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Western Colorado Research Center 2013 Research Report

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Table of Contents

Foreword 3

Contributing Authors 4

Site descriptions 5

Personnel 2012 7

Advisory Committee 8

Beet Curly Top Virus Control in Commercial Tomatoes, 2012 9

Applying Biostimulant Products in Pasture in Western Colorado 2011-12 13

Winter Wheat Variety Performance Trial at Hayden, Colorado 2012 30

Roundup-Ready Soybean Variety Performance Trial and Number of Seed Rows on a Bed at Fruita, Colorado 2012 36

Soybean Variety Performance Trial 37

Research Project/Publications - 2012 46

- Dr. Horst W. Caspari 47
- Dr. Stephen D. Menke 48
- Dr. Calvin H. Pearson 49

Foreword

Over the past two plus years, I have been the Interim Manager of the Western Colorado Research Center (WCRC) coupled with my responsibilities as Associate Director, Agricultural Experiment Station (AES) in Fort Collins. I am retiring from CSU on June 30, 2013.

This is my last opportunity to express my thoughts about the future and WCRC. Over my 32 years in the AES and my responsibilities for our off-campus centers, where I see the WCRC programs, staffing and center/sites today bodes well for the future in serving our clientele.

Our faculty and staff are looking at years down the road by asking and answering critical questions about the "what, why, where, and how much" we can make a difference in serving our clientele and then addressing our personnel, infrastructural and financial resources to execute our vision, i.e. the "who, how and when." This has been a rewarding process in assessing our strengths, weakness, opportunities and challenges. This truly has been a "journey."

You can be assured that we have the most talented and experienced faculty and staff in years whom are committed to excellence in what they do for you. We have hired two new Research Associates to fill open positions. Kevin Gobbo began working at WCRC-Fruita on March 1 and Emily Dowdy joined us at WCRC – Orchard Mesa on April 15. A search is underway to hire a Manager/Research Associate for WCRC.

I have enjoyed the challenges and opportunities I've had at WCRC and the friendships I've made. My wife and I plan to be in the Grand Valley for pleasure and to renew friendships in the future. I'm sure that, in good humor, I'll be reminded by our faculty and staff of my screw-ups. I would expect nothing less.

Frank P. Johnson PhD CPA

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Site descriptions

Fruita Site

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

The Fruita site is located 15 miles northwest of Grand Junction. With an average growing season of 180 days at an elevation of 4600 ft, a diversity of agronomic research is conducted at the Western Colorado Research Center at Fruita, including variety performance trials in alfalfa, corn silage, corn grain, canola, grasses, small grains; new and alternative crops; irrigation; cropping systems; soil fertility; and new crop trait evaluation. The Colorado Foundation Bean Program is located at Fruita. The specialized laboratory facilities at Fruita allow research to be conducted on tissue culture and natural rubber extraction and quantification in various plant species.

Orchard Mesa Site

3168 B1/2 Road
Grand Junction CO 81503
Tel (970) 434-3264 *fax* (970) 434-1035

The Orchard Mesa site is located 7 miles southeast of Grand Junction. Site elevation is approximately 4700 ft. with an average growing season of 182 frost-free days. The research conducted at this site includes tree fruits, wine grape production, and ornamental horticulture. This site has alternative crops (e.g. pistachio nuts and edible honeysuckle), greenhouses, offices and laboratory facilities.

Acknowledgments

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Grand Valley Hybrids
Mesa County Conservation District
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Van Well Nursery

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Advisory Committee

The Western Colorado Research Center (WCRC) Advisory Committee has two roles - advocacy and advisory. The advocacy role is to actively promote WCRC research and outreach activities with policy makers, producers, and the general public. Advocacy is the primary mission of the Committee. The advisory role is to provide input and feedback on research and outreach activities conducted through the programs of the Western Colorado Research Center.

The members of the WCRC Advisory Committee for 2011 are listed below. Committee members serve voluntarily without compensation. WCRC Advisory Committee meetings are open to the public. For the current membership list please visit our web page: http://www.colostate.edu/programs/wcrc/.

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Beet Curly Top Virus Control in Commercial Tomatoes, 2012

Bob Hammon[1] and Melissa Franklin[2]

Background

Beet curly top virus (BCTV), *Curtovirus*, can have significant impact on commercial and home garden tomato production in Western Colorado. In severe years there can be total loss of some varieties, especially Roma types. The virus is transmitted by beet leafhopper, *Circulifer tenellus*. Management of the virus is difficult given that a brief feeding period by the leafhopper is all that is required for transmission. We conducted research in 2012 to evaluate a systemic insecticide for curly top control in commercial tomatoes.

Materials and Methods

2012 trials were conducted at the Western Colorado Research Center at Orchard Mesa. Plants of two varieties of tomatoes, Monica (Roma) and Shady Lady (slicer), were purchased from a local greenhouse grower and transplanted with volunteer manual labor during the first week of May. These varieties were chosen because they are commonly used in commercial tomato production in the Grand Valley. Each variety was planted in a block of four 30" paired rows, eight feet apart. There were approximately 340 plants per row-pair at 18" within-row spacing. The field was fertilized preplant with 100 lbs/acre 18-46-0 broadcast and incorporated with a roller harrow. Trifluralin HF pre-emergent herbicide was applied at a rate of 2 pt/acre and incorporated with the same harrow pass as the fertilizer, a week before planting. The plots were hand weeded once during the growing season. The field was furrow irrigated every 7-10 days during the heat of the summer, watering three 30" furrows on each row-pair (Fig. 1).

Figure 1. Tomato plants were planted in double 30" rows spaced eight feet apart. Photo by Bob Hammon.

The experiment was arranged in a randomized complete block, split plot design with four replications. Variety was treated as main plot and insecticide treatment as subplot. Each paired row was divided into three 100 plant plots. One of three insecticide treatments (foliar, soil, or un-treated) was randomly assigned to each plot.

Dinotefuran (Scorpion insecticide, Gowan Corp.) was applied at a rate of 0.27 lb a.i. /A (10.5 fl. oz./A) in both the foliar and soil

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treatments. The foliar treatment was split in three foliar applications of 0.09 lb a.i./A (3.5 fl. oz./A) each. They were applied on May 30, June 12 and June 21 using a hand held CO_2 sprayer with 7.5' boom mounted with four 04F80 nozzles. The sprayer was calibrated to apply 30 gal/A of spray material at 40 psi.

Figure 2. Soil injection needle used to deliver insecticide to the root zone of the plants. Photo by Melissa Franklin.

The soil treatment was applied on May 17, using soil injection needle purchased from Warne Supply, Rapid City SD, (Fig 2) calibrated to deliver 0.0009 fl. oz. of insecticide in 7.7 fl. oz. H_2O per plant. This rate was calculated to correspond to a planting of 11,616 plants per acre or 3.75 sq. ft. per plant. The insecticide was injected directly into the root zone of the transplants.

Virus infection rate was evaluated on 6 dates (Jun 15, Jun 20, Jun 26, Jul 2, Jul 6, and Jul 13) with a visual inspection. Plants with BCTV symptoms were counted and removed on each date. Symptoms used to verify BCTV were whole plant color change, rolling of leaves and purple coloration of veins (Fig. 3). Any plants with questionable symptoms were left in the field until further symptom development occurred in the next sample date.

Analysis of variance was conducted on cumulative virus infection rate data using MSTAT-C. Means were separated using LSD method ($P<0.05$).

Figure 3. Curly top virus expresses whole plant symptoms, with color change, rolled leaves and purpling of the veins. The plant on the left is displaying all the symptoms of BCTV infection. Photo by Bob Hammon.

Leafhopper populations were monitored with 4 x 5 ½" yellow sticky cards, stapled to wooden lath and placed randomly within a tomato row. Two cards were placed in each variety block; the cards were placed at plant height, facing south. Cards were set out May 21 and changed every 5-8 days. After collection, they were taken back to the lab and beet leafhoppers counted.

Results

There was a relatively severe BCTV infection in the experimental area. The loss in untreated tomatoes due to BCTV was 21.3% overall, with 24.3% of Monica and 18.2% of Shady Lady plants being removed due to BCTV infection (Table 1).

Table 1. Curly top virus infection rates in tomatoes. Means within a section followed by the same letter are not significantly different, P<0.05.

Variety	Treatment	% BCTV Infected Plants
Monica		20.3 A
Shady Lady		12.1 B
p-Value		0.0000
	Foliar	16.6 B
	Soil	10.7 A
	Untreated	21.3 C
p-Value		0.0001
Monica	Foliar	23.9 A
Monica	Soil	12.7 C
Monica	Untreated	24.3A
Shady Lady	Foliar	9.4 C
Shady Lady	Soil	8.6 C
Shady Lady	Untreated	18.2 B
p-Value		0.0254

Soil-applied dinotefuran significantly reduced the overall BCTV infection rate by 49.7%, with a 47.7% reduction in Monica and a 52.7% reduction in Shady Lady when compared with the untreated plots (Fig. 4).

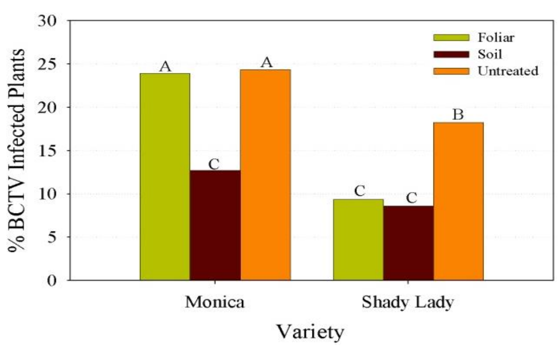

Figure 3. Soil-applied dinotefuran reduced BCTV infection rate; foliar applications had greater effect in Shady Lady than Monica.

Foliar applications reduced the incidence of BCTV by 48.3% in Shady Lady's, but only 1% in Monica. The reduction was 22.1% averaged over the entire experiment (Fig. 5).

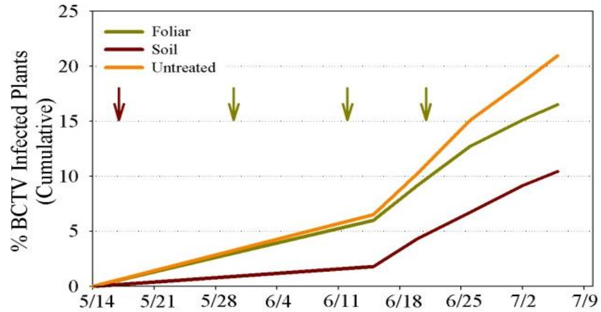

Figure 4. Cumulative BCTV infection rate in three insecticide treatments. Arrows denote application dates.

The BCTV infection rate was significantly lower in the Shady Lady (12.1%) than in the Monica (20.3%). This confirms many years of field observations in Western Colorado in which Roma types were much more susceptible to the virus than slicer types.

The initial BCTV infected plants appeared in late May, prior to the first evaluation date (June 15). Symptomatic plants continued to appear in the field until the second week of July, after which there were no new infections.

The first beet leafhoppers were captured in late May, and the population peaked in late June (Fig. 6). The peak capture was on June 21, when more than 25 leafhoppers per day were captured. This is more beet leafhoppers per day than we have caught in total during the past two years.

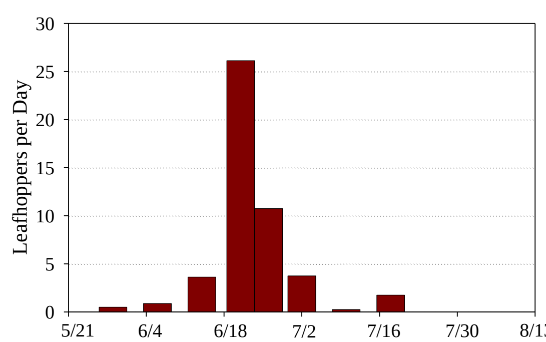

Figure 5. Beet leafhopper captures on yellow sticky traps set in the tomato field. Average capture on four traps is displayed.

Discussion

The soil-applied dinotefuran appeared to be more effective in reducing the incidence of BCTV than foliar applications. It must be noted that the application method used in this trial concentrated the insecticide in the tomato root zone and represented the maximum allowable rate. Differences in infection rate between the soil treatment and the foliar and untreated plots were apparent from the time the initial symptoms appeared in the field.

There were no apparent differences in BCTV infection rate in the foliar and untreated plots until mid June, at which time there were great increases in beet leafhopper flights. The June 12 and June 21 applications appeared to have the greatest effect on reducing BCTV incidence.

Dinotefuran appears to be an effective treatment to reduce losses due to BCTV in tomatoes. Soil applications are more effective than foliar treatments and have the advantage of giving early season control while leafhopper populations are too low to detect in sticky traps, but high enough for early season transmission of the virus.

Acknowledgements

We thank John Wilhelm and Bryan Braddy for their assistance in maintaining the tomato field. WCRC-OM provided land and equipment for growing the crop. The Tri River Area Master Gardener program provided volunteer labor for planting and weeding. Amanda McQuade, Grow Another Row, coordinated mid and late season harvest of tomatoes for the project which was self funded with early season tomato sales.

Applying Biostimulant Products in Pasture in Western Colorado 2011-12

Calvin H. Pearson[1]

Summary

Producers are interested in identifying and adopting technologies that are profitable, sustainable, and productive. Biostimulant products are commercially available and are being marketed to producers. These products are designed to stimulate beneficial microflora, balance soil pH for more favorable release of soil nutrients, and provide essential micronutrients, among other things. The objective of this research was to evaluate biostimulant products developed and marketed by Enviro Consultant Service (ECS)[2] on forage yield in perennial pasture at Fruita, CO during the 2011 and 2012 growing seasons. Forage in the perennial pasture was a mixture of orchardgrass, smooth brome, tall fescue, and a small amount of alfalfa, red clover, and birdsfoot trefoil. The application of N fertilizer increased forage yields significantly in both years. The application of ECS biostimulant products had positive effects on hay yields in all three cuttings and the total annual yield in both 2011 and 2012 and the 2-year total hay yield. This effect of increasing hay yields was more pronounced at the lower N fertilizer rates and decreased as rates increased from 50 to 90 lbs N/acre, although even at the 90 lb N/acre the effect was notable.

Introduction

As costs for crop production inputs increase producers are more interested in finding alternative technologies that reduce production input costs. Biostimulant products are commercially available and are being marketed to producers. These products are designed to stimulate beneficial microbes, balance soil pH for more favorable release of soil nutrients, and provide essential micronutrients, among other things.

Bio-Stimulant by ECS™ functions as a catalyst. As a catalyst, its mode of action accelerates the reproduction of aerobic soil organisms thereby increasing the collective activities of these organisms. Enhanced activities of aerobic soil organisms improve the decomposition of crop residue and other organic matter (Robbi Jackson, personal communication, 2013).

Enviro Consultant Service (ECS) biological products supply sulfur, calcium, and iron and contain small quantities of nitrogen, manganese, zinc, and plant-derived enzymes. The enzymes in the ECS Biological Products stimulate aerobic soil organisms such as bacteria and fungi including mycorrhizae fungi (Robbi Jackson, personal communication, 2013).

Photo 1. Calvin Pearson applying ECS biostimulant solution in plot area in pasture grass at WCRC-Fruita on April 15, 2011. Photo taken by Jennifer Phillips.

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

The objective of this research was to evaluate biostimulant products developed and marketed by ECS on forage yield in perennial pasture at Fruita in 2011 and 2012 growing seasons.

Materials and Methods

A field study was conducted at the Colorado State University Western Colorado Research Center at Fruita during the 2011 and 2012 growing seasons to determine the effects of biostimulant ECS products in perennial pasture (Photo 1). Forage in the pasture was a mixture of orchardgrass, smooth brome, tall fescue, and a small amount of alfalfa, red clover, and birdsfoot trefoil and had been in continuous production for more than 10 years.

Photo 2. ECS biostimulant plot area in pasture grass at the Western Colorado Research Center at Fruita just prior to harvest on October 11, 2012. Photo by Calvin Pearson.

Eight treatments were tested. The treatment descriptions are presented in Table 1. Plot size was 10 feet wide by 15 feet long (Photos 1, 2). The experiment design was a randomized complete block with four replications. The soil was a Hanksville silty clay loam. The elevation at Fruita is 4600 feet. The average annual precipitation is 8.4 inches and the average frost-free days are 181 (28ºF base).

No phosphorus or potassium fertilizers were applied to the experiment area during the 2011 and 2012 growing seasons. Phosphorus and potassium levels were adequate for crop production.

The soil was sampled on March 15, 2011 in an area where the plots were to be established. Eight soil cores were obtained within the plot area and bulked. Soil test results are shown in Table 2.

Soil was also sampled in each plot with two cores per plot on March 22, 2012. Two soil cores in the middle of the two center rows of each plot of the four replicates of each treatment were sampled and bulked. The soil was also sampled on each of the two long sides of the experiment at a distance of 15 feet outside of the plot area.

The application rates of ECS products were Bio-Stimulant™ at 32 oz/acre plus Harvest Energy® at 32 oz/acre plus Fulvic Electrolyte at 8 oz/acre. ECS products were applied with a CO_2–powered backpack sprayer (Photo 1). Teejet 8004VS nozzles were used to apply treatments at 50 gallons H_2O per acre (30 psi). Distilled water was used in the biostimulant treatment solutions. The fertilizer was dry urea and was broadcast applied by hand. The field was irrigated within 24 hours after treatments were applied.

Biostimulant treatments and fertilizer were applied on the same dates and were applied on April 15, 2011, June 15, 2011, and August 15, 2011. In 2012, biostimulant treatments and fertilizer were also applied on the same dates and were applied on April 9, 2012, June 8, 2012, and August 6, 2012. Environmental conditions during application of biostimulant ECS products were excellent.

Plots were harvested with an automated forage plot harvester that was designed and constructed at the Western Colorado Research Center at Fruita (Pearson, 2007). During harvest a small forage sample was obtained from each plot and placed in a paper bag (Photos 3, 4). That sample was used for moisture determination and forage quality analyses. Pasture samples were oven dried at 55°C and yields were calculated and reported on a dry matter basis.

Results and Discussion

The 2011 growing season in the Grand Valley was rather short at 157 days. The last spring killing frost occurred on May 3 (28ºF) and the first fall killing frost occurred on October 7 (28ºF).

In the first cutting in 2011, the application of ECS products without any fertilizer increased hay yields by 78% when compared to the check which received no fertilizer or ECS products (Table 3; Fig. 1). The application of 50 lbs N/acre with ECS products increased hay yields by 59% compared to the treatment that received 50 lbs N/acre without ECS products. Hay yields of the treatment that received 70 lbs N/acre with ECS products was similar to those of the treatment that received 70 lbs N/acre without ECS products. Also, hay yields of the treatment that received 90 lbs N/acre with ECS products was similar to those of the treatment that received 90 lbs N/acre without ECS products.

In the second cutting in 2011, the application of ECS products without any fertilizer increased hay yields by 135% when compared to the check which received no fertilizer or ECS products (Table 3; Fig. 1). The application of 50 lbs N/acre with ECS products increased hay yields by 95% compared to the treatment that received 50 lbs N/acre without ECS products. The application of 70 lbs N/acre with ECS products increased hay yields by 48% compared to the treatment that received 70 lbs N/acre without ECS products. The application of 90 lbs N/acre with ECS products increased hay yields by 19% compared to the treatment that received 90 lbs N/acre without ECS products.

In the third cutting in 2011, the application of ECS products without any fertilizer increased hay yields by 286% when compared to the check which received no fertilizer or ECS products (Table 3; Fig. 1). The application of 50 lbs N/acre with ECS products increased hay yields by 187% compared to the treatment that received 50 lbs N/acre without ECS products. The application of 70 lbs N/acre with ECS products increased hay yields by 47% compared to the treatment that received 70 lbs N/acre without ECS products. The application of 90 lbs N/acre with ECS products increased hay yields by 21% compared to the treatment that received 90 lbs N/acre without ECS products.

In the total 2011 yield, the application of ECS products without any fertilizer increased hay yields by 140% when compared to the check which received no fertilizer or ECS products (Table 3; Fig. 3). The application of 50 lbs N/acre with ECS products increased hay yields by 104% compared to the treatment that received 50 lbs N/acre without ECS products. The application of 70 lbs N/acre with ECS products increased hay yields by 26% compared to the treatment that received 70 lbs N/acre without ECS products. The application of 90 lbs N/acre with ECS products increased hay yields by 15% compared to the treatment that received 90 lbs N/acre without ECS products.

The 2012 growing season was favorable for forage production. The last spring frost occurred on April 16, 2012 and the first fall frost occurred

Photo 3. Harvesting third cutting ECS plots on October 11, 2012. Samples bags in each plot are used to determine moisture contents at harvest and forage quality. Photo by Calvin Pearson.

Photo 4. Jennifer Phillips picking up sample bags following first cutting harvest on June 9, 2011. Photo by Calvin Pearson.

on October 7, 2012, thus, the frost-free days for 2012 was 174 (28°F base).

In the first cutting in 2012, the application of ECS products without any fertilizer increased hay yields by 102% when compared to the check which received no fertilizer or ECS products (Table 4; Fig. 2). The application of 50 lbs N/acre with ECS products increased hay yields by 74% compared to the treatment that received 50 lbs N/acre without ECS products. The application of 70 lbs N/acre with ECS products increased hay yields by 36% compared to the treatment that received 70 lbs N/acre without ECS products. The application of 90 lbs N/acre with ECS products increased hay yields by 32% compared to the treatment that received 90 lbs N/acre without ECS products.

In the second cutting in 2012, the application of ECS products without any fertilizer increased hay yields by 71% when compared to the check which received no fertilizer or ECS products (Table 4, Fig. 2). The application of 50 lbs N/acre with ECS products increased hay yields by 45% compared to the treatment that received 50 lbs N/acre without ECS products. The application of 70 lbs N/acre with ECS products increased hay yields by 30% compared to the treatment that received 70 lbs N/acre without ECS products. The application of 90 lbs N/acre with ECS products increased hay yields by 24% compared to the treatment that received 90 lbs N/acre without ECS products.

In the third cutting in 2012, the application of ECS products without any fertilizer increased hay yields by 168% when compared to the check which received no fertilizer or ECS products (Table 4, Fig. 2). The application of 50 lbs N/acre with ECS products increased hay yields by 148% compared to the treatment that received 50 lbs N/acre without ECS products. The application of 70 lbs N/acre with ECS products increased hay yields by 33 % compared to the treatment that received 70 lbs N/acre without ECS products. The application of 90 lbs N/acre with ECS products increased hay yields by 21% compared to the treatment that received 90 lbs N/acre without ECS products.

In the 2012 total yield, the application of ECS products without any fertilizer increased hay yields by 112% when compared to the check which received no fertilizer or ECS products (Table 4, Fig. 3). The application of 50 lbs N/acre with ECS products increased hay yields by 86% compared to the treatment that received 50 lbs N/acre without ECS products. The application of 70 lbs N/acre with ECS products increased hay yields by 33% compared to the treatment that received 70 lbs N/acre without ECS products. The application of 90 lbs N/acre with ECS products increased hay yields by 26 % compared to the treatment that received 90 lbs N/acre without ECS products.

In the two-year total yield, the application of ECS products without any fertilizer increased hay yields by 123% when compared to the check which received no fertilizer or ECS products (Table 4, Fig. 4). The application of 50 lbs N/acre with ECS products increased hay yields by 93% compared to the treatment that received 50 lbs N/acre without ECS products. The application of 70 lbs N/acre with ECS products increased hay yields by 30% compared to the treatment that received 70 lbs N/acre without ECS products. The application of 90 lbs N/acre with ECS products increased hay yields by 21 % compared to the treatment that received 90 lbs N/acre without ECS products.

Conclusions

The application of ECS biostimulant products and N fertilizer had positive effects on hay yields in both years. The ECS biostimulant effect was more pronounced at the lower N fertilizer rates and decreased as rates increased from 50 to 90 lbs N/acre, although even at the 90 lb N/acre the effect was notable. Furthermore, the data indicate that time (which may be associated with an increase in temperature) is needed for biostimulants to work more effectively.

Acknowledgments

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Table 1. Biostimulant ECS treatments in a biostimulant ECS study conducted in permanent pasture at the Western Colorado Research Center at Fruita during 2011-2012.

Treatment
1. Untreated control, no fertilizer, no ECS products.
2. ECS products application only (no fertilizer)
3. 50 lbs N/acre (dry urea)
4. 50 lbs N/acre + ECS products
5. 70 lbs N/acre
6. 70 lbs N/acre + ECS products
7. 90 lbs N/acre
8. 90 lbs N/acre + ECS products

Table 2. Baseline soil test result from soil sampling prior to establishing the expanded pasture study of ECS biostimulant treatments during spring 2011 at the Colorado State University, Western Colorado Research Center at Fruita, CO. Baseline soil test result from soil sampling prior to establishing the expanded pasture study of ECS biostimulant treatments during spring 2011 at the Colorado State University, Western Colorado Research Center at Fruita, CO.

Treatment	O.M.	pH	CEC	Salts	N	P	K	Mg
	%		meq/100g	mmhos/cm	ppm	ppm	ppm	ppm
Baseline soil sample	2.0	8.4	20.8	0.5	2	13	120	351

Treatment	Ca	Na	S	Zn	Mn	Fe	Cu	B
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Baseline soil sample	3408	125	26	5.2	2	29	1.4	0.9

Table 3. Forage yields for a biostimulant ECS study conducted in permanent pasture at the Western Colorado Research Center at Fruita during 2011.

Treatment	**First cutting June 9, 2011**	**Second cutting August 9, 2011**	**Third cutting October 11, 2011**	**2011 Total yield**
	Tons dry matter/acre			
Untreated control, no fertilizer, no ECS products	0.50 c	0.31 d	0.22 d	1.03 e
ECS products application only (no fertilizer)	0.89 b	0.73 c	0.85 c	2.47 d
50 lbs N/acre (dry urea)	0.51 c	0.39 d	0.30 d	1.19 e
50 lbs N/acre + ECS products	0.81 b	0.76 c	0.86 c	2.43 d
70 lbs N/acre	1.22 a	0.77 c	0.97 c	2.96 c
70 lbs N/acre + ECS products	1.15 a	1.14 ab	1.43 a	3.72 ab
90 lbs N/acre	1.21 a	1.03 b	1.27 b	3.50 b
90 lbs N/acre + ECS products	1.26 a	1.23 a	1.54 a	4.02 a
Average	0.94	0.79	0.93	2.67
LSD (0.10)	0.16	0.15	0.14	0.38
C.V.(%)	11.8	12.5	10.1	9.7

[1]Numbers within a column followed by a different letter are significantly different at P < 0.10 level of probability.

Table 4. Hay yields in a biostimulant ECS study conducted in permanent pasture at the Western Colorado Research Center at Fruita during 2012 and the two-year total hay yield.

Treatment	**First cutting May 29, 2012**	**Second cutting July 25, 2012**	**Third cutting October 11, 2012**	**2012 Total yield**	**Two-year total**
	Tons dry matter/acre				
Non-treated control, no fertilizer, no ECS products	0.54f	0.52c	0.44e	1.49g	2.52f
ECS products application only (no fertilizer)	1.09d	0.89b	1.18d	3.16e	5.63e
50 lbs N/acre (dry urea)	0.78e	0.60c	0.54e	1.92f	3.11f
50 lbs N/acre + ECS products	1.36c	0.87b	1.34b	3.57d	6.00de
70 lbs N/acre	1.14d	0.91b	1.46b	3.50de	6.47d
70 lbs N/acre + ECS products	1.55b	1.18a	1.94a	4.67b	8.39b
90 lbs N/acre	1.49bc	0.95b	1.62b	4.07c	7.57c
90 lbs N/acre + ECS products	1.97a	1.18a	1.96a	5.11a	9.14a
Average	1.24	0.89	1.31	3.44	6.10
LSD (0.10)	0.18	0.16	0.14	0.37	0.60
C.V.(%)	12.0	14.8	8.6	8.8	8.1

[1]Numbers within a column followed by a different letter are significantly different at $P < 0.10$ level of probability.

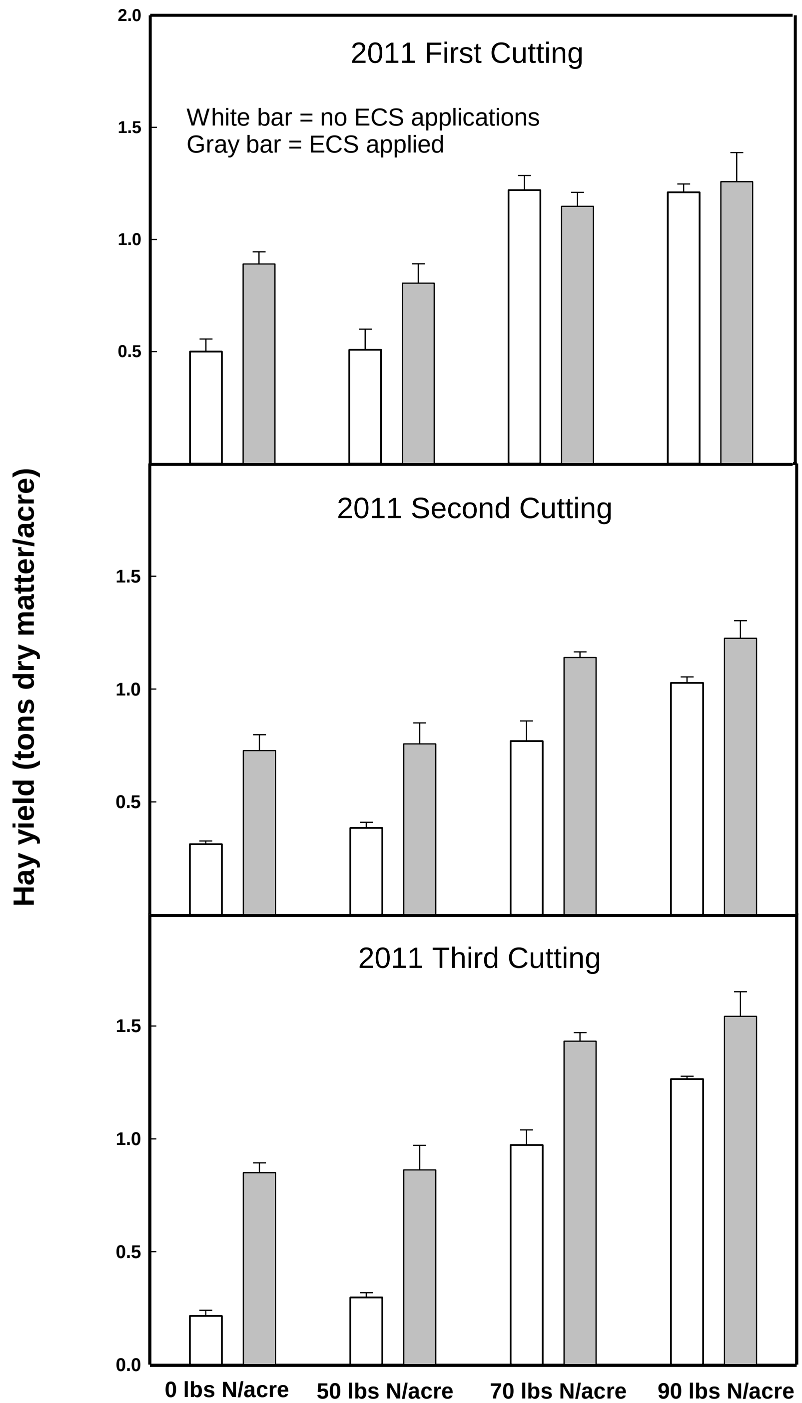

Fig.1. Pasture hay yields as affected by nitrogen fertilizer and application of ECS biostimulant products for each of three cuttings during the 2011 growing season at the Western Colorado Research Center at Fruita.

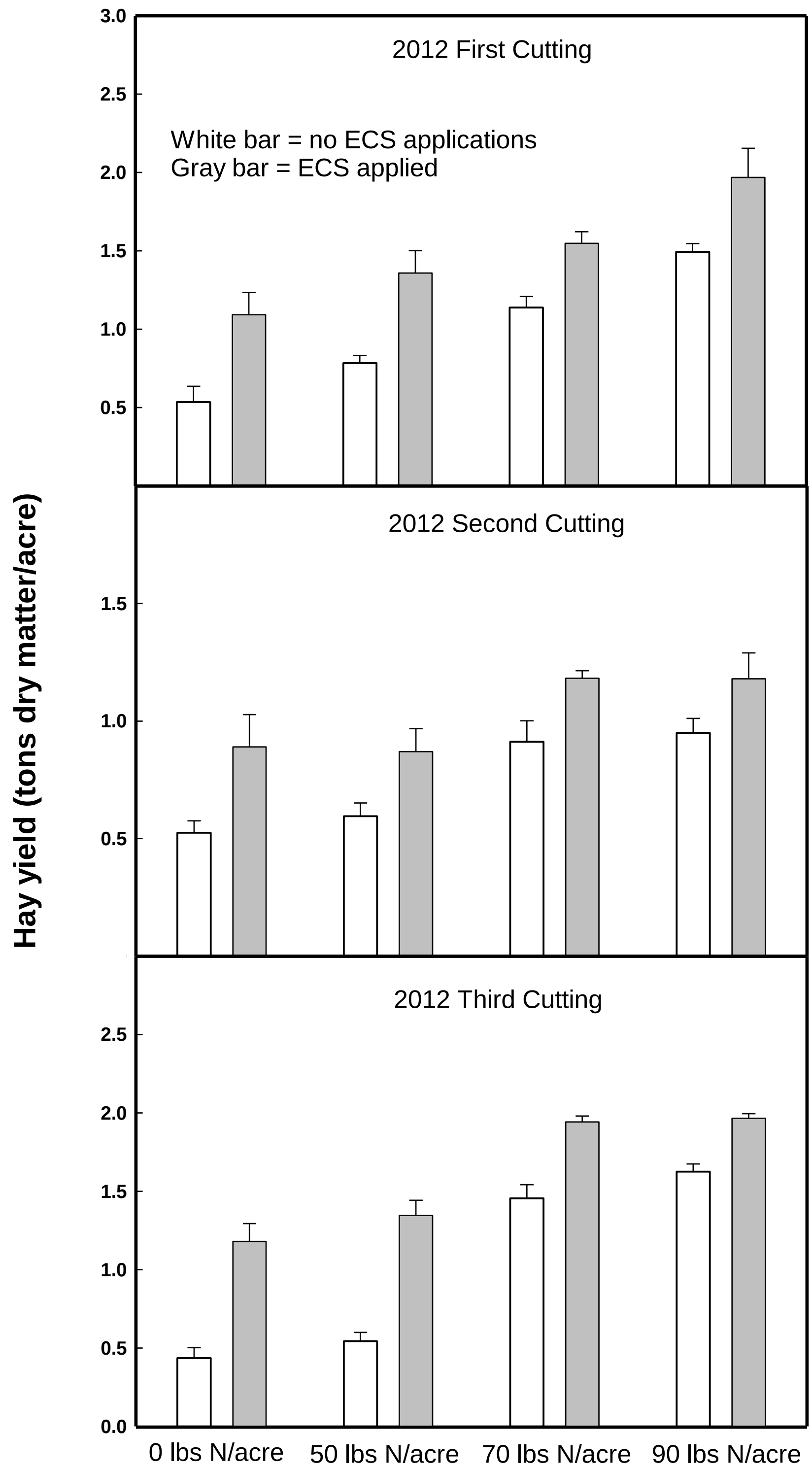

Fig. 2. Pasture hay yields as affected by nitrogen fertilizer and application of ECS biostimulant products for each of three cuttings during the 2012 growing season at the Western Colorado Research Center at Fruita.

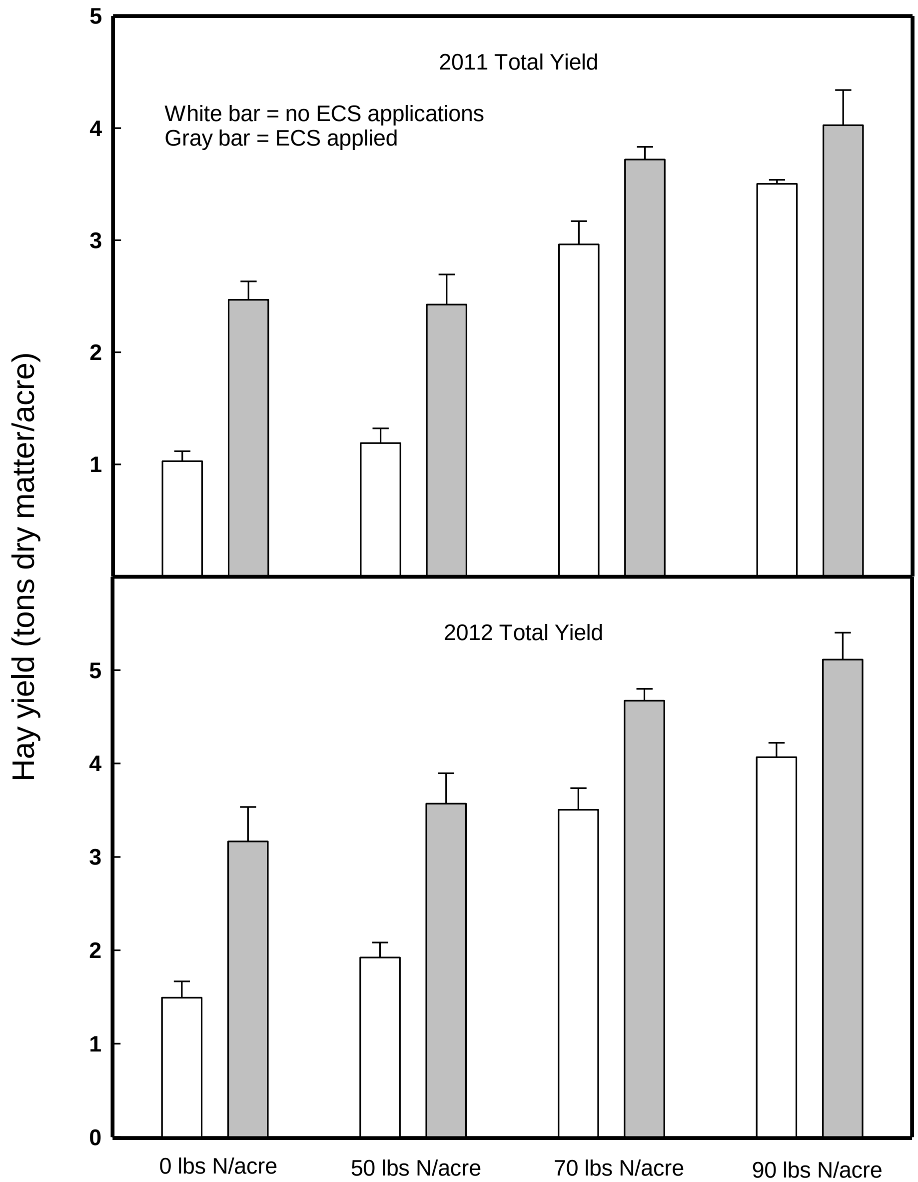

Fig. 3. Pasture hay yields as affected by nitrogen fertilizer and application of ECS biostimulant products during the 2011 and 2012 growing seasons at the Western Colorado Research Center at Fruita.

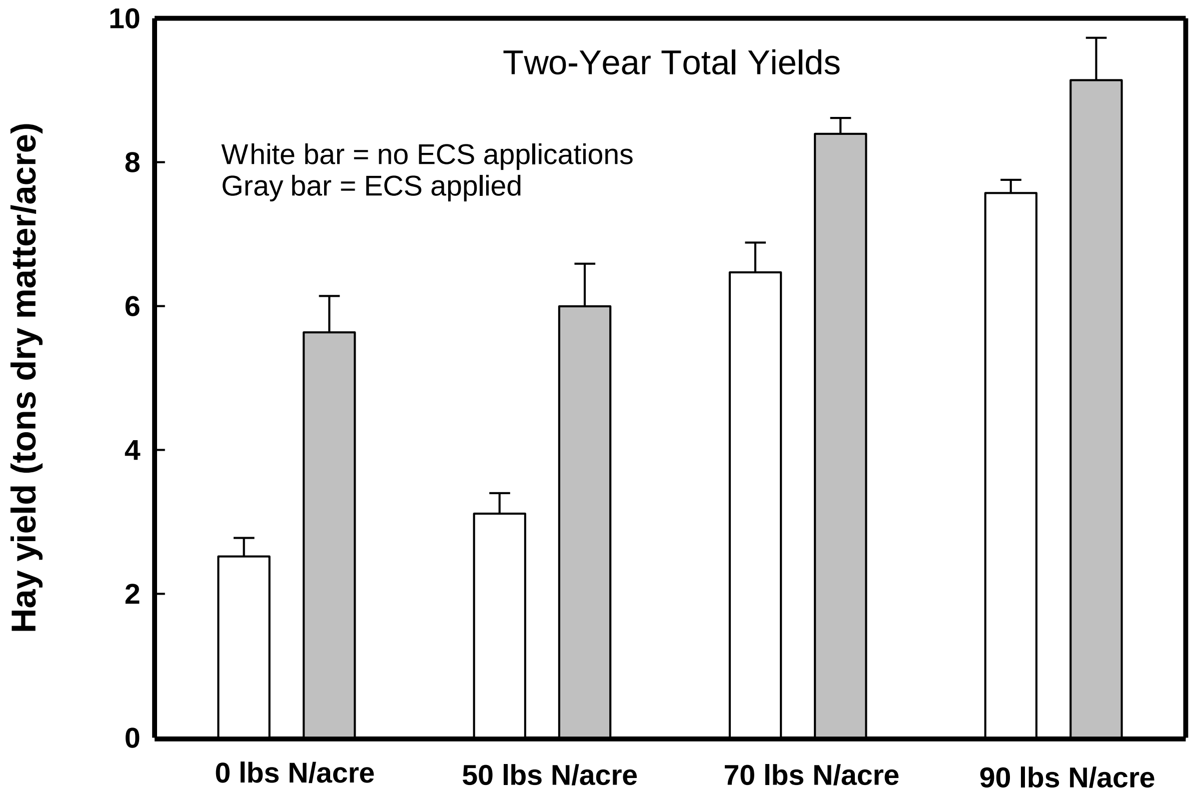

Fig. 4. Two-year total pasture hay yields as affected by nitrogen fertilizer and application of ECS biostimulant products during the 2011 and 2012 growing seasons at the Western Colorado Research Center at Fruita.

Appendix 1. Forage quality analysis of Enviro Consultant Service, biostimulant product and nitrogen fertilizer evaluation study 2011. Colorado State University, Western Colorado Research Center, Fruita, Colorado. (non-replicated data)

Treatment	Crude Protein (%)	Acid Deterg. Fiber (ADF - %)	Neutral Deterg. Fiber (NDF - %)	Total Digestible Nutrients (TDN - %)	Net Energy Gain (Mcal/lb)	Relative Feed Value (RFV)	Sulfur (%)	Phosphorus (%)	Magnesium (%)	Calcium (%)	Potassium (%)	Sodium (%)	Iron (ppm)	Manganese (ppm)	Zinc (ppm)	Copper (ppm)
First Cutting																
No N; No ECS products	9.27	31.1	55.7	67.1	0.41	108	0.28	0.45	0.27	0.72	2.12	0.11	99	31	23	5
No N; just ECS products	10.60	33.1	54.3	64.8	0.37	108	0.30	0.40	0.30	0.97	2.17	0.16	100	31	21	4
50 lbs N/ac; No ECS products	9.18	32.0	57.5	66.1	0.39	103	0.25	0.32	0.23	0.55	2.44	0.16	91	28	20	4
50 lbs N/acre + ECS products	9.22	32.4	57.9	65.6	0.39	102	0.30	0.38	0.27	0.59	2.48	0.13	95	28	21	4
70 lbs N/ac; No ECS products	8.29	34.3	59.6	63.4	0.36	97	0.23	0.31	0.22	0.47	2.47	0.16	86	26	19	4
70 lbs N/acre + ECS products	9.25	30.5	56.4	67.8	0.42	107	0.29	0.32	0.26	0.68	2.58	0.16	91	30	20	5
90 lbs N/ac; No ECS products	10.60	30.5	57.5	67.8	0.42	105	0.23	0.28	0.21	0.48	2.71	0.18	74	26	20	4
90 lbs N/acre + ECS products	10.80	29.8	53.5	68.6	0.43	114	0.26	0.28	0.29	0.82	2.51	0.16	91	29	21	6
Second Cutting																
No N; No ECS products	14.20	32.5	51.0	65.5	0.38	116	0.41	0.52	0.44	1.57	2.62	0.14	87	39	27	6
No N; just ECS products	13.70	31.4	51.0	66.8	0.40	118	0.42	0.49	0.41	1.43	2.57	0.16	98	39	27	6
50 lbs N/ac; No ECS products	11.20	34.0	61.1	63.8	0.36	95	0.41	0.46	0.38	0.80	3.43	0.18	71	39	21	4
50 lbs N/acre + ECS products	12.20	33.4	60.9	64.5	0.37	96	0.43	0.48	0.38	0.87	3.33	0.15	76	43	24	5
70 lbs N/ac; No ECS products	11.70	34.0	60.8	63.8	0.36	96	0.41	0.48	0.40	0.89	3.14	0.25	75	45	22	4
70 lbs N/acre + ECS products	12.50	34.0	58.2	63.8	0.36	100	0.40	0.47	0.39	0.86	3.25	0.19	78	47	23	5
90 lbs N/ac; No ECS products	11.80	35.7	61.9	61.9	0.33	92	0.34	0.38	0.36	0.70	3.35	0.27	74	38	22	5
90 lbs N/acre + ECS products	12.20	36.2	61.5	61.3	0.33	92	0.38	0.41	0.36	0.73	3.47	0.24	77	45	23	5
Third Cutting																
No N; No ECS products	12.70	28.6	52.6	69.9	0.45	118	0.50	0.58	0.35	0.80	2.57	0.21	67	46	28	10
No N; just ECS products	12.30	27.8	52.5	70.9	0.46	119	0.45	0.47	0.31	0.79	2.36	0.18	63	38	24	9
50 lbs N/ac; No ECS products	11.70	28.4	52.2	70.2	0.45	119	0.38	0.44	0.31	0.65	2.90	0.24	65	35	31	11
50 lbs N/acre + ECS products	11.60	27.6	52.0	71.1	0.46	121	0.42	0.45	0.32	0.68	2.94	0.22	60	41	31	11
70 lbs N/ac; No ECS products	12.20	27.5	52.8	71.2	0.46	119	0.40	0.46	0.33	0.73	2.79	0.32	75	41	27	12
70 lbs N/acre + ECS products	12.40	28.7	54.1	69.8	0.44	114	0.38	0.41	0.34	0.71	2.90	0.32	67	39	28	11
90 lbs N/ac; No ECS products	12.60	29.9	57.5	68.5	0.43	106	0.33	0.40	0.32	0.55	2.96	0.48	72	36	29	14
90 lbs N/acre + ECS products	12.90	26.2	55.5	72.7	0.48	115	0.37	0.41	0.32	0.65	3.01	0.32	71	39	28	14

Appendix 1 (continued). Forage quality analysis of Enviro Consultant Service, biostimulant product and nitrogen fertilizer evaluation study 2011.
Colorado State University, Western Colorado Research Center. Fruita, Colorado. (non-replicated data)

Treatment	Crude Protein (%)	Acid Deterg. Fiber (ADF - %)	Neutral Deterg. Fiber (NDF - %)	Total Digestible Nutrients (TDN - %)	Net Energy Gain (Mcal/lb)	Relative Feed Value (RFV)	Sulfur (%)	Phosphorus (%)	Magnesium (%)	Calcium (%)	Potassium (%)	Sodium (%)	Iron (ppm)	Manganese (ppm)	Zinc (ppm)	Copper (ppm)
2011 Average																
No N; No ECS products	12.06	30.7	53.1	67.5	0.41	114	0.40	0.52	0.35	1.03	2.44	0.15	84	38.7	26.0	7.0
No N; just ECS products	12.20	30.8	52.6	67.5	0.41	115	0.39	0.45	0.34	1.06	2.37	0.17	87	36.0	24.0	6.3
50 lbs N/ac; No ECS products	10.69	31.5	56.9	66.7	0.40	106	0.35	0.41	0.31	0.67	2.92	0.19	76	34.0	24.0	6.3
50 lbs N/acre + ECS products	11.01	31.1	56.9	67.1	0.41	106	0.38	0.44	0.32	0.71	2.92	0.17	77	37.3	25.3	6.7
70 lbs N/ac; No ECS products	10.73	31.9	57.7	66.1	0.39	104	0.35	0.42	0.32	0.70	2.80	0.24	79	37.3	22.7	6.7
70 lbs N/acre + ECS products	11.38	31.1	56.2	67.1	0.41	107	0.36	0.40	0.33	0.75	2.91	0.22	79	38.7	23.7	7.0
90 lbs N/ac; No ECS products	11.67	32.0	59.0	66.1	0.39	101	0.30	0.35	0.30	0.58	3.01	0.31	73	33.3	23.7	7.7
90 lbs N/acre + ECS products	11.97	30.7	56.8	67.5	0.41	107	0.34	0.37	0.32	0.73	3.00	0.24	80	37.7	24.0	8.3

Appendix 2. Forage quality analysis of Enviro Consultant Service, biostimulant product and nitrogen fertilizer evaluation study 2012. Colorado State University, Western Colorado Research Center, Fruita, Colorado. (non-replicated data)

Treatment	Crude Protein (%)	Acid Deterg. Fiber (ADF - %)	Neutral Deterg. Fiber (NDF - %)	Total Digestible Nutrients (TDN - %)	Net Energy Gain (Mcal/lb)	Relative Feed Value (RFV)	Sulfur (%)	Phosphorus (%)	Magnesium (%)	Calcium (%)	Potassium (%)	Sodium (%)	Iron (ppm)	Manganese (ppm)	Zinc (ppm)	Copper (ppm)
First Cutting																
No N; No ECS products	9.37	37.8	62.4	59.4	0.35	89	0.23	0.36	0.25	0.60	2.34	0.10	126	20.4	29.6	19.6
No N; just ECS products	8.22	37.6	62.7	59.7	0.35	88	0.23	0.34	0.22	0.48	2.31	0.11	106	19.2	28.2	17.4
50 lbs N/ac; No ECS products	9.48	35.1	63.2	62.5	0.34	91	0.22	0.27	0.23	0.50	2.48	0.12	119	19.6	29.1	21.5
50 lbs N/acre + ECS products	7.79	36.5	63.5	60.9	0.32	89	0.19	0.28	0.20	0.43	2.13	0.12	103	21.0	23.8	13.6
70 lbs N/ac; No ECS products	9.00	35.9	62.5	61.6	0.33	91	0.23	0.29	0.23	0.51	2.50	0.14	134	21.6	29.0	18.8
70 lbs N/acre + ECS products	9.22	35.5	62.7	62.1	0.34	91	0.22	0.29	0.24	0.46	2.41	0.17	109	22.1	27.2	17.4
90 lbs N/ac; No ECS products	11.40	34.1	63.8	63.7	0.36	91	0.23	0.26	0.27	0.52	2.60	0.30	123	23.8	30.1	18.0
90 lbs N/acre + ECS products	8.08	35.2	62.9	62.4	0.34	91	0.22	0.28	0.24	0.47	2.28	0.15	129	26.2	26.7	17.3
Second Cutting																
No N; No ECS products	14.10	33.8	53.7	64.0	0.36	108	0.35	0.44	0.42	1.20	2.44	0.16	77	26.6	32.8	17.1
No N; just ECS products	13.70	32.8	53.4	65.2	0.38	110	0.43	0.50	0.42	1.17	2.80	0.13	106	27.9	34.9	22.6
50 lbs N/ac; No ECS products	12.40	32.1	55.2	66.0	0.39	108	0.38	0.41	0.41	0.91	2.76	0.17	80	26.4	31.9	24.8
50 lbs N/acre + ECS products	12.90	32.3	54.8	65.7	0.39	108	0.42	0.45	0.42	1.02	2.84	0.14	90	32.5	33.7	22.4
70 lbs N/ac; No ECS products	12.70	32.7	58.1	65.3	0.38	102	0.38	0.44	0.42	0.86	2.84	0.28	75	31.0	32.1	23.2
70 lbs N/acre + ECS products	12.70	31.8	57.6	66.3	0.40	104	0.41	0.45	0.43	0.88	3.05	0.20	74	32.5	31.9	23.6
90 lbs N/ac; No ECS products	11.20	32.8	58.8	65.2	0.38	100	0.36	0.38	0.43	0.80	2.98	0.36	72	29.8	31.7	23.5
90 lbs N/acre + ECS products	12.30	30.7	58.1	67.5	0.41	104	0.37	0.39	0.42	0.80	3.02	0.28	77	34.5	29.6	22.7
Third Cutting																
No N; No ECS products	12.00	27.1	43.9	71.6	0.47	144	0.41	0.38	0.34	1.16	2.42	0.21	57	24.7	29.2	5.2
No N; just ECS products	12.40	23.1	41.6	76.2	0.53	158	0.40	0.33	0.32	1.36	2.15	0.18	60	23.2	23.6	4.5
50 lbs N/ac; No ECS products	11.10	24.8	44.7	74.3	0.51	145	0.30	0.27	0.28	0.63	2.37	0.24	42	21.5	17.3	3.2
50 lbs N/acre + ECS products	10.40	26.9	49.8	71.9	0.47	127	0.37	0.34	0.30	0.72	3.06	0.24	46	27.0	23.5	4.2
70 lbs N/ac; No ECS products	11.20	25.3	49.0	73.7	0.50	131	0.32	0.30	0.31	0.67	2.72	0.32	50	25.0	19.4	4.1
70 lbs N/acre + ECS products	10.10	26.3	47.5	72.6	0.48	134	0.31	0.31	0.30	0.53	2.74	0.32	49	26.6	17.4	3.9
90 lbs N/ac; No ECS products	11.70	25.3	47.2	73.7	0.50	136	0.32	0.29	0.31	0.62	2.56	0.48	45	25.6	19.5	4.3
90 lbs N/acre + ECS products	10.60	27.4	49.7	71.3	0.46	126	0.32	0.31	0.32	0.51	2.73	0.43	44	25.8	16.6	3.7

Appendix 3. Non-replicated data of soil sample comparison of March 24, 2011 and December 7, 2012 soil samplings in a biostimulant product and nitrogen fertilizer study. Colorado State University, Western Colorado Research Center. Fruita, Colorado.																	
Treatment	**pH**	**Soil Organic Matter**	**CEC**	**P1 - Weak Bray**	**P2 - Strong Bray**	**Nitrate**	**Ca**	**Mg**	**K**	**Na**	**Sulfur**	**P2 : P1 Ratio**	**Ca:Mg ratio**	**Water Soluble P**	**Water Soluble Ca**	**Water Soluble K**	**Water Soluble Na**
	6.6 to 6.9	**3% to 5%**	**Depends on texture**	**20 to 30 ppm**	**40 to 60 ppm**	**40 lbs/ac**	**70 to 80% base sat.**	**12 to 15% base sat.**	**3 to 5% base sat.**	**Less than 1%**	**20 to 30 ppm**	**No more than 2:1**	**7:1 (ppm)**		**2.5 to 3.5 X's Water Sol. K**		
OUT OF PLOT																	
March 24, 2011, #11-078-0053	8.4	2.0	20.9	3	5	4	3423	358	114	120	23	0.3	9.6	8	370	91	122
BI-CARB.P x 1.4, OR BASE SAT. (%)			12	X 1.4 =	17		81.8	14.3	1.4	2.5							
Dec. 7, 2012, #12-339-0650	8.2	2.0	17.9	2	3	5	2861	318	128	147	22	0.1	9.0	18	974	276	201
BI-CARB.P x 1.4, OR BASE SAT. (%)			17	X 1.4 =	24		79.8	14.8	1.8	3.6							
Change (%)	-2.4%	0.0%	-14.4%	41.7%	-40.0%	25.0%	-16.4%	-11.2%	12.3%	22.5%	-4.3%	-57.6%	-5.9%	125.0%	163.2%	203.3%	64.8%
BI-CARB.P OR BASE SAT'N Change (%)							-2.4%	3.5%	28.6%	44.0%							
NO Nitrogen, No Biostimulant																	
March 24, 2011, #11-078-0053	8.4	2.0	20.8	3	4	4	3408	351	120	125	26	0.2	9.7	6	254	60	123
BI-CARB.P x 1.4, OR BASE SAT. (%)			13	X 1.4 =	18		81.8	14.1	1.5	2.6							
Dec. 7, 2012, #12-339-0650	8.3	1.9	19.2	2	3	11	3051	331	133	186	29	0.1	9.2	9	438	119	209
BI-CARB.P x 1.4, OR BASE SAT. (%)			17	X 1.4 =	24		79.6	14.4	1.8	4.2							
Change (%)	-1.2%	-5.0%	-7.7%	30.8%	-25.0%	175.0%	-10.5%	-5.7%	10.8%	48.8%	11.5%	-42.6%	-5.1%	50.0%	72.4%	98.3%	69.9%
BI-CARB.P OR BASE SAT'N Change (%)							-2.7%	2.1%	20.0%	61.5%							
NO Nitrogen, With Biostimulant																	
March 24, 2011, #11-078-0053	8.4	2.0	20.8	3	4	4	3408	351	120	125	26	0.2	9.7	6	254	60	123
BI-CARB.P x 1.4, OR BASE SAT. (%)			13	X 1.4 =	18		81.8	14.1	1.5	2.6							
Dec. 7, 2012, #12-339-0650	8.2	1.9	19.2	2	3	4	3120	312	125	165	25	0.2	10.0	5	230	61	175
BI-CARB.P x 1.4, OR BASE SAT. (%)			11	X 1.4 =	15		81.1	13.5	1.7	3.7							
Change (%)	-2.4%	-5.0%	-7.7%	-15.4%	-25.0%	0.0%	-8.5%	-11.1%	4.2%	32.0%	-3.8%	-11.4%	3.0%	-16.7%	-9.4%	1.7%	42.3%
BI-CARB.P OR BASE SAT'N Change (%)							-0.9%	-4.3%	13.3%	42.3%							
50 LBS Nitrogen, No Biostimualant																	
March 24, 2011, #11-078-0053	8.4	2.0	20.8	3	4	4	3408	351	120	125	26	0.2	9.7	6	254	60	123
BI-CARB.P x 1.4, OR BASE SAT. (%)			13	X 1.4 =	18		81.8	14.1	1.5	2.6							
Dec. 7, 2012, #12-339-0650	8.2	1.9	21.0	1	2	18	3346	361	140	203	32	0.1	9.3	5	244	54	220
BI-CARB.P x 1.4, OR BASE SAT. (%)			22	X 1.4 =	31		79.8	14.3	1.7	4.2							
Change (%)	-2.4%	-5.0%	1.0%	69.2%	-50.0%	350.0%	-1.8%	2.8%	16.7%	62.4%	23.1%	-70.5%	-4.5%	-16.7%	-3.9%	-10.0%	78.9%
BI-CARB.P OR BASE SAT'N Change (%)							-2.4%	1.4%	13.3%	61.5%							
50 LBS Nitrogen, With Biostimulant																	
March 24, 2011, #11-078-0053	8.4	2.0	20.8	3	4	4	3408	351	120	125	26	0.2	9.7	6	254	60	123
BI-CARB.P x 1.4, OR BASE SAT. (%)			13	X 1.4 =	18		81.8	14.1	1.5	2.6							
Dec. 7, 2012, #12-339-0650	8.2	1.9	20.8	2	4	11	3306	358	143	205	28	0.3	9.2	3	198	30	193
BI-CARB.P x 1.4, OR BASE SAT. (%)			11	X 1.4 =	15		79.6	14.3	1.8	4.3							
Change (%)	-2.4%	-5.0%	0.0%	-15.4%	0.0%	175.0%	-3.0%	2.0%	19.2%	64.0%	7.7%	18.2%	-4.9%	-50.0%	-22.0%	-50.0%	56.9%
BI-CARB.P OR BASE SAT'N Change (%)							-2.7%	1.4%	20.0%	65.4%							

Appendix 3. Non-replicated data of soil sample comparison of March 24, 2011 and December 7, 2012 soil samplings in a biostimulant product and nitrogen fertilizer study.
Colorado State University, Western Colorado Research Center. Fruita, Colorado.

Treatment	pH	Soil Organic Matter	CEC	P1 - Weak Bray	P2 - Strong Bray	Nitrate	Ca	Mg	K	Na	Sulfur	P2 : P1 Ratio	Ca:Mg ratio	Water Soluble P	Water Soluble Ca	Water Soluble K	Water Soluble Na
70LBS Nitrogen, No Biologicals																	
March 24, 2011, #11-078-0053	8.4	2.0	20.8	3	4	4	3408	351	120	125	26	0.2	9.7	6	254	60	123
BI-CARB.P x 1.4, OR BASE SAT. (%)			13	X 1.4 =	18		81.8	14.1	1.5	2.6							
Dec. 7, 2012, #12-339-0650	8.2	2.0	20.6	2	3	9	3247	364	132	222	35	0.2	8.9	4	187	29	207
BI-CARB.P x 1.4, OR BASE SAT. (%)			11	X 1.4 =	15		79.0	14.7	1.6	4.7							
Change (%)	-2.4%	0.0%	-1.0%	-15.4%	-25.0%	125.0%	-4.7%	3.7%	10.0%	77.6%	34.6%	-11.4%	-8.1%	-33.3%	-26.4%	-51.7%	68.3%
BI-CARB.P OR BASE SAT'N Change (%)							-3.4%	4.3%	6.7%	80.8%							
70 LBS Nitrogen, With Biostimulant																	
March 24, 2011, #11-078-0053	8.4	2.0	20.8	3	4	4	3408	351	120	125	26	0.2	9.7	6	254	60	123
BI-CARB.P x 1.4, OR BASE SAT. (%)			13	X 1.4 =	18		81.8	14.1	1.5	2.6							
Dec. 7, 2012, #12-339-0650	8.3	2.0	20.0	1	7	5	3171	348	129	203	27	0.4	9.1	4	188	40	191
BI-CARB.P x 1.4, OR BASE SAT. (%)			13	X 1.4 =	18		79.4	14.5	1.7	4.4							
Change (%)	-1.2%	0.0%	-3.8%	0.0%	75.0%	25.0%	-7.0%	-0.9%	7.5%	62.4%	3.8%	75.0%	-6.2%	-33.3%	-26.0%	-33.3%	55.3%
BI-CARB.P OR BASE SAT'N Change (%)							-2.9%	2.8%	13.3%	69.2%							
90 LBS Nitrogen, No Biostimulant																	
March 24, 2011, #11-078-0053	8.4	2.0	20.8	3	4	4	3408	351	120	125	26	0.2	9.7	6	254	60	123
BI-CARB.P x 1.4, OR BASE SAT. (%)			13	X 1.4 =	18		81.8	14.1	1.5	2.6							
Dec. 7, 2012, #12-339-0650	8.1	2.0	21.3	2	4	13	3358	368	182	221	33	0.3	9.1	4	157	22	208
BI-CARB.P x 1.4, OR BASE SAT. (%)			11	X 1.4 =	15		78.9	14.4	2.2	4.5							
Change (%)	-3.6%	0.0%	2.4%	-15.4%	0.0%	225.0%	-1.5%	4.8%	51.7%	76.8%	26.9%	18.2%	-6.0%	-33.3%	-38.2%	-63.3%	69.1%
BI-CARB.P OR BASE SAT'N Change (%)							-3.5%	2.1%	46.7%	73.1%							
90 LBS Nitrogen, With Biostimulant																	
March 24, 2011, #11-078-0053	8.4	2.0	20.8	3	4	4	3408	351	120	125	26	0.2	9.7	6	254	60	123
BI-CARB.P x 1.4, OR BASE SAT. (%)			13	X 1.4 =	18		81.8	14.1	1.5	2.6							
Dec. 7, 2012, #12-339-0650	8.1	1.9	20.4	1	9	23	3249	343	157	196	26	0.4	9.5	4	246	31	186
BI-CARB.P x 1.4, OR BASE SAT. (%)			16	X 1.4 =	22		79.8	14.0	2.0	4.2							
Change (%)	-3.6%	-5.0%	-1.9%	23.1%	125.0%	475.0%	-4.7%	-2.3%	30.8%	56.8%	0.0%	82.8%	-2.4%	-33.3%	-3.1%	-48.3%	51.2%
BI-CARB.P OR BASE SAT'N Change (%)							-2.4%	-0.7%	33.3%	61.5%							

Winter Wheat Variety Performance Trial at Hayden, Colorado 2012

Calvin H. Pearson[1] and Scott Haley[2]

Summary

A winter wheat variety performance test was conducted at Hayden, Colorado in 2012 to identify varieties that are adapted for commercial production in northwest Colorado. Twenty-four varieties and breeding lines were evaluated in the 2012 trial. Growing conditions during the 2012 cropping season in Hayden were challenging for winter wheat production compared to many other years. Grain yield in the winter wheat variety performance trial averaged 2101 lbs/acre (35.0 bu/acre). The highest yielding variety was CO050322 at 2465 lbs/acre (41.1 bu/acre). Several winter wheat varieties were higher yielding than other varieties, with seven varieties in the top statistical (LSD) yield group. Protein concentration in 2012 averaged 10.5%. Protein concentration ranged from a high of 11.2% for UI SRG to a low of 9.8% for Hatcher and Golden Spike.

Introduction

Winter wheat variety performance testing has been conducted in northwest Colorado for many years (Pearson and Haley, 2010; Pearson et al., 2003; 2004; 2005; 2007; 2008; 2009; Golus et al., 1997). Winter wheat variety performance tests are conducted each year in northwest Colorado to identify varieties that are adapted for commercial production in the region. The 2012 winter wheat variety performance test was conducted at Hayden, Colorado.

Materials and Methods

Twenty-four winter wheat varieties and breeding lines were evaluated during the 2012 growing season at the Mike Williams Farm near Hayden just a short distance south of the intersection of Highway 40 and 20-mile Road. The experiment design was a randomized complete block with four replications. Plot size was 4-ft. wide by 40-ft. long with six seed rows per plot. The seeding rate was 680,000 seeds/acre and planting occurred on 29 Sept. 2011. An application of Ally at 1/10 oz/acre plus 4 oz/acre 2,4-D was applied in 8 gal. water per acre during end of May 2012. No fertilizer was applied. Plant height and lodging were evaluated just prior to harvest. Harvest occurred on 14 Aug. 2012 using a Hege small plot combine. Grain samples were cleaned in the laboratory using a small Clipper cleaner to remove plant tissue that remained in the grain sample following threshing. Grain moistures and test weights were determined using a DICKEY-john GAC2100b™ Grain Analysis Computer[3]. Grain yields were

Planting winter wheat plots at the Mike Williams Farm at Hayden, Colorado, September 29, 2011. Photo by Calvin H. Pearson.

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

Winter wheat plots at the Mike Williams Farm at Hayden, Colorado on January 9, 2012. Photo by Calvin H. Pearson.

calculated at 12% moisture content. Grain protein concentration was determined by whole grain near infrared reflectance spectroscopy with a Foss NIRSystems 6500 (reported on a 12% moisture basis).

Results and Discussion

The results of the soil test analysis for the 2012 plot area at Hayden were: a sandy clay loam soil with a pH 7.7, 0.5 mmhos/cm, 1.3 % organic matter, 22 ppm NO_3-N, 29.7 ppm P, 60 ppm K, 2.3 ppm Zn, 81.7 ppm Fe, 3.2 ppm Mn, and 1.6 ppm Cu.

Growing conditions during the 2012 cropping season in Hayden were challenging for winter wheat production. The average maximum temperature for June 2012 at Hayden, Colorado was 86.3EF (Fig. 1). Precipitation at Hayden during the 2011-12 winter/spring growing season (September 2011 through August 2012, 12-month period) totaled 6.20 inches (data for Sept 2011, Apr 2012, and July 2012 are missing). This is a very low amount of precipitation in spite of the missing data. Winter moisture in the Hayden area was low (Fig. 2). During September 2011 through February 2012, a total of 6.2 inches of precipitation was received (data were missing for Sept 2011), and from April through Aug 2012 (data were missing for Apr 2012 and July 2012) most of the growing season precipitation was received at Hayden at a total of 2.45 inches of precipitation. This is a very low amount of precipitation, keeping in mind the missing data for two months during this period. Precipitation during the 2012 summer growing season was low at Hayden and had a major impact on crop production in the area. (Fig. 2).

Precipitation in the Craig/Hayden area is often the major limiting factor for crop production. Precipitation varies considerably from month to month and year to year. If timely precipitation occurs, grain yields of winter wheat will be good. If precipitation does not occur in a timely fashion, wheat yields will be low. Because the amount of precipitation is so variable and spotty during the growing season in the Craig/Hayden area, wheat yields often vary considerably from year to year.

Grain moisture in the winter wheat variety performance test at Hayden averaged 10.3% (Table 1). Grain moisture content ranged from a high of 11.1% for Bryd to a low of 8.9 % for Fairview.

Grain yield for the winter wheat varieties averaged 2101 lbs/acre (35.0 bu/acre) (Table 1).

Winter wheat plots at maturity at the Mike Williams Farm at Hayden, Colorado, August 6, 2012. Photo by Calvin H. Pearson.

Grain yield ranged from a high of 2465 lbs/acre (41.1 bu/acre) for CO050322 to a low of 1620 lbs/acre (27.0 bu/acre) for Hayden. Several winter wheat varieties were higher yielding than others, with seven varieties having grain yields in the top group according to LSD (0.05) mean separation. According to the Colorado Agricultural Statistics Service, the average wheat yield in northwest Colorado in 2011 was 25.7 bu/acre (Colorado Department of Agriculture, 2012)

Test weights averaged 60.1 lbs/bu (Table 1). Test weights ranged from a high of 61.9 lbs/bu for Weston to a low of 57.9 lbs/bu for Golden Spike.

There was no lodging in the winter wheat variety performance test in 2012.

Plant height averaged 23.3 inches (Table 1).Plant height ranged from a high of 28.0 inches for Lucin CL to a low of 20.3 inches for CO07W245.

Protein concentration averaged 10.5% (Table 1). Protein concentration ranged from a high of 11.2% for UI SRG to a low of 9.8% for Hatcher and Golden Spike.

Acknowledgements

The farmer-cooperator for this trial was Mike Williams. We thank Mike for his willingness to participate with us in conducting this research. We also thank Western Colorado Research Center staff (Fred Judson) and Calvin Rock (summer research assistant) who assisted with this research. Appreciation is also extended to the Colorado Wheat Administrative Committee for funding this research.

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Table 1. Winter wheat variety performance test at Hayden, Colorado 2012. Farmer-Cooperator: Mike Williams.

Variety	Market class[1]	Grain moisture	Grain yield		Test weight	Plant height	Protein
		(%)	bu/acre	lbs/acre	lbs/bu	in.	(%)
CO050322	HRW	10.6	41.1	2465	59.8	22.0	9.9
Hatcher	HRW	10.7	41.0	2455	59.8	20.8	9.8
Deloris	HRW	10.2	40.1	2406	60.6	26.8	11.0
CO050337-2	HRW	10.7	38.5	2310	60.2	23.1	10.1
Golden Spike	HWW	10.0	38.0	2283	57.9	23.2	9.8
CO07W245	HWW-NEW	10.2	37.0	2216	60.0	20.3	10.1
Brawl CL Plus	HRW CL2	10.8	36.6	2193	61.2	22.4	10.9
CO05W111	HWW	10.8	35.9	2153	60.5	23.2	10.3
Byrd	HRW	11.1	35.4	2124	59.2	22.4	10.3
Snowmass	HWW	11.0	35.3	2119	58.2	23.3	10.2
UI LHS	HWW	10.0	35.0	2104	58.4	22.0	11.0
Lucin CL	HRW CL	9.8	34.7	2084	60.6	28.0	10.4
CO050233-2	HRW CL	10.4	34.6	2078	60.9	22.2	9.9
Curlew	HRW	9.9	34.6	2076	60.2	23.4	11.1
Gary	HWW	10.4	34.4	2063	59.5	23.4	10.4
Weston	HRW	10.5	33.6	2016	61.9	26.7	11.1
CO050303-2	HRW	10.0	33.4	2004	61.1	20.9	9.9
UI Darwin	HWW	10.8	33.1	1986	60.7	25.7	10.7
CO050173	HRW	10.7	32.8	1964	60.8	22.2	10.3
UI Silver	HWW	10.4	32.6	1957	60.8	22.1	10.6
Fairview	HRW	8.9	32.1	1926	59.5	24.5	10.5
UI SRG	HRW	10.0	31.9	1911	59.1	25.2	11.2
IDO816	HRW	9.4	31.9	1915	58.9	22.0	10.8
Hayden	HRW	9.8	27.0	1620	61.4	23.5	11.1
AVE.		10.3	35.0	2101	60.1	23.3	10.5
LSD (0.05)		0.8	5.0	302	0.6	2.2	
CV (%)		5.4	10.2	10.2	0.7	6.8	

[1] HRW = hard red winter wheat; HWW = hard white winter wheat; CL = Clearfield* wheat; CL2 = two-gene Clearfield* wheat.

Planted – September 29, 2011. Harvested – August 14, 2012.

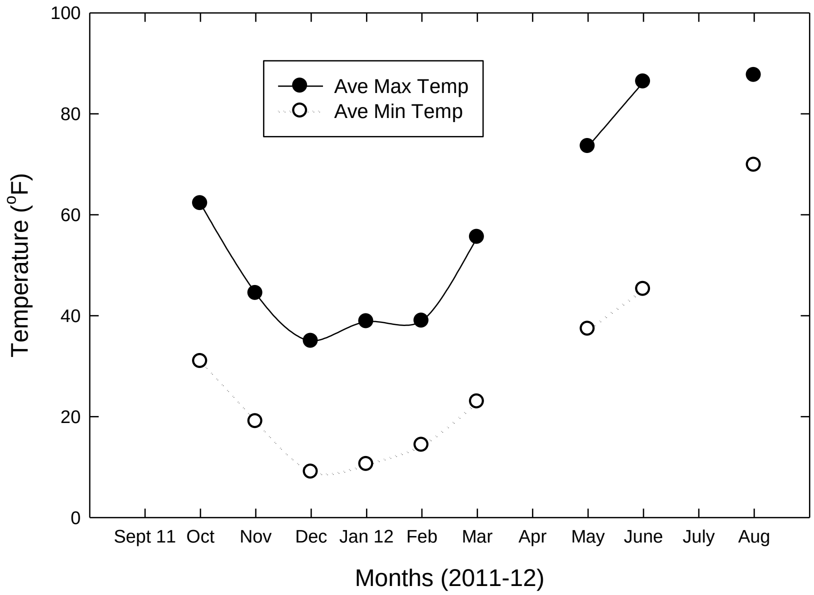

Fig. 1. Average maximum monthly and average minimum monthly temperatures for Sept 2011 through Aug 2012 at Hayden, Colorado. Data were missing for Sept 2011, Apr 2012, and July 2012.

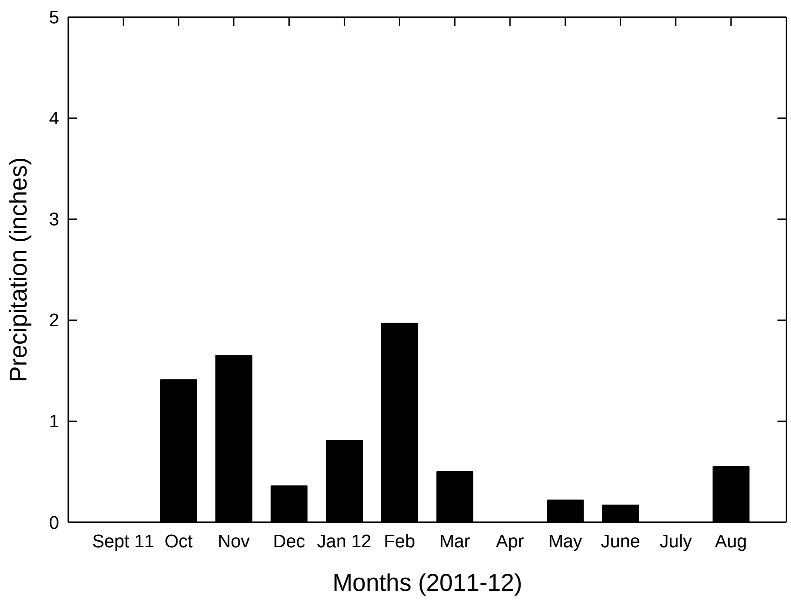

Fig. 2. Monthly precipitation for Sept. 2011 through Aug 2012 at Hayden, Colorado. Data were missing for Sept 2011, Apr 2012, and July 2012.

Roundup-Ready Soybean Variety Performance Trial and Number of Seed Rows on a Bed at Fruita, Colorado 2012

Calvin H. Pearson[1] and Fred M. Judson[2]

Summary

Commercial soybeans are being grown in the Grand Valley of western Colorado. Soybean production in the Grand Valley is quite possibly the farthest west in the country for commercial production of soybeans. New production technology is needed to support the production of soybeans in this unique, high desert environment. Numerous new Roundup-Ready soybean varieties have become available for production. The objectives of our 2012 research were to evaluate Roundup-Ready soybean varieties for seed yield and related agronomic characteristics and determine how these varieties perform when produced in single and twin-seed rows on 30-inch beds in the Grand Valley. Weed control in the soybean variety trial in 2012 was excellent. Weeds in the field and plot area were controlled with two Roundup (glyphosate) applications. Maturity ratings for the ten varieties ranged from early Group 2 to late Group 3. Average seed yield of the fifteen soybean varieties was 4435 lbs/acre (73.9 bu/acre). Seed yield ranged from a high of 4944 lbs/acre (82.5 bu/acre) for S39-U2 to a low of 1841 lbs/acre (30.8 bu/acre) for S20-Y2. Seed yield for the twin seed rows in 2011 was 221 lbs/acre (3.7 bu/acre) higher than the single seed row. Seed yield for the twin seed rows was not significantly different from the single row in 2012. In general, soybean varieties with late Group 2 and maturity Group 3 produced the highest seed yield in both years. Based on our research results in western Colorado over two years we cannot definitively promote twin-seed production of soybeans, but neither can the planting of twin seeds rows be discouraged. Planting twin seed rows of soybean on a 30-inch bed may be advantageous for commercial soybean producers in western Colorado particularly if moderate to low yield conditions are anticipated and high plant populations are desired. Planting twin seed rows may be viewed as insurance in promoting high yields year after year.

Introduction

Commercial soybeans are being grown in the Grand Valley of western Colorado. Soybean production in the Grand Valley is quite possibly the farthest west in the country for commercial production of soybeans. New production technology is needed to support the commercial production of soybeans in this unique, high desert environment. New soybean varieties continue to be available for commercial agriculture. Selecting the proper variety and production practices for local adaptation and performance is critical to the profitability of producing crops including soybean. Interest in growing soybeans hinges mainly on the production ease and the residual nitrogen soybeans provide to subsequent crops such as corn. Also, in many cases, growers can use the same equipment to grow soybeans that they already have at their farm. Furthermore, soybeans work well in rotation with other crops such as corn. Additionally, soybeans do not require high levels of costly production inputs as compared to other crops such as corn. Farm gate prices for soybeans have been quite attractive in recent years.

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Photo 1. Irrigating soybeans June 28, 2012 soybean variety/number of seed rows per bed trial at the Western Colorado Research Center at Fruita. Photo by Calvin H. Pearson.

Weed control can be a major challenge and can contribute significantly to seed yield variations. Commercial production of soybean using Roundup-Ready varieties offers producers with considerable crop management flexibility. Roundup-Ready soybean varieties can be planted on a more timely and flexible basis than conventional soybeans given that conventional soybean varieties require the use of preplant incorporated herbicides that have to be applied following detailed and precise procedures. Commercial production of Roundup-Ready soybean varieties allows for flexible timing of herbicide application and relative ease for control of weeds during the growing season. Furthermore, applying glyphosate can be accomplished more quickly and often with fewer concerns for weed control than operations involving cultivation used to obtain satisfactory weed control.

In 2004, a soybean trial was conducted at the Western Colorado Research Center at Fruita to evaluate new Roundup-Ready soybean varieties for their adaptation and performance under local conditions (Pearson, 2005). These Roundup-Ready soybean varieties evaluated in 2004 were found to perform in a similar manner to the conventional varieties evaluated in western Colorado years earlier.

Research conducted in western Colorado during the 1988-1989 showed that the multiple seed rows per bed increased yields (Pearson and Golus, 1988; Pearson et al., 1989). Bruns (2011) recently conducted research in Mississippi and he did not promote twin-row soybean production, but neither did he discourage planting twin seeds rows.

The objectives of our 2012 research were to evaluate Roundup-Ready soybean varieties for seed yield and related agronomic characteristics and determine how these varieties perform when produced in single and twin-seed rows on 30-inch beds in the Grand Valley of western Colorado.

Materials and Methods

Soybean Variety Performance Trial

A Roundup-Ready® soybean variety performance test was conducted at the Western Colorado Research Center at Fruita, Colorado during 2012. The experiment was a randomized complete block with four replicates. Fifteen varieties were included in the trial. Plot size was 5-feet wide by 25-feet long (2, 30-inch rows). The previous crop was dry bean.

Planting occurred on May 17, 2012 with a cone plot planter. Seeding rate was approximately 185,000 seeds/acre.

Photo 2. Field of soybeans in the variety/number of seed rows per bed trial at the Western Colorado Research Center at Fruita. .June 28, 2012. Photo by Calvin H. Pearson.

Glyphosate (Glystar) herbicide was applied at 2 qt/acre plus with 1 qt Bio 90 plus 1 gallon urea ammonium nitrate fertilizer in 100 gals of water at 30 psi at 22 gallons/acre on May 30, 2012. Another application of glyphosate (Glystar) herbicide was applied at 2 qt/acre plus 1 qt/acre of Activator 90 plus 1 gallon of urea ammonium nitrate fertilizer per 100 gallon of water at 40 psi at 27 gallon/acre on June 20, 2012.

Photo 3. Soybeans beginning to mature at the Western Colorado Research Center at Fruita. September 6, 2012. Photo by Calvin H. Pearson.

The experiment was furrow-irrigated using gated pipe. The plot area was irrigated eight times during the season, averaging 24 hours per irrigation set. Data were collected for seed yield, seed moisture, seed yield, test weight, plant population, days to maturity, plant height, height to first pod, test weight, seed shattering, lodging, and seeds/lb. Seed moisture and test weight were determined using a Seedburo GMA-128 seed analyzer. Seeds/lb was determined by hand-counting and weighing 200 seeds followed by calculating the number of seeds per pound. The variety performance trial was harvested on October 15 and October 19, 2012 using a Hege small plot combine.

Number of Seed Rows per Bed

In 2012 we planted a single seed row and twin-seed rows on 30-inch beds with 8 inches between the seed rows. The fifteen soybean varieties in the variety trial were planted on both single and twin-seed rows at the same population. A cone plot planter was used for planting both the single and twin seed rows. Plant depth was approximately 1 inch. Crop production practices and data collection were the same as the variety performance trial. The experiment was a split-block design with four replications.

Single row plots were harvested on Oct. 15, 2012 and twin row plots were harvested on October 19, 2012 using a Hege small plot combine.

Results and Discussion

Weed control across the entire plot area was excellent (Photos 1-4). Application of Roundup was convenient and provided flexibility in applying the herbicide and obtaining effective weed control. Weeds in the field and plot area were readily controlled with the two Roundup applications.

The cost of applying Roundup for commercial production of Roundup-Ready soybeans in western Colorado, based on rates, application costs, and adjuvants used in our study, ranges from \$20 to \$25 per acre per application.

The 2012 growing season in the Grand Valley was quite long at 174 days. The last spring killing frost occurred on April 16 (28ºF) and the first fall killing frost occurred on October 7 (28ºF). The average growing season for the Grand Valley is 181 days (28ºF). Adequate irrigation water was available during the growing season and was not a limiting factor for crop production.

Soybean Variety Performance Trial

Maturity ratings of the fifteen varieties ranged from early Group 2 to late Group 3 (Table 1). Six varieties were Maturity Group 2 and nine varieties were Maturity Group 3.

Average seed moisture content at harvest was 9.7% (Table 1). There were no significant differences among soybean varieties for seed moisture. In 2011, average seed moisture content of the ten varieties evaluated in a variety performance test was 9.6% (Pearson, 2012).

Soybean seed yields in 2012 in the variety performance trial were very excellent and were among the highest yields achieved in field research conducted in western Colorado over the past approximately 30 years. Average seed yield for the fifteen soybean varieties was 4435 lbs/acre (73.9 bu/acre) (Table 1). Seed yields ranged from a high of 4944 lbs/acre (82.5 bu/acre) for S39-U2 to a low of 1841 lbs/acre (30.8 bu/acre) for S20-Y2. Other high yielding soybean varieties in this study were S38-S4, S38-H8, S37-B1, S36-B6, S34-N3, and S31-L7.

Photo 4. Soybeans at harvest maturity at the Western Colorado Research Center at Fruita. October 11, 2012. Photo by Calvin H. Pearson.

In 2011, average seed yield for the ten soybean varieties was 2702 lbs/acre (45.0 bu/acre). Seed yields ranged from a high of 3098 lbs/acre (51.6 bu/acre) for S31-L7 to a low of 1846 lbs/acre (30.9 bu/acre) for S20-Y2. The 2011 and 2012 yields for S20-Y2 were similar. Other high yielding soybean varieties in 2011 were S34-N3, S28-K1, S28-B4, and S30-F5.

Test weight in 2012 averaged 56.2 lbs/bu and ranged from a high of 57.3 lbs/bu for S38-S4 to a low of 55.1 lbs/bu for S20-Y2 and S23-P8 (Table 1). There were significant differences among the fifteen soybean varieties for test weights. Test weights in 2012 were comparable to those obtained in most other years. Test weight in 2011 averaged 57.6 lbs/bu and ranged from a high of 58.5 lbs/bu for S31-L7 and S34-N3 to a low of 56.6 lbs/bu for S20-Y2 (Pearson, 2012). In 2004, test weights averaged 56.6 lbs/bu (Pearson, 2005). In 1986, test weights averaged 58.3 lbs/bu (Pearson et al., 1987), 57.8 lbs/bu in 1987 (Pearson and Golus, 1988), 57.2 lbs/bu in 1988 (Pearson et al., 1989), and 56.3 lbs/bu in 1989 (Pearson et al., 1990).

Average plant population in 2012 in the soybean variety performance study was 170,223 plants/acre (Table 1). S23-P8 soybean variety had the highest plant population at 205,095 plants/acre and S37-B1 had the lowest plant population at 135,762 plants/acre. The most plausible explanation for differences in plant populations among varieties are due to seed quality but there are likely other factors that affect plant populations in the field such as planting depth and disease, although no diseases were observed in the trial.

Average plant population in 2011 in the soybean variety performance study was 120,153 plants/acre (Pearson, 2012). Plant populations in 2011 could have been a limiting factor for obtaining higher seed yields, although we also had a shorter growing season than normal compared to 2012. Based on previous research in western Colorado, grain yields increased as plant populations increased up to 170,000 plants/acre (Pearson et al., 1989). Thus, plant populations in 2012 were not likely a limiting factor for seed yields, given the plant populations and the high seed yields obtained in 2012, although we had a longer growing season in western Colorado than in 2011.

The average number of days for the soybean varieties to reach maturity in 2012 was 139 (Table 2). Soybean variety S20-Y2 matured earlier than other varieties at 132 days and several soybean varieties matured at 143 days mostly because a killing frost occurred on October 7, 2012.

The average number of days for the soybean varieties to reach maturity in 2011 was 104 (Pearson, 2012). Soybean variety S20-Y2 also matured earlier than other varieties at 99 days compared to 132 days in 2012.

Plant height in 2012 averaged 3.8 feet (44 inches) and the tallest variety was S36-B6 at 4.2 feet (50.0 inches) (Table 2). The shortest variety was S25-R3 at 3.3 feet (39 inches).

Plant height in 2011 averaged 29.3 inches and the tallest variety was S30-F5 at 37.0 inches. The shortest variety in 2011 was S22-C5 at 22.4 inches (Pearson, 2012).

In 2004, the average plant height of 23 soybean varieties was 47.0 inches. The range in plant height in 2004 was from 37.6 to 54.7 inches (Pearson, 2005).

In 1987, the average plant height of 15 soybean varieties was 37.7 inches. The range in plant height in 1987 was from 29.4 to 49.0 inches (Pearson and Golus, 1988). In 1988, average plant height of 21 soybean varieties was 37.0 inches. The range in plant height in 1988 was from 24.1 to 46.1 inches (Pearson et al., 1989).

Height to first pod is an important harvest factor. Pods that are produced close to the soil surface are difficult for the combine to harvest and thus, yield losses can occur. Harvest efficiency is increased when the first pod is set higher up the plant.

Average height from the soil surface to the first pod in 2012 was 7.7 inches (Table 2). Soybean varieties with the greatest height to the first pod were S36-B6 at 9.4 inches, S38-H8 at 9.2 inches, S38-S4 at 9.1 inches, S39-U2 at 8.6 inches, S24-K2 at 8.4 inches, S28-U7 at 8.4 inches, and S37-B1 at 8.1 inches. Soybean varieties with the lowest height to the first pod were S0-Y2 at 5.4 inches, S23-P8 at 5.5 inches, and S25-R3 at 6.7 inches.

Average height from the soil surface to the first pod in 2011 was 4.5 inches (Pearson, 2012). Soybean varieties with the greatest height to the first pod were S31-L7 at 5.6 inches, S28-K1 at 5.3 inches, S34-N3 at 5.1 inches and S30-F5 at 5.0 inches. Soybean varieties with the lowest height to the first pod were S22-C5 at 3.2 inches, and S21-E4 at 3.8 inches.

Photo 5. Soybeans produced during the 2012 growing season had a larger seed size compared to many other years. Photo by Calvin H. Pearson.

Average height from the soil surface to the first pod in the 2004 trial was much higher than that in the 2011 trial (Pearson, 2005) and somewhat higher than in 2012. The average height to the first pod in 2004 was 9.1 inches and heights ranged from a high of 11.8 inches to a low of 6.8 inches.

In 1987, the average height to the first pod of 15 soybean varieties was 5.7 inches. The range in height to first pod was from 2.9 to 7.4 inches (Pearson and Golus, 1988). In 1988, average height to the first pod of 21 soybean varieties was 3.9 inches. The range in height to the first pod was from 2.6 to 5.3 inches (Pearson et al., 1989).

The desired height to the first pod should be at least 6 inches so the combine head will be able to cut low enough without leaving pods still attached to the stem and still be high enough that soil does not get into the head and combine. Thus, many of the varieties evaluated in 2012 had pod heights that were acceptable for efficient harvesting.

Seed shattering for the fifteen varieties in 2012 averaged 1.3 (Table 2). The early-maturing variety S20-Y2 had the highest shattering rating at 4.5 while twelve of the fifteen varieties had no shattering (shattering score of 1.0).

Seed shattering for the ten varieties in 2011 averaged 1.5 (Pearson, 2012). As in 2012, S20-Y2 had the highest shattering rating at 3.8 while six of the ten varieties had shattering scores less than 1.5.

Seed shattering for the twenty-three varieties in 2004 averaged 1.2 (Pearson, 2005). In 1987, seed shattering averaged 0.5 (Pearson and Golus, 1988), 0.7 in 1988 (Pearson et al., 1989), and 0.3 in 1989 (Pearson et al., 1990).

Lodging in 2012 averaged 2.2 and ranged from 2.8 for S24-K2 and S36-M8 to a low of 1.4 for S20-Y2 (Table 2). There were significant differences among the fifteen soybean varieties for lodging.

Average seed size for the fifteen soybean varieties in 2012 was 2261 seeds/lb (Table 2; Photo 5-6). S23-P8 had the largest seed size at 1960 seeds/lb and S31-L7 had the smallest seed size at 2620 seeds/lb. There were significant differences among the soybean varieties for seed size. In 2004, average seed size for the twenty-three soybean varieties was 2683 seeds/lb (Pearson, 2005). In 1986, seeds/lb averaged 2560 (Pearson et al., 1987), 2550 in 1987 (Pearson and Golus, 1988), 3059 in 1988 (Pearson et al., 1989), and 2366 in 1989 (Pearson et al., 1990).

<u>Number of Seed Rows per Bed</u>

Seed moisture content for the single seed row treatment was 2.4 percentage points higher than the twin seed row treatment (Table 1). Because of equipment breakdowns and scheduling the twin seed row plots were harvested four days later than the single row soybeans. The delay in harvest of the twin row soybeans likely resulted in lower moisture contents than soybean grown in single rows.

In 2011, seed moisture content for the twin seed rows was slightly higher than the single seed row (Pearson, 2012). The difference in seed moisture between the twin and single seed row was only 0.2 percentage points.

Photo 6. Soybeans grown during the 2012 at the Research Center had high quality seed. Photo by Calvin Pearson.

Seed yields between the single and twin seed row soybeans were similar in 2012 (Table 1). In 2011, seed yield for the twin seed rows was 221 lbs/acre (3.7 bu/acre) higher than the single seed row. The represents an 8.5% increase in yield when twin seed rows were planted compared to a single seed row in a 30-inch bed.

Test weight of the twin seed rows in 2012 was slightly higher (2%) than in the single seed row treatment (Table 1). In 2011, seed rows per bed did not affect test weight of soybean (Pearson, 2012).

Plant population of twin seed rows per bed was 13% higher than the single seed row per bed (Table 1). This finding was similar to the response in 2011. Plant population of twin seed rows per bed in 2011 was 25% higher than the single seed row per bed (Pearson, 2012). The reason for the higher plant population on the twin seed rows compared to the single seed row may be due to improved germination because twin rows were closer to the furrow and soybeans seeds may have imbibed water more readily.

In 2012, the number of seed rows did not affect days to maturity, plant height, seed size, shattering, and lodging (Table 2). However, soybean plants grown in twin seed rows set their first pod 1.0 inch higher on the plant than soybeans planted on a single seed row. In 2011, soybean plants grown in twin seed rows set their first pod 0.6 inch higher on the plant than soybeans planted on a single seed row (Pearson, 2012).

In 2011, soybeans planted in a single seed row matured one day earlier than soybean grown on twin seed rows (Pearson, 2012). Soybean plants grown in twin seed rows in 2011 were 2 inches taller than soybeans grown on a single seed row.

Shattering was 14% higher when soybean was grown in a single seed row compared to a twin seed row in 2011 (Pearson, 2012). Seed size was not affected by the number of seed rows on a 30-inch bed (Pearson, 2012).

Summary

Roundup-Ready soybean varieties provide producers with a convenient, cost-effective, and a highly effective weed control management tool that results in weed-free fields and promotes soybean productivity. In general, soybean varieties with late maturity Group 2 and maturity Group 3 produced the highest seed yields.

Compared to a single seed row on a 30-inch bed, planting twin seed rows increased plant population, seed yield, seed moisture at harvest, matured slightly later, was taller, set the first pod higher up on the bottom of the plant, and reduced shattering. Based on our research results in western Colorado we draw a similar conclusion to Bruns (2011) from research in Mississippi– twin-row soybean production cannot be definitively promoted, but neither can the planting of twin seeds rows be discouraged. Planting twin seed rows of soybean on a 30-inch bed may be advantageous for commercial soybean producers in western Colorado particularly if moderate to low yield conditions are anticipated and high plant populations are desired. Planting twin seed rows may be considered as insurance to promote high yields year after year.

Acknowledgments

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Table 1. Soybean variety performance trial and number of seed rows on a 30-inch bed. Fruita, CO 2012.

Variety	Maturity group	Moisture (%)	Seed yield (lbs/acre)	Test weight (lbs/bu)	Plant population (plants/acre)	Seed yield (bu/acre)
S20-Y2	2.0	9.0	1841	55.1	177,144	30.8
S23-P8	2.3	10.0	4506	55.1	205,095	75.0
S24-K2	2.4	10.2	4514	56.3	174,966	75.1
S25-R3	2.5	9.5	4039	55.8	148,830	67.2
S28-K1	2.8	9.9	4604	56.6	192,390	76.9
S28-U7	2.8	10.0	4617	55.4	149,556	76.9
S30-E9	3.0	9.7	4597	56.7	181,863	76.6
S31-L7	3.1	9.2	4644	56.6	181,863	77.4
S34-N3	3.4	10.0	4649	56.3	147,015	77.5
S36-B6	3.6	9.2	4903	56.8	147,378	81.6
S36-M8	3.6	10.4	4315	56.3	169,884	71.9
S37-B1	3.7	9.5	4666	56.0	135,762	77.8
S38-H8	3.8	9.5	4761	56.9	192,390	79.2
S38-S4	3.8	10.0	4923	57.3	171,336	82.1
S39-U2	3.9	9.6	4944	56.7	177,870	82.5
Ave		9.7	4435	56.2	170,223	73.9
CV (%)		15.2	7.6	1.1	16.5	7.6
LSD (0.05)		NS	332	0.6	27,864	5.6
Seed rows per bed						
Single		10.9	4353	55.8	159,817	72.6
Twin		8.5	4517	56.7	180,629	75.2
LSD (0.05)		***	NS	***	***	NS

.***, statistically significant at the 0.001 level of probability.

Table 2. Soybean variety performance trial and number of seed rows on a 30-inch bed. Fruita, CO 2012.

Variety	Days to Maturity (no.)	Plant height (ft.)	Height to first pod (in.)	Seeds/lb (no.)	Shattering (1-5)[1]	Lodging (1-5)[2]
S20-Y2	132	3.5	5.4	2189	4.5	1.4
S23-P8	139	3.6	5.5	1960	1.0	2.0
S24-K2	139	3.6	8.4	2421	1.0	2.8
S25-R3	134	3.3	6.7	2411	2.2	1.9
S28-K1	136	3.9	7.5	2053	1.0	2.1
S28-U7	137	3.6	8.4	2162	1.0	2.4
S30-E9	143	3.7	7.3	2237	1.0	2.2
S31-L7	136	3.9	7.8	2620	1.0	2.6
S34-N3	135	3.9	7.0	2204	1.0	1.9
S36-B6	143	4.2	9.4	2243	1.0	2.3
S36-M8	143	3.7	7.5	2162	1.0	2.8
S37-B1	143	3.7	8.1	2187	1.0	2.0
S38-H8	143	4.0	9.2	2396	1.0	2.1
S38-S4	143	3.9	9.1	2245	1.1	2.2
S39-U2	143	4.1	8.6	2421	1.0	2.4
Ave.	139	3.8	7.7	2261	1.3	2.2
CV (%)	1.4	5.2	18.4	2.1	8.1	16.4
LSD (0.05)	1.9	0.2	1.4	48	0.1	0.4
Seed rows per bed						
Single	139	3.8	7.2	2258	1.3	2.2
Twin	140	3.8	8.2	2263	1.3	2.2
LSD (0.05)	NS	NS	**	NS	NS	NS

[1]Shattering scale (1 = no shattering, 5 = totally shattered).

[2]Lodging scale (1 = no lodging, 5 = completely lodged).

**, statistically significant at the 0.01 level of probability.

Research Project/Publications - 2012

Dr. Horst W. Caspari

2012 Research Projects*

Viticulture and enology programs for the Colorado wine industry (Colorado Wine Industry Development Board; S. Menke & R. Pokharel, CSU)*

Coordinated wine grape variety evaluations in the western US (Colorado Association for Viticulture and Enology)

*Sponsors/Cooperators are noted in parentheses.

2012 Publications

Refereed Publication

Einhorn, T.C., H.W. **Caspari**, and S. Green. 2012. Total soil water content accounts for augmented ABA leaf concentration and stomatal regulation of split-rooted apple trees during heterogeneous soil drying. J. Exp. Bot. 63(14):5365-5376.

Non-Refereed WEB Publications:

Caspari, H. 2012. 2011 Grower Survey. www.colostate.edu/programs/wcrc/pubs/viticulture/Survey2011.pdf

Caspari, H. 2012. Performance of cool-climate grape varieties in Delta County. www.colostate.edu/programs/wcrc/pubs/viticulture/Grape variety evaluation at Rogers Mesa.pdf

Caspari, H. and A. Montano. 2012. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Rogers Mesa near Hotchkiss, Colorado, 2011/12. www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardinessrm11.pdf

Caspari, H. and A. Montano. 2011. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Orchard Mesa near Grand Junction, Colorado, 2011/12. www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardiness11.pdf

Caspari, H. and A. Montano. 2011. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Rogers Mesa near Hotchkiss, Colorado, 2012/13. www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardinessrm12.pdf

Caspari, H. and A. Montano. 2011. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Orchard Mesa near Grand Junction, Colorado, 2012/13. www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardiness12.pdf

Caspari, H. and A. Montano 2012. Alternative training to maintain and improve yield. www.colostate.edu/programs/wcrc/pubs/viticulture/Quadrilateral VSP.pdf

Dr. Stephen D. Menke

2011-12 Technical Publications

"Joint Colorado and Nebraska Wine Quality Assurance Study Wine Sensory Evaluation Using

Quantitative and Hedonistic Panels and a Composite Score", Western Colorado Research Center annual Report, TR 12-15, 2012, ed. S. Menke and F. Johnson

"Wine Aroma Profiling of Five Colorado-grown Cultivars

Comparisons of Cultivar Profiles for Wine Volatile Aromas by GC/MS Direct Injection", *Western Phytoworks*, Spring 2012, ed. S. Menke

2012 Research Projects

Development of industry-shared internship program for Ram's Point Winery, an educational commercial Winery, housed at WCRC-OM (L. Sommers, F. Johnson, D. Iovanni/C. Beyrouty/S. Wallner /WCRC/College of Agricultural Sciences/Department of Horticulture and Landscape Architecture, Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology)

2012 Continuing Research Projects

Production of varietal and blended experimental wines from WCRC grapes (H. Caspari/Western Colorado Research Center, Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture

Establishment of baseline aroma profiles for several Colorado varietal wines by GC/MS analysis (H. Caspari, J. Weinke/ Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

Comparison of scoring for two types of wine quality assurance panels with a derived composite score of both panels, a joint quality assurance evaluation of Colorado and Nebraska wines (J. Reiling and P. Read/University of Nebraska-Lincoln, Colorado Wine Industry Development Board, Nebraska Grape and Winery Board, Nebraska Winery and Grape Growers Association, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

Development of Joint Colorado/Nebraska Wine Quality Training and Assessment Program (D. Caskey/ H. Caspari, Colorado Wine Industry Development Board/WCRC, Colorado Association of Viticulture and Enology, Nebraska Grape and Winery Board, Nebraska Winery and Grape Growers Association, CSU Department of Horticulture and Landscape Architecture)

Establishment of crop load aroma profiles for Colorado Cabernet sauvignon wines by GC/MS analysis (H. Caspari, J. Weinke/ Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

*Cooperators/collaborators/sponsors are noted in parentheses

Dr. Calvin H. Pearson

2012 Research Projects*

Winter wheat cultivar performance test – Hayden (Mike Williams, Dr. Scott Haley, and the Colorado Wheat Administrative Committee)
Application of FoliarBlend by Agri-Gro in alfalfa on alfalfa yield and hay quality – Fruita (Bio-Tec Solutions)
Evaluation of seed treatments in alfalfa – Fruita (Becker Underwood)
Alfalfa variety performance test (2011-2014) – Fruita (seed companies, breeding companies, private industry)
Application of bio-stimulant and harvest energy products in pasture grass and winter wheat as a sustainable nutrient input – Fruita (Enviro Consultant Service, LLC)
Evaluation of alfalfa genetic material 2009-2011 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of RR alfalfa genetic material 2011-2013 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of perennial plant species and production input for sustainable biomass and bioenergy production in Western Colorado – (Fruita, Rifle, and Meeker)
Evaluation of basin wildrye and basin x creeping wildrye hybrids as a biomass resource – Fruita (Dr. Steven Larson and Dr. Kevin Jensen, USDA-ARS Logan, UT)
Evaluation of corn hybrid breeding material for grain and silage – Fruita (DOW AgroSciences)
Roundup-Ready soybean variety performance trial – Fruita (Syngenta)
Evaluation of Optunia cactus for potential source of biomass for biofuel – Fruita
Performance of sub-surface drip irrigation in alfalfa for improved irrigation efficiency and environmental enhancement – Fruita (Colorado Water Conservation Board)

2013 Research Projects* (Continuing, New, or Planned)

Winter wheat cultivar performance test – Hayden (Mike Williams, Dr. Scott Haley, and the Colorado Wheat Administrative Committee)
Alfalfa variety performance test (2012-2014) – Fruita (seed companies, breeding companies, private industry)
Evaluation of alfalfa genetic material 2011-2013 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of RR alfalfa genetic material 2012-2014 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of seed treatments in alfalfa – Fruita (Becker Underwood)
Application of FoliarBlend by Agri-Gro in alfalfa on alfalfa yield and hay quality – Fruita (Bio-Tec Solutions)
Evaluation of perennial plant species and production input for sustainable biomass and bioenergy production in Western Colorado – (Fruita, Rifle, and Carbondale)
Evaluation of basin wildrye and basin x creeping wildrye hybrids as a biomass resource – Fruita (Dr. Steven Larson and Dr. Kevin Jensen, USDA-ARS, Logan, UT)
Evaluation of corn hybrid breeding material for grain and silage – Fruita (DOW AgroSciences)
Evaluation of canola varieties – Fruita (Dr. Mike Stamm, Kansas State University)
Evaluation of Optunia cactus for potential source of biomass for biofuel – Fruita
Performance of sub-surface drip irrigation in alfalfa for improved irrigation efficiency and environmental enhancement – Fruita (Colorado Water Conservation Board)
Turf grass seed production trial – Fruita
Water banking in alfalfa – Fruita (Dr. Joe Brummer)

*Cooperators/collaborators/sponsors are noted in parentheses.

2012 Publications

Pearson, Calvin H., J. Barry Ogg, Mark A., Brick and Abdel Berrada. 2012. Popping and yield characteristics of nuna bean lines developed for temperature climates. Agron. J. 104:1574-1578.

Reich, D. and C. Pearson. 2012. Irrigation Outreach in Afghanistan: Exposure to Afghan Water Security Challenges. Journal of Contemporary Water Research and Education 149:33-40.

Pearson, C.H., K. Cornish, and D.J. Rath. 2013. Extraction of natural rubber and resin from guayule using an accelerated solvent extractor. Ind. Crop Prod. 41:506-510.

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Pearson, Calvin. 2012. Intermountain grass and legume forage production manual recently published. *In*: Western PhytoWorks (Stephen D. Menke, ed.). Spring 2012. Newsletter of the Western Colorado Research Center, Agricultural Experiment Station, Colorado State University.