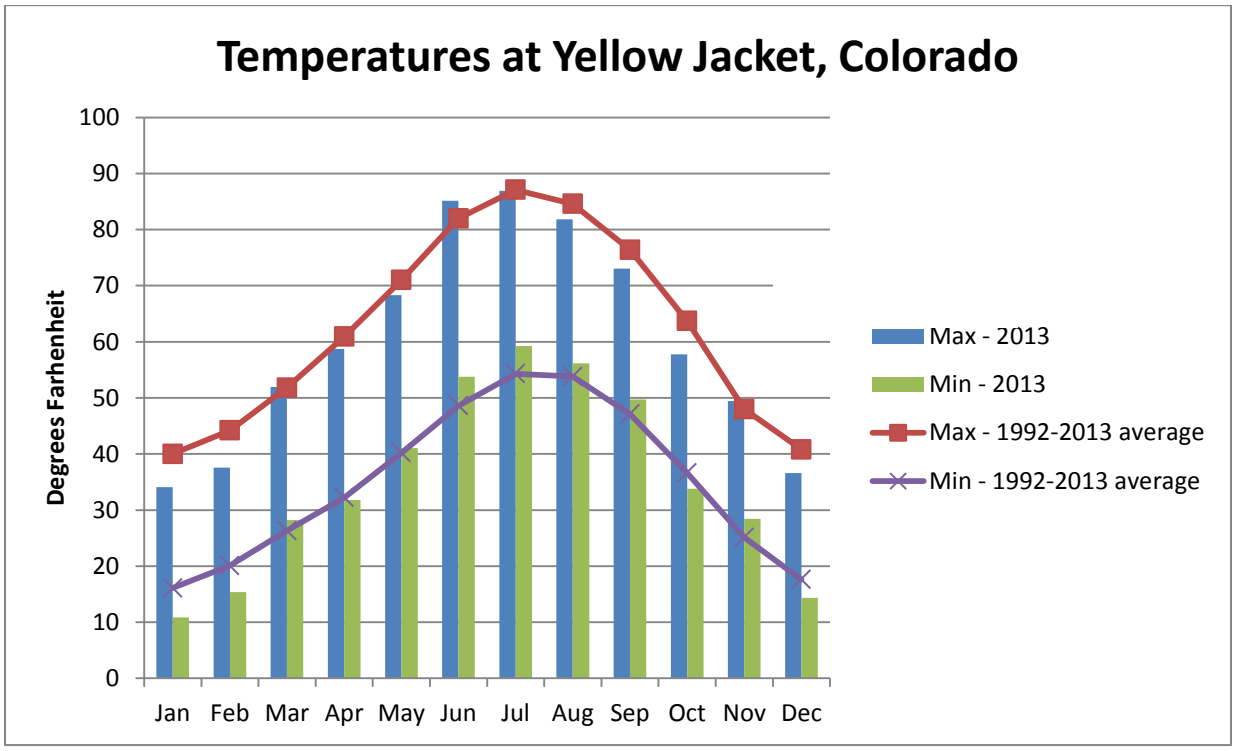


Figure 2: Monthly maximum and minimum temperatures at Yellow Jacket, CO



Overall Crop Production Summary

Abdel Berrada[1]

Table 1: Crop summary

Crop	Irrigation	Seeding Date	Harvest Date	Seed Yield	Unit
Safflower	8.5"	May 13, 2013	Oct 21, 2013	1003	bu/ac
Safflower	No	May 13, 2013	Oct 17, 2013	1223	lb/ac
Winter Camelina	No	Sep 6, 2012	Jul 3, 2013	549	lb/ac
Winter Canola	No	Sep 6, 2012	Not harvested		
Winter Wheat	No	Sep 28, 2012	Jul 25, 2013	30.5	bu/ac
Malting Barley	Yes[2]	Apr 26, 2013	Aug 29, 2013	80.8	bu/ac
Malting Barley	No	May 2, 2013	Aug 15, 2013	11.9	bu/ac
Dry Bean	No	May 30, 2013	Oct 8, 2013	325	lb/ac
Corn	No	May 20, 2013	Oct 15, 2013	3460	lb/ac
Sunflower[3]	No	May 24, 2013	Oct 28, 2013	797	lb/ac

Fall-seeded crops did not yield well given the dry conditions in the fall of 2012 and spring of 2013. The winter wheat variety trial averaged 30.5 bu/acre, which was similar to 2012 (27.4 bu/acre) but much below the 2011 average of 51.1 bu/acre. Winter canola was not harvested due to a poor stand in the fall and significant bird damage during grain maturation.

The drought of 2012 through June 2013 resulted in severe irrigation water shortages. Irrigation water allocation in 2013 was 6.1 inches/acre compared to the normal allocation of 22.6 inches for the Fairview service area of the Dolores Project. Precipitation in August and September 2013 was substantially above average, which benefited corn, safflower, and sunflower. These crops sustained some damage from three hail storms in early September. Hail damage was greatest for malting barley and dry bean.

This was the first year of testing malting barley at the research center. The results were not encouraging due to hail damage and to drought during the first half of 2013. The dryland trial averaged 12 bu/acre while the irrigated trial averaged 81 bu/acre. The combination of drought and nitrogen availability resulted in grain protein contents that exceeded the acceptable levels (7.5% to 14%) for malting quality.

The irrigated safflower variety trial had a poor stand and was weedy in spite of a pre-plant application of Trifluralin. The dryland safflower variety trial was much cleaner and had a better stand, which explains its superior performance.

In the dryland crop rotation trial, sunflower produced 1162 lb/acre when grown after winter wheat and only 551 lb/acre after dry bean. Dry bean did poorly due to drought and hail. Dry bean

[1] Senior Research Scientist and Manager of the SWCRC.
[2] 5 sideroll irrigations
[3] Data is for the sunflower in the dryland crop rotation.

after winter wheat produced 375 lb/acre while dry bean after dry bean produced 225 lb/acre. The winter-wheat-sunflower-fallow rotation had the highest estimated profit of $23.53, followed by winter wheat-safflower-fallow ($18.78) and winter wheat-fallow ($12.99). Twice as much NO_3-N was available in the top 2.0 ft. of soil in the fall than in the spring prior to crop planting. As would be expected, more NO_3-N was present in the soil following dry bean than following sunflower, safflower or winter wheat.

In the sunflower irrigation study, sunflower seed yield was significantly greater with the full irrigation treatment (I-2) than with the other treatments. The standard height hybrid Mycogen 8H449CLDM outperformed the short stature hybrid Triumph s870HCL at I-2 and I-3 (Irrigation from R1 to R6). Contrary to soil test recommendation, nitrogen fertilizer (60 lb N/acre) had no significant effect on seed yield nor did N by irrigation or N x sunflower variety interactions.

The alfalfa irrigation termination study headed by Dr. Joe Brummer produced interesting results. Alfalfa hay yield reductions at the three sites where this study was conducted (Fruita, Gunnison, and Yellow Jacket) ranged from 42% to 71% when irrigation was stopped after the first cutting and from 0% to 54% when irrigation was stopped after the second cutting. The complete fallow treatment, which was only implemented at the Yellow Jacket site, showed a 77% yield reduction compared to the full irrigation treatment. Potential crop ET at the alfalfa sites ranged from 38.3 to 41.6 inches as measured with an atmometer and rainfall ranged from 3.93 to 6.32 inches.

Yield reductions at the season-long fallowed grass sites ranged from 24% to 70%. Potential crop ET for the season ranged from 16.5 to 25.6 inches and precipitation from rain and snow ranged from 3.22 to 6.74 inches.

Fruit production increased by 36% compared to 2012, despite a dry spring and hail in early September. Fruit quality was good due to successful pest management (especially codling moth) and fruit thinning--both chemical and manual methods were used.

2013 Dryland Safflower Variety Trial[1]

Abdel Berrada

Table 2: Results of the 2013 dryland safflower variety trial

Variety	Brand	Primary Oil Type	Seed Yield (lb/ac)[2]	Seed Oil Content (%)	Seed Moisture (%)	Plant Height (in.)	Seed Test Weight (lb/bu)	50% Bloom Date
S-333	SeedTec	Oleic	1539	41.3	5.5	13.8	39.7	31-Jul
6159	SeedTec	Oleic	1366	41.6	5.4	14.3	41.6	29-Jul
CW 88OL	Cal/West Seeds	Oleic	1335	41.3	5.3	14.5	38.5	29-Jul
7325	SeedTec	Oleic	1258	42.3	5.3	14.0	40.4	25-Jul
S-541	SeedTec	Linoleic	1241	41.6	5.2	13.8	40.2	25-Jul
CW 3268OL	Cal/West Seeds	Oleic	1239	42.0	5.3	13.8	39.7	28-Jul
S-208	SeedTec	Linoleic	1147	42.4	5.2	13.3	39.4	25-Jul
CW 99OL	Cal/West Seeds	Oleic	1059	41.8	5.2	13.3	37.7	25-Jul
S-719	SeedTec	Linoleic	1037	40.6	5.3	12.5	40.3	25-Jul
CW 1221	Cal/West Seeds	Linoleic	1012	45.0	5.1	12.3	38.8	26-Jul
Average			**1223**	**42.0**	**5.3**	**13.5**	**39.6**	**27-Jul**
CV (%)			16	2.7	-	6.2	3.1	
LSD.05			279	1.7	0.2	1.2	1.7	

[1] Trial conducted at Colorado State University's Southwestern Colorado Research Center. Design: RCB, # reps: 4
[2] Adjusted to 10% moisture

Trial information

Seeded: May 13, 2013 @ 348,480 seeds/ac
Harvested: October 17, 2013
Previous crop: Summer fallow
Fertilizer: 15 lb N + 69 lb P_2O_5 + 40 S/ac on August 30, 2012
Herbicide: Trifluralin @ 1.6 pt/acre on August 28, 2012
Rainfall (Planting - Sept.): 9.36 in. (140-150% of normal)

Comments

Soil moisture at planting was adequate but there was little rain until mid-July. August and September had substantially more rainfall than normal. Applying Trifluralin in late summer 2012 combined with light tillage and occasional hand hoeing kept the plot area clean throughout the 2012-2013 season. Seed oil content may be overestimated due to higher than usual percentage of broken kernels.

2013 Irrigated Safflower Variety Trial[1]

Abdel Berrada

Table 3: Results of the 2013 irrigated safflower variety trial

Variety	Brand	Primary Oil Type	Seed Yield (lb/ac)[2]	Seed Oil Content (%)	Seed Moisture (%)	Plant Height (in.)	Seed Test Weight (lb/bu)	50% Bloom Date
6159	SeedTec	Oleic	1228	34.7	5.2	19.5	34.5	3-Aug
S-333	SeedTec	Oleic	1167	34.9	5.4	18.5	33.0	5-Aug
S-719	SeedTec	Linoleic	1092	38.3	5.0	15.0	36.9	29-Jul
7325	SeedTec	Oleic	1040	36.6	5.1	16.0	36.5	31-Jul
S-541	SeedTec	Linoleic	1001	39.0	5.0	16.5	35.3	2-Aug
CW 3268OL	Cal/West Seeds	Oleic	981	35.2	5.0	16.5	37.4	31-Jul
CW 99OL	Cal/West Seeds	Oleic	970	42.2	4.8	18.5	35.6	28-Jul
CW 88OL	Cal/West Seeds	Oleic	958	36.6	4.9	16.5	32.5	31-Jul
CW 1221	Cal/West Seeds	Linoleic	944	38.4	4.9	16.0	31.6	30-Jul
S-208	SeedTec	Linoleic	653	39.7	5.3	15.5	37.7	1-Aug
Average			**1003**	**37.5**	**5.0**	**16.9**	**35.1**	
CV (%)			14	5.1	1.5	7.3	4.6	
LSD.05			NS[3]	4.3	0.2	NS	3.6	2.3
LSD.10			258	3.5	0.1	2.2	2.9	2.2

[1] Trial conducted at Colorado State University's Southwestern Colorado Research Center. Reps 1 & 2 had too many stand problems; therefore only reps 3 & 4 are included in the results.
[2] Adjusted to 10% moisture
[3] Non Significant at P = 0.05

Trial information

Seeded: May 13, 2013 @ 348,480 seeds/ac
Harvested: October 21, 2013
Previous crop: Spring wheat
Fertilizer: 92 lb N + 30 lb P_2O_5/ac on April 24, 2013
Herbicide: Trifluralin @ 1.5 pt/ac on May 3, 2013
Irrigation: Approximately 8.5 in. (gross amount) in four applications
Rainfall (Planting - Sept.): 9.36 in. (140-150% of normal)

Comments

The seedbed at planting was dry, thus safflower germination and emergence were erratic. The first irrigation was applied approximately one week after planting. Subsequent irrigations were spaced about one month apart due to water shortage. Because of a severe drought in February through June, we only received 25% of our water allocation. The plot area was weedy in spite of

the application of Trifluralin on 3-May. It was hand hoed on June 21 & 24. Dryland safflower performed better than irrigated safflower this year due to better (fuller and more uniform) and cleaner (fewer weeds) stand.

2012-2013 Winter Camelina Variety Trial

Abdel Berrada, Charlie Rife[4]

Table 4: Results of the 2012-2013 winter camelina variety trial

Variety	Yield (lb/ac)[5]	Stand on 5/15/13 (0-10)[6]	Grain moisture (%)	Grain test weight (lb/bu)	50% bloom date	90% harvest maturity date
HPX-WG4-1	842	3.5	7.2	51.4	May 13	June 23
HPX-WG1-6	831	6.2	7.4	50.5	May 12	June 21
HPX-WG1-24	649	2.9	7.4	52.1	May 16	June 23
HPX-WG1-35	593	4.8	7.3	51.3	May 13	June 26
Joelle	566	4.3	7.4	50.1	May 20	June 27
HPX-WG1-29	516	2.9	7.3	52.6	May 19	June 24
HPX-WG4	483	3.7	7.4	50.4	May 17	June 24
Bison	465	2.0	7.4	50.9	May 19	June 28
HPX-WG1-8	443	2.8	7.5	50.4	May 16	June 26
HPX-WG1	439	2.5	7.4	52.2	May 19	June 27
HPX-WG1-33	403	2.3	7.4	51.8	May 18	June 28
HPX-WG2	338	1.2	7.6	50.7	May 20	July 2
Average	**549**	**3.3**	**7.4**	**51.1**	**May 17**	**June 26**

Table 5: 2012-2013 winter camelina variety trial information

Previous crop	Summer fallow
Planting date	9/6/12
Seeding rate	7.47 lb/ac
Harvest date	7/3/13
Fertilizer applied	15 lb N + 69 lb P_2O_5 + 40 S/ac on August 30, 2012
Pesticide applied	Trifluralin @1.6 pt/ac on 8/28/12
Precipitation (planting to harvest)	6.08 inches
Comments	The trial had four replications but replication 1 and part of replication 2 were not harvested because of a very poor stand. Yield, moisture, and test weight data were not collected from the non-harvested plots. For a few of these plots, 90% harvest maturity dates were recorded, but most of the non-harvested plots had not reached 90% harvest maturity by the time the trial was harvested.

[4] Crop breeder, High Plains Crop Development, LLC, Torrington, WY
[5] Adjusted to 8.5% moisture
[6] 0 = no stand, 10 = perfect stand

2012-2013 National Winter Canola Variety Trial

Abdel Berrada, Michael Stamm[7], Jerry Johnson[8]

Table 6: Results of the 2012-2013 National Winter Canola Variety Trial

Variety	Fall stand (0-10)[9]	Fall vigor (0-5)[10]	Winter survival (%)	Bloom date	90% harvest maturity date	plant height (in)
46W94	4.0	0.9	17%	May 17	July 20	34
46W99	1.8	1.1	27%	May 24	July 18	25
Baldur	2.4	1.1	47%	May 14	July 16	34
CHROME	4.3	1.1	20%	May 27	July 31	30
Claremore	2.2	0.7	0%			
Dimension	3.6	1.0	30%	May 19	July 23	30
DKW41-10	5.4	1.3	27%	May 18	July 20	26
DKW44-10	4.4	0.6	7%	May 15	July 22	26
DKW46-15	5.6	1.0	20%	May 22	July 20	30
DKW47-15	4.4	0.8	33%	May 25	July 27	28
Dynastie	1.4	0.6	3%	May 27		28
Edimax	2.9	1.3	13%	May 22	July 17	26
Flash	2.8	1.0	7%	May 27		
Gladius	3.2	0.9	3%	June 7		
Hornet	2.6	0.8	10%	May 25	July 29	29
HPX-7228	3.0	1.3	17%	May 20	July 15	30
HPX-7341	3.9	1.5	63%	May 17	July 17	29
HyCLASS115W	5.5	1.1	20%	May 20	July 22	30
HyCLASS125W	4.3	1.0	27%	May 20	July 18	32
Inspiration	7.5	1.4	47%	May 13	July 19	29
KS4428	1.8	1.3	27%	May 24	July 15	28
KS4476	5.4	1.8	23%	May 20	July 15	28
MH07J14	5.2	0.9	27%	May 17	July 25	29
MH09H19	6.0	1.5	37%	May 22	July 18	36
NKPETROL	4.7	1.5	40%	May 21	July 21	31
NKTechnic	4.5	1.5	43%	May 25	July 26	28
Riley	2.8	0.6	13%	May 24	July 24	27
Rossini	4.0	1.2	30%	May 15	July 19	28

[7] Canola breeder, Kansas State University
[8] Crops testing coordinator, Colorado State University
[9] 0 = no stand, 10 = perfect stand
[10] 0 = least vigorous, 5 = most vigorous

Variety	Fall stand (0-10)[9]	Fall vigor (0-5)[10]	Winter survival (%)	Bloom date	90% harvest maturity date	plant height (in)
Rumba	7.3	0.9	13%	May 22	July 22	26
Safran	2.9	1.1	30%	May 17	July 17	32
Sitro	3.8	0.9	20%	May 24	July 22	31
Sumner	4.7	0.7	37%	May 15	July 15	31
SY Regata	3.6	1.5	33%	May 19	July 29	30
TCI/F13	5.6	0.9	7%	May 22	July 18	28
Visby	7.0	1.2	47%	May 24	July 21	27
Wichita	6.8	1.3	17%	May 21	July 18	30
Average	**4.2**	**1.1**	**24%**	**May 21**	**July 21**	**29**

Table 7: 2012-2013 National Winter Canola Variety Trial Information

Previous crop	Summer fallow
Planting date	9/6/12
Seeding rate	5 lb/ac
Harvest date	Not harvested
Fertilizer applied	15 lb N + 69 lb P_2O_5 + 40 S/ac on August 30, 2012
Pesticide applied	Trifluralin @1.6 pt/ac on 8/28/12
Precipitation (planting to July 31, 2013)	7.42 inches
Comments	The stand was very poor. Birds ate a lot of the canola as it was maturing. There was not much left by the time most of the plots reached harvest maturity so the trial was not harvested.

2012-2013 Winter Wheat Variety Trial

Abdel Berrada, Scott Haley[11], Jerry Johnson

Table 8: Results of the 2012-2013 winter wheat variety trial

Variety	Type[12]	Yield (lb/ac)[13]	Protein (%)[14]	Grain moisture (%)	Test weight (lb/bu)	Plant height (inches)	50% Heading Date
Byrd	HRW	33.3	15.7	12	54	23	June 3
Ripper	HRW	33.3	16.3	11	53	21	May 31
TAM 112	HRW	32.8	15.4	12	56	23	June 1
CO07W245	HWW	32.7	16.3	12	55	21	June 4
Brawl CL Plus	HRW-CL2	32.2	15.9	12	56	23	May 31
Juniper	HRW	31.9	17.3	11	57	26	June 10
CO050173	HRW	31.8	16.5	12	56	23	June 3
UI SRG	HRW	31.2	17.1	11	53	24	June 10
Snowmass	HWW	30.9	16.4	11	54	23	June 4
Hatcher	HRW	30.9	15.1	11	54	22	June 3
Cowboy	HRW	30.6	16.5	11	55	22	June 10
Denali	HRW	30.2	15.7	11	56	24	June 10
Lucin CL	HRW-CL	29.8	17.3	11	56	24	June 10
Curlew	HRW	28.9	17.2	11	52	25	June 10
UI Darwin	HWW	28.8	17.0	12	55	24	June 10
Fairview	HRW	24.7	16.9	11	53	24	June 10
IDO1103	HRW	24.5	17.2	11	53	18	June 10
Average		**30.5**	**16.5**	**11**	**55**	**23**	**June 6**
$LSD_{.05}$		4.1	1.3	0.3	1.1	2.0	

Table 9: 2012-2013 winter wheat variety trial information

Previous crop	Summer fallow
Planting date	9/28/12
Seeding rate	700,000 seeds/ac
Harvest date	7/25/13
Fertilizer applied	60.5 lb/ac of 11-52-0 on 9/21/12
Pesticide applied	2,4-D amine @ 1.0 pt/ac + Warrior @ 3.8 oz/ac on 5/4/13
Precipitation	5.54 inches (planting to harvest)

[11] Wheat breeder. Colorado State University
[12] HRW: Hard Red Wheat; HWW: Hard White Wheat; CL: Clearfield (resistant to 'Beyond' herbicide)
[13] Adjusted to 12 % moisture
[14] 12% moisture basis

Comments	The seedbed was dry at planting. The months of October through December and February through June had well below normal precipitation. Season precipitation was approximately 49% of normal. There was no lodging and no noticeable disease infestation. Grasshoppers reached the threshold for control in early May and were consequently sprayed with Warrior.

2013 Irrigated Barley Trial[15]

Table 10: Results of the 2013 irrigated barley trial

Variety	Yield (bu/ac)	% Yield of Mor 069	% Plump	Test Weight (lb/bu)	Barley Protein (%)	Barley Moisture (%)	Plant Height[16] (in)	% Lodging	Straw Breakdown[17]	Maturity[18]	Head Nod[19]
Moravian 143	87.6	131	92.7	50.2	15.9	9.8	18	0	2	3	4
Moravian 139	85.2	127	90.9	50.2	15.2	10.1	16.5	0	2	3	4
Moravian 142	83.3	124	86.9	48.4	15.7	9.7	17.5	0	2	3	4
Moravian 069	67.1	100	83.2	48.5	15.1	10.3	15.5	0	2	3	4
Trial Mean	**80.8**		**88.4**	**49.3**	**15.5**	**9.9**	**16.9**	**0**	**2**	**3**	**4**
Trial Std Dev	9.6		4.1	1	0.4	0.3	1.1	0	0	0	0
CV%	11.9		4.5	1.9	2.8	2.6	6.7	.	0	0	0

Table 11: 2013 irrigated barley trial information

Previous crop	Dry bean in 2012
Plot size	6 ft. by 200 ft.
Number of reps	2
Fertilizer application	92 lb N/ac + 30 lb P_2O_5/ac on 04/24/13 based on soil test recommendation for malting barley.
Planting rate	834,500 seeds/acre at 12-inch row spacing
Planting date	04/26/13
Pest control	Curtail @ 2.5 pt/ac on 06/08/13, aerial spraying
Harvest date	08/29/13
Irrigation	Irrigation applications with sideroll on 5/22, 6/17, 7/8, 7/11, and 7/26 for a total of approximately 14 inches gross
Rainfall	5.93 inches (Planting to harvest)
Comments	Seed yield was below expectation due to drought and irrigation water shortage & scheduling. Seed yields of Moravian 139, 142, and 143 were similar and significantly more than the yield of Moravian 069. Grain protein content was above the acceptable range for malting barley (Table 12).

[15] The results summary/table was provided by MillerCoors™.
[16] Not including the awns.
[17] 1 = little to no straw breakdown, 2 = partial straw breakdown, 3 = complete straw breakdown. There wasn't much plant material on the ground.
[18] 1 = all green. 2 = 50% green, 50% mature. 3 = mature (no green).
[19] 1 = the head is standing straight up, 4 = the head is horizontal or lower.

Table 12: Quality standards for malting barley as shown in Exhibit A of the purchase agreement with MillerCoors™ for the 2013 growing season.

Moisture	≤ 13%
Plumpness (6/64"x3/4" screen)	≥ 70%
Protein (dry matter basis)	≥ 7.5% & ≤ 14.0%
Germination at 72 hours	≥ 97%
Skinned & Broken Kernels	≤ 3.0% by weight
Foreign Kernels	≤ 0.5% by weight
Immature Kernels	≤ 2.0% by weight

Damaged & Diseased Kernels	≤ 5.0% by weight
Ergot Pieces	≤ 0.1% by weight
Wild Oats (uncleaned sample)	≤ 2.5% by weight
Detectable Sprout Damage	0.0%
Detectable Frost Damage	≤ 1.0%
Detectable Deoxynivalenol (DON)	≤ 0.5 ppm
Treated Seeds	0.0%

2013 Dryland Barley Trial[20]

Table 13: Results of the 2013 dryland barley trial

Variety	Yield (bu/ac)	% Yield of Mor 069	% Plump	Test Weight (lb/bu)	Barley Protein (%)	Barley Moisture (%)	Plant Height[21] (in)	% Lodging	Straw Breakdown[22]	Maturity[23]	Head Nod[24]	Yield of Earlier Trial[25] (Bu/acre)
Moravian 142	13.7	124	15.1	42.7	17.3	9.0	12.0	3.3	1.0	2.5	2.0	9.7
Moravian 139	13.1	118	25.2	44.2	17.6	9.2	12.7	6.7	1.0	2.5	2.7	9.3
Moravian 069	11.1	100	17.3	43.4	16.8	9.3	11.7	0.0	1.0	2.0	2.7	7.9
Moravian 143	9.7	87	49.2	45.0	17.5	9.1	12.0	20.0	1.0	1.8	2.7	6.9
Trial Mean	**11.9**		**26.7**	**43.8**	**17.3**	**9.1**	**12.1**	**7.5**	**1.0**	**2.2**	**2.5**	**8.5**
Trial Std Dev	2.1		14.3	1.0	0.4	0.2	0.8	12.2	0.0	0.3	0.5	
CV%	17.7		53.6	2.2	2.1	1.7	6.6	162	0.0	15.5	20.9	

Table 14: 2013 dryland barley trial information

Previous crop	Summer fallow
Plot size	6 ft. by 200 ft.
Number of replications	3
Fertilizer application	None
Planting rate	530,250 seeds/ac at 12-in row spacing
Planting date	05/02/13
Pest control	Sprayed with 2,4-D Amine @ 1.0 pt/ac on 06/05/13
Harvest date	8/15/13
Rainfall	4.22 in from planting to harvest
Comments	Seed yield was very low due dry conditions from February through mid-July. Grain plumpness was much below standard while grain protein was above the upper limit (14%) of acceptable grain protein for malt barley.

[20] The results summary/table was provided by MillerCoors™.
[21] Not including the awns.
[22] 1 = little to no straw breakdown, 2 = partial straw breakdown, 3 = complete straw breakdown. There wasn't much plant material on the ground.
[23] 1 = all green. 2 = 50% green, 50% mature. 3 = mature (no green).
[24] 1 = the head is standing straight up, 4 = the head is horizontal or lower.
[25] This trial was planted on April 25 with the seeds planted at a depth of 2.5-3.0" to get it into the moist soil. Yield was converted from pounds to bushels using 43.8 lb/bu.

Evaluation of Sunflower in Dryland Cropping Systems: 2011-2013 Results

Investigators: Abdel Berrada, Kim Dillivan[26], and Bob Hammon[27]

This ongoing study has the following objectives:

- Determine the effects of sunflower in rotation with other crops on:
  - Crop yield and quality (seed oil or protein concentration)
  - Soil moisture availability
  - Nutrient (N & P) availability
- Assess the agronomic and economic feasibility of various cropping systems

The following crop rotations were tested:

- Winter Wheat-Fallow
- Winter Wheat-Safflower-Fallow
- Winter Wheat-Sunflower-Fallow
- Winter Wheat-Dry Bean-Sunflower-Fallow
- Winter Wheat-Dry Bean-Dry Bean-Fallow
- Winter Wheat-Opportunity Crop-Sunflower-Opportunity Crop. The opportunity crop was camelina in 2010 and 2011 and corn in 2012 and 2013.

The experiment is located at the Southwestern Colorado Research Center, which is near Yellow Jacket, CO. It was started in the spring of 2010. The 2010 results are not included in this summary since the site was irrigated for approximately 20 years before it was converted to dryland in the summer of 2009.

Yield by crop

Sunflower yielded 797 lb/ac in 2013 which is slightly above the 3-year average of 763 lb/ac (Table 15). The estimated average annual crop value of sunflower is $193.71/ac, which is below corn for grain, winter wheat, and safflower, but above the value of dry bean, corn for forage, and camelina.

Corn grown for grain in 2013 benefited from above average precipitation in August and September. It produced 3460 lb/ac with an estimated crop value of $444.80/ac. However, the yield of corn has been very unreliable and corn prices have been on the decline from their historic highs in 2012 and early 2013. In 2012—which was a very dry year—corn failed to produce much grain.

[26] Former Director of Extension in Dolores County, CO.
[27] Extension Agent, Entomology, Tri River Extension, Grand Junction, CO

Table 15: 2011-2013 crop yield and value

Crop	2011 yield (lb/ac)	2012 yield (lb/ac)	2013 yield (lb/ac)	Average yield (lb/ac)	Crop price ($/lb)[28]	Average crop value ($/ac)
Corn for Grain	-	-	3460	3460	$ 0.13[29]	$ 444.80
Winter Wheat	2530	1741	1089	1787	$ 0.13[30]	$ 227.81
Safflower	1498	129	642	756	$ 0.28	$ 207.98
Sunflower	1063	428	797	763	$ 0.25	$ 193.71
Dry Bean	578	218	325	374	$ 0.39	$ 143.81
Corn for Forage	-	1804	-	1804	$ 0.03	$ 60.99
Camelina	0	-	-	0	$ 0.15	$ 0.00

Yield by crop rotation

The 2011 to 2013 average crop value and yield for each rotation are shown in Table 16. The results in the Table 16 assume that a fallow year has a crop value of $0/ac and a yield of 0 lb/bu.

Crop rotations that included sunflower were more profitable than other crop rotations. The winter wheat-sunflower-fallow rotation did the best with an average yield of 862 lb/ac and an estimated profit of $23.53, followed by winter wheat-safflower-fallow ($18.78). The winter wheat-fallow rotation averaged 739 lb/ac and a modest profit of $12.99/ac. Winter wheat followed by two years of dry bean and one year of fallow had the lowest average crop yield and a loss of $13.93/ac. Winter wheat-Opportunity Crop-Sunflower-Fallow and Winter wheat-Dry bean-Sunflower-Fallow averaged around 736 and 777 lb/ac, respectively and similar crop value of $144/ac. The estimated profit from these 4-year crop rotations was below $10/ac.

Table 16: 2011-2013 average crop yield and profit for each crop rotation

Crop Rotation	Average yield (lb/ac)	Average crop value per year ($/ac)	Estimated profit per year ($/ac)
Winter Wheat-Fallow	739	$115.84	$12.99
Winter Wheat-Sunflower-Fallow	862	$152.37	$23.53
Winter Wheat-Safflower-Fallow	827	$139.96	$18.78
Winter Wheat-Opportunity Crop-Sunflower-Fallow	736	$144.64	$9.75
Winter Wheat-Dry Bean-Sunflower-Fallow	777	$143.46	$3.71
Winter Wheat-Dry Bean-Dry Bean-Fallow	643	$123.73	($13.92)
Average	**758**	**$ 137.80**	**$7.55**

[28] Crop prices are from 2012 except for camelina (2011) and corn for forage (2011).
[29] Converted from $/bushel using 56 lb/bu.
[30] Converted from $/bushel using 60 lb/bu.

In 2013, sunflower did best when grown after winter wheat and averaged 1162 lb/ac yield (Table 17). When grown after dry bean, sunflower only yielded 551 lb/ac, which was unexpected. Dry bean did not do well in 2013 due to drought early in the season and hail during the second week of September. Dry bean after dry bean did poorly in 2013 and in previous years (Berrada, 2011 and 2012 CSU-AES Technical Reports TR 12-7 and 13-8).

Table 17. The effect of the previous year's crop on the yield of the 2013 crop.

2013 crop	2012 crop	Crop yield in 2013 (lb/ac)[31]
Sunflower	Winter Wheat	1162
	Corn for forage	677
	Dry Bean	551
Safflower	Winter Wheat	642
Winter Wheat	Fallow	1089
Dry Bean	Winter Wheat	375
	Dry Bean	225
Corn	Winter Wheat	3460

Pre-plant soil moisture availability

Plots that were seeded to winter wheat the previous year had the highest plant-available water at 2.6 in. in the top three feet of soil in the spring of 2013. In contrast, plots that were in dry bean or corn (harvested for forage) only had 1.8 and 1.7 in. of available soil moisture, respectively (Table 18). The difference may be due to the longer fallow period after wheat harvest than after dry bean or corn harvest.

In the fall of 2013, prior to winter wheat seeding, plots that were in sunflower or safflower in 2012 had 2.3 to 2.5 in. of available water in the top three feet of soil, compared with 3.1 to 3.3 in. in plots that were in dry bean or winter wheat in 2012 (Table 18). Overall, there was more soil moisture available in the fall (2.6 in.) than in the spring (2.3 in.) of 2013, probably due to the above average precipitation in August and September.

Pre-plant nitrate N

There was more than twice the nitrate N available in the soil in the fall than in the spring 2013 (Table 18). More nitrogen may have been mineralized during the long fallow period prior to wheat planting in the fall. The above average precipitation in August and September 2013 may have also contributed to greater N mineralization and possibly more N release from residual fertilizer; although no N fertilizer was applied in 2012 or 2013. Land following dry bean had greater nitrate N (65 lb N/ac-ft) in the spring 2013 than land following winter wheat (24 lb N/ac-ft). Land following corn harvested for forage had 56 lb N/ac-ft).

[31] Adjusted to appropriate moisture.

Fall 2013 soil nitrate N was highest in plots that were in dry bean in 2012 (120 lb/ac-ft), followed by plots that were in sunflower (112 lb N/ac-ft on average) or safflower (105 lb N/ac-ft) and well ahead of plots that were in winter wheat (53 lb N/ac-ft). Winter wheat produced approximately seven times more grain (in lb/ac) in 2012 than dry bean, safflower and sunflower on average, and thus may have taken up more nitrogen. Land that was in sunflower in 2012 and winter wheat in 2011 had a similar amount of nitrate N than land that was in dry bean two years in a row (Table 18), possibly due to low N fixation in addition to N removal by the low-yielding bean crops.

Table 18: Available soil water and nitrate-N in the spring and fall 2013

Sampling date	2012 crops	2011 crops	Available water (in.) in 0-3 ft.	Available nitrate N (lb/ac.-ft.)
Spring 2013 (plots to be planted to corn, dry bean, safflower or sunflower)				
	Winter wheat[32]	Fallow	2.7	24.0
	Dry bean	Winter wheat	1.9	65.5
	Corn for forage	Winter wheat	1.7	56.0
Average			2.3	40.4
Fall 2013 (plots to be planted to winter wheat)				
	Winter wheat[32]	Fallow	3.3	53.5
	Dry bean	Dry bean	3.1	120.0
	Sunflower	Dry bean	2.6	103.8
	Sunflower	Corn	2.3	109.5
	Sunflower	Winter wheat	2.1	123.2
	Safflower	Winter wheat	2.5	105.5
Average			2.6	102.6

After fallowing over the summer, average soil nitrogen levels more than doubled to 103 lb of N/acre by the fall of 2013. Plots that were in dry bean in 2012 still had the highest nitrogen level at 120 lb of N/acre. Plots that were in sunflower the previous year had a surprisingly high nitrogen level of 112 lb of N/acre.

After the land had fallowed over the summer, plant-available soil moisture from samples taken in the fall of 2013 had increased to 2.6” in the top three feet of soil. Plant-available soil moisture was still the highest in plots that were in winter wheat the previous year at 3.3”. Plots that were in sunflower in 2012 had the lowest amount of plant-available soil moisture at 2.3”. This may indicate that sunflower is more effective than the other crops at extracting water from the soil, but it also means that crops following sunflowers may not do as well particularly if it is a dry year.

[32] Winter wheat crop that was harvested in 2012

Preliminary conclusion

In 2011-2013, growing two crops (winter wheat, safflower or sunflower) in three years performed better than growing three crops in four years or one crop every other year. Sunflower did best in 2013 when it was grown after winter wheat than after corn or dry bean. Land that was in sunflower in 2012 had less available soil moisture at 0-3 ft. in the fall of 2013 than land that was in winter wheat or dry bean.

More testing and more detailed analyses, including the statistical significance of the main results, will be performed before making recommendations as to the feasibility dryland cropping systems that include sunflower in SW Colorado.

Boosting Sunflower Production in SW Colorado with Supplemental Irrigation: 2013 Result Summary

Investigators: Abdel Berrada and Joel Schneekloth[33]
Sponsor: The National Sunflower Association

The main objective of this study was to determine the response of two sunflower hybrids to four irrigation treatments and three nitrogen (N) rates. Treatments I-1 and I-4 were similar in 2013 (Table 19) due to the short irrigation season. Also, only one N rate (60 lb N/ac) plus the unfertilized check were tested in 2013. The recommended rate based on soil test results and a yield goal of 2500 lb/ac was 55 lb N/ac.

Materials & Methods

The trial was conducted at the Southwestern Colorado Research Center near Yellow Jacket, CO. Plot size was 100 ft. long by 10 ft. (4 rows) wide. Spacing between drip tapes was 5 ft. with the first drip tape placed between sunflower rows 1 and 2 and the second drip tape placed between rows 3 and 4. The whole plot area was sprayed with Sonalan at 2.25 pt/ac on May 28. Additional weed control was accomplished with hand hoeing during the growing season.

Sunflower hybrids Mycogen 8H449CLDM and Triumph s870CL were planted on June 7, 2013 at 27,198 seeds/ac. The combination of dry weather in the spring (Figure 3) and lack of pre-plant irrigation resulted in a poor stand of sunflower. Post-planting irrigation applications with a sprinkler system did not improve plant emergence due to soil crusting. Irrigation of treatment I-2 (with the drip system) began on July 5. Dissolved Urea was applied through the drip system to the designated plots at 60 lb N/acre on July 11.

Treatments were arranged in a split-split plot design with three randomized complete blocs. Irrigation treatments were assigned to the main plots, sunflower hybrids to the split-plots, and N rates to the split-split plots.

Drip tape irrigation efficiency was assumed to be 90% and sideroll irrigation efficiency was assumed to be 70%. Precipitation and evapotranspiration data was retrieved from the website www.coagmet.com . Irrigation plus precipitation matches crop ET fairly well except during the early part of the growing season (Figure 4).

Sunflower heads were harvested on October 23. Because the sunflower stand was poor and erratic, only areas of each plot where there was a relatively uniform stand were harvested. The heads were then threshed using a corn sheller and the seed was run through a seed cleaner twice in most cases and some of debris that remained was removed by hand.

[33] Extension Water Resource Specialist, Akron, CO.

Table 19: Irrigation treatments

Name	Planned treatment	Net irrigation (in)[1]	Crop ET (in)[2]
I-1	Pre-planting irrigation only	3.7	17.4
I-2	Irrigate from planting until physiological maturity so that irrigation plus precipitation equals evapotranspiration (ET).	9.9	18.9
I-3	Irrigate from the beginning of the R-1 growth stage to the end of the R-6 growth stage so that total irrigation plus precipitation equals ET between those growth stages.	5.4	18.4
I-4	Irrigation from R-4 through R-6 to meet ET during this period	3.7	17.4
Season precipitation (rainfall)		9.3	

[1] There was no pre-planting irrigation. Several irrigations were applied, mostly with a sprinkler system, in the first 40 days after planting to try to improve emergence (to no avail) and to apply nitrogen fertilizer. There was no difference in irrigation application amount or timing between I-1 and I-4.

[2] From planting to the end of R-8. No irrigation water was available after Sep. 10 due a severe drought from September 2012 through June 2013.

Figure 3: Monthly precipitation at Yellow Jacket in 2012 and 2013

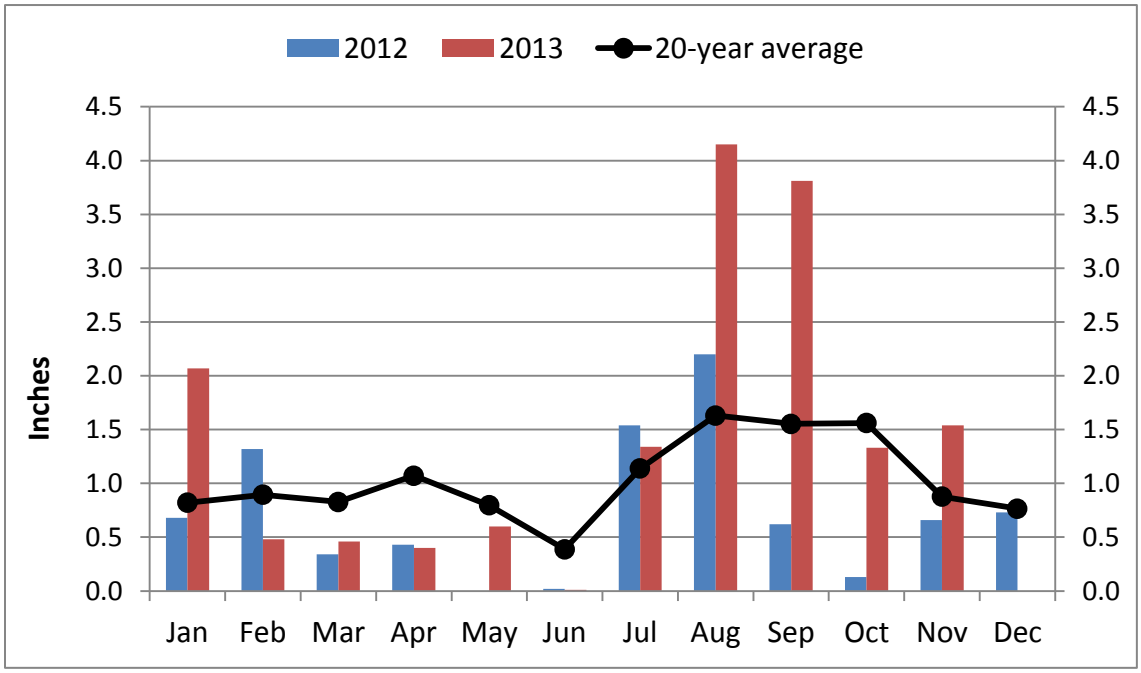
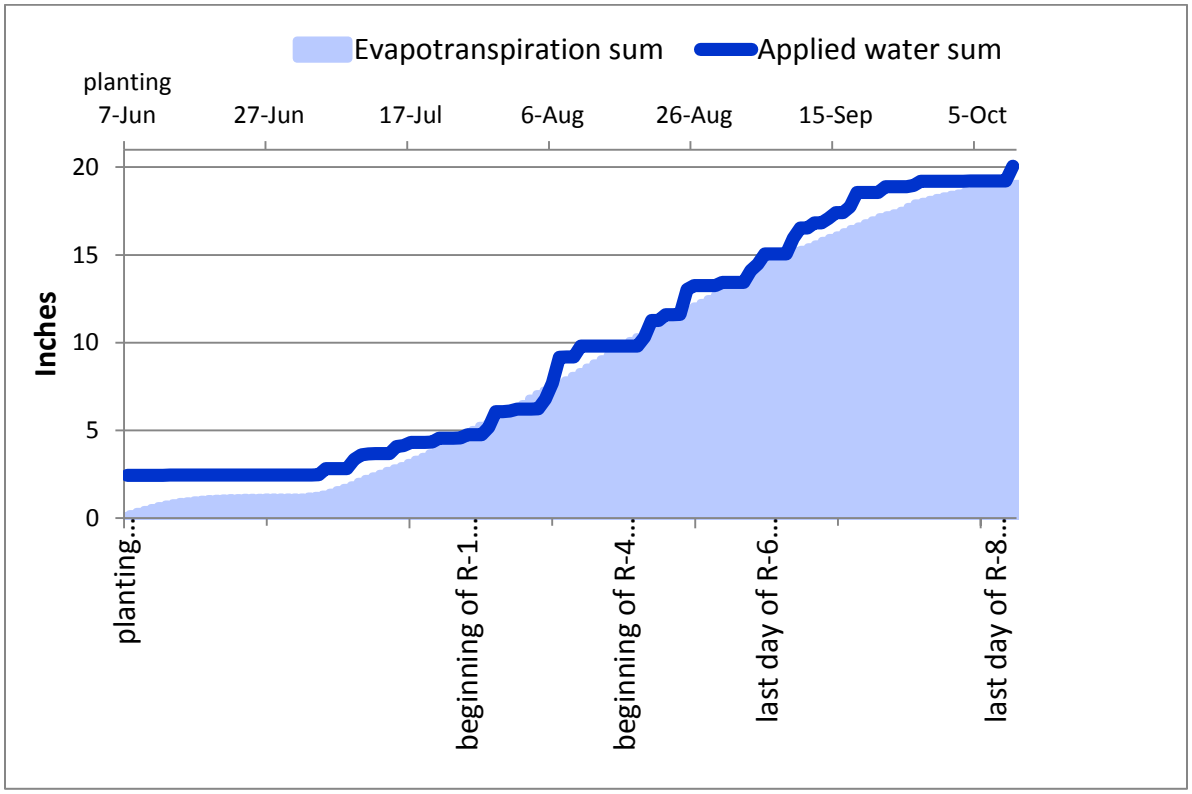


Figure 4: Evapotranspiration and applied water for the I-2 treatment



Results

Seed yields of Mycogen 8H449CLDM and Triumph s870HCL were similar at I-1 (Table 20) while Mycogen 8H449CLDM outperformed Triumph s870HCL at I-2 and I-3. On average, I-2 had the highest seed yield and plant height. Above average precipitation in August and September (Figure 3) boosted sunflower seed yield but it was not enough to meet ET demand at I-1 and I-3. Moreover, there was substantial runoff in August and three hail storms in early September. The latter may have reduced seed yield of all the treatments.

A would be expected Mycogen 8H449CLDM had taller plants than Triumph s870HCL. It also had greater test weight.

There was no significant effect of N rate, N x Irrigation or N x Variety interaction on seed yield, test weight or plant height (data not shown).

The variety 8H449CLDM had higher seed oil content than s870CL. Differences in seed oil content between irrigation treatments and nitrogen treatments were not significant.

Table 20: Sunflower seed yield, test weight, and plant height in 2013

Irrigation treatment	Sunflower variety	Seed yield[1] (lb/ac)	Test weight (lb/bu)	Plant height (in.)	Seed Oil Content (%)
I-1	8H449CLDM	1429 a[2]	29.4	29.3	44.3
	s870CL	1599 a	26.4	23.2	42.8
I-2	8H449CLDM	3227 a	29.8	39.4	45.1
	s870CL	2635 b	24.2	29.1	43.0
I-3	8H449CLDM	2022 a	30.4	30.9	45.1
	s870CL	1297 b	26.8	20.4	42.4
I-1		1514	27.9 a	26.2 b	43.6
I-2		2931	27.0 b	34.2 a	44.1
I-3		1659	28.6 a	25.7 b	43.7
	8H449CLDM	2226	29.8 a	33.2 a	44.8 a
	s870CL	1843	25.8 b	24.2 b	42.7 b

[1] Seed yield was adjusted to 10% moisture.
[2] Means followed by the same letter, within each irrigation treatment, are not statistically different at α=0.05.

Boosting Sunflower Production in SW Colorado with Supplemental Irrigation: 2010-2012 Results[34]

Investigators: Abdel Berrada and Joel Schneekloth
Sponsor: The National Sunflower Association

Abstract. A study was conducted in 2010-2012 in SW Colorado to quantify the response of sunflower to water deficit. Water was applied pre-plant only (Pre-P), during the growing season (Full), at bud initiation through flowering (R1-6), or during flowering (R4-6). Another treatment was added to mimic irrigation with siderolls (Veg). The Full irrigation treatment outperformed the other treatments in 2010 and 2011 but was similar to R1-6 in 2011. Seed yields of Veg, R4-6 and R1-6 were similar in 2010 while R4-6 ≡ R1-6 in 2011. In 2012, Mycogen 8H449CLDM had greater seed yield than the short stature hybrid Triumph s870HCL, except at Full. The latter is more suitable to irrigation with siderolls, which are prevalent in SW Colorado. Irrigation plus rain closely matched sunflower ET at Full. Season rainfall was greatest in 2010, with 3.3 in. recorded in August. Precipitation use efficiency was generally highest with Pre-P and lowest with Full. In contrast, seed oil content of Full was significantly more than that of the other treatments. The treatment that received little or no irrigation after planting (Pre-P) had the lowest seed oil content in 2010 and especially in 2011. Full irrigation and Veg had the tallest plants while Pre-P and R4-6 had the shortest plants. Applying water mostly during bloom did not affect seed yield or oil content in 2010 and 2011 compared to R1-6. Substantial water conservation and use efficiency can be achieved with limited but targeted irrigation of sunflower.

Keywords. Sunflower, irrigation scheduling, seed yield, oil content, plant height.

Introduction

Contrary to popular belief, sunflower may use as much or more water than other field crops such as corn to produce maximum yield (Meyer at al., 2009). With its deep taproot (Stone, 2002), sunflower can extract water down to 7 or 8 ft., thus reducing the need for additional water from rain or irrigation to meet evapotranspiration (ET).

At Akron, CO, Nielsen (2007) derived the following response of sunflower to irrigation:

Yield (lb/acre) = 150.6*(inches water use – 6.9)

Seed production started at 6.9 in. of water consumption. Each additional inch of water produced approximately 151 lb/acre.

Long-term average precipitation from May through September in Yellow Jacket is 6.7 in. Assuming 6.0 in. of effective rainfall during the growing season and 4.0 in. of available soil

[34] This paper was published in the Proceedings of the 2013 Irrigation & Education Conference in Austin, TX and listed as: "Berrada, A., and J. Schneekloth. 2013. Response of sunflower to deficit irrigation. 2013 Irrigation Show, 4-8 Nov. 2013, Austin, TX. Irrigation Association, Falls Church, VA.

moisture at planting, it would take an additional 2.2 in. of water to produce 800 lb/acre of 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.

Sunflower is most sensitive to water stress "just before flowering through seed development" (Meyer et al., 2009). Schneekloth (2007) achieved 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. 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. Seed yield was similar to that of when irrigation was withheld until R-6 to R-7.

The area where this study was conducted is within the Dolores Irrigation Project, which provides irrigation water to approximately 62,000 acres of crop land in Dolores and Montezuma counties. Pressurized water of excellent quality is delivered to each farm in the full service area (FSA) of the project. Each farmer is allocated close to 2.0 acre feet of water per season. The total FSA annual water allocation was reached or exceeded several times since irrigation began in 1987. Reasons for this include frequent droughts and the predominance of alfalfa (> 80% of the irrigated acreage), which is a high water user. Wheel-line sprinkler systems (siderolls) prevail in the FSA. The price FSA irrigators pay for water has been on the rise due to increases in pumping and maintenance costs. Thus conserving water and enhancing its efficiency is important to the long-term sustainability of the FSA.

Alfalfa fields are 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 e.g., to mine the residual water and nitrogen that may be available beyond the reach of dry bean or spring cereals. Moreover, it appears that sunflower responds well to deficit irrigation.

The main objective of this study was to determine the response of sunflower to irrigation deficit.

Materials and Methods

A field trial was conducted at the Southwestern Colorado Research Center in Yellow Jacket, CO in 2010, 2011, and 2012. The soil at the study site is Wetherill loam (fine-silty, mixed, superactive, mesic Aridic Haplustalfs). Normal annual precipitation is 15.9 in., with June being the driest month (0.5 in.), and Aug., Sept., and Oct. the wettest months (1.7 to 1.9 in.). The elevation at the site is 6900 ft. Approximately 40% of the annual precipitation comes from snow.

Sunflower planting dates and irrigation scheduling are shown in Table 21 and Table 22, respectively. Sunflower was planted in 30-in rows with a 4-row Monosem NG Vacuum Planter. Row length varied from 50 to 100 ft. The two middle rows were harvested in full or partially for yield estimates. There were four replications in 2010 and 2011 and three in 2012.

Table 21: Sunflower planting dates and rates.

	2010	2011	2012	
Sunflower hybrid	Mycogen 8H449CLDM	Mycogen 8H449CLDM	Mycogen 8H449CLDM	Triumph s870HCL
Planting date	4-Jun	1-Jun	1-Jun	1-Jun
Planting rate (seeds/acre)	15,488 & 22,082	22,082	25,344	25,344
Harvest date	11-Nov	Oct. 17-20	Oct. 31 & Nov. 1	

Table 22: Irrigation treatments and amounts.

Irrigation treatment	Description	Net post-planting irrigation depth (in.)[1]		
		2010	2011[2]	2012
Pre-P	Pre-plant irrigation (PPI) only	0.0	2.5	0.0
Full	PPI + Full-season irrigation[3]	11.4	18.1	16.2
R1-6	PPI+ Irrigation at R-1 to R-6[3]	3.1	11.7	8.7
R4-6	PPI + Irrigation at R-4 to R-6[3]	2.6	7.2	4.5
Veg	PPI + Sideroll Irrigation[4]	6.6	4.9	NA
PPI (with sideroll)		1.8	0.8	2.5
Rainfall		7.1	4.2	4.4
Full irrigation treatment crop ET		19.8	21.9	20.5

[1] Depth of irrigation after planting. Post-planting water was applied with subsurface drip irrigation (SDI) at approximately 90% efficiency.
[2] Two irrigations were applied early in the season to all the treatments to enhance seed germination and seedling emergence.
[3] Irrigation to meet crop ET during the designated treatment period. R-1: The terminal bud forms a miniature floral head, R-4: The inflorescence begins to open, R-6: Flowering is complete.
[4] Treatment to mimic irrigation with sideroll. Irrigation is terminated when sunflower interferes with the movement of the sideroll, which usually occurs at R-1 for standard-height sunflower.

Results and Discussion

2010

Irrigation scheduling had a significant impact on seed yield, oil yield, and plant height. The full irrigation treatment (Full) produced the highest seed yield of approximately 3000 lb/acre while pre-plant irrigation only (Pre-P) produced the lowest yield of 2334 lb/acre (Figure 5). Treatments R1-6 and R4-6 received a total of 3.1 and 2.6 in. of net irrigation amount (in addition to pre-plant irrigation), respectively, which is about half the amount (6.6 in) received by Veg and yet, all three treatments had similar yields of approximately 2600 lb/acre. The sideroll-alike treatment (Veg) received most of the irrigation water during the mid-vegetative to early reproductive growth stages or until sunflower plants were too tall to irrigate with the sideroll.

In general, sunflower production in 2010 was enhanced by good water availability at planting and timely and above average rainfall during the reproductive growth stages. Precipitation use efficiency (lb of seeds/in. of rain plus irrigation) was highest at Pre-P and lowest at Full and Veg

(Figure 5). R4-6 and R1-6 had similar precipitation use efficiencies of around 280 lb/in.

The Full treatment had the highest seed oil content, significantly more than the other irrigation treatments, although the range in seed oil content values (39.9 to 41.3%) was small (Figure 9). The Full and Veg treatments had the tallest plants on average, followed by R1-6. Pre-P and R4-6 had similar plant height of 55 in. (Figure 12).

Increasing seeding rate from 15,488 to 22,082 seeds/acre increased seed yield by only 121 lb/acre on average (Data not shown). A larger increase (454 lb/acre) was observed at R4-6.

2011

Irrigation treatments that received water during reproductive growth (Full, R4-6, and R1-6) outperformed Pre-P and Veg (Figure 6). The Full irrigation treatment and R1-6 produced around 3100 lb seeds/acre while R4-6 averaged 2878 lb/acre. The pre-plant irrigation treatment had the lowest yield (1854 lb/acre) followed closely by Veg. All the treatments received 2.5 in. of irrigation water shortly after planting due to dry conditions at planting. Precipitation use efficiency was highest with Pre-P and R4-6 and lowest with Full (Figure 6).

Seed oil content increased in a near linear fashion with increasing irrigation amounts (Figure 10). The Full irrigation regime averaged 41.3% followed by R1-6 and R4-6. The Pre-P treatment lagged behind with 37.5%. Sunflower plants averaged 45.7 in. in height with Pre-P and R4-6 and 51.4 in. with the other treatments. As in 2010, restricting irrigation mostly to the flowering period (R4-6) reduced plant height but it did not negatively impact seed yield or oil content when compared with R1-6.

2012

Seed yield increased significantly with increasing irrigation amounts (Figure 7). Mycogen H449CLDM outperformed Triumph s870HCL at all irrigation levels, except at Full. Mycogen H449CLDM had higher precipitation use efficiency (PUE) at Pre-P and R4-6 and similar PUE at R1-6 and Full (Figure 8).

On average, Full had the highest seed oil content of 43.8%, significantly more than that of R4-6 and R1-6. Treatment Pre-P had the lowest seed oil content of 41.7% (Figure 11). Mycogen 8H449CLDM and Triumph s870HCL averaged 43.2% and 41.9%, respectively. Plants of both hybrids were tallest at Full followed by R1-6. Treatments R4-6 and Pre-P had similar plant heights (Figure 14). As would be expect, s870HCL was much shorter than 8H449CLDM.

Conclusion

The full irrigation treatment outperformed the other treatments in 2010 and 2011 but was similar to R1-6 in 2011. Seed yields of Veg, R4-6 and R1-6 were similar in 2010 while R4-6 ≡ R1-6 in 2011, at P=0.05. In 2012, Mycogen 8H449CLDM had greater seed yield than the short stature hybrid Triumph s870HCL, except at Full. Mycogen 8H449CLDM appears to respond better to deficit irrigation than Triumph s870HCL, possibly due to its more extensive root system. The latter is more suitable to irrigation with siderolls, which are prevalent in SW Colorado.

Irrigation plus rain closely matched sunflower ET at Full. Season rainfall was greatest in 2010,

with 3.3 in. recorded in August (Figure 15). Precipitation use efficiency was generally highest with Pre-P and lowest with Full. In contrast, seed oil content of Full was significantly more than that of the other treatments. The treatment that received little or no irrigation after planting (Pre-P) had the lowest seed oil content in 2010 and especially in 2011. The full irrigation and the sideroll-alike (Veg) treatments had the tallest plants while Pre-P and R4-6 had the shortest plants.

Applying water mostly during bloom did not affect seed yield or oil content in 2010 and 2011 compared to R1-6.

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Acknowledgments

This study was sponsored by the National Sunflower Association with additional support from Colorado State University Agricultural Experiment Station.

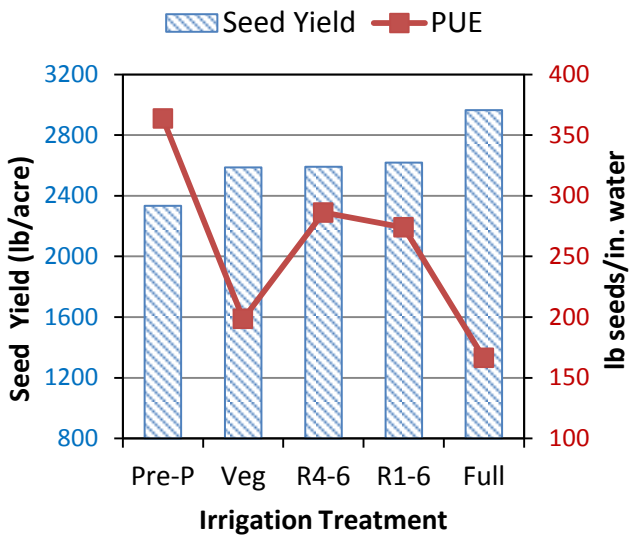

Figure 5: Seed yield and precipitation use efficiency (PUE) in 2010 as affected by irrigation scheduling

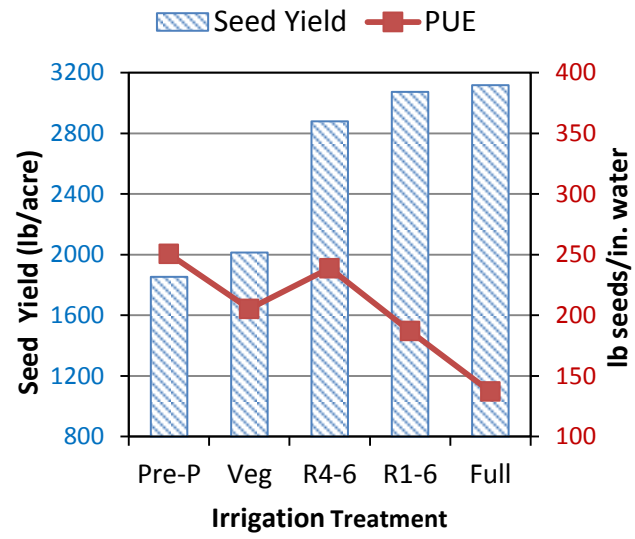

Figure 6: Seed yield and precipitation use efficiency (PUE) in 2011 as affected by irrigation scheduling

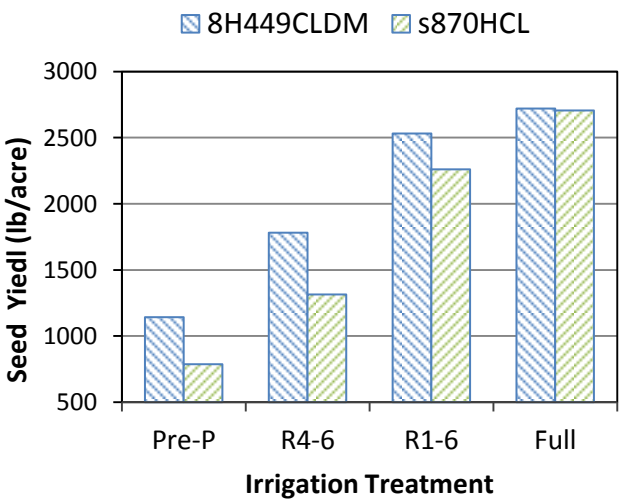

Figure 7: Seed yield of two sunflower hybrids in 2012 as affected by irrigation scheduling

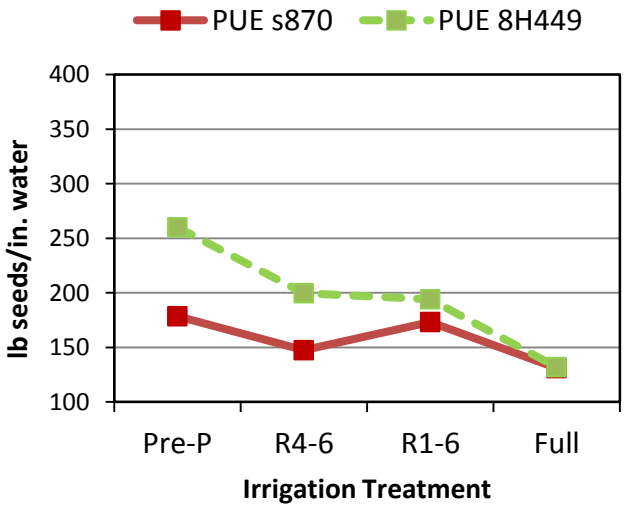

Figure 8: Precipitation use efficiency (PUE) of two sunflower hybrids in 2012 as affected by irrigation scheduling

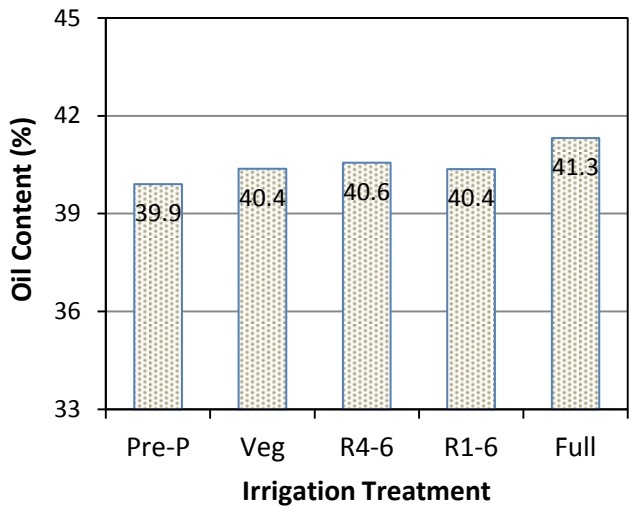

Figure 9: Oil content of sunflower hybrid 8H449CLDM in 2010 as affected by irrigation scheduling

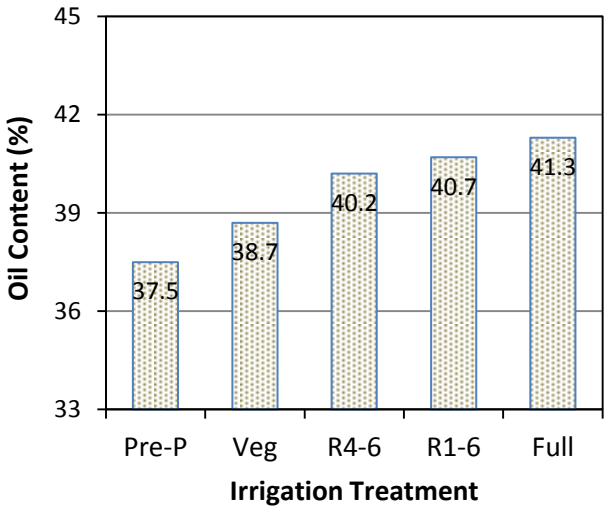

Figure 10: Oil content of sunflower hybrid 8H449CLDM in 2011 as affected by irrigation scheduling

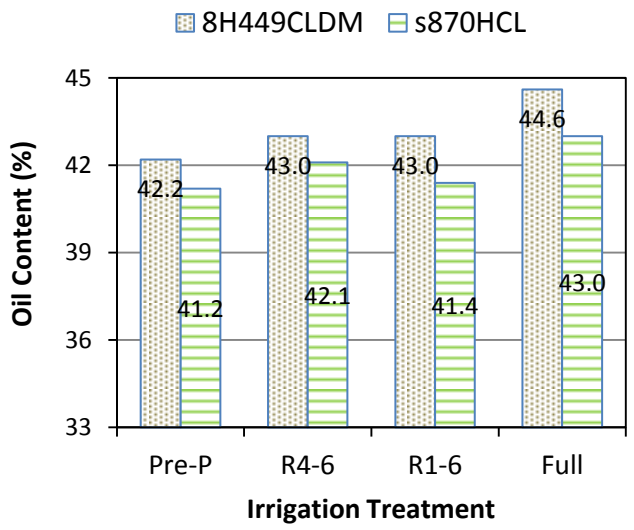

Figure 11: Oil content of two sunflower hybrids in 2012 as affected by irrigation scheduling

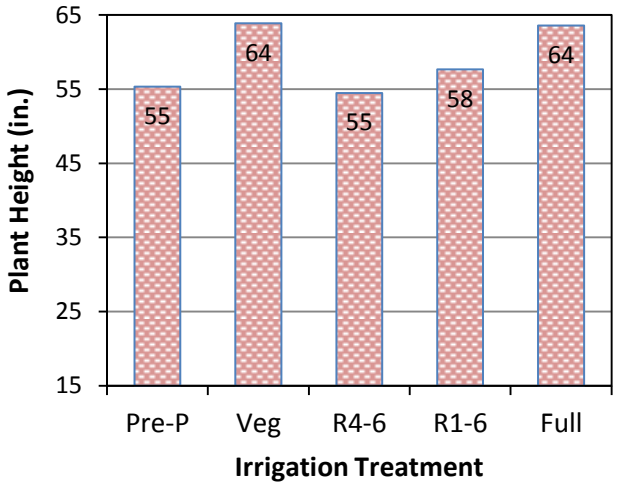

Figure 12: Plant height of sunflower hybrid 8H449CLDM in 2010 as affected by irrigation scheduling

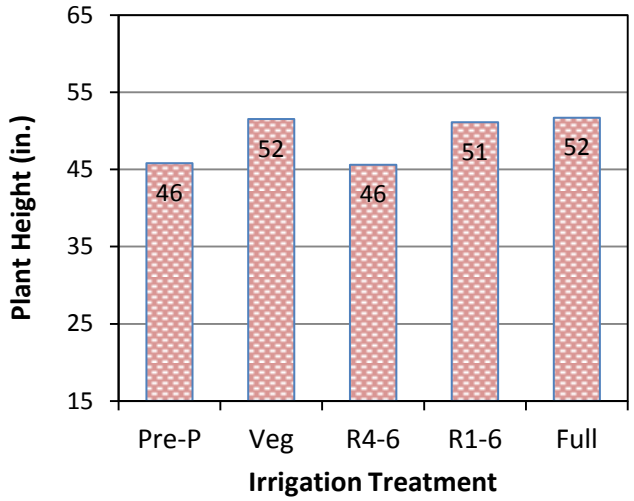

Figure 13: Plant height of sunflower hybrid 8H449CLDM in 2011 as affected by irrigation scheduling

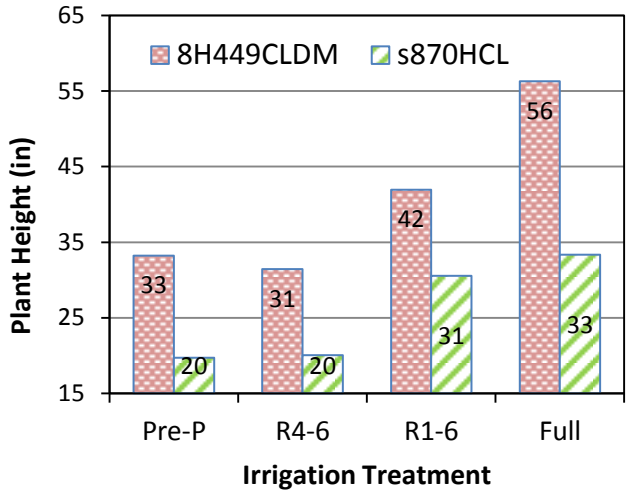

Figure 14: Plant height of two sunflower hybrids in 2012 as affected by irrigation scheduling

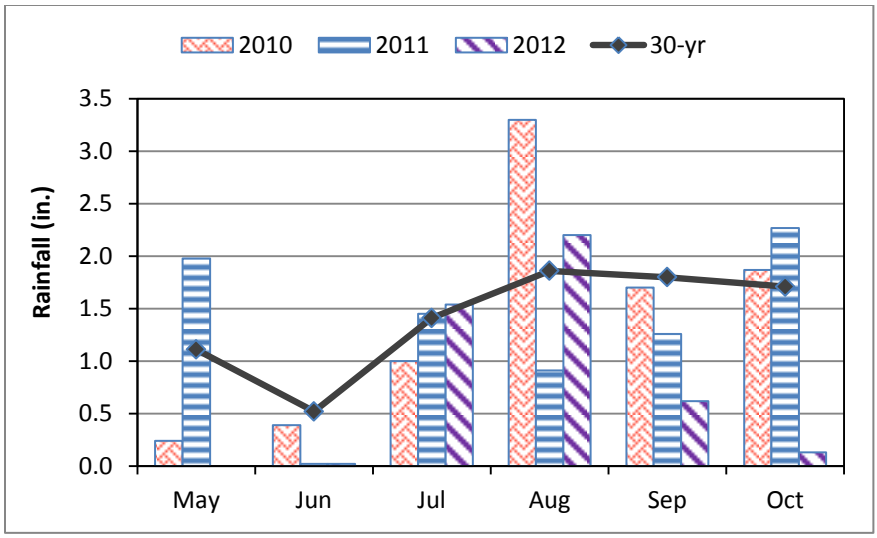

Figure 15: Rainfall in May through September at the study site

Agronomic Responses to Partial and Full Season Fallowing of Alfalfa and Grass Hayfields

Lyndsay Jones[35], Joe Brummer[36], Calvin Pearson[37], and Abdel Berrada

The Colorado River is managed under several acts and federal laws dating back to The Colorado River Compact of 1922. Over the years, numerous acts, agreements, and treaties have altered the way the river is managed. The act of 1922 separated the seven states involved into the upper basin and lower basin. Each basin is allowed 7.5 million-acre feet (MAF) of the river's annual flow. In 1944, a treaty stated that Mexico was also entitled to receive 1.5 MAF. Colorado legally utilizes just over 50% of the 7.5 MAF allocated to the upper basin. The western slope of Colorado alone, accounts for close to 1.3 MAF of the rivers annual flow. Although insufficient amounts of water were not a critical factor in the past, in recent years, a combination of drought, increased development, and growing populations have increased pressure on river resources. Since the upper basin must legally send 7.5 MAF of water to the lower basin, water shortages are a growing concern. One possible approach to this issue that is gaining interest is a water-banking system where water would be taken out of agricultural production to free up water to meet compact obligations and/or be leased for other uses.

Colorado State University is currently working on a research study meant to assess the agronomic feasibility of drying up hayfields as part of a Western-Slope Waterbank. This study hopes to provide enough information for local hay producers to confirm if this approach is worth pursuing. More specifically, this project is intended to determine the impacts to forage yield, quality, and associated recovery period for fallowed and partially fallowed hayfields on the Western Slope.

The experiment includes side-by-side fallowing treatments of three alfalfa hayfields and four grass hayfields located on the Western Slope. Treatments on the alfalfa sites include fully irrigated (control), stop irrigating after the first cutting, and stop irrigating after the second cutting. One alfalfa site also included a complete fallow (no irrigation) treatment. The grass sites include a fully irrigated treatment and a full season fallow, or non-irrigated treatment.

Test sites are spread throughout the Western Slope including the Yampa River basin, the Upper Gunnison River basin, the Upper and Lower Colorado River basins, and the San Juan/Dolores River basin. Grass sites are located at the Carpenter Ranch near Hayden, CO, the Fetcher Ranch near Steamboat Lake, CO, the Trampe Ranch near Gunnison, CO, and the Blue Valley Ranch near Kremmling, CO. Alfalfa sites include the Kehmeier Farm near Eckert, CO, the Western CO Research Center near Fruita, CO, and the Southwestern CO Research Center near Yellow Jacket, CO.

Measurements and data collected will determine impacts to forage yield and quality (crude protein, neutral detergent fiber (NDF), and NDF digestibility), changes in species composition in

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grass hayfields, changes in plant density in alfalfa hayfields, and changes in soil nutrients at all sites. Evapotranspiration (ET) rates, precipitation, and temperature data will also be collected throughout the growing season to be used in evaluation of overall data. Species composition data, plant density data, and soil analyses are to be taken at the beginning of each growing season. Forage samples for both yield and quality are taken prior to each harvest.

The first year's data has been summarized to determine annual yield reductions and regrowth rates between the various treatment groups. Yield reductions at the season-long fallowed grass sites ranged from 24% to 70%. Potential crop ET for the season ranged from 16.5 to 25.6 inches and precipitation ranged from 3.22 to 6.74 inches. Yield reductions at the alfalfa sites for the treatment where irrigation was stopped after the second irrigation ranged from 0% to 54%, while in the areas where irrigation was stopped after the first irrigation, reductions ranged from 42% to 71%. The complete fallow treatment, only implemented at the Yellow Jacket site, showed a 77% yield reduction (Table 23). Potential crop ET at the alfalfa sites was between 38.3 to 41.6 inches and precipitation ranged from 3.93 to 6.32 inches.

In 2014, grass plots that were fallowed will be returned to normal irrigation while the alfalfa plots will receive the same partial irrigation treatments. Identical data will be collected and analyzed to determine the effects of the previous year's treatments on the hay crops and soils. Effects to hay crop yields, quality, possible recovery period, increase in weeds, decrease in desirable forages or plant density, and changes in soil nutrients will all be analyzed to help determine if using water from hayfields for a water banking system has potential for hay producers on the Western Slope.

Table 23: Results at Yellow Jacket (alfalfa) in 2013

Treatment	DM (tons/ac)	% of fully irrigated	Yield reduction (%)
Fully irrigated	4.4	100	0
Stop after 1st cutting	2.6	59.1	41
Stop after 2nd cutting	4.4	100	0
Complete fallow	1.0	22.7	77
Potential ET (in): 39.6		Rainfall (in): 9.3	

The reason there was no decline in alfalfa DM yield at Yellow Jacket when irrigation was stopped after the second cutting is because of the above average precipitation in August and September (7.96 in.).

Yellow Jacket Fruit Tree and Vineyard Research and Demonstration Project: 2013 Report

Tom Hooten[38] - Colorado State University Extension, Montezuma County Director
Dan Fernandez[39] - Colorado State University Extension, former Dolores County Director
Abdel Berrada - Colorado State University, Southwestern Colorado Research Center Manager

Figure 16: U-PICK Day. Master Gardeners (persons wearing orange vests) were on hand to answer customer questions. Photo taken by Abdel Berrada.

Project Background

The Fruit Tree and Vineyard Research and Demonstration Project was implemented in April 1991, and is a cooperative effort among Montezuma County Extension, Dolores County Extension, Natural Resources and Conservation Service in Dolores County, and the Colorado

[38] Director of CSU Extension in Montezuma County
[39] Former Director of CSU Extension in Dolores County

State University Southwest Colorado Research Center at Yellow Jacket, Colorado. The completion of the Dolores Irrigation Project resulted in a substantial number of new client requests for local research based information/data on fruit tree and vineyard varieties, equipment usage, and cultural practices. Prior to this project, all fruit tree information originated from the Grand Junction area Experiment Stations which have a considerably different growing environment. Presently, the Team is evaluating 44 different fruit tree varieties including 21 field apples, 12 trellised apple varieties, 2 apple varieties planted in a "super high density," 4 peach varieties, 4 pear varieties, and 3 plum varieties. The Team is also studying 6 trellised grape varieties, 1 raspberry variety, and 14 grass varieties.

Orchard management practices such as irrigation techniques, frost and freeze management, high-density apple planting, trellised apple planting, fruit thinning, tree pruning, and integrated pest (insect, disease, weed, and wildlife) management have been tested and demonstrated. Thirteen grass species or varieties and one legume were planted between fruit tree and grape rows in 1993 and 1995 to control soil erosion and suppress weeds. A popular fruit tree pruning workshop is held every year. The proceeds from the sale of the fruit during an annual "U-Pick" help fund the operation of the orchard. The annual "U-Pick" attracts hundreds of people and is also used as an educational opportunity to inform the public of different fruit varieties and their uses, fruit processing and preservation, as well as proper long-term storage of fruit. The fruit tree and vineyard demonstration project is managed by the Extension personnel of Dolores and Montezuma Counties. It has generated considerable interest and attracts a large number of visitors throughout the year, including students from Fort Lewis College in Durango and San Juan College in New Mexico, elementary students and teachers from area elementary schools, and visitors from the Ute Mountain Ute Senior Center.

Highlights of the 2013 Season

The 2013 season started with another exceptionally dry and warm spring. This led to a 2-3 week earlier timing for orchard development. The earlier development persisted through the year and resulted in a "U-Pick" harvest two weeks earlier (at September 21) than normal. There were two hail events during the week before harvest; fortunately, the damage was limited to the East side and mainly exteriors of the trees. U-pick sales were not affected. Fruit production also increased; with an increase of 38% in apples and a 36% increase in total fruit production compared to 2012 (see Table 24). Fruit quality was good due to successful pest management (especially codling moth) and fruit thinning (both chemical and manual methods were used). Altacor and Delegate were used for codling moth control. Alternating products helps in managing insect resistance. It was very successful when timed with codling moth monitoring. "Organic" weed management (hoeing and hand pulling) was again demonstrated. However, the weeds were difficult to manage with these methods. It was deemed too labor intensive to continue and management was again switched to chemical using glyphosate later in the year.

Variety Testing Results to Date

Apples - The apples have performed exceptionally well since they began producing. With the exception of four seasons (a freeze in 2001 and hail in 1995, 2003, and 2004), the orchard has experienced consistent production. Even with the hail damage in 2004, over 7,000 pounds of fruit were sold. Tree losses included 4 trees out of 226 planted, with 3 of those lost as the result

of severe trunk damage due to excessive crop overload. Ten trees were lost in the trellis due to herbicide drift in 2010. They were replaced in 2011 with Improved Golden Delicious and four new varieties: Scarlet Spur, Spartan, Ruby Mac, and Schlect Spur. With the exception of varieties on the wrong rootstock for field or trellis applications, additional varieties that are questionable for our area include Honey Crisp, Improved Red Delicious, and possibly Idared. Roughly 1/4 of the crop (16,400 lbs.) was sold at the annual "U-Pick" in 2013.

Peaches - A much different situation exists here when compared with the apples. Virtually all of the plantings (old and new) have suffered 50% tree losses within the first year. This is attributed in part to a late planting date for peaches and the possibility that planted trees were of too large a diameter with a limited root system. The peach trees arrived partially leafed out, and when this is compounded with tree transplant shock, early tree death is inevitable. The first 2 varieties planted in 1991, Redskin and J.H. Hale, have been eliminated with one crop in seven years and significant yearly die-back. Four new varieties have been added: Flamin'Fury PF#15A, Starfire FA11, Suncrest, and Red Globe which seem to have more promise. The severe hail of 2004 damaged the upper surface of branches that led to infection with perennial canker. Many of the peach trees exhibit gradual decline and branch death since then. However, the warm season of 2013 led to the most production to date (7,600 lbs.).

Pears - The four varieties planted; Max Red Bartlet, Du Comice, D'Anjou, and Bronze Beauty have all developed well with minor problems. They do require considerable limb training and are highly susceptible to the pear slug and pear psylla. A small outbreak of Fire Blight occurred in 2007, but immediate action of pruning out the infected wood, complete cleanup of leaves and debris and several applications of Streptomycin have apparently taken care of the problem for now. No evidence of the disease has been observed to date (2013). Pears take time to produce with the Max Red and Du Comice (planted in 1996) producing their first crop in 2001. All trees are now in production and have produced generously with the exception of 2013. Production was low for unknown reasons.

Plums - Three varieties of plum on Myro rootstocks (Empress, Improved Duarte, and President) were planted in 2008 in three row-groups of five trees each. Initial growth was very good. However, in 2010 President suffered significant die-back to the main scaffold limbs due to freezing temperatures. The damaged trees required substantial reconstructive pruning. Recovery has been very good. Observations will continue. The first significant crop of 1,000 lbs. was produced in 2012. Production was 2,000 lbs. in 2013.

Grapes - Of the original 8 varieties planted in 1994, Seyval Blanc, Pinot Noir, and White Riesling were removed in 1998. These varieties require a longer growing season than what is "normal" for the location of the vineyard. In their place, Cayuga White, DeChaunac, Edelweiss, and Chardonel were planted in 1999. The performance of these four varieties has been extremely disappointing. The year 2001 was the third growing season and the vines have not performed any better. The reason for this poor performance is baffling as these vines received the same treatment as the more mature plantings. In 2000, there was a 100% infestation of crown gall in the Foch, Gewurztraminer, Merlot, and Chardonnay vines. When the infestation of 2000 occurred in all of the 4 above named varieties, they were removed.

The only remaining original planting is Lemberger. This red variety has produced crops from the

third season until present. Shoot thinning and cluster removal prior to veraison are methods used to promote fruit development and maturation. This is continuing, though labor for the tasks is limited. Discussion has occurred regarding elimination of the grape trial due to poor performance.

Grasses - Thirteen different grasses along with one legume were planted between the fruit tree rows in the demonstration orchard between April 1993 and November 1995 to evaluate their erosion control potential. These were dryland plantings with no supplemental water given. Lovington blue grama, Canbar canby bluegrass, birdsfoot trefoil/Ephraim crested wheatgrass mix, and Topgun buffalograss have been judged unsuitable for erosion control.

Irrigation

The team is currently evaluating a variety of irrigation systems including various types of drip emitters, several types of maxi and mini sprinklers, pulsators, and surface drip tubing. We currently use a 50-mesh filtration system due to very good irrigation water quality. Plugging of the filter screens has not been a problem, though they do need occasional cleaning. Our only significant problem has been with the maxi and mini sprinklers that have moving parts. A slight buildup of calcium carbonate causes the spinners to jam and spray only in one direction. These were removed and replaced with static sprinkler heads with a 360-degree spray pattern.

Additional Investigations

Work continues on frost protection management for the fruit trees and grapes, bird control, and integrated pest management of insects and diseases. Workshops on pruning and fruit management are conducted every year in cooperation with the Colorado Master Gardener program. Volunteers from the program are instrumental in maintaining the viability of the orchard project.

Strong emphasis continues to be placed on demonstrating, evaluating, and testing varieties, irrigation equipment, orchard equipment, and cultural practices that are cost effective, user friendly, and available through local suppliers.

Interest in “organic” production methods has been increasing. Some methods have been utilized on a trial basis (see **Highlights of the 2013 Season** above) but have been limited by cost and labor. Investigation into alternative management practices will continue as time and resources allow.

The team continues to investigate marketing opportunities as well as “Home-Based Business” opportunities as they relate to fruit and vineyard product utilization, i.e. fruit by-products. In addition, there has recently been interest in landowners to begin to rejuvenate some of the old, neglected apple orchards in Montezuma County. This may be due to the surging interest in local food production that has been burgeoning in SW Colorado over the last several years. The Fruit Tree and Vineyard Research and Demonstration Project will continue to attract interest and visitors as it remains relevant to the needs of the stakeholders in Southwest Colorado.

Table 24: 2013 orchard production information

Variety	Tree Count	lbs. / tree	Total Production (lbs.)
Apples *		ESTIMATES	ESTIMATES
Scarlet Gala	20	750	15,000
Nured Jonathan	2	125	250
Lustre Elstar	4	10	40
Super Jon	5	600	3,000
Red Jonagold	5	300	1,500
Golden Delicious	10	400	4,000
Honey Crisp	5	100	500
Red Fuji *Trellis	16	300	4,800
Swiss Gourmet *Trellis	16	250	4,000
Royal Empire *Trellis	16	250	4,000
Liberty *Trellis	16	250	4,000
Mor-Spur McIntosh	5	400	2,000
Improved Red Delicious	5	400	2,000
Royal Gala *Trellis	5	200	1,000
Rubinstar	4	50	200
Ida Red	4	250	1,000
Gravenstein	0	0	0
Lodi	0	0	0
Myra Fuji *Trellis	8	300	2,400
Sun Fuji	5	700	3,500
Galaxy Gala	5	700	3,500
Improved Gala	5	700	3,500
Pacific Gala	5	600	3,000
Pinova	5	150	750
Cameo	5	250	1,250
Improved Golden Delicious	5	0	0
Golden Supreme	5	0	0
Nured Jonathan Sport	18	125	2,250
Improved McIntosh *Trellis	5	200	1,000
Buckeye Gala	5	400	2,000
September Wonder Fuji **SHD	10	5	50
Honey Crisp **SHD	10	10	100
Scarlet Spur *Trellis	4	0	0
Imp. Golden Delicious *Trellis	5	0	0
Spartan *Trellis	4	0	0

Variety	Tree Count	lbs. / tree	Total Production (lbs.)
Ruby Mac *Trellis	4	0	0
Schlect Spur *Trellis	5	0	0
TOTAL CROP	256		70,590
Peaches			
Suncrest	4	400	1,600
Flamin' Fury	5	400	2,000
Red Globe	5	400	2,000
Starfire FA11	5	400	2,000
TOTAL CROP	19		7,600
Pears			
Max Red Bartlett	5	75	375
D'Anjou	3	150	450
Bronz Beauty	3	100	300
DuComice	5	150	750
TOTAL CROP	16		1875
Plums			
Improved Duarte	5	100	500
Empress	5	150	750
President	5	150	750
TOTAL CROP	15		2000
Grand Total			82,065

* Trellis - Trees on Trellis
**SDH - Trees in Super High Density Trial

Table 25: Historical weather events at the orchard

Year	Comments
2002	Freezes occurred 4/16/02, 27˚, 4/20/02, 28˚, 4/21/02, 21.9˚, 5/22/02, 29˚. Hail Storm 9/9 eliminated crop.
2004	Crop was hail damaged
2005	No damage to crop
2007	Crop was partially damaged by a freeze on June 8, 2007 & later by birds
2008	Freezes on May 23 & 24 affected the lower portion of the orchard
2009	Cold May and June delayed peach and pear harvest
2010	Several Spring Freezes Damaged Crop
2011	Ten new apple trees to replace those damaged by herbicide drift. Freeze April 26 - May 3: no production loss
2012	Warm spring resulted in high production and two week earlier harvest.
2013	Minor hail damage to apples one week before harvest. Did not affect u-pick sales.

Annual Meeting of the Advisory Committee of the Colorado State University Southwestern Colorado Research Center

February 12, 2014
Pleasant View Fire Department
15529 County Road CC, Pleasant View, CO 81331

The morning session consisted of presentations by:

- Dr. Jeff Steiner, Deputy Director of the Agricultural Experiment Station and Associate Dean of the College of Agricultural Sciences (CAS)
- Dr. Gene Kelly, Head, Department of Soil & Crop Sciences
- Dr. Abdel Berrada, Senior Research Scientist and Manager, Southwestern Colorado Research Center

In addition, brief updates were given by Darrin Parmenter, Gus Westerman, and Tom Hooten, Directors of CSU Extension in La Plata, Dolores, and Montezuma counties, respectively. Tom Hooten also presented the topics to be discussed after lunch.

Dr. Jeff Steiner showed a quote from a June 5, 2014 speech by President Tony Frank that read, "Our goal is to more fully engage the AES with the larger university mission", and then proceeded to discuss research relevance in the context of CAS strategic initiatives, which are:

- Meat and produce safety & quality
- Optimizing agriculture's water foot print
- Land use systems for sustainable agriculture and urban environments
- Profitable and environmentally sound beef and dairy production systems
- Enhanced food for human health

Research is deemed relevant if it is able to explain the results and their importance, predict their impact, support decision making, and benefit Colorado agriculture. Dr. Steiner believes in engagement from the bottom-up.

> *"What keeps you awake at night?"*
>
> *"What do you need us to give you that would help?" and,*
>
> *"How do you want to be involved in developing the solution?" he asked.*

Dr. Steiner briefly discussed the AES budget and commended the Southwestern Colorado Research Center for producing the best return on investment of all the research centers.

Dr. Gene Kelly gave updates about student numbers, instruction, staffing, and grants. The number of online courses increased to eight. As part of strategic staffing, three new positions will be created: Hydrology and Environmental Engineer, Range Science/Ecology/Management, and Biochemistry of Intensely Managed Ecosystems. Dr. Meagan Schipanski was hired as the new Cropping Systems specialist and will join the department in the spring of 2014. Several faculty

members received national and international recognition in 2013. Three alumni, Dr. Russell Snyder (70), Time Hume (93), and George Skaracis (84) were honored by the department. Another alumnus, Dr. Paul Skinner, was honored by the university.

The value of the Department of Soil and Crop Sciences to CSU is based on the number of students enrolled in classes offered by the department, the number of degrees awarded, and the volume of funded research. Research productivity stems from the department's excellent faculty but it is tied to the research conducted by graduate students and the theses and dissertations they produce. Students are the future leaders of the many fields of Agricultural Sciences the department offers.

Dr. Berrada presented the highlights of the 2013 season, the details of which are included in this report.

The purpose of the afternoon session was to help guide the research center's programs for the next 3 to 5 years. Four topics of discussion were proposed by the session moderators, Tom Hooten, Abdel Berrada, and David McCart.

1. Getting the most out of limited water supplies. Sub-topics could include:
    a. Irrigation system efficiency e.g., drip irrigation
    b. Irrigation scheduling e.g., deficit irrigation
    c. Crop selection
    d. Soil & crop management

2. Sustainability of Dryland Farming. Sub-topics could include:
    a. Incorporate cover crops in dryland (or irrigated) cropping systems
    b. Grazing & forage production
    c. Reduced tillage
    d. Other

3. Specialty Crops. Sub-topics could include:
    a. Malting barley
    b. Potatoes
    c. Oilseed crops
    d. Quinoa
    e. Hemp
    f. Fruits/other horticultural crops

4. Traditional Crops (alfalfa, winter wheat, dry bean, oat, etc.). Sub-topics could include:
    a. Importance of crop variety testing
    b. On station vs. on farm testing
    c. Importance of new variety releases
    d. Importance of certified seeds. Supplies of certified seed are becoming less and less available.

The following comments, ideas or questions were voiced by the meeting participants:

1. **Water management**
    - Which crops and crop sequences should be chosen when there is limited irrigation water available?
    - What are some crops that take advantage of winter moisture?
    - Which crops would work for double cropping?
    - The rainfall can be erratic and much of the yearly rainfall may come down during a short window of time. Is there a way to coordinate the timeline for irrigation with the rainfall?
    - Last summer after we got the rain it was no longer necessary to irrigate. However, a lot of people kept irrigating. This indicates that more education about irrigation water management may be needed.
    - We had good results irrigating alfalfa with subsurface drip irrigation. Is this something we want to try with other crops such as vegetables or herbs?
    - Water management is an important issue and will be an even more important issue in the future. The orchard is able to produce a lot on a small amount of land. Could areas such as the corners of center pivot corners be made more productive? Could we look at drip irrigation, sprinkler modifications, configurations, and new equipment? What kind of specialty crops could be grown on small areas of land?
    - If water supplies are limited we have to learn how give our soils as much water holding capacity as possible. There are several ways to increase water holding capacity including adding organic matter, increasing porosity, and mulching. Different kinds of mulches include crop byproducts and wool. There could be experimentation to see which kinds of mulch work well.
    - When there is a limited supply of water, what is the best time to apply that water to different crops? Is there a need for more studies of this type?
    - Capture expert information (survey) from producers about how they adapted to limited water supplies. Some dryland farmers know how to grow orchards and gardens without water; can we collect some of that wisdom.
    - What are the economics of a drip irrigation system? How long does it have to last for it to make economic sense to install a drip system?
    - How is a drip irrigation system maintained?

- The NRCS has had a lot of inquiries about drip irrigation. However, they have been hesitant to put government money into it until some issues are addressed including: problems with rodents, problems caused when the land has about a 3% gradient or more, and the high cost of the filtration system. A lot of the inquiries have been about drip irrigation systems on small acreages. Currently this would require installing a $10,000 sand filter. What can be done to reduce the cost of a drip irrigation system on a small acreage?
- What are efficient drip irrigation system designs?

2. Dryland farming

- Last year about ½ the annual precipitation came during about a 6 week period. This caused a lot of erosion. However, areas planted with the right kinds of grass suffered very little erosion. Additionally, the grass was able to survive the drought by going dormant and then greening up when the rains came. What are good varieties of grass to grow for this area and what are the best management practices? Which species or varieties compete more effectively with weeds?
- Grazing animals can be used for weed management. Which types of grazing animals work best in different situations? How should the grazing be managed?
- Rotational grazing can be used for weed management.
- Research can be done on integrated crop/livestock systems.
- What about 7, 10, 13 year rotations where grass is planted, livestock can be grazed, and later it can be intercropped?
- Integrate permanent vegetation with the crops. For example, a strip of sumac, a strip of grass, and a strip of wheat. Strip cropping could reduce erosion and build the soil. This is also known as shelter-belts. What is right mix of plants?
- This area used to have great winter moisture and the monsoons were better. It seems like there has been a change in the climate. How do we deal with the drier conditions?
- There may need to be an educational effort about cover crops.
- Education should help farmers make decisions and reduce the risk of trying new things. Part of the educational process should be demonstrations, both at the Research Center and on farmer's fields.
- Dolores Conservation District is going to have a Master Steward program coming up soon. Maybe there needs to be a stronger connection between some of CSU—including the experiment station—and programs like this.
- Get articles into the local newspaper about topics such as how to double-crop.
- When studies are done, data that helps to determine the economic feasibility of the system should be reported. This data may include costs, the amount of time it takes, efficiency, and what kind of return can be expected.

- What are some diversified systems that could yield steady income regardless of whether there is drought or there is good precipitation?
- What kind of changes may need to be made over the long term due to factors such as low stream flow and sage grouse?
- Will Allen (author of "Growing Power) has a system where he is able to feed 30,000 people off three acres of land using a diversified system that includes greenhouses and fish.
- How could systems that work in other areas of the country be adapted so that they work in this area?
- By using creativity we can take a new look at things that seem like barriers (such as sage grouse) and try to turn them into opportunities.
- There is a lot of information that could help farmers. However, there are only 3 or 4 production people at this meeting. The information is not getting out to them effectively. How do we improve communication with the farmers? Granges and co-ops used to provide this function. [Editor's note: Approximately 16 ag producers (crop, vegetable or livestock production) plus seven landowners attended the meeting.]

3. Alternative crops

- There is a lot of interest in growing hemp. However, CSU is waiting for legal guidance before moving forward with research on hemp.
- Some flax has been grown in this area but it has never taken off.
- There is interest in growing garlic, potatoes, Swiss chard, and catnip.
- The research center could provide systematic guidance on new crops. This could include information on the supply chain of the crop. Some of the barriers for new crops are barriers that already exist for established crops.
- Alternative feed crops include turnips, pumpkins, Jerusalem artichokes, sorghum/Sudan grass, and amaranth.
- Research is needed on what crops such as sorghum/Sudan grass do to the soil. Forage analysis research is also needed.
- One research possibility is cooperation between farmers, CSU, and seed companies to put trials on farms.
- One problem with growing alternative crops on larger farms is that the market may get flooded with the product, causing the price to fall. What are some alternative crops that work for larger farms?
- Research on oilseed crops should continue.
- How to keep wildlife (deer, elk, and birds) from destroying crops?
- What can be done to revitalize co-ops and granges? There may be federal funds available through the USDA.

4. **Traditional crops**

    - Certified seeds could be grown in this area, but they cost more so farmers tend to either save seed and replant it or buy seed from an elevator. Additionally, there are noxious weeds which have to be removed manually and this makes growing certified seeds more expensive.
    - Growing certified seeds maybe profitable for some higher value crops. However, an economic analysis is needed.
    - How should resources be allocated between developing new varieties and trying new crops, methods, and systems?
    - Potato virus Y has the potential to wipe out the certified potato industry in the San Luis Valley in the next 5 years. Could southwestern Colorado produce virus-free certified seed potatoes?
    - Peruvian purple potatoes do very well in this area.
    - There hasn't been an alfalfa variety trial in a long time, but county extension and the research center get calls from people asking which variety to plant. However, most people are growing roundup-ready alfalfa and there are only a few varieties to choose from.
    - Niches within the traditional crop market include non-GMO crops.
    - Another niche is gluten-free grain such as proso millet, sorghum, and chickpeas or developing low-gluten varieties of wheat or barley.

Lon Varnis, Chairman of the Dolores Conservation District, gave a presentation about soil health:

> The leaves of plants can be thought of as solar panels: they take solar energy and convert it to sugar. Soil organisms have a symbiotic relationship with the roots of the plants. The soil organisms receive liquid carbon (sugar) from the plant in exchange for giving the plant water and nutrients. The best example of this in nature is prairies. Food producers need to think of themselves as managing an ecosystem. Residue is armor for the soil: it protects it from wind erosion, water erosion, and minimizes the peak temperature. It gives off carbon dioxide which acts as a growth accelerator for plants. Worms act as the plows. If organic matter in the soil goes from 1% to 3% the water holding capacity will be doubled.
>
> I converted to no-till because of the economics. The difference in cost between no-till and conventional tillage is 30 to 40% in favor of no-till. When I bought a no-till drill there was nobody to talk to around here about what works or doesn't work. There is a family in the area that grows a rotation of dryland beans and wheat. One fall they couldn't finish their plowing. They had greater crop yield where they didn't plow than where they did. They have since gotten rid of their moldboard plow. The no-till system reduces soil erosion and increases water infiltration. We're in a position where our soils are so degraded that we have to regenerate some of it in order to be sustainable. Don't blame it on the pioneers; they did the best they could with the information they had at the time.

No-till will lower the peak soil temperature. Evaporation doesn't give you any benefit. ET stands for evapotranspiration. This system will take the E out of ET.

You want diversity in your system. For example, if you grow cover crops in your rotation, you'll want to represent each type in the cover crop mix in order to reduce weeds. You always want to have live roots in the soil so that the relationship between plants and microbes still functions. The soil should be covered, bare soil is not good. If the soil is bare you are missing out on the insulation and micronutrients. This system is based on soil chemistry.

Somebody told me that they had a neighbor who always shot the crows at his place, but he had to spray for grasshoppers. Another story is about somebody who didn't have a horse so he hoed 5 acres by hand. Within about 5 years he couldn't do it anymore because he had degraded the soil.

The conventional system is characterized by more erosion, poor infiltration of the water, and poor water holding capacity. When you do tillage, the microbes become homeless. Imagine what Joplin, Missouri was like after the tornado two or three years ago; that's how a microbe would relate to tillage. Organic material is low. In the first three years of tillage on a soil my understanding is that you'll lose 1/3 of the organic material. We had some of the best soils in the whole world. Now we've lost half the top soil.

How does this affect your bottom line? If you want to have a better bottom line you will probably at least think about stopping tillage. If anybody is going to implement no-till it is really a transition process and I have two very good sources you want to read, they are shop manuals for a successful transition. You don't stop one way and begin another - you aren't going to like the results in the first couple of years. The way the no-tillage system works best is if you sell your plow because in the first year or so you are going to want to use it. It's not a night and day change.

The no-till system uses about 1.5 gallons/acre of fuel while conventional tillage uses about 4.5 gallons/acre of fuel. You need a smaller tractor--most people wouldn't like that so much. The hardest job your tractor now is going to do is pull your planter or your drill. You need less equipment and less labor. You'll have a lot more free time.

You're in a situation where you're always ready to plant, not waiting for the soil to get enough moisture so you can plow and not waiting for it to dry up enough so you can get out in the field. When those conditions are there you're planting and your neighbor is plowing.

The no-till system requires no or minimal stone-picking and you're going to have some residue. If anybody questions how organic matter gets into the soil without plowing the Conservation District has a video that shows an earthworm pulling corn residue into the ground. So you don't really have to plow to get plant materials into the ground. Pet peeve of mine, you probably want to stop cultivated fallow, it's expensive and you've pretty well killed what's in the soil. You save water with a no-till system. More or less every time you go over the field doing some kind of tillage you're going to use up 1/2 to 3/4 inch of

rain. More passes means more loss. You may substitute cover crops for fallow. Everywhere in the United States I've researched this it's worked positively; however it has never been done here. The Conservation District would like to have someone to volunteer to do a trial.

You probably want to have each major plant group represented in a cover crop mix. It's going to help with weed control. One of the reasons we have weeds is we don't have diversity. If you introduce grazing to this system you'll have an opportunity to make revenue from the grazing. I was in the San Luis valley three years ago looking at cover crop usage. There was a Texan there who used movable fence and he would pay people for the right to graze their cover crops.

You're going to save fuel and save on ownership and maintenance costs of equipment. You'll use less herbicide and fertilizer. You may want to think of producing animals versus grain and forage. It's something that may make sense. Some systems that are used think cows don't have legs, but they do. Grazing is a very cost effective way of raising cows. You'll have most of your nutrients retained and you'll have more organic material which will help to retain it. If you're integrating animals into the system you want to look at the nutrition of a plant, not whether it is called a weed.

You may look at alternative crops. Around here we need a critical mass of specialty crops to get them shipped to the appropriate places. We've got a little work to do in that regard. When I take grain to market I take a 40% cut compared to what I would get in major markets. I don't fully understand why. Costs could be reduced by many farmers getting together and placing bids for say 50,000 gallons of fuel or many tons of fertilizer. We're missing that but perhaps that's a good idea. I know we had co-ops before and I don't know what happened to them.

There's an example of a marketing co-op in Eastern Washington called Shepard's Grains. It's a system where they've developed a brand name. Their product tastes better, it has more nutrients, and on the bag it identifies the farmer so you know who produced it and if you need to talk to him/her you can. A comment on our healthcare system: I've heard it characterized more as a disease management system than a healthcare system and more nutritious food is one step along the way.