Western Colorado Research Center Research Report 1999

Agricultural Experiment Station
Technical Report
TR00-4

Colorado State University

Knowledge to Go Places

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Western Colorado Research Center 1999 Research Report

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WESTERN COLORADO RESEARCH CENTER

1999 ANNUAL REPORT

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EQUIPMENT TRAFFIC DURING ALFALFA HARVEST CAN AFFECT YIELD AND QUALITY.

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Summary

Cultural practices used to harvest alfalfa often subject large portions of the field to tractor and equipment traffic. This traffic occurs from field operations from swathing to bale removal. Understanding the extent these practices affect plant growth patterns will aid in quantifying their impact and may be useful in mitigating damage they cause. The objective of this study was to determine the effect of harvest traffic on alfalfa yield and plant quality. The experiment consisted of four treatments with various amounts of traffic, ranging from 0 to 89%, applied seven days after swathing. This is the third year of a four-year experiment. There was no significant difference in yield among treatments during the first two years of production. Plots with 89% trafficked area had a significant reduction in yield the third and fourth cuttings in the third year of production. Quality, as measured by relative feed value, was significantly higher in third and fourth cuttings of every year in trafficked plants. This has consequences in breeding programs where quality variables are being compared between small untrafficked research plots and a growers operation. Increased quality in the trafficked lanes in the latter harvests of all three years may have little impact on the quality determination for an entire field. Under the conditions of this experiment, traffic was not shown to significantly reduce yield until the later cuttings in the third year of production. Long-term yields may be affected when relatively large portions of the field are subjected to harvest traffic. To achieve optimal yields growers should implement procedures that minimize the area of the field subjected to traffic.

Introduction

Management strategies used to optimize yield in alfalfa usually are concerned with variety selection, insect and weed control, and harvest schedules (Hanson et al., 1987). There is little scientific information on how harvest traffic may influence yield. This aspect on alfalfa production needs some definitive answers as to the impact of harvest traffic given the weight of the machinery used, the percentage of the field impacted, and the timing of the different operations during harvest.

In southern California a major research project was conducted to quantify how tractor traffic applied to alfalfa during harvest affected soil parameters and alfalfa regrowth. This alfalfa production system used a semi-dormant variety and averaged 7 cuttings a year. These experiments studied the impact of tractor traffic on soil bulk density and water infiltration rates (Meek et al., 1988, 1989) fine root growth patterns, water use efficiency, and over all yield (Rechel et al., 1990, 1991a,b). Data on the development of leaf area and changes in leaf/stem ratios (Rechel, 1996) suggested traffic may also alter alfalfa quality.

To better understand how tractor traffic affects alfalfa growth, data are needed from a range of climates and agricultural systems. Alfalfa production in western Colorado provides a production system that can be compared to the California study. The major differences are the use of dormant varieties averaging 3.5 cuttings a year. This is the third year of a four year experiment. The objectives of this study were to 1) quantify long term yield and compare it to the studies conducted in California, and 2) determine if harvest traffic affects alfalfa quality.

Methods and Materials

Alfalfa, variety WL 323, was planted August 1996 at the Colorado State University Fruita Research Station at 18 pounds per acre. The experiment will be terminated in the fall of 2000. The soil is a Youngston clay loam. The elevation is 4510 feet, with an average rainfall of 8.4 inches per year. The field consists of rows on 30 inch centers with furrows approximately 4 inches deep and 6 inches wide. Each plot is 12 feet wide (4 rows) and 20 feet long.

Alfalfa is subjected to 4 different levels of tractor traffic with 4 replications. At each harvest all plots receive traffic from the swather. During the next 3 to 5 days the harvested alfalfa was removed by hand from all plots. Seven days after swathing traffic treatments were applied with a John Deere 2955 as follows:

Treatment 1 - No additional traffic applied.
Treatment 2 - One pass of the tractor over each plot with the right wheel centered over the same row as the right wheel of the swather. This represents 22% of the plot being trafficked.
Treatment 3 - All four rows in each plot were trafficked from single passes of the tractor. This represents 44% of the plot being trafficked.
Treatment 4 - All four rows and furrows were trafficked representing 89% of the plot being trafficked.

The above traffic created lanes of alfalfa in each plot subjected to different degrees of traffic. Four of these patterns were selected for further measurement and were defined as (a) NT, rows never receiving traffic, (b) S, the row receiving only swather traffic, (c) TR, rows receiving traffic seven days after swathing, and (d) STR, rows receiving traffic from the swather and traffic seven days after swathing. Forage yield and relative feed value (RFV) were determined in these four treatments by harvesting a randomly selected 2.8 ft^2 area in each plot. Forage yield across the entire plot was also determined.

The experimental design for the whole plot yields was a Latin square. Data for trafficked and RFV were analyzed as a randomized complete block.

Results and Discussion

In the California studies, yield was a result of an interaction between the amount of traffic, year of production, when the harvest occurred within a year (Rechel et al., 1990). When the traffic was applied in a manner to simulate grower conditions there was no significant reduction in yield the first year (Rechel et al., 1991). In contrast, the treatment where 100% of the plot was trafficked after each harvest there was a significant reduction in yield the first year of production.

Our study showed no significant decrease in total yield the first two years of production among traffic treatments (Fig. 1). In the third year only the treatment where 89% of the plot was trafficked was there a significant reduction in yield and this was evident only in the third and fourth cuttings.

Harvest traffic effects on alfalfa production may not become evident during the first several cuttings or even during the first year of production. In the California studies it was not until the third cutting in the second year that grower-simulated traffic reduced yield. In our study it was not until the latter cuttings in the third year, when 89% of the field was trafficked, that yield was significantly reduced.

Yield from the small plot samples, taken in the different trafficked lanes, also showed no significant difference until the third and fourth harvests in the third year of production (Table 1). At this time the repeated traffic at the time of swathing and seven days later caused a decrease in yield. The results from the small plot yields follow the trend of the whole plot yields i.e., traffic did not significantly affect yield until the third year of production.

In contrast to the yield data significant difference in RFV were observed in all three years during the third and fourth harvests (Table 1). It was the trafficked STR lane of the plots that had significantly higher quality than the non-trafficked NT and S lanes of the field (Table 1). The increased RFV can usually be attributed to some form of plant stress (Buxton and Fales, 1994) which in our experiment was tractor traffic.

Temperature, water deficit, soil nutrient concentration, and insect pests can all cause plant stress and subsequently effect forage quality (Buxton and Fales, 1994). They review the numerous environmental factors responsible for higher quality and comment that a change in leaf/stem ratio may have the greatest influence. In the recent book Forage Quality, Evaluation, and Utilization (Fahey 1994) there was no mention however, of tractor traffic affecting quality.

It must be remembered the increased RFV was only determined in specific trafficked lanes within a specific traffic treatment. Growers take several random samples from each lot which are then combined for quality determination. Under their commercial production system growers may not detect differences similar to our findings. There may, however, be increased variability in quality measurements from third and fourth cuttings. This suggests more samples maybe required from these cuttings to accurately ascertain quality.

This experiment examined only one variable; the portion of the field trafficked after each cutting by a specific tractor. However, to thoroughly define the response of alfalfa to harvest traffic, several additional variables should be quantified. These include the number of days after swathing the traffic is applied, the weight of the equipment, and the number of times the alfalfa is subjected to traffic at each harvest. The results presented here suggest all these may have a significant negative impact on alfalfa growth. To achieve long-term optimal yields a grower should consider modifying the harvesting procedure to reduce the number of passes over the field at each harvest and remove the hay as expediently as possible after swathing.

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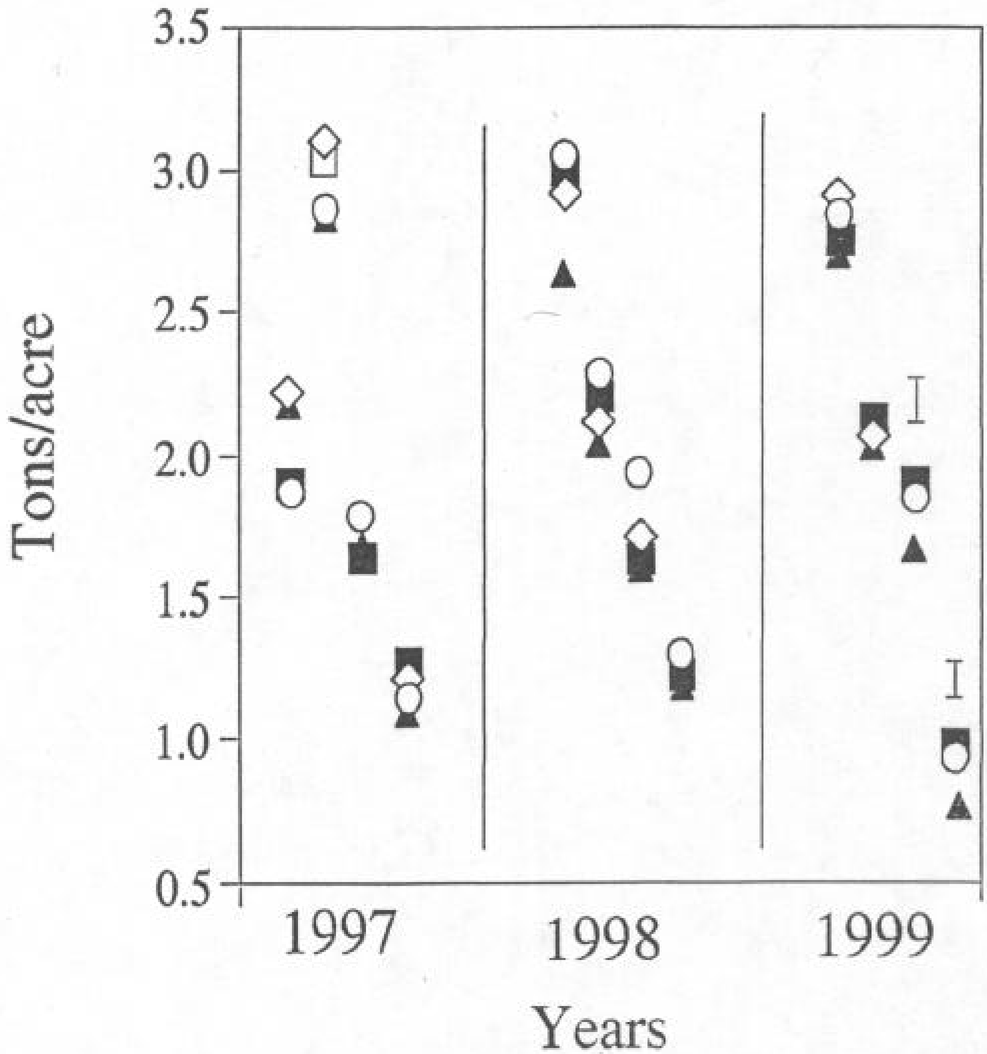

Figure 1. Alfalfa yield at each harvest as affected by no traffic after swathing (■), 22% of the plot trafficked (◇), 44% of the plot trafficked (○), and 89% of the plot trafficked (▲) 7 days after swathing. Vertical bars represent LSD at the 0.05 probability level.

Table 1. Yields from 2.8 ft.^{2} quadrates and relative feed value for each cutting in the different traffic lanes for three years of alfalfa production.

	1997	Small plots yield lbs /yd^2	Relative Feed Value
May 27	Swather	1.13	157.2
	Non-Traffic	1.17	159.2
	Swather + Traffic	1.03	159.8
	Traffic	1.00	159.0
July 3	Swather	0.79	151.6
	Non-Traffic	0.92	148.7
	Swather + Traffic	0.75	154.1
	Traffic	0.71	151.7
August 15	Swather	0.53	143.2a*
	Non-Traffic	0.55	144.0a
	Swather + Traffic	0.44	156.0b
	Traffic	0.50	151.3ab
October 1	Swather	0.40	179.3a
	Non-Traffic	0.42	172.0a
	Swather+ Traffic	0.32	190.0b
	Traffic	0.37	189.1b
	1998		
May 27	Swather	1.10	153.1
	Non-Traffic	1.05	148.2
	Swather + Traffic	0.87	157.4
	Traffic	0.93	155.4
July 8	Swather	0.84	136.8
	Non-Traffic	0.88	132.1
	Swather + Traffic	0.78	141.5
	Traffic	0.83	140.9
August 18	Swather	0.52	141.7ab
	Non-Traffic	0.49	138.3a
	Swather + Traffic	0.38	149.1c
	Traffic	0.40	144.6bc
October 8	Swather	0.48	188.1ab
	Non-Traffic	0.43	184.9a
	Swather + Traffic	0.36	193.9b
	Traffic	0.41	194.2b
	1999		
May 28	Swather	1.02	172.6ab
	Non-Traffic	1.02	168.6a
	Swather + Traffic	0.86	181.5b
	Traffic	0.89	178.5b
July 7	Swather	0.80	140.6
	Non-Traffic	0.97	141.7
	Swather + Traffic	0.80	137.2
	Traffic	0.93	138.1
August 19	Swather	0.83a	142.4a
	Non-Traffic	0.83a	146.0a
	Swather + Traffic	0.52b	165.2b
	Traffic	0.69ab	160.1b
October 19	Swather	0.34b	222.9b
	Non-Traffic	0.45a	209.6a
	Swather + Traffic	0.27c	234.6c
	Traffic	0.34b	231.5bc

* Values within a column, within a year, within a cutting, followed by the same letter are not significantly different by LSD ($P \leq 0.05$).

NATIVE POLLINATORS OF ALFALFA GROWN FOR SEED IN WESTERN COLORADO

Robert Hammon, Entomologist

Summary

Native bees were sampled in the seed alfalfa producing areas of Mesa and Delta Counties to determine if any were plentiful enough to provide sufficient pollination for economic seed yield. Alkali bees were found commonly in the area around Fruita, and also in the region west of Delta. Native bees appeared to be present in enough numbers to provide nearly complete pollination of the alfalfa seed crop in several fields. Five alkali bee nesting sites were located, and landowners informed of their value. One nesting site was determined to be threatened with development, and will be moved to an artificial nesting site. Other bees collected from alfalfa seed production included several species of bumblebees and honeybees, but none were abundant enough to provide adequate pollination. Many other bee species were collected in the area around alfalfa seed production fields, but few were responsible for pollination of alfalfa flowers.

Background

Acreage of alfalfa grown for seed has increased to almost 4000 acres in 1999. Pollination of the crop is done primarily with leafcutter bees (*Megachile rotundata*). These bees are imported from Canada, with initial stocking costs of about $250 per acre, and approximately $100 to $125 per acre in subsequent years under current management strategies. Alkali bees (*Nomia melanderi*) are used in several other alfalfa seed production areas at much lower cost to producers. An effort was made in 1999 to determine if bees other than introduced leafcutters were pollinating western Colorado seed alfalfa.

Methods

Simple sampling of seed alfalfa fields and surrounding areas was conducted in the region around Fruita and western Delta County during the spring and summer of 1999. Flowering plants were visually inspected and any bees were captured with nets, killed, labeled with locality and host plant information, and placed in a collection. Alfalfa seed growers and seed company fieldmen were asked to watch for other bees and contact the research center if any were seen. All bees were identified by specialists at the USDA Bee Systematics and Biology Laboratory in Logan, UT.

Results

Alkali bees were found to be abundant in two areas: the region north and east of Fruita, and an area west of Delta. Alkali bees were in sufficient numbers in one area north of Fruita to provide complete pollination of the seed alfalfa crop. Five nesting sites were located in the area around Fruita, and landowners were contacted to educate them about the value of these beds to local alfalfa seed growers. At least one site has been active for many years, but the history of the other sites could not be determined. One site at the Fruita Research Center was initially colonized in 1999. One alkali bee nesting bed was determined to be threatened with development, and permission was obtained to move the bees to an artificial nesting site. This project was scheduled to take place in the late winter or early spring of 2000.

A list of bee genera collected in the ongoing survey is included in Table 1. Most specimens were identified to the genus level. Some were identified to species. Several nesting sites of species other than alkali bees were located. These are noted in Table 1.

Acknowledgements

This work was done with the help and cooperation of James Cane and Terry Griswold of the

USDA Bee systematics and Biology lab in Logan UT. Amber Richens, Western Colorado Research Center, assisted in the collection and preservation of bee specimens. Mike Crumly, Grand Junction assisted with identification of specimens.

Table 1. Bee taxa collected in western Colorado during the summer of 1999.

Family	Genus/species	Comments
Halictidae	*Nomia melanderi*	Alkali bee. Abundant near Fruita and west of Delta. Several nesting beds were located. They were collected from knapweed and tamarisk flowers as well as from alfalfa.
	Dialictus spp. *Halictus* spp. *Eryalcius* spp.	Sweat bees. These small, mostly solitary or eusocial bees include many species that are mostly ground nesting. They may become abundant at times. They were commonly collected from whitetop, flixweed, thistle, globemallow and other plants. The fly throughout the summer.
	Agapostemon spp.	These beautiful metallic green bees are common ground nesters throughout the west. They pollinate many species of native and introduced plants.
Anthophoridae	*Triepeolus* sp.	A single specimen of this cuckoo (parasitic upon other bees) bee was collected in Delta Co.
	Anthophora spp.	Several species of these bees were collected. A ground nesting site was located at the Fruita Research Center. A few specimens were collected at alfalfa flowers. Some species are bumblebee mimicks.
	Xylocopha tabaniformis	A single specimen of this large black carpenter bee was captured in Grand Junction. They are rare in western Colorado.
	Peponapis sp.	These bees specialize on squash flowers. They were found in Kabocha squash flowers, and nesting in soil in Delta County
	Melissoides sp.	These were found nesting in soil, as well as at several species of flowers in Delta and Mesa Counties.
	Svastra spp.	These large bees were located at ground nesting sites in Delta and Mesa Counties.
Megachilidae	*Megachile rotundata*	The common alfalfa leafcutting bees are managed for alfalfa pollination. They have escaped and naturalized throughout western Colorado.
	Lithurge sp.	These carpenter bees were found in Gunnison County
Apidae	Apis mellifera	The common honey bee can be found throughout Colorado.
	Bombus spp.	Many species of the familiar bumblebees were collected in all areas. They are common pollinators in alfalfa fields, and are important pollinators of many crops.
Andrenidae	*Andrena* spp.	Several species of these small bees were collected, mostly early in the season from whitetop and flixweed.

WESTERN COLORADO ALFALFA VARIETY PERFORMANCE AND EVALUATION OF ADVANCED ALFALFA BREEDING LINES AT FRUITA 1999

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist

Summary and Recommendations

Many new alfalfa varieties are released by private companies each year in the U.S. Testing of all new alfalfa varieties is not possible. A variety performance test is conducted at the Fruita Research Center in which some new alfalfa varieties are evaluated during a three-year testing period. The performance of these varieties are evaluated under local conditions, thus, the findings from this test has relevance to similar grower conditions in western Colorado. This is a progress report for an ongoing study. Forage yields in the first, second, third, and fourth cuttings in the alfalfa variety performance test at Fruita in 1999, averaged across all twenty varieties, was 2.62, 2.44, 1.99, and 1.31 tons/acre, respectively. Total 1999 forage yield in the alfalfa variety performance test averaged 8.36 tons/acre. Forage yields in the first, second, third, and fourth cuttings in the advanced alfalfa breeding line evaluation, averaged across all twenty-five varieties, was 2.26, 1.91, 1.32, and 0.72 tons/acre, respectively. Total forage yield of the advanced breeding lines averaged 6.21 tons/acre in 1999.

Introduction and Objectives

Alfalfa is produced on more acres in western Colorado than any other single crop. Evaluating varieties under western Colorado conditions provides local information to assist growers when selecting varieties for their farm. Local variety performance information is also of value to breeding and seed companies in knowing how to develop and market seed of their varieties. During 1999 we conducted two alfalfa performance tests. The cultivar performance test is conducted for a three-year testing period. Prior to planting the test plots, alfalfa breeding and seed companies are solicited for entries to enter into the test. These companies determine which of their varieties to include in the test. They pay a fee to the University for each entry. Usually, one or more public, check varieties are selected by research center personnel to include in the test.

Materials and Methods

Alfalfa Variety Performance Test

This study was conducted at the Colorado State University Western Colorado Research Center at Fruita. The experiment is a randomized complete block with four replications. The soil is a Billings silty clay loam. The elevation at Fruita, Colorado is 4510 feet. Average annual precipitation is 8.4 inches. Average frost-free days is 181 days. The last spring frost was April 17, 1999 and the first fall frost was October 17, 1999. The frost-free days in 1999 was 183 days (28EF base).

Fertilizer applied to plots in this study was 416 lbs P_2O_5/acre and 88 lbs N/acre broadcast as 11-52-0 on August 13, 1998 and plowed down prior to planting. Planting occurred on August 27, 1998 at 13 lbs/acre. Pursuit was applied for weed control during 1999 at 1.44 oz/acre on 24 February. Harvest dates for each cutting are shown in Table 1.

Advanced Alfalfa Breeding Lines

This study was conducted at the Colorado State University Western Colorado Research Center at Fruita to evaluate advanced breeding lines for a private company to provide them with data collected under field conditions. The data from this test and tests conducted elsewhere are used by the alfalfa breeder to select lines that could become released varieties for commercial production. The experiment is a randomized complete block with four replications. Plot size is 10-feet wide by 15-feet long. The soil is a

Billings silty clay loam. Fertilizer applied to plots in this study was 312 lbs P_2O_5/acre and 66 lbs N/acre broadcast as 11-52-0 on August 19, 1997 and plowed down prior to planting. Planting occurred on 29 August 1997 at the rate of 7 lbs seed/acre. Harvest dates for each cutting are shown in Table 2.

On September 19, 1997, Poast herbicide at 2 pts/acre and 1 qt/acre Butyrac plus 1 qt/acre of crop oil was applied in a tank mix using 31 gallons of water per acre at 40 psi. Pursuit was applied for weed control during 1999 at 1.44 oz/acre on 24 February.

Results and Discussion

Alfalfa Variety Performance Test

The 1999 results of Colorado State University's alfalfa variety performance test at Fruita are shown in Table 1. Plots were planted fall 1998 and data from 1999 are for the first year of the three-year testing period. Stands are excellent. Summer 1999 in western Colorado was quite rainy which made haymaking a challenge for most cuttings. Hay yields in the first cutting averaged across all twenty varieties was 2.62 tons/acre. There was a small amount of volunteer wheat in the first cutting. Fourteen of the twenty alfalfa varieties had high yields in the first cutting in 1999. Hay yields in the second cutting averaged 2.44 tons/acre. Fourteen of the twenty alfalfa varieties also had high yields in the second cutting. High-yielding varieties in the second cutting were not necessarily all the same varieties that had high yields in the first cutting. Hay yields in the third cutting averaged 1.99 tons/acre. Thirteen varieties had high third cutting yields. Hay yields in the fourth cutting averaged 1.31 tons/acre. Six varieties (DK 142, ZX 9453, Archer, Garst 6420, DK 140, ZX 9451) had high fourth cutting yields. Total 1999 forage yield averaged 8.36 tons/acre. Several varieties of alfalfa were high yielding in the four cuttings with several of the same varieties producing high yields in two or more cuttings and in the 1999 total. Fourteen of the twenty varieties had high 1999 total yields; however, Ranger and Ladak were among the low yielding alfalfa varieties in most of the cuttings and were the two low yielding varieties for the 1999 total yield.

Advanced Alfalfa Breeding Lines

Forage yield of the advanced breeding lines during 1999 averaged across all entries was 6.21 tons/acre, somewhat higher than 6.08 tons/acre for 1998 (Table 2). Yields in the advanced alfalfa breeding lines were for the second year of production and were more than 2 tons/acre lower than the average yield for alfalfa variety performance test. Data for this test is valuable for identifying productive lines that could eventually be named and released as commercial varieties. Data will be collected in this trial for another year to complete the three-year testing period.

Acknowledgments

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Table 1. Forage yields of 20 alfalfa varieties at the Western Colorado Research Center at Fruita in 1999.[1]

Variety	Brand/Source	1st Cut May 28	2nd Cut July 7	3rd Cut Aug 19	4th Cut Oct 12	1999 Total[2]
		------------------------ tons/acre[3] ---------------------- -				
DK 142	DEKALB	2.76	2.61	1.92	1.46	8.74
Pinnacle	Arkansas Valley Seed Co.	2.81	2.46	2.14	1.33	8.74
WL 232HQ	Germains	3.00	2.50	1.99	1.22	8.70
ZX 9451	ABI	2.72	2.51	2.13	1.35	8.70
Garst 6420	Garst	2.83	2.42	2.02	1.41	8.69
Millennia	IFA	2.83	2.53	1.99	1.32	8.68
ZX 9453	ABI	2.47	2.59	2.09	1.45	8.60
Archer	America's Alfalfa	260	2.57	1.96	1.42	8.55
Archer II	America's Alfalfa	2.61	2.46	2.10	1.34	8.51
DK 140	DEKALB	2.77	2.41	1.94	1.38	8.51
TMF Multiplier II	Mycogen	2.69	2.46	2.02	1.27	8.44
ABT 350	ABT	2.64	2.50	2.00	1.26	8.40
WL 325 HQ	Germains	2.65	2.58	1.88	1.28	8.39
Baralfa 54	Seekamp Seed	2.51	2.44	2.14	1.31	8.39
Innovator+Z	America's Alfalfa	2.69	2.30	1.90	1.30	8.20
Reno	Novartis	2.41	2.45	2.01	1.31	8.18
TMF 421	Mycogen	2.67	2.45	1.80	1.16	8.08
DK 134	DEKALB	2.30	2.42	1.98	1.29	7.99
Ranger	public	2.31	2.09	1.87	1.18	7.45
Ladak	public	2.07	2.14	1.90	1.08	7.20
Ave.		2.62	2.44	1.99	1.31	8.36
CV (%)		11.24	5.17	6.80	5.85	4.16
LSD (0.05)		0.42	0.18	0.19	0.11	0.49

[1]Trial conducted at the Western Colorado Research Center at Fruita; seeded 27 August 1998.
[2]Table is arranged by decreasing, 1999 total yield.
[3]Yields were calculated on an air-dry basis.

Table 2. Forage yields of 25 advanced alfalfa breeding lines and check varieties at the Western Colorado Research Center at Fruita in 1999.[1]

Variety	Brand/Source	1st Cut May 28	2nd Cut July 7	3rd Cut Aug 19	4th Cut Oct 12	1999 Total	1998 Total	98-99 Total
		------------------------------------ tons/acre[2] -------------------------------------						
Line 1	Forage Genetics	2.26	1.96	1.39	0.75	6.36	6.34	12.71
Line 2	Forage Genetics	2.32	1.95	1.47	0.77	6.51	6.18	12.69
Line 3	Forage Genetics	2.35	1.94	1.34	0.72	6.35	6.29	12.63
Line 4	Forage Genetics	2.23	1.96	1.40	0.76	6.34	6.13	12.47
Line 5	Forage Genetics	2.27	1.92	1.40	0.66	6.26	6.20	12.46
Rushmore	Novartis Seeds	2.28	1.94	1.34	0.67	6.23	6.22	12.45
Line 6	Forage Genetics	2.33	1.91	1.31	0.74	6.30	6.15	12.45
Line 7	Forage Genetics	2.37	1.92	1.33	0.70	6.32	6.11	12.43
Line 8	Forage Genetics	2.16	1.90	1.33	0.69	6.08	6.29	12.37
Line 9	Forage Genetics	2.18	1.98	1.28	0.75	6.18	6.16	12.34
Tahoe	Novartis Seeds	2.23	1.93	1.34	0.75	6.25	6.08	12.33
Line 10	Forage Genetics	2.32	1.94	1.30	0.69	6.24	6.08	12.32
Line 11	Forage Genetics	2.23	1.89	1.31	0.78	6.21	6.11	12.31
Line 12	Forage Genetics	2.29	1.86	1.33	0.73	6.21	6.10	12.31
Line 13	Forage Genetics	2.36	1.85	1.32	0.73	6.27	6.00	12.27
Line 14	Forage Genetics	2.27	1.92	1.27	0.73	6.19	6.03	12.21
Line 15	Forage Genetics	2.22	1.90	1.30	0.72	6.13	6.05	12.18
Line 16	Forage Genetics	2.11	1.88	1.33	0.75	6.07	6.10	12.17
Line 17	Forage Genetics	2.09	1.84	1.33	0.77	6.03	6.05	12.07
Line 18	Forage Genetics	2.28	1.87	1.26	0.71	6.12	5.93	12.05
P5396	Pioneer Hi-Bred	2.45	1.93	1.21	0.62	6.22	5.83	12.04
Line 19	Forage Genetics	2.21	1.85	1.32	0.65	6.04	6.00	12.04
Line 20	Forage Genetics	2.21	1.86	1.26	0.69	6.02	5.99	12.02
Line 21	Forage Genetics	2.21	1.93	1.27	0.79	6.19	5.77	11.97
Line 22	Forage Genetics	2.21	1.92	1.32	0.71	6.16	5.76	11.91
Ave.		2.26	1.91	1.32	0.72	6.21	6.08	12.29
CV (%)		5.21	4.07	6.57	7.36	3.03	4.10	
LSD (0.05)		0.19	0.12	0.14	0.08	0.30	0.39	

[1]Trial conducted at the Western Colorado Research Center at Fruita; seeded 27 August 1998.
[2]Yields were calculated on an air-dry basis.

CHEMICAL CONTROL OF ALFALFA STEM NEMATODE AND ALFALFA WEEVIL AT FRUITA COLORADO, 1999

Robert Hammon, Entomologist

Summary

An early season treatment of Furadan 4F at a rate of 1.0 lb a.i./a (2 pt/a) in a 4 year old alfalfa field yielded 122% of the untreated control. Furadan 4F treatments, applied at 0.5 lb a.i./a 14 days before harvest, yielded 113% of the untreated control. Gross returns from the Furadan 4F treatments were $29.70 and $17.10 per acre for the 1.0 lb/a and 0.5 lb/a treatments respectively. Chemical treatments had no effect on the number of alfalfa stem nematodes extracted from plants four days before harvest, but both treatments had fewer alfalfa weevil larvae than the untreated control.

Background

Alfalfa stem nematodes, *Ditylenchus dipsaci*; *Aphelenchoides ritzemabosi* (ASN), are a major pest of alfalfa hay production throughout western Colorado. Yields are reduced and stand persistence is affected in infested fields. Virtually all irrigated alfalfa in western Colorado is infected with stem nematode to some degree. Resistant varieties are the major strategy used to manage ASN, but even the best varieties can be affected. We observed a growth response in alfalfa to an early season 1.0 lb a.i./a application of Furadan 4F as early as 1993, and initiated a research program into the use of Furadan 4F at that rate in 1996. This report presents the details of the 1999 experiment and reviews the results of the1996-1999 experiments.

Methods

The 1999 Furadan 4F rate experiment was placed in a field of 'WL 323' used for ASN management research since it was planted in 1996. Three treatments were applied to 7.5 ft x 25 ft plots replicated eight times: 1) Furadan 4F , 0.5 lb a.i./a; 2) Furadan 4F, 1.0 lb a.i./a; untreated). The 1.0 lb/a rate was applied on 24 Mar 1999, and the 0.5 lb/a rate was applied 11 May 1999, using a CO_2 pressure boom sprayer calibrated to apply 15 gal/a finished spray material. The 24 Mar 1.0 lb/a application was made to the soil surface and incorporated by rainfall on 2 Apr. The 11 May 0.5 lb/a application was made to alfalfa foliage. Alfalfa weevil abundance was sampled on 26 May by taking 5 sweeps per plot with a standard 15" sweep net. Alfalfa stem nematodes were extracted from plant material collected from each plot on 24 May. Samples were placed in Baermann funnels and extracted in water for 24h, before counting under an inverted compound microscope. The number of ASN per gram of plant material was calculated from the amount of material placed in the funnels, and the extracted ASN counts. Plots were harvested on 28 May 1999, and yields calculated on an air-dry basis.

Results

Alfalfa hay yield, ASN counts and alfalfa weevil counts are displayed in Table 1. Yield was increased by Furadan 4F application at both rates when compared with the untreated control. The 0.14 t/a yield difference between the two Furadan 4F rates was not statistically significant. The data showed no significant differences in alfalfa weevil count between the two Furadan 4F rates, but both had lower counts than the untreated control. However, when plots were visually evaluated prior to harvest, less alfalfa weevil damage was observed in the Furadan 4F, 0.5 lb/a plots. There were no differences between treatments in ASN numbers. The reason for this is unknown, but ASN numbers analyzed over three years have consistently shown no differences. Stem nematode counts ranged from 0 to 400 ASN per gram of plant material, but no pattern was detected in the data.

Results of four years of Furadan 4F rate trials are summarized in Table 2. Alfalfa yields have been increased significantly by Furadan 4F applications in all but the first year of these studies. The field in which the experiments were conducted was a new seeding at that time, and alfalfa weevil and ASN had not had time to build to economic levels. The percent yield increase was the greatest in the 1.0 lb/a application rate in all seasons since the second production year. Application of Furadan 4F at either rate gave positive economic return in the last three years of the studies. This statement assumes a Furadan price of $20.00 per lb a.i., application costs of $5.00 per acre, and selling price of the alfalfa of $90.00 per ton. There is little question that Furadan 4F, applied at a rate of 1.0 lb/a in the early spring has an effect on yield that cannot be accounted for by control of alfalfa weevil alone. The effect is greatest after ASN becomes established in the field, but at this point there is no data to point to ASN control as the cause of the yield increase. This is one area that further research is needed.

Alfalfa weevil control is better with the 0.5 lb/a Furadan 4F rate applied about two weeks before harvest than with the higher rate early in the spring, but both treatments had fewer alfalfa weevil larvae than the untreated control. The timing of the spring treatment will have to be a tradeoff between alfalfa weevil and ASN control, as ASN damage has been observed at first spring growth in recent years.

More years of research and data collection are needed to fully understand the complex interrelationships between soils, varieties, irrigation management, harvest management and chemical management on ASN damage.

Acknowledgments

FMC Corporation has funded this ongoing experiment since its inception. Calvin Pearson, Lot Robinson and Fred Judson assisted with different phases of fieldwork and harvest. Amber Richens assisted in sampling of both alfalfa weevil and alfalfa stem nematodes.

Table 1. Results from 1999 experiment. Means followed by the same letter are not significantly different (LSD á=0.05)

Treatment	Yield Tons/a	ASN per gram of plant material	Alfalfa weevil per sweep
Furadan 4F 0.5 lb a.i./a	1.699 a	58.2	0.7 a
Furadan 4F 1.0 lb a.i./a	1.837 a	72.8	1.1 a
Untreated	1.511 b	71.5	3.9 b
LSD	0.144	ns	1.7

Table 2. Summary of Furadan 4F rate studies in alfalfa, 1996-1999.
[1] Return calculated at alfalfa value of $90.00/ton. [2] Furadan4F value of $20.00/lb, $5.00/a application cost

Year	Yield Ton/acre			Yield % of untreated		Gross return[1]		Net return[2]	
	0.5 lb/a	1.0 lb/a	untreated	0.5 lb/a	1.0 lb/a	0.5 lb/a	1.0 lb/a	0.5 lb/a	1.0 lb/a
1999	1.70	1.84	1.51	113	122	$17.10	$29.70	$2.10	$4.20
1998	1.82	2.06	1.42	128	145	$36.00	$57.60	$21.00	$22.60
1997	2.37	2.53	2.14	111	118	$20.70	$35.10	$5.70	$10.10
1996	2.55	2.43	2.40	106	101	$13.50	$2.70	-$1.50	-$22.30

PASTURE GRASS, FORAGE LEGUME, AND MIXED SPECIES EVALUATION AT MEEKER, COLORADO 1999

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist

Summary and Recommendations

Fifty single and mixed grass and forage legume species are being evaluated for forage yield at Meeker. This is a progress report for an ongoing study. The study was planted in the fall of 1996. Yield data for 1999 reflect forage species performance after three years of production. Averaged across all 50 entries, forage yield in the first cutting in 1999 was 2.07 tons/acre. Yields in the first cutting in 1999 ranged from a high of 3.2 tons/acre to a low of 0.02 tons/acre. Averaged across all entries, forage yield in the second cutting in 1999 was 1.13 tons/acre. Yields in the second cutting ranged from a high of 2.28 tons/acre to a low of 0.09 tons/acre. The 3-year total yield, averaged across all entries, was 7.81 tons/acre. Seven entries were high yielding for the 3-year total. They were smooth brome +orchardgrass + intermediate wheatgrass + alfalfa at 12.36 tons/acre, smooth brome + orchardgrass + meadow brome + alfalfa at 12.13 tons/acre, Newhy + alfalfa in alternate seed rows at 11.67 tons/acre, smooth brome + alfalfa planted as a seed mixture at 12.09 tons/acre, smooth brome + alfalfa planted in alternate seed rows at 12.05 tons/acre, 'AV120' alfalfa + 'Norcen' birdsfoot trefoil at 10.89 tons/acre, and 'AV120' alfalfa at 11.12 tons/acre. This study will continue for several more years to determine forage yields over an extended period of time.

Introduction and Objectives

Grasses and forage legumes are produced on more land in western Colorado than any other single crop. Both irrigated and non-irrigated pastures and meadows, and ranges are found throughout the mountain and valley areas of western Colorado. These crop and rangelands produce forage for grazing animals and hay for livestock. These forages are essential to support the large livestock industry of western Colorado.

Pastures, meadows, and ranges in western Colorado contain a diversity of forage plant species, some of which are native while others are introduced species. Proper selection and management of grass and legumes species for pastures, meadows, and ranges will effect the productivity of these forage lands during establishment and throughout the life of the field or range. The objectives of this research were to: 1) Identify grass and forage legume species and mixtures that produce high yields and high quality, 2) Determine the performance of cool and warm season grasses when planted in mixtures or in alternate seed rows, 3) Determine the performance of forage legumes when planted in mixtures or in alternate seed rows with a grass species, and 4) Assess grass and forage legume species for stand establishment, weed competition, and stand persistence. Fifty entries of single grass and forage legume species and mixed grass and legume species were evaluated at Meeker, Colorado during 1999.

Materials and Methods

This study was conducted at the Upper Colorado Environmental Plant Materials Center at Meeker, Colorado. The experiment design is a randomized complete block with four replications. Plot size is 10 feet wide by 15 feet long. The elevation at Meeker is 6240 feet. The mean maximum annual temperature is 60.4 ˚F and the mean minimum annual temperature is 26.8 ˚F.

The experiment was planted on August 9, 1996. Most entries established well. Warm season grasses did not establish with the fall planting. All plots were replanted on June 25, 1997. This was done to thicken the stand in some plots and to attempt to establish the warm season grasses. It was easier to replant all plots rather than selected ones.

Fertilizer applications in 1997 were 50 lbs N/acre as ammonium nitrate on May 14, 1997; 73 lbs N/acre and 104 lbs P_2O_5/acre as 11-52-0 and ammonium nitrate on August 25, 1997. Fertilizer applications in 1998 were 46 lbs N/acre as ammonium nitrate on July 7, 1998. Fertilizer applications in 1999 were 46 lbs N/acre as ammonium nitrate on July 6, 1999; 15 lbs N/acre and 70 lbs P_2O_5/acre as 11-52-0 on September 15, 1999. No herbicides have been applied to the plots.

The experiment has been sprinkler irrigated each year generally four times or less - one or twice before the first cutting and once or twice before the second cutting. Typically, plots have been not irrigated after the second cutting for the remainder of the year.

Plots were harvested with a John Deere 2280 commercial swather that had was equipped with a weigh bin and an electronic weighing system. The weigh bin was fitted underneath the swather to catch the forage as it was discharged from the crimper. This automated, forage plot harvesting system has been in use for several years and has performed extremely well. During harvest a small forage sample was obtained from each plot and used for moisture determination.

Results and Discussion

Yield data for 1999 reflect forage species performance after three years of production. Averaged across all 50 entries, forage yield in the first cutting in 1999 was 2.07 tons/acre. Yields in the first cutting ranged from a high of 3.2 tons/acre to a low of 0.02 tons/acre. Fourteen entries had forage yields in the first cutting equal to or greater than 2.75 tons/acre. Averaged across all entries, forage yield in the second cutting in 1999 was 1.13 tons/acre. Yields in the second cutting ranged from a high of 2.28 tons/acre to a low of 0.09 tons/acre. Eight entries had forage yields in the second cutting that were greater than 2 tons/acre.

Entries 37, 48, 33, 46, and 22 had high yields in both the first and the second cuttings. Average total 1999 forage yield was 3.20 tons/acre. Eight entries (48, 37, 33, 46, 22, 19, 41, and 26) were high yielding for the 1999 total yield.

Average total 1998 forage yield was 2.89 tons/acre. Eight entries (33, 37, 41, 46, 19, 26, 48, and 22) were high yielding for the 1998 total yield. Average total 1997 forage yield was 1.72 tons/acre. Fifteen entries (21, 46, 9, 48, 8, 50, 17, 47, 41, 7, 1, 49, 43, 20, 37) were high yielding for the 1997 total yield. High total yields for 1997 may be an indicator of how quickly an entry becomes established and how productive it is during establishment.

The 3-year average total yield was 7.81 tons/acre. Seven entries (48, 46, 37, 33, 41, 19, and 26) were high yielding for the 3-year total. All of these entries included alfalfa either alone or as a mixture with other species. The only other entry to include alfalfa that was not in the high yielding category was Entry #22 and it was ranked as #8 out of the 50 entries for yield.

A few observations about some of the entries at Meeker are worth mentioning. The forage chicory stand is thinning rapidly. Cicer milkvetch is not very prevalent in plots. ‘San Luis’ slender wheatgrass growth is poor. Plots with San Luis are quite weedy. Four entries were planted in 1999 (‘Dacotah’ switchgrass, ‘Bison’ big bluestem, ‘Liso’ smooth brome, and ‘Garnet’ mountain brome) to replace other entries that did not perform well at Meeker. These new plots had some weeds and although the new plantings had good stands they were not expected to be very productive during the establishment year.

Acknowledgments

This study is conducted at the Upper Colorado Environmental Plant Materials Center at Meeker. We express our appreciation to Steve Parr, Gary Noller, Rodney Dunham, and other members of the staff at the Plant Materials Center for allowing us to conduct this research at their facility and for the irrigating, baling, and other care they have provided for the plots. Thanks also to Bill Ekstrom, CSU Cooperative Extension County Director at Meeker, and Alvin Jones, NRCS based at Meeker for their assistance during plot harvest. Also, thanks to Larry Holtzworth and John Sheets of the Plant Materials Center at Bridger, Montana for providing seed for ‘Bison’ big bluestem and ‘Dacotah’ switchgrass. Lot Robinson and Fred Judson provided assistance with field work. Sara Albertson and Daniel Dawson assisted with data collection, data entry, and data management. Many companies have provided assistance in various ways (i.e., seed and funding support). These companies include Arkansas Valley Seed Company, Sharp Brothers, Ampac Seed Company, and Peterson Seed Company. The assistance of these companies is gratefully acknowledged.

Table 1. Forage yields of single and mixed species of pasture grasses and forage legumes at Meeker, Colorado, 1999.

Entry	Cut 1 Sept 9	Cut 2 July 1	1999 Total	1998 Total	1997 Total	3-Yr Total	Air-dry fraction
	--------------------------------------tons/acre[1]------------------------------------						
1. Smooth brome 'Liso'†	0.02	0.19	0.21	0.81	2.27	3.28	42.6
2. Creeping foxtail 'Garrison	1.46	0.47	1.93	1.56	0.82	4.31	46.2
3. Reed canarygrass 'Venture'	1.26	0.82	2.08	1.92	1.04	5.04	43.1
4. Tall fescue 'Advance'	1.51	0.85	2.36	2.38	1.76	6.50	40.7
5. Orchardgrass 'Duke'	1.57	1.16	2.73	2.24	2.00	6.96	44.9
6. Orchardgrass 'Tekapo'	1.33	0.93	2.26	1.62	1.45	5.33	44.4
7. Meadowbrome 'Fleet'	2.51	0.93	3.47	2.91	2.27	8.65	43.4
8. Intermediate wheatgrass 'Oahe'	2.53	0.56	3.08	3.09	2.66	8.83	42.0
9. Pubescent wheatgrass 'Luna'	2.69	0.70	3.39	3.15	2.77	9.31	43.1
10. Slender wheatgrass 'San Luis'	1.42	0.58	1.99	1.84	1.37	5.20	44.8
11. Hybrid wheatgrass 'Newhy'	2.19	1.42	3.60	2.85	1.87	8.32	44.9
12. Beardless wildrye 'Shoshone'	1.44	0.65	2.09	1.42	0.49	3.99	42.4
13. Big bluestem 'Bison'†	0.02	0.12	0.14	1.36	0.20	1.70	40.1
14. Switchgrass 'Dacotah'†	0.02	0.20	0.22	1.01	0.21	1.43	40.8
15. Timothy 'Climax'	1.49	0.41	1.90	1.85	1.39	5.14	42.1
16. Tall fescue 'Enforcer'	2.11	0.83	2.94	2.57	1.67	7.18	41.9
17. Intermediate wheatgrass 'Rush'	2.37	0.85	3.21	3.12	2.58	8.91	40.5
18. Mountain brome 'Garnet'†	0.02	0.09	0.11	1.99	0.63	2.73	40.2
19. Alfalfa 'AV120'	2.51	2.22	4.72	4.39	2.01	11.12	36.8
20. Forage chicory 'LaCerta'	1.23	0.99	2.21	2.00	2.22	6.42	29.6
21. Mountain brome 'Bromar'	1.43	0.64	2.06	1.72	2.78	6.56	42.1
22. Alfalfa 'Spredor III'	2.79	2.01	4.81	4.06	1.89	10.75	36.9
23. Birdsfoot trefoil 'ARS2620'	2.75	1.20	3.95	3.14	0.34	7.43	34.8
24. Ladino clover 'Will'	0.81	0.53	1.34	1.44	0.38	3.16	40.7
25. Redtop	1.38	0.65	2.03	1.45	0.98	4.45	43.6
26. Alfalfa 'AV120' + Birdsfoot trefoil 'Norcen'	2.51	2.15	4.66	4.35	1.88	10.89	36.7
27. Cicer milkvetch 'Windsor'	2.38	1.77	4.15	3.74	0.95	8.84	37.4
28. Sainfoin 'Remont'	3.20	1.31	4.50	3.31	0.87	8.68	38.7
29. Switchgrass + Newhy (alternate seed rows)	1.96	0.85	2.81	2.58	1.50	6.89	44.4
30. Switchgrass + tall fescue (alternate seed row)	1.94	0.86	2.79	2.85	1.59	7.23	42.1
31. Switchgrass + Newhy (mixed)	2.10	0.68	2.78	2.62	2.07	7.47	44.3

Table 1 (continued). Forage yields of single and mixed species of pasture grasses and forage legumes at Meeker, Colorado 1999 .

Entry	Cut 1 Sept 9	Cut 2 July 1	1999 Total	1998 Total	1997 Total	3-Yr Total	Air-dry fraction
	----------	----------	----------	tons/acre[1]	----------	----------	
32. Switchgrass + tall fescue (mixed)	1.72	0.75	2.47	2.52	1.63	6.62	43.4
33. Smooth brome + alfalfa (alternate seed rows)	2.99	2.25	5.24	4.75	2.05	12.05	42.3
34. Smooth brome + birdsfoot trefoil (alternate seed rows)	2.90	1.30	4.20	3.77	1.82	9.78	42.2
35. Smooth brome + cicer milkvetch (alternate seed rows)	2.67	1.88	4.55	3.76	1.93	10.23	40.9
36. Smooth brome + sainfoin (alternate seed rows)	2.84	1.27	4.11	3.64	1.44	9.18	41.8
37. Smooth brome + alfalfa (mixed)	3.08	2.18	5.26	4.69	2.15	12.09	42.7
38. Smooth brome + birdsfoot trefoil (mixed)	2.49	1.19	3.68	3.22	1.81	8.70	42.7
39. Smooth brome + cicer milkvetch (mixed)	2.87	1.74	4.61	3.80	1.84	10.25	42.5
40. Smooth brome + sainfoin (mixed)	3.15	1.39	4.53	3.38	1.50	9.40	42.3
41. Newhy + alfalfa (alternate seed rows)	2.50	2.18	4.68	4.59	2.40	11.67	40.2
42. Newhy + birdsfoot trefoil (alternate seed rows)	2.75	1.41	4.16	3.55	1.67	9.38	40.8
43. Newhy + cicer milkvetch (alternate seed rows)	2.56	1.70	4.26	3.66	2.23	10.15	42.0
44. Newhy + sainfoin (alternate seed rows)	2.91	1.13	4.03	3.25	1.78	9.05	42.0
45. Smooth brome + orchardgrass + meadow brome	1.95	1.29	3.24	2.63	1.88	7.75	45.1
46. Smooth brome + orchardgrass + meadow brome + alfalfa	2.83	2.03	4.86	4.51	2.77	12.13	41.0
47. Smooth brome + orchardgrass + intermediate wheatgrass	2.39	1.14	3.53	3.01	2.51	9.04	42.1
48. Smooth brome + orchardgrass + intermediate wheatgrass + alfalfa	3.00	2.28	5.27	4.33	2.76	12.36	38.3
49. Smooth brome +orchardgrass + meadow brome + creeping foxtail	1.93	1.14	3.07	2.90	2.26	8.22	44.0
50. Smooth brome ‘Bounty’	2.98	0.60	3.57	3.51	2.63	9.71	44.2
Average	2.07	1.13	3.20	2.89	1.72	7.81	0.42
CV (%)	15.5	23.0	14.4	17.5	27.4	14.4	5.2
LSD (0.05)	0.45	0.36	0.64	0.71	0.66	1.58	3.02

In entries 29-49 we used ‘Blackwell’ switchgrass, ‘Fawn’ tall fescue, ‘Manchar’ smooth brome, ‘AV120' alfalfa, ‘Norcen’ birdsfoot trefoil, ‘Remont’ sainfoin, ‘Windsor’ cicer milkvetch, ‘Tekapo’ orchardgrass, ‘Regar’ meadow brome, ‘Oahe’ intermediate wheatgrass, and ‘Garrison’ creeping foxtail

[1]Yields were calculated on an air-dry basis.

[†]‘Liso’ smooth brome, ‘Dacotah’ switchgrass, ‘Bison’ big bluestem, and ‘Garnet’ mountain brome were planted July 6, 1999 to replace ‘Matua’ bromegrass, ‘Blackwell’ switchgrass, ‘Praireland’ altai wildrye, and ‘Kaw’ big bluestem, respectively, that did not establish at Meeker.

PASTURE GRASS, FORAGE LEGUME, AND MIXED SPECIES EVALUATION AT HOTCHKISS, COLORADO 1999

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist
Dr. Alvan G. Gaus, Research Scientist/Extension Specialist

Summary and Recommendations

Fifty single and mixed grass and forage legume species are being evaluated for forage yield at Hotchkiss. The study was planted in spring 1998 and is similar to the study being conducted at Meeker. This is a progress report for an ongoing study. The data for 1999 are for the first full year of production. Averaged across all 50 entries, forage yields in the first cutting, second cutting, and the 1999 total yield were 2.28 tons/acre, 2.16 tons/acre, and 5.68 tons/acre, respectively. Eight entries were high yielding in the 1999 total yield. Averaged across all 50 entries, the 2-year total yield was 6.92 tons/acre. Eight entries were high yielding in the 2-year total yield. They were 'AV120' alfalfa, 'LaCerta' forage chicory, 'AV120 alfalfa + 'Norcen' birdsfoot trefoil, smooth brome + alfalfa in alternate seed rows, smooth brome + alfalfa planted as a mixture, Newhy + alfalfa in alternate seed rows, and smooth brome + orchardgrass + meadow brome + alfalfa. These were the same eight entries that had high yields in the 1999 total yield, although the ranking was slightly different. This research will continue for several more years to determine the productivity of these entries under long term production.

Introduction and Objectives

Grasses and forage legumes are produced on more land in western Colorado than any other crop. Both irrigated and non-irrigated pastures and meadow, and ranges are found throughout the mountain and valley areas of western Colorado. These crop and rangelands produce forage for grazing animals or hay that is fed later. These forages are essential to support the large livestock industry in western Colorado. Pastures, meadows, and ranges in western Colorado contain a diversity of forage plant species, some of which are native while others are introduced species.

Proper selection and management of grass and legumes species for pastures, meadows, and ranges will effect the productivity of these forage lands during establishment and throughout the life of the field or range. The objectives of this research were to: 1) Identify grass and forage legume species and mixtures that produce high yields and high quality, 2) Determine the performance of cool and warm season grasses when planted in mixtures or in alternate seed rows, 3) Determine the performance of forage legumes when planted in mixtures or in alternate seed rows with a grass species, and 4) Assess grass and forage legume species for stand establishment, weed competition, and stand persistence. Fifty entries of single grass and forage legume species and mixed grass and legume species were evaluated at the Rogers Mesa Research Center at Hotchkiss, Colorado during 1999.

Materials and Methods

This study was conducted at the Colorado State University, Western Colorado Research Center at Rogers Mesa. The elevation at Hotchkiss is 5,800 feet. The experiment was a randomized complete block with four replications. Plots size is 10 feet wide by 15 feet long. Plots were planted on April 28, 1998. The plot area was flailed on July 16, 1998 to control weeds, particularly sweetclover and annual weeds. Fertilizer applied during 1998 occurred on July 21 and was 38.8 lbs N/acre and 44.8 lbs P_2O_5/acre. Fertilizer applied in 1999 was 35 lbs/acre of 18-46-0 and 36 lbs N as ammonium nitrate on April 29 and 74 lbs N/acre as ammonium nitrate on June 26. No herbicides have been applied. The experiment is furrow-irrigated.

Plots were harvested with a John Deere 2280 commercial swather that had was equipped with a weigh bin and an electronic weighing system. The weigh bin was fitted underneath the swather to catch the forage as it was discharged from the crimper. This automated, forage plot harvesting system has been in use for several years and has performed extremely well. During harvest a small forage sample was obtained from each plot and used for moisture determination.

Results and Discussion

Plots were planted in spring 1998 and one cutting was obtained in 1998. The data for the 1998 cutting reflect stand establishment and productivity of a new stand (Table 1). Entries with high yields established more readily and were more productive than those entries with low yields. Averaged across all 50 entries, forage yields in the 1998 cutting were 1.24 tons/acre. Eight entries were high yielding entries in the 1998 cutting. They were ‘AV120' alfalfa, ‘LaCerta’ forage chicory, ‘AV120 alfalfa + ‘Norcen’ birdsfoot trefoil, smooth brome + alfalfa in alternate seed rows, smooth brome + alfalfa planted as a mixture, Newhy + alfalfa in alternate seed rows, smooth brome + orchardgrass + meadow brome + alfalfa, and smooth brome, orchardgrass + intermediate wheatgrass + alfalfa.

The data for 1999 are for the first full year of production. Two cuttings were obtained. The 1999 results of the pasture grass, forage legume, and mixed species evaluation study at Hotchkiss are shown in Table 1. Averaged across all 50 entries, forage yields in the first cutting were 2.28 tons/acre. Three single specie grass entries were the highest-yielding entries in the first cutting in 1999. They were ‘Fleet’ meadowbrome (3.01 tons/acre), ‘Oahe’ intermediate wheatgrass (3.08 tons/acre), and ‘Luna’ pubescent wheatgrass (3.46 tons/acre).

Forage yields in the second cutting averaged 2.16 tons/acre. Ten entries were high yielding in the 1999 second cutting. These entries were: ‘Matua’ bromegrass, ‘Blackwell’ switchgrass, ‘AV120' alfalfa, ‘LaCerta’ forage chicory, ‘Spredor III’ alfalfa, ‘AV120' alfalfa + ‘Norcen’ birdsfoot trefoil, smooth brome + alfalfa in alternate seed rows, smooth brome + alfalfa planted as a mixture, ‘Newhy’ + alfalfa in alternate seed rows, and smooth brome + orchardgrass + meadow brome + alfalfa.

Averaged across all 50 entries, 1999 total forage yields were 5.68 tons/acre. Eight entries were high yielding in the 1999 total yield. They were ‘AV120' alfalfa, ‘LaCerta’ forage chicory, ‘AV120' alfalfa + ‘Norcen’ birdsfoot trefoil, smooth brome + alfalfa in alternate seed rows, smooth brome + alfalfa planted as a mixture, ‘Newhy’ + alfalfa in alternate seed rows, and smooth brome + orchardgrass + meadow brome + alfalfa. Entries with low yields were obviously not as productive those entries with high yields, but often entries with low yields were a combination of forage yield and weeds. All the entries had good stands and low forage yields were not the result of poor stand establishment.

The 2-year total yield averaged 6.92 tons/acre. Eight entries were high yielding in the 2-year total yield. They were ‘AV120' alfalfa, ‘LaCerta’ forage chicory, ‘AV120' alfalfa + ‘Norcen’ birdsfoot trefoil, smooth brome + alfalfa in alternate seed rows, smooth brome + alfalfa planted as a mixture, ‘Newhy’ + alfalfa in alternate seed rows, and smooth brome + orchardgrass + meadow brome + alfalfa. These were the same entries that were high yielding for the 1999 total yield, although the ranking was slightly different.

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Table 1. Forage yields of single and mixed species of pasture grasses and forage legumes at Hotchkiss, Colorado, 1999.

Entry	Cut 1 June 16	Cut 2 Aug. 31	1999 Total	1998 Total	2-Yr Total	Average air-dry fraction
	---------------tons/acre[1]	---------------	---------------	---------------	---------------	
1. Bromegrass 'Matua'	2.10	2.69	6.38	1.58	7.96	33.0
2. Creeping foxtail 'Garrison	1.85	1.48	4.22	0.90	5.12	28.5
3. Reed canarygrass 'Venture'	1.76	2.25	5.25	1.24	6.49	31.1
4. Tall fescue 'Advance'	1.78	1.94	5.15	1.42	6.57	27.4
5. Orchardgrass 'Duke'	1.75	1.97	5.11	1.40	6.50	26.4
6. Orchardgrass 'Tekapo'	1.59	2.05	5.05	1.41	6.46	28.6
7. Meadowbrome 'Fleet'	3.01	1.71	5.87	1.16	7.03	31.5
8. Intermediate wheatgrass 'Oahe'	3.08	1.52	5.91	1.31	7.22	30.3
9. Pubescent wheatgrass 'Luna'	3.46	1.71	6.50	1.34	7.84	29.8
10. Slender wheatgrass 'San Luis'	2.32	2.08	5.14	0.74	5.88	28.2
11. Hybrid wheatgrass 'Newhy'	2.57	1.59	5.36	1.20	6.57	33.1
12. Beardless wildrye 'Shoshone'	2.27	2.05	4.94	0.63	5.57	29.3
13. Switchgrass 'Blackwell'	1.89	3.10	5.97	0.98	6.95	30.1
14. Big bluestem 'Kaw'	2.07	2.25	4.92	0.60	5.52	27.0
15. Timothy 'Climax'	2.40	1.97	5.09	0.72	5.82	27.7
16. Tall fescue 'Enforcer'	2.04	2.15	5.61	1.42	7.02	30.0
17. Intermediate wheatgrass 'Rush'	2.94	1.53	5.75	1.28	7.03	31.8
18. Altai wildrye 'Praireland'	2.05	1.77	4.47	0.65	5.12	28.1
19. Alfalfa 'AV120'	2.38	2.94	7.19	1.87	9.06	27.8
20. Forage chicory 'LaCerta'	1.97	3.05	6.86	1.84	8.70	17.4
21. Mountain brome 'Bromar'	2.58	2.25	6.18	1.35	7.53	32.2
22. Alfalfa 'Spredor III'	2.40	2.75	6.66	1.51	8.17	28.0
23. Birdsfoot trefoil 'ARS2620'	1.81	1.99	4.58	0.78	5.36	26.5
24. Ladino clover 'Will'	1.69	1.29	4.28	1.31	5.60	19.5
25. Redtop	2.03	1.69	4.41	0.70	5.12	28.1
26. Alfalfa 'AV120' + Birdsfoot trefoil 'Norcen'	2.60	2.78	7.28	1.90	9.19	27.4
27. Cicer milkvetch 'Windsor'	2.14	2.05	4.96	0.76	5.72	26.4
28. Sainfoin 'Remont'	2.37	1.89	5.18	0.93	6.11	28.5
29. Switchgrass + Newhy (alternate seed rows)	2.62	2.67	6.45	1.16	7.61	32.5
30. Switchgrass + tall fescue (alternate seed row)	1.68	2.27	5.25	1.30	6.54	29.1
31. Switchgrass + Newhy (mixed)	2.26	1.66	5.10	1.18	6.28	32.8

Table 1 (continued). Forage yields of single and mixed species of pasture grasses and forage legumes at Hotchkiss, Colorado 1999.

Entry	Cut 1 June 16	Cut 2 Aug. 31	1999 Total	1998 Total	2-Yr Total	Average air-dry fraction
	--------------------------------tons/acre[1]	--------------------------				
32. Switchgrass + tall fescue (mixed)	1.90	2.22	5.39	1.28	6.67	26.8
33. Smooth brome + alfalfa (alternate seed rows)	2.44	2.80	7.14	1.90	9.05	29.1
34. Smooth brome + birdsfoot trefoil (alternate seed rows)	2.03	2.20	5.26	1.04	6.29	29.7
35. Smooth brome + cicer milkvetch (alternate seed rows)	2.13	2.28	5.40	0.98	6.38	31.1
36. Smooth brome + sainfoin (alternate seed rows)	2.31	2.09	5.66	1.26	6.92	30.7
37. Smooth brome + alfalfa (mixed)	2.67	2.87	7.42	1.88	9.30	28.2
38. Smooth brome + birdsfoot trefoil (mixed)	2.43	2.33	5.85	1.08	6.93	31.5
39. Smooth brome + cicer milkvetch (mixed)	2.57	2.49	6.16	1.10	7.27	31.3
40. Smooth brome + sainfoin (mixed)	2.40	2.23	5.71	1.09	6.80	29.9
41. Newhy + alfalfa (alternate seed rows)	2.47	2.71	6.96	1.78	8.74	28.0
42. Newhy + birdsfoot trefoil (alternate seed rows)	2.54	1.84	5.52	1.15	6.67	31.1
43. Newhy + cicer milkvetch (alternate seed rows)	2.55	1.77	5.52	1.20	6.73	31.6
44. Newhy + sainfoin (alternate seed rows)	2.61	1.85	5.61	1.15	6.76	28.7
45. Smooth brome + orchardgrass + meadow brome	1.82	1.95	4.86	1.09	5.96	29.0
46. Smooth brome + orchardgrass + meadow brome + alfalfa	2.71	3.00	7.67	1.96	9.64	27.9
47. Smooth brome + orchardgrass + intermediate wheatgrass	2.20	1.84	5.43	1.39	6.82	28.8
48. Smooth brome + orchardgrass + intermediate wheatgrass + alfalfa	2.52	2.63	6.90	1.76	8.66	26.9
49. Smooth brome +orchardgrass + meadow brome + creeping foxtail	1.93	1.97	5.15	1.25	6.40	29.5
50. Smooth brome ‘Bounty’	2.51	1.97	5.54	1.06	6.60	31.6
Average	2.28	2.16	5.68	1.24	6.92	29.0
CV (%)	15.5	14.1	10.8	14.7	10.6	5.1
LSD (0.05)	0.49	0.43	0.85	0.25	1.02	2.07

In entries 29-49 we used ‘Blackwell’ switchgrass, ‘Fawn’ tall fescue, ‘Manchar’ smooth brome, ‘AV120' alfalfa, ‘Norcen’ birdsfoot trefoil, ‘Remont’ sainfoin, ‘Windsor’ cicer milkvetch, ‘Tekapo’ orchardgrass, ‘Regar’ meadow brome, ‘Oahe’ intermediate wheatgrass, and ‘Garrison’ creeping foxtail

[1]Yields were calculated on an air-dry basis.

PASTURE GRASS SPECIES EVALUATION AT FRUITA, COLORADO 1999

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist

Summary And Recommendations

A pasture grass species study is being conducted at the Western Colorado Research Center at Fruita in which forage yields of sixteen grass entries have been determined since 1995. This is a progress report for an ongoing study. Hay yields for the total 1999 yield ranged from a high of 5.88 tons/acre for 'Blackwell' switchgrass to a low of 2.54 tons/acre for 'Palaton' reed canarygrass. The test average for the total 1999 yield was 3.83 tons/acre. High-yielding entries for 1999 were 'Blackwell' switchgrass and 'Fawn' tall fescue. Hay yields totaled across the five years we have collected data in this study ranged from a high of 32.71 tons/acre for 'Blackwell' switchgrass to a low of 16.85 tons/acre for 'Palaton' reed canarygrass. The test average for the 5-year total was 22.08 tons/acre. High-yielding entries over this five-year testing period were Blackwell switchgrass and Fawn tall fescue, the same ones as in the individual years. Other entries that have been good forage producers are: 'Newhy' hybrid wheatgrass, 'Regar' meadow brome, 'Potomac' orchardgrass, 'Luna' pubescent wheatgrass, Economy pasture mix, and Premium pasture mix. Forage yields in this study will continue to be collected for several more years. Forage quality, which should also be an important consideration in pasture management, is discussed in another report in this publication.

Introduction And Objectives

Hay other than alfalfa was produced on 600,000 acres in Colorado in 1998. Much of the hay produced in Colorado, other than alfalfa hay, is grass hay. Grass hay in Colorado is produced in pastures, meadows, and other grasslands. Grass hay is an important feed for livestock and many farmers and ranchers depend on pastures, meadows, and other grasslands, not only for hay production, but also for grazing, wildlife habitat, environmental services, crop rotation and cropping system needs, and other reasons.

Pasture grass and forage legume species evaluation and performance studies have been conducted in past years in Colorado (Hoff and Dotzenko, 1969; Marquiss, 1970; Siemer and Hall, 1970; Marquiss and Davis, 1971; Siemer and Willhite, 1972; Stewart, 1973; Rothman and Sprock, 1988). Recent pasture grass and forage legume research, other than alfalfa, in the valley areas of Colorado has been limited. The objectives of this ongoing research are to identify grass species and mixtures that produce high yields and high forage quality; to evaluate grass species for stand establishment, weed competition, and stand persistence; and to disseminate the findings of this research to clientele using printed material, electronic media, and oral presentations.

Materials and Methods

This study was conducted at the Colorado State University Western Colorado Research Center at Fruita. The experiment is a randomized complete block with four replications. The soil is a Glenton very fine sandy loam. The elevation at Fruita is 4510 feet. The average annual precipitation 8.4 inches and the average frost-free days is 181 days. The last spring frost occurred on April 17, 1999 and the first fall frost occurred on October 17, 1999, thus the 1999 frost-free days was 183 days (28EF base). The plots were planted on April 22, 1994. Fertilizer applications, mostly nitrogen sources, have been applied in split applications in each of the previous years. Fertilizer applications during 1999 were 50 lbs N/acre as ammonium nitrate applied on March 3, 1999 and 55 lbs N/acre as ammonium nitrate applied on August 31, 1999. Plots were harvested with an automated, forage plot harvester that was designed and built at the Fruita Research Center (Pearson and Robinson, 1994). It has been in used in our forage plot research for seven years at the Fruita Research Center and it is considered to be a valuable piece of research equipment.

Results and Discussion

The application of herbicides in this study have been conscientiously avoided in order to determine which of these grass entries are most competitive against invading weeds without requiring additional herbicide inputs. Plots were evaluated in spring 2000 for weed infestation. The main weed present in the plots at the time of evaluation was dandelion. The results of that evaluation are shown in Table 1.

Forage yields for the pasture grass species test are shown in Table 2. Hay yields in the first cutting in 1999 ranged from a high of 2.68 tons/acre for 'Fawn' tall fescue to a low of 0.74 tons/acre for 'Palaton' reed canarygrass. The test average for the first cutting in 1999 was 1.71 tons/acre. High-yielding entries were 'Fawn' tall fescue and the Economy pasture mix.

Hay yields in the second cutting in 1999 ranged from a high of 4.39 tons/acre for ‘Blackwell’ switchgrass to a low of 1.13 tons/acre for ‘Oahe’ intermediate wheatgrass. The test average for the second cutting in 1999 was 1.69 tons/acre. The highest-yielding entry in the second cutting was ‘Blackwell’ switchgrass.

Hay yields in the third cutting in 1999 ranged from a high of 0.79 tons/acre for ‘Fawn’ tall fescue to a low of 0.25 tons/acre for ‘Latar’ orchardgrass. The test average for the third cutting in 1999 was 0.43 tons/acre. High-yielding entries were ‘Fawn’ tall fescue and the ‘Economy’ pasture mix, which were also high yielding in the first cutting.

Hay yields for the total 1999 yield ranged from a high of 5.88 tons/acre for ‘Blackwell’ switchgrass to a low of 2.54 tons/acre for ‘Palaton’ reed canarygrass. The test average for the total 1999 yield was 3.83 tons/acre. High-yielding entries for 1999 were Blackwell switchgrass and Fawn tall fescue.

Hay yields totaled across the five years we have collected data in this study ranged from a high of 32.71 tons/acre for ‘Blackwell’ switchgrass to a low of 16.85 tons/acre for ‘Palaton’ reed canarygrass. The test average for the 5-year total was 22.08 tons/acre. High-yielding entries over this five-year testing period were Blackwell switchgrass and Fawn tall fescue, the same ones as in the individual years. Other entries that have been good forage producers are: ‘Newhy’ hybrid wheatgrass, ‘Regar’ meadow brome, ‘Potomac’ orchardgrass, ‘Luna’ pubescent wheatgrass, Economy pasture mix, and Premium pasture mix.

This study will continue for several more years. These data will be useful to determine the persistence and productivity of these entries over a long period of time.

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Table 1. Pasture grass response to dandelion invasion, March 2000 evaluation.

Pasture Grass	Dandelion infestation rating	Comments
‘RS-H’ experimental	XX	some dandelion present in all reps
‘Newhy’ hybrid wheatgrass	XX	some dandelion present in all reps
‘Regar’ meadow brome	X	a few dandelion present, two reps clean
‘Lincoln’ smooth brome	X	a few dandelion present, one rep clean
‘Manchar’smooth brome	X	a few dandelions present, one rep clean
‘Potomac’ orchardgrass	-	very weed-free, all reps quite clean
‘Latar’ orchardgrass	-	quite weed-free, one rep had some dandelion
‘Luna’ pubescent wheatgrass	XXX	two reps had considerable dandelion present
‘Climax’ timothy	X	a few dandelion present in all reps
‘Bozoisky-Select’ Russian wildrye	XX	one rep had a lot of dandelion, other reps had some
‘Fawn’ tall fescue	-	very weed-free
‘Palaton’ reed canarygrass	XXX	two reps had a lot of dandelion
‘Blackwell’ switchgrass	XXX	two reps had a lot of dandelion
‘Oahe’ intermediate wheatgrass	XXX	two reps had a lot of dandelion
Economy pasture mix	-	weed-free, very clean in all reps
Premium pasture mix	-	weed-free, very few weeds in any of the reps

- none, X = few, XX = moderate amount, XXX = heavy amount of dandelion present.

Table 2. Hay yields[1] of irrigated pasture grasses at the Western Colorado Research Center. Fruita, Colorado 1999.

Pasture Grass	1st cutting June 3	2nd cutting Aug 19	3rd cutting Oct 12	1999 Total	1998 Total	1997 Total	1996 Total	1995 Total	5-yr Total
	---------- tons/acre ----------								
‘RS-H’ experimental	1.52	1.32	0.34	3.18	2.62	4.09	3.45	6.89	20.23
‘Newhy’ hybrid wheatgrass	1.89	1.48	0.41	3.79	3.11	4.69	3.77	7.37	22.73
‘Regar’ meadow brome	2.08	1.84	0.43	4.36	3.48	5.20	4.26	7.19	24.49
‘Lincoln’ smooth brome	1.81	1.26	0.32	3.38	2.48	4.56	2.86	5.75	19.03
‘Manchar’smooth brome	1.46	1.40	0.27	3.14	2.38	4.90	3.27	5.62	19.31
‘Potomac’ orchardgrass	1.84	1.50	0.49	3.82	2.63	5.48	3.51	6.13	21.57
‘Latar’ orchardgrass	1.32	1.72	0.25	3.30	2.48	4.59	3.16	5.91	19.44
‘Luna’ pubescent wheatgrass	1.74	1.25	0.40	3.39	2.94	4.94	3.92	7.36	22.56
‘Climax’ timothy	1.84	1.55	0.32	3.72	2.97	4.82	3.39	5.74	20.64
‘Bozoisky-Select’ Russian wildrye	1.26	1.37	0.48	3.11	2.82	4.19	2.79	4.57	17.48
‘Fawn’ tall fescue	2.68	1.89	0.79	5.36	5.05	6.92	4.64	8.40	30.37
‘Palaton’ reed canarygrass	0.74	1.48	0.32	2.54	2.26	4.12	2.70	5.24	16.85
‘Blackwell’ switchgrass	1.12	4.39	0.36	5.88	6.48	6.21	5.51	8.63	32.71
‘Oahe’ intermediate wheatgrass	1.60	1.13	0.39	3.12	2.42	3.88	3.45	6.48	19.34
Economy pasture mix[2]	2.54	1.90	0.75	5.19	3.81	6.22	3.58	6.21	25.02
Premium pasture mix[3]	1.90	1.58	0.49	3.98	2.82	5.48	3.10	6.08	21.45
Average	1.71	1.69	0.43	3.83	3.17	5.02	3.58	6.47	22.08
LSD (0.05)	0.37	0.28	0.13	0.64	0.90	0.98	0.91	1.50	4.29
CV (%)	15.5	11.4	21.1	11.9	19.9	13.8	17.9	16.3	13.8

[1]Yields were calculated on an air-dry basis.

[2]Economy pasture mix consisted of 35% ‘Potomac’ orchardgrass, 25% ‘Fawn’ tall fescue, 20% ‘Lincoln’ smooth brome, and 20% tetraploid perennial ryegrass.

[3]Premium pasture mix consisted of 30% ‘Regar’ meadowbrome, 25% ‘Dawn’ orchardgrass, 25% ‘Potomac’ orchardgrass, and 20% tetraploid perennial ryegrass.

FORAGE QUALITY OF PASTURE GRASS SPECIES AT FRUITA, COLORADO

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist

Summary and Recommendations

Forage quality is an important consideration when determining how to best utilize forages. Forage quality of sixteen grass entries were determined from cuttings in 1996, 1997, and 1999. Generally, in most cuttings in 1996, 'Lincoln' smooth brome, 'Manchar' smooth brome, and 'Climax' timothy had high digestibility and crude protein. 'Oahe' intermediate wheatgrass had high digestibility in all three cuttings in 1996. 'Blackwell' switchgrass had low digestibility and crude protein in most cuttings in 1996. The most consistent response in the 1997 and 1999 cuttings was the poor quality exhibited by 'Blackwell' switchgrass. 'Regar' meadow brome and 'Bozoisky-Select' Russian wildrye also exhibited poor forage quality characteristics in most cuttings. 'Climax' timothy, 'RS-H' experimental, 'Newhy' hybrid wheatgrass, 'Palaton' reed canarygrass, and 'Oahe' intermediate wheatgrass showed a trend toward better forage quality than many other grasses. Other grass entries had variable responses to forage quality characteristics, depending on the cutting. All grass species received the same management and were harvested at the same time in our study. There were significant differences among grass species in the cuttings evaluated, yet there was no consistent responses among many entries across cuttings. This is interpreted to mean these grasses are sufficiently diverse that specific managements are likely needed to obtain optimum forage quality for individual grass entries. Other have recognized this finding, but specific managements for optimum performance of individual grass species have not been thoroughly determined for many grass species.

Introduction and Objectives

The yield of a forage species is an important aspect of forage production. The quality of a forage species is also important consideration when determining how to best utilize forages. A pasture grass species evaluation study was planted in spring 1994 and forage yields have been obtained for five years beginning in 1995. Forage quality analysis of the sixteen grass entries was determined from samples obtained in 1996, 1997, and 1999. The objective of this research was to determine forage quality periodically of the sixteen grass species as forage yields were collected over the years.

Materials and Methods

This study was conducted at the Colorado State University Western Colorado Research Center at Fruita. The experiment is a randomized complete block with four replications. The soil is a Glenton very fine sandy loam. The elevation at Fruita is 4510 feet. The average annual precipitation 8.4 inches and the average frost-free days is 181 days. The last spring frost occurred on April 17, 1999 and the first fall frost occurred on October 17, 1999, thus, the 1999 frost-free days was 183 days (28EF base). The plots were planted on April 22, 1994. Fertilizer applications during 1999 were 50 lbs N/acre as ammonium nitrate applied on March 3, 1999 and 55 lbs N/acre as ammonium nitrate applied on August 31, 1999. Plots have been fertilized regularly each year and furrow-irrigated as needed during each growing season.

As plots were harvested for yield, a subsample was taken for moisture determination. After moistures were determined, samples were oven-dried at 50 ^{N}C and then ground in a Wiley Mill. Samples remained frozen until forage quality analysis was conducted. Samples from 1996 were analyzed for digestibility and crude protein by Dr. Joe Brummer at the Mountain Meadow Research Center at Gunnison, Colorado. The samples obtained during 1997 and 1999 were analyzed by Dr. Rod Hintz (1997 samples) and Susan Selman (1999 samples) at the W-L Research laboratory at Evansville, Wisconsin using wet chemistry procedures.

Results and Discussion

Data for forage yields, digestibility, and crude protein of the sixteen grass entries for the first, second, and third cuttings in 1996 are shown in Tables 1, 2, and 3, respectively. Generally, in most cuttings, 'Lincoln' smooth brome, 'Manchar' smooth brome, and 'Climax' timothy had high digestibility and crude protein. 'Oahe' intermediate wheatgrass had high digestibility in all three cuttings in 1996. 'Blackwell' switchgrass had low digestibility and crude protein in most cuttings in 1996. Other grass species showed mixed responses to forage quality, depending on the cutting.

Data for neutral detergent fiber, acid detergent fiber, lignin, in vitro true digestibility, cell wall digestibility, digestible dry matter, dry matter intake, and relative feed value of sixteen grass entries for the second and third cuttings in 1997 are shown in Tables 4 and 5, respectively. Data for neutral detergent fiber, acid detergent fiber, lignin, in vitro true digestibility, cell wall digestibility, digestible dry matter, dry matter intake, and relative feed value of sixteen grass entries for the first, second, and third cuttings in 1999 are shown in Tables 6, 7, and 8, respectively. Generally speaking, forage quality differed by cutting. Each of the quality characteristics in the two cuttings evaluated in 1997 and the three cuttings evaluated in 1999 had significant differences among the sixteen grass species. However, a consistent response in forage quality among grass entries in the 1997 and 1999 cuttings was not apparent. The most consistent response was the poor quality exhibited by ‘Blackwell’ switchgrass. ‘Regar’ meadow brome and ‘Bozoisky-Select’ Russian wildrye also exhibited poor forage quality characteristics in most cuttings. ‘Climax’ timothy, ‘RS-H’ experimental, ‘Newhy’ hybrid wheatgrass, ‘Palaton’ reed canarygrass, and ‘Oahe’ intermediate wheatgrass showed a trend toward better forage quality than many other grasses. Other grass entries had variable responses to forage quality characteristics, depending on the cutting.

All grass species received the same management and were harvested at the same time in our study. There were significant differences among grass species in the cuttings evaluated, yet there was no consistent responses among the entries across cuttings. This is interpreted to mean these grasses are sufficiently different that specific managements are likely needed to obtain optimum forage quality for each grass entry. Other researchers have recognized this finding, but identifying specific managements that are needed for optimum performance of individual grass species is not well known or understood.

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Table 1. Forage yield, digestibility, and crude protein for the first cutting of sixteen grass entries at the Colorado State University, Western Colorado Research Center at Fruita in 1996.

Pasture grass	Forage yield	Digestibility	Crude protein
	tons/acre	%	%
‘RS-H’ experimental	1.16	77.7	12.4
‘Newhy’ hybrid wheatgrass	1.63	76.9	11.9
‘Regar’ meadow brome	1.40	77.7	11.2
‘Lincoln’ smooth brome	0.99	78.7	12.5
‘Manchar’ smooth brome	0.94	79.6	12.6
‘Potomac’ orchardgrass	1.26	75.1	10.6
‘Latar’ orchardgrass	0.59	77.6	12.7
‘Luna’ pubescent wheatgrass	1.39	77.7	10.6
‘Climax’ timothy	0.75	80.3	13.7
‘Bozoisky-Select’ Russian wildrye	1.00	76.9	10.1
‘Fawn’ tall fescue	1.58	76.1	11.0
‘Palaton’ reed canarygrass	0.38	76.3	13.6
‘Blackwell’ switchgrass	0.52	77.8	11.2
‘Oahe’ intermediate wheatgrass	1.17	78.8	10.6
Economy pasture mix[1]	0.99	75.4	11.2
Premium pasture mix[2]	0.86	77.0	11.0
Average	1.04	77.5	11.7
LSD (0.05)	0.38	1.9	1.2
CV (%)	26.1	1.7	7.0

[1]Economy pasture mix consisted of 35% ‘Potomac’ orchardgrass, 25% ‘Fawn’ tall fescue, 20% ‘Lincoln’ smooth brome, and 20% tetraploid perennial ryegrass.
[2]Premium pasture mix consisted of 30% ‘Regar’ meadowbrome, 25% ‘Dawn’ orchardgrass, 25% ‘Potomac’ orchardgrass, and 20% tetraploid perennial ryegrass.

Table 2. Forage yield, digestibility, and crude protein for the second cutting of sixteen grass entries at the Colorado State University, Western Colorado Research Center at Fruita in 1996.

Pasture grass	Forage yield	Digestibility	Crude protein
	tons/acre	%	%
'RS-H' experimental	0.99	67.8	10.8
'Newhy' hybrid wheatgrass	0.79	69.4	11.1
'Regar' meadow brome	1.14	71.1	10.8
'Lincoln' smooth brome	0.76	69.9	12.0
'Manchar' smooth brome	0.83	72.0	12.2
'Potomac' orchardgrass	0.98	65.2	10.2
'Latar' orchardgrass	1.33	68.7	9.2
'Luna' pubescent wheatgrass	1.32	68.4	9.1
'Climax' timothy	1.76	72.4	9.7
'Bozoisky-Select' Russian wildrye	0.62	71.8	12.1
'Fawn' tall fescue	1.22	69.0	9.2
'Palaton' reed canarygrass	1.02	65.7	10.5
'Blackwell' switchgrass	2.44	63.2	7.2
'Oahe' intermediate wheatgrass	1.38	70.5	9.0
Economy pasture mix[1]	1.14	68.0	9.5
Premium pasture mix[2]	1.04	66.8	10.6
Average	1.17	68.7	10.2
LSD (0.05)	0.32	3.1	1.3
CV (%)	19.1	3.2	8.9

[1]Economy pasture mix consisted of 35% 'Potomac' orchardgrass, 25% 'Fawn' tall fescue, 20% 'Lincoln' smooth brome, and 20% tetraploid perennial ryegrass.
[2]Premium pasture mix consisted of 30% 'Regar' meadowbrome, 25% 'Dawn' orchardgrass, 25% 'Potomac' orchardgrass, and 20% tetraploid perennial ryegrass.

Table 3. Forage yield, digestibility, and crude protein for the third cutting of sixteen grass entries at the Colorado State University, Western Colorado Research Center at Fruita in 1996.

Pasture grass	Forage yield	Digestibility	Crude protein
	tons/acre	%	%
‘RS-H’ experimental	1.22	67.5	9.2
‘Newhy’ hybrid wheatgrass	1.26	67.7	9.9
‘Regar’ meadow brome	1.46	67.8	8.2
‘Lincoln’ smooth brome	1.04	71.1	10.8
‘Manchar’ smooth brome	1.43	70.0	9.8
‘Potomac’ orchardgrass	1.10	65.9	9.7
‘Latar’ orchardgrass	1.13	67.6	8.8
‘Luna’ pubescent wheatgrass	1.09	67.7	8.9
‘Climax’ timothy	0.75	72.0	11.2
‘Bozoisky-Select’ Russian wildrye	0.96	67.1	10.0
‘Fawn’ tall fescue	1.54	66.4	8.5
‘Palaton’ reed canarygrass	1.19	66.8	8.7
‘Blackwell’ switchgrass	2.38	61.7	7.5
‘Oahe’ intermediate wheatgrass	0.78	70.8	10.1
Economy pasture mix[1]	1.22	68.2	8.8
Premium pasture mix[2]	1.05	67.8	9.6
Average	1.22	67.9	9.4
LSD (0.05)	0.34	2.5	1.3
CV (%)	19.3	2.5	10.0

[1]Economy pasture mix consisted of 35% ‘Potomac’ orchardgrass, 25% ‘Fawn’ tall fescue, 20% ‘Lincoln’ smooth brome, and 20% tetraploid perennial ryegrass.
[2]Premium pasture mix consisted of 30% ‘Regar’ meadowbrome, 25% ‘Dawn’ orchardgrass, 25% ‘Potomac’ orchardgrass, and 20% tetraploid perennial ryegrass.

Table 4. Forage quality for the second cutting of sixteen grass entries at the Colorado State University, Western Colorado Research Center at Fruita in 1997.

Pasture grass	Neutral detergent fiber	Acid detergent fiber	Lignin	In vitro true digestibility	ADFD	Digestible dry matter	Dry matter intake	Relative feed value
	%	%	%	%	%			
‘RS-H’ experimental	59.0	32.6	3.8	67.7	44.8	63.5	2.04	100.8
‘Newhy’ hybrid wheatgrass	57.6	31.6	3.9	68.7	45.0	64.3	2.08	103.9
‘Regar’ meadow brome	64.8	38.3	5.7	69.5	52.8	59.1	1.86	84.9
‘Lincoln’ smooth brome	57.9	33.2	4.7	76.5	60.2	63.0	2.08	101.4
‘Manchar’ smooth brome	56.7	32.1	3.5	72.4	50.7	63.8	2.12	104.9
‘Potomac’ orchardgrass	58.3	32.0	2.3	73.8	54.5	63.9	2.06	102.2
‘Latar’ orchardgrass	61.9	35.7	2.8	73.8	59.1	61.1	1.94	92.1
‘Luna’ pubescent wheatgrass	58.6	33.0	4.6	75.4	61.0	63.2	2.05	100.5
‘Climax’ timothy	60.0	33.8	3.9	68.3	47.1	62.5	2.00	97.0
‘Bozoisky-Select’ Russian wildrye	61.9	33.8	4.0	71.4	52.8	62.6	1.94	94.2
‘Fawn’ tall fescue	60.4	32.5	2.9	66.6	48.2	63.6	1.99	97.9
‘Palaton’ reed canarygrass	62.7	34.0	3.5	64.4	42.5	62.4	1.92	93.0
‘Blackwell’ switchgrass	70.7	39.2	3.4	58.9	41.8	58.4	1.70	76.8
‘Oahe’ intermediate wheatgrass	59.0	33.5	3.7	72.3	54.1	63.0	2.04	99.7
Economy pasture mix[1]	59.0	32.5	3.8	71.4	53.5	63.6	2.04	100.3
Premium pasture mix[2]	57.7	32.2	2.6	74.4	56.6	63.8	2.08	103.1
Average	60.4	33.7	3.7	70.3	51.5	62.6	2.00	97.0
LSD (0.05)	3.0	2.2	2.1	4.2	7.4	1.7	0.10	7.2
CV (%)	3.5	4.6	39.7	4.2	10.1	1.9	3.4	5.2

[1]Economy pasture mix consisted of 35% ‘Potomac’ orchardgrass, 25% ‘Fawn’ tall fescue, 20% ‘Lincoln’ smooth brome, and 20% tetraploid perennial ryegrass.
[2]Premium pasture mix consisted of 30% ‘Regar’ meadowbrome, 25% ‘Dawn’ orchardgrass, 25% ‘Potomac’ orchardgrass, and 20% tetraploid perennial ryegrass.

Table 5. Forage quality for the third cutting of sixteen grass entries at the Colorado State University, Western Colorado Research Center at Fruita in 1997.

Pasture grass	Neutral detergent fiber	Acid detergent fiber	Lignin	In vitro true digestibility	ADFD	Digestible dry matter	Dry matter intake	Relative feed value
	%	%	%	%	%			
‘RS-H’ experimental	58.5	33.1	3.5	71.8	51.9	63.1	2.06	100.5
‘Newhy’ hybrid wheatgrass	59.0	33.6	5.4	69.0	49.3	62.7	2.04	98.9
‘Regar’ meadow brome	60.9	37.0	4.9	70.0	50.4	60.1	1.97	91.9
‘Lincoln’ smooth brome	58.3	33.6	3.8	70.7	50.3	62.7	2.07	100.6
‘Manchar’ smooth brome	57.3	33.2	3.4	70.4	48.3	63.0	2.10	102.6
‘Potomac’ orchardgrass	60.7	33.6	3.3	68.1	46.4	62.7	1.98	96.1
‘Latar’ orchardgrass	59.9	34.2	2.6	72.9	53.9	62.2	2.01	96.7
‘Luna’ pubescent wheatgrass	57.9	33.8	5.0	72.5	54.8	62.6	2.09	101.4
‘Climax’ timothy	56.8	31.2	2.8	71.9	51.2	64.6	2.12	106.1
‘Bozoisky-Select’ Russian wildrye	63.9	36.6	5.2	64.7	44.3	60.4	1.88	88.1
‘Fawn’ tall fescue	59.9	31.9	2.1	67.7	47.9	64.1	2.01	99.7
‘Palaton’ reed canarygrass	52.8	28.3	3.3	67.5	37.1	66.8	2.28	117.9
‘Blackwell’ switchgrass	60.2	34.6	3.7	65.3	44.6	62.0	2.00	96.2
‘Oahe’ intermediate wheatgrass	57.8	33.4	3.5	69.4	47.4	62.9	2.08	101.6
Economy pasture mix[1]	58.4	32.4	2.2	70.8	51.0	63.7	2.06	101.4
Premium pasture mix[2]	60.4	34.7	3.1	70.8	52.4	61.9	1.99	95.3
Average	58.9	33.4	3.6	69.6	48.8	62.8	2.04	99.7
LSD (0.05)	3.5	2.0	1.9	3.6	6.0	1.6	0.13	8.5
CV (%)	4.2	4.3	37.9	3.6	8.7	1.8	4.4	6.0

[1]Economy pasture mix consisted of 35% ‘Potomac’ orchardgrass, 25% ‘Fawn’ tall fescue, 20% ‘Lincoln’ smooth brome, and 20% tetraploid perennial ryegrass.

[2]Premium pasture mix consisted of 30% ‘Regar’ meadowbrome, 25% ‘Dawn’ orchardgrass, 25% ‘Potomac’ orchardgrass, and 20% tetraploid perennial ryegrass.

Table 6. Forage quality for the first cutting of sixteen grass entries at the Colorado State University, Western Colorado Research Center at Fruita in 1999.

Pasture grass	Neutral detergent fiber	Acid detergent fiber	Lignin	In vitro true digestibility	Cell wall digestibility	Digestible dry matter	Dry matter intake	Relative feed value
	%	%	%	%	%			
'RS-H' experimental	62.4	31.6	1.4	75.6	61.0	64.3	1.94	97.2
'Newhy' hybrid wheatgrass	67.5	34.7	1.8	71.9	58.5	61.8	1.78	85.3
'Regar' meadow brome	72.6	39.6	2.4	64.5	51.1	58.0	1.65	74.4
'Lincoln' smooth brome	67.2	34.2	2.0	72.8	60.1	62.3	1.80	86.8
'Manchar' smooth brome	68.6	35.3	2.0	67.4	52.4	61.4	1.75	83.2
'Potomac' orchardgrass	70.7	36.3	1.8	63.3	48.2	60.6	1.70	79.9
'Latar' orchardgrass	69.0	33.8	1.4	70.8	58.0	62.6	1.74	84.4
'Luna' pubescent wheatgrass	67.6	34.5	1.6	73.1	60.1	62.0	1.78	85.4
'Climax' timothy	66.3	31.2	1.0	80.5	70.7	64.6	1.81	90.7
'Bozoisky-Select' Russian wildrye	70.0	35.4	2.2	69.2	56.0	61.3	1.72	81.6
'Fawn' tall fescue	67.0	34.4	1.8	65.4	48.4	62.2	1.80	86.4
'Palaton' reed canarygrass	69.1	31.9	0.8	73.6	61.8	64.0	1.74	86.4
'Blackwell' switchgrass	68.6	32.9	1.2	76.9	66.2	63.3	1.75	85.8
'Oahe' intermediate wheatgrass	67.1	33.6	1.4	75.7	64.0	62.7	1.79	87.1
Economy pasture mix[1]	67.0	34.4	1.4	68.4	52.9	62.1	1.80	86.4
Premium pasture mix[2]	71.4	37.7	2.4	65.4	51.6	59.5	1.68	77.6
Average	68.2	34.4	1.7	70.9	57.6	62.0	1.76	84.9
LSD (0.05)	3.8	3.2	0.8	6.2	8.1	2.5	0.11	8.5
CV (%)	3.9	6.6	34.8	6.2	9.8	2.8	4.5	7.0

[1]Economy pasture mix consisted of 35% 'Potomac' orchardgrass, 25% 'Fawn' tall fescue, 20% 'Lincoln' smooth brome, and 20% tetraploid perennial ryegrass.
[2]Premium pasture mix consisted of 30% 'Regar' meadowbrome, 25% 'Dawn' orchardgrass, 25% 'Potomac' orchardgrass, and 20% tetraploid perennial ryegrass.

Table 7. Forage quality for the second cutting of sixteen grass entries at the Colorado State University, Western Colorado Research Center at Fruita in 1999.

Pasture grass	Neutral detergent fiber	Acid detergent fiber	Lignin	In vitro true digestibility	Cell wall digestibility	Digestible dry matter	Dry matter intake	Relative feed value
	%	%	%	%	%			
‘RS-H’ experimental	61.2	30.2	1.9	78.6	65.1	65.4	1.97	99.6
‘Newhy’ hybrid wheatgrass	60.7	30.1	2.0	79.6	66.4	65.5	1.98	100.6
‘Regar’ meadow brome	65.9	35.4	1.5	78.1	66.8	61.4	1.82	86.6
‘Lincoln’ smooth brome	66.9	34.2	2.7	74.0	62.0	62.3	1.81	87.5
‘Manchar’ smooth brome	61.4	30.1	1.4	80.4	68.1	65.4	1.96	99.1
‘Potomac’ orchardgrass	64.2	32.8	1.6	78.1	66.0	63.4	1.89	92.6
‘Latar’ orchardgrass	65.9	33.3	1.0	78.4	67.3	63.0	1.83	89.1
‘Luna’ pubescent wheatgrass	65.4	33.0	1.6	76.5	64.3	63.2	1.84	90.3
‘Climax’ timothy	64.2	31.1	1.7	80.7	70.0	64.7	1.87	94.2
‘Bozoisky-Select’ Russian wildrye	65.7	32.5	2.6	74.8	61.6	63.5	1.83	90.1
‘Fawn’ tall fescue	65.4	29.7	0.8	76.5	64.1	65.8	1.84	93.6
‘Palaton’ reed canarygrass	60.6	28.2	1.9	73.3	56.8	66.9	2.00	104.1
‘Blackwell’ switchgrass	73.7	40.3	3.7	61.9	48.6	57.5	1.63	73.0
‘Oahe’ intermediate wheatgrass	65.3	32.2	1.7	78.6	67.4	63.9	1.84	91.3
Economy pasture mix[1]	65.8	31.4	1.5	74.6	61.6	64.4	1.83	91.7
Premium pasture mix[2]	67.0	33.4	2.0	75.6	63.5	62.9	1.79	87.4
Average	64.9	32.4	1.8	76.2	63.7	63.7	1.86	91.9
LSD (0.05)	5.6	3.0	0.9	7.6	8.6	2.4	0.17	11.1
CV (%)	6.1	6.6	35.8	7.0	9.5	2.6	6.5	8.5

[1]Economy pasture mix consisted of 35% ‘Potomac’ orchardgrass, 25% ‘Fawn’ tall fescue, 20% ‘Lincoln’ smooth brome, and 20% tetraploid perennial ryegrass.
[2]Premium pasture mix consisted of 30% ‘Regar’ meadowbrome, 25% ‘Dawn’ orchardgrass, 25% ‘Potomac’ orchardgrass, and 20% tetraploid perennial ryegrass.

Table 8. Forage quality for the third cutting of sixteen grass entries at the Colorado State University, Western Colorado Research Center at Fruita in 1999.

Pasture grass	Neutral detergent fiber	Acid detergent fiber	Lignin	In vitro true digestibility	Cell wall digestibility	Digestible dry matter	Dry matter intake	Relative feed value
	%	%	%	%	%			
'RS-H' experimental	49.0	21.1	1.1	89.9	79.2	72.4	2.46	138.0
'Newhy' hybrid wheatgrass	48.8	21.1	0.9	90.2	79.9	72.5	2.47	138.6
'Regar' meadow brome	52.0	24.6	1.1	89.9	80.6	69.7	2.31	124.9
'Lincoln' smooth brome	49.8	21.3	1.0	90.2	80.2	72.3	2.42	135.2
'Manchar' smooth brome	49.2	21.0	0.8	90.7	81.1	72.6	2.45	137.7
'Potomac' orchardgrass	51.6	21.4	0.9	89.4	79.4	72.2	2.33	130.4
'Latar' orchardgrass	50.2	21.1	0.6	91.0	82.0	72.5	2.40	134.7
'Luna' pubescent wheatgrass	49.7	21.9	1.1	90.7	81.3	71.9	2.42	134.8
'Climax' timothy	50.9	20.3	0.5	91.2	82.7	73.1	2.36	133.7
'Bozoisky-Select' Russian wildrye	53.4	23.2	0.9	89.4	80.3	70.8	2.25	123.8
'Fawn' tall fescue	52.3	22.8	0.7	87.9	76.7	71.2	2.30	126.6
'Palaton' reed canarygrass	48.4	19.6	0.8	90.3	79.9	73.7	2.48	141.6
'Blackwell' switchgrass	53.9	23.9	0.8	86.2	74.4	70.3	2.23	121.5
'Oahe' intermediate wheatgrass	47.4	22.0	1.0	91.0	80.8	71.8	2.54	141.6
Economy pasture mix[1]	52.5	22.4	0.3	89.7	80.4	71.4	2.29	126.6
Premium pasture mix[2]	51.2	21.9	0.7	90.4	81.2	71.8	2.34	130.5
Average	50.6	21.8	0.8	89.9	80.0	71.9	2.38	132.5
LSD (0.05)	2.6	1.1	0.6	1.4	2.7	0.9	0.13	8.0
CV (%)	3.6	3.7	52.2	1.1	2.4	0.9	3.7	4.3

[1]Economy pasture mix consisted of 35% 'Potomac' orchardgrass, 25% 'Fawn' tall fescue, 20% 'Lincoln' smooth brome, and 20% tetraploid perennial ryegrass.

[2]Premium pasture mix consisted of 30% 'Regar' meadowbrome, 25% 'Dawn' orchardgrass, 25% 'Potomac' orchardgrass, and 20% tetraploid perennial ryegrass.

CHEMICAL CONTROL OF HIGH PLAINS DISEASE IN SWEET CORN

Robert Hammon, Entomologist

Summary

The data generated from the 1999 experiment reaffirms the 1998 results that Furadan 4F, applied at a rate of 0.5 lb a.i./a, either in-furrow or side-dressed at planting is effective in controlling HPD in sweet corn. The data from this experiment do not show any benefit in the amount or term of HPD control from increasing the planting time rate from 1.2 fl oz/1000 ft to 2.5 fl oz/1000 ft. There was no benefit in HPD control in a split application, either side-dress or foliar. Disease pressure was extreme because of the experimental design, incorporating HPD vector/inoculum sources, and the use of a HPD susceptible sweet corn inbred.

Background

High Plains Disease (HPD) is a wheat curl mite (WCM) transmitted virus disease that affects wheat, corn, and sweet corn in Colorado. The greatest economic impact of HPD in western Colorado is on sweet corn, especially sweet corn grown for seed. The high value of the sweet corn crop, and production practices which require uniformity of maturity for harvest quality make even low level HPD infection economically significant in many cases. Research on the epidemiology of HPD was initiated in 1997, and a chemical control trial was done in 1998. Furadan 4F was the only insecticide tested in 1998 that gave acceptable control of the disease by controlling the WCM vector of the disease. Furadan 4F, applied in-furrow at planting at a rate of 0.5 lb a.i./a gave excellent control for 30 days, at which time HPD symptoms began appearing in a small percentage of the plants under extreme pressure from infected mites. It was decided to conduct an experiment to investigate rates and application methods of Furadan 4F to extend the period of protection against HPD infection.

The 1999 sweet corn experiment was designed to:

1) Determine if Furadan 4F applied at a rate of 1 lb a.i./a gives longer term control of HPD than Furadan 4F applied at a rate of 0.5 lb a.i./a.

2) Determine if there are differences between in-furrow and side-dress planting time applications of Furadan 4F in HPD control.

3) Determine if split applications of Furadan 4F (0.5 lb a.i./a + 0.5 lb a.i. @ 30 Days after planting (DAP) give longer term control of HPD than higher rates applied at planting.

Materials and Methods

The experiment was placed adjacent to an early-planted strip of wheat that was infested with WCM and HPD. A HPD susceptible sweet corn inbred used in hybrid seed production was planted on 2 June 1999 in plots at the Fruita Research Center (Mesa Co., CO). Individual plots were 10 ft. wide (4-30"rows) by 50 ft. long, and planted at a population of 20930 seeds per acre. Chemical treatments were:

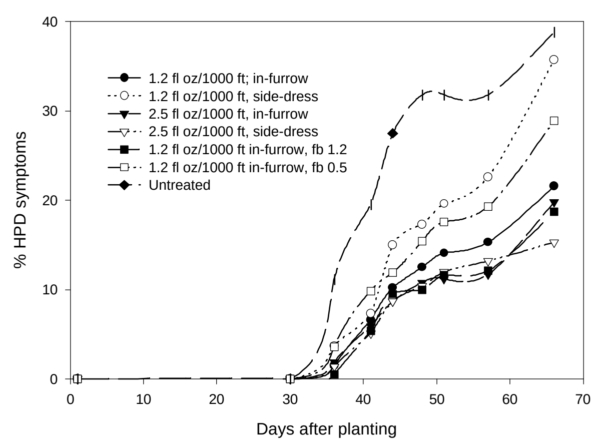

Figure 1. Percent HPD symptomatic plants for different treatments over time.

1) Furadan 4F 1.2 fl oz/1000 ft, in-furrow
2) Furadan 4F 1.2 fl oz/1000 ft, side-dress
3) Furadan 4F 2.5 fl oz/1000 ft, in furrow
4) Furadan 4F 2.5 fl oz/1000 ft, side-dress
5) Furadan 4F 1.2 fl oz/1000, in-furrow; fb Furadan 4F 1.2 fl oz/1000, side-dress @ 30 DAP
6) Furadan 4F 1.2 fl oz/1000, in-furrow; fb Furadan 4F 0.5 lb a.i./a, foliar @ 30 DAP
7) Untreated

In-furrow and side-dress treatments were applied with a CO_2 pressurized apparatus using a Redball® four row chemical manifold calibrated to apply 45 gal/a of mixture. The application setup was placed on a White® air-planter for in-furrow applications, and on a liquid fertilizer applicator for side-dress applications. Side-dress treatments were applied approximately four inches from the irrigated side of the seed row immediately after planting. The plots were furrow irrigated as soon as side dress applications were made. The foliar treatment was applied 26 DAP using a CO_2 pressured sprayer calibrated to apply 20 GPA through a 10 ft boom. The side-dress application on treatment #5 was also applied 26 DAP.

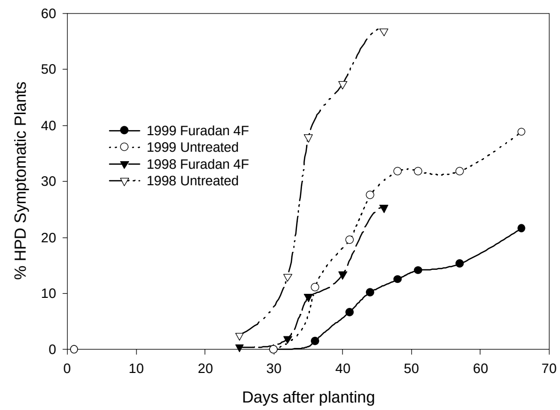

Figure 2. Comparison of 1998 and 1999 HPD symptom development in treated and untreated plots.

The plots were evaluated for HPD symptoms twice weekly after plant emergence. All plots were observed, and the number of plants showing typical HPD symptoms were recorded on each evaluation occasion. Percent HPD infection was calculated by dividing symptomatic plants by the total number of plants in each plot. Statistical analysis was conducted with MSTAT-C, and means separated with the LSD test.

Results

The percent HPD infection rate for each of the treatments and all evaluation dates is displayed in Figure 1, and are presented in Table 1. HPD symptoms did not appear in any plots until the 36 DAP evaluation. The untreated plots had significantly higher HPD infection rate than Furadan treated plots on all evaluation dates, although differences decreased later in the season. There were no differences between Furadan 4F application rates or placement on any of the evaluation dates.

The data generated from the 1999 experiment confirms the 1998 results that Furadan 4F, applied at a rate of 0.5 lb a.i./a, either in-furrow or side-dressed at planting is effective in controlling HPD. The data from this experiment do not show any benefit in the amount or term of HPD control from increasing the planting time rate from 1.2 fl oz/1000 ft to 2.5 fl oz/1000 ft. HPD control did not benefit from a split application, either side-dress or foliar. The disease pressure was much greater that would ever be experienced in a commercial planting because of the inoculum/vector strips of wheat planted adjacent to the sweet corn.

The timing of HPD symptom development was later in 1999 than in 1998. Figure 2 shows the symptom development in the untreated and Furadan 4F 1.2 fl oz/1000 ft in-furrow treatments in both years. Symptom development in untreated plots was delayed approximately 10 days in 1999. Overall HPD pressure was much lower in 1999.

The benefit of Furadan 4F applications in both years of experiments is expressed in two ways. The first is in suppression of HPD symptoms. There were significantly fewer HPD symptoms in Furadan 4F treated plots in both years. The second benefit is in the delay in symptom development. Furadan 4F treated plots had the first symptom expression seven to ten days later than untreated plots. This delay could translate to higher seed yield, as the earlier the symptoms develop, the more damage occurs.

Furadan 4F was used by many commercial and sweet corn seed growers during the 1999 season as part of an integrated pest management strategy. The HPD risk to a field was determined by variety, planting date, and the presence of winter annual grasses in the field vicinity. Fields determined to be high risk were treated at planting with Furadan 4F, with excellent control of HPD reported in all cases. The Furadan 4F was tank mixed with starter fertilizer and side-dressed in almost all cases.

Table 1. Results from the 1999 experiment. Means within a column followed by the same letter are not significantly different (á=0.05)

Treatment	Percent infestation						
	8 Jul	13 Jul	16 Jul	20 Jul	23 Jul	29 Jul	6 Aug
1.2 fl oz in-furrow	1.5 ab	6.6 a	10.2 a	12.5 a	14.1 a	15.3 a	21.7 ab
1.2 fl oz side-dress	3.7 b	7.3 a	15.0 a	17.3 a	19.6 a	22.6 ab	35.7 c
2.5 fl oz in-furrow	1.9 ab	5.9 a	8.7 a	10.8 a	11.2 a	11.7 a	19.8 ab
2.5 fl oz side-dress	1.4 ab	5.2 a	8.8 a	10.4 a	112.0 a	13.2 a	15.3 a
1.2 fl oz in furrow fb 1.2 fl side-dress	0.5 a	5.4 a	9.5 a	10.0 a	11.7 a	12.1 a	18.7 ab
1.2 fl oz in-furrow fb 0.5 lb/a foliar	3.6 b	9.8 a	11.9 a	15.4 a	17.6 a	19.3 a	28.9 bc
Untreated	11.1 c	19.5 b	27.2 b	31.8 b	31.8 b	31.8 b	38.8c
LSD	2.8	8.6	10.2	11.8	11.9	11.2	10.9

YIELD IMPACT AND CONTROL OF CORN EARWORM ON FIELD CORN WITH *Bt* MODIFIED CORN VARIETIES

Robert Hammon, Entomologist

Summary

Two traditional corn varieties and their counterparts which were genetically modified to produce the *Bacillus thuringensis* (*Bt*) protein that is toxic to lepidoptera larvae (Yieldgard®) were grown at the Fruita Research Center in an attempt to determine their activity against corn earworm. A related experiment used chemical control to determine the extent of yield loss that could be attributed to corn earworm under western Colorado conditions. Corn earworm abundance was very low during the 1999 growing season, which resulted no measurable effect of corn earworm on yield of non *Bt* varieties during the 1999 growing season. The experiment designed to determine if the *Bt* modified varieties impacted corn earworm populations showed an effect on percent earworm infestation and the amount of earworm feeding damage per ear. Yieldgard® modified corn varieties had fewer damaged ears, and less feeding damage per damaged ear than their unmodified counterparts. Yieldgard® performed differently in the two genetic backgrounds, but both were better than the unmodified varieties. Initial results show there may be benefits of using Yieldgard® modified corn varieties in years with high corn earworm populations.

Background

Corn varieties modified to include an insecticidal protein produced by the bacterium *Bacillus thuringensis* subsp. *kurstaki* have gained widespread use throughout parts of the world in the past few years. The insecticidal properties of these modified corn varieties are limited to controlling the larvae of most Lepidoptera (moths and butterflies). Several different modifications using the same gene, known as events, have been made by different companies. Monsanto Co. has produced an event (Mon 810) that utilizes the Cry1A protein produced by *Bt*, which has been marketed as Yieldgard®.

The primary target pest of *Bt* modified corn varieties in the Midwest and Great Plains has been European corn borer, *Ostrina nubialis*. First generation European corn borers feed on corn leaves before boring into stems. Second and third generation corn borers feed within stems and on ears. Yieldgard® and other *Bt* modified corns have performed well against European corn borers. European corn borers are not present in western Colorado. Corn earworm, *Helicoverpa zea*, is the major lepidopteran pest of corn in western Colorado. This insect is primarily a late season pest that feeds on developing ears and corn kernels. Corn earworm can reach very high infestation levels in many years in western Colorado. In severe infestation years, earworm can be found on 90% of the ears within a field. There has been limited research regarding the use of *Bt* modified corn varieties on corn earworm. In the research that has been done, Yieldgard® has performed well.

Experiments were designed in 1999 to address two aspects of corn earworm control with Yieldgard® modified corn varieties. The two research questions that were addressed were:

1) What is the yield impact of corn earworm on corn grown under Grand Valley conditions? (Yield experiment)

2) Is Yieldgard® effective in controlling corn earworm? (Benefit experiment)

Methods

Two experiments were designed and planted at the Fruita Research Center. They are referred to as the Yield and Benefit experiments.

Yield experiment: A block of a bulk planting of ‘GVX 9258' was selected for the experimental area. Plots measuring 5 ft x 50 ft were flagged out early in the season. One half of the plots were treated weekly, beginning at silking, with Warrior T (3.84 fl oz/a) to control corn earworm. The plots were arranged as a randomized complete block with fifteen replications. Insecticides were applied with a hand held CO_2 pressured sprayer with two nozzles arranged to place insecticide on the ears of corn in two adjacent rows. The sprayer was calibrated to apply 15 gal/a of spray material. There was no sampling other than harvest for yield, moisture and test weight.

Benefit experiment: Two corn hybrids and their Yieldgard® modified counterparts were planted in an experiment designed as a randomized complete block with six replications. The corn was allowed to grow, and was not treated with any insecticide other than those used for spider mite control. These miticides were applied before ear formation, and had no effect on corn earworm populations. The individual plots were 10 ft x 50 ft. Each four row plot was divided in half, with two rows designated for destructive sampling and the other two rows for harvest. The rows designated for destructive sampling were evaluated on 8 Sep 1999 by choosing 25 random ears per plot, recording the number of damaged ears, and measuring the total corn earworm feeding galley length on those ears with damage. The rows designated for harvest were left untouched until harvest, when yield, moisture and test weight were measured.

Common treatment of both experiments: The corn was planted on 12 May 1999, in the east half of a field located on the SW corner of the Fruita Research Center (NE corner of 19 & L Rds). All corn was seeded at a population of 31410 seeds per acre. The field was fertilized with 200 #/a of 18-46-0 incorporated on 6 May, followed by 180 #/a N (32-0-0) side dressed as a split application on each side of the plant on 22 June. Weeds were controlled with Bladex 4l applied on 11 May, followed by two mechanical cultivations. Spider mites were controlled with a ground application of Dimethoate (1 pt/a) on 21 June, followed by an aerial application of Comite II (2 1/4 pt/a) on 18 July. The field was furrow irrigated 8 times during the season. The plots were harvested on 26 Oct, with a modified Gleaner combine with on board scales. Test weight and moisture were measured in the laboratory from samples taken from each plot at harvest.

Corn earworm moth flights were monitored with a cone type pheromone trap. Pheromone lures were changed every three weeks. The trap was checked daily, and the number of moths recorded.

Results

Corn earworm flights were extremely low during the 1999 growing season, as illustrated by comparison of past years trap captures in Figure 1. The average1999 capture was less than 1/3 that of any of the other years that data was available.

The yield effect experimental results are displayed in Table 1. There were no statistical differences between treated and untreated plots on corn yield, moisture or test weight recorded by the experiment.

Apparent differences in yield in the benefit experiment were not statistically significant, and independent of corn earworm activity. Any apparent differences in yield due to variety, Yieldgard® or the interaction of the two were not statistically significant due to variability in the data. The non Yieldgard® varieties had a statistically significant greater test weight than their Yieldgard® counterpart. The difference in test weight was not consistent between the two varieties, with non Yieldgard®

Figure 1. Average daily pheromone trap capture during July and August at the Fruita Research Center for all years that data is available.

GVH8937 having a greater test weight than its Yieldgard® counterpart, but the two GVH9258 varieties having statistically equal test weights. The non Yieldgard® varieties were harvested at a lower moisture than the Yieldgard® varieties, and the difference was statistically significant.

There were significant differences in corn earworm abundance and damage in the Yieldgard® and non Yieldgard® varieties. There were statistically fewer percent infested ears, and less feeding galley length in the Yieldgard® varieties compared with the non Yieldgard® counterparts. The difference was 23.3% infested versus 6.3% infested in the non Yieldgard® versus the Yieldgard® protected corn. Feeding galley length was an average of 1.42 inches in the non Yieldgard® versus 0.39 inches in the Yieldgard® varieties. There were significant differences between the two Yieldgard® varieties, with the Yieldgard® protected GVH9258 having fewer infested ears (2.0% vs 10.7%) than the Yieldgard® protected GVH8937. Average feeding galley length was 0.21 inches in the Yieldgard® GVH9258 and 0.57 inches in the Yieldgard® GVH8937, with that difference being statistically significant.

Several conclusions can be drawn from these experiments:

1) Corn earworm flights were much lower than in past years. The low corn earworm pressure minimized any yield effect of Yieldgard® technology during the 1999 growing season.

2) Yieldgard® technology is effective in reducing both infestation levels and feeding damage by corn earworm. This statement is strongly supported by the data.

3) The Yieldgard® gene performs differently in different genetic backgrounds. This statement is supported by the significant differences in percent infestation and feeding galley length between the two Yieldgard® protected varieties.

4) Yieldgard® may produce differences in agronomic qualities beyond protection against Lepidoptera pests. This is demonstrated by differences in test weight and moisture between the Yieldgard® and non Yieldgard® varieties.

5) The use of Yieldgard® protection would not have been justified during the 1999 growing season. Given the low corn earworm pressure during the growing season, further research is needed to quantify its effect during higher pressure growing seasons.

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Table 1. Results from yield effect experiment. Data values are average of fifteen replications. Statistical analysis was paired T-test, with á=0.05.

	Yield bu/a @15.5%	Test weight lb/bu	% moisture	Stand count
Treated	226.5	57.05	14.8	156.5
Untreated	221.4	56.6	15.1	158.8
P-value	0.696	0.668	0.458	0.270

Table 2. Results from the Yieldgard® benefit experiment. Values within a column grouping followed by the same letter are not significantly different (LSD, á=0.05).

Variety	*Bt*	Corn earworm		Yield bu/a @15.5 %	Test weight lb/bu	% moisture	Stand count
		% infested	galley length/ infested ear (inches)				
9258		14.3	0.89	196.4	56.5	15.0 a	152.3
8937		15.3	0.92	207.3	57.1	15.9 b	152.4
P-value		0.408	0.475	0.304	0.340	0.022	0.336
	N	23.3 a	1.42 a	208.3	57.2 a	15.0 a	159.0
	Y	6.3 b	0.39 b	195.4	56.4 b	15.9 b	145.8
P-value		<0.0001	<0.0001	0.228	0.023	0.039	0.060
9258	N	26.7 a	1.57 a	200.1	56.6 b	14.5	156.5
9258	Y	2.0 c	0.21 c	192.6	56.5 b	15.4	148.2
8937	N	20.0 a	1.27 a	216.4	57.9 a	15.5	161.5
8937	Y	10.7 b	0.57 b	198.1	56.2 b	16.3	143.3
P-value		0.007	0.01	0.607	0.030	0.771	0.462
LSD á=0.05		0.8	0.08		1.03		

CONTROL OF CORN EARWORM, *Heliothis zea*, WITH SPINOSAD AT ROGERS MESA RESEARCH CENTER, HOTCKISS, CO 1999

Rick Zimmerman and Bob Hammon

The sweet corn was planted into black plastic mulch on June 3. Irrigation water was applied using trickle tape (T-Tape, San Diego, CA). Four treatments were applied: 1) Spinosad (0.045 lb a.i./ ac) (Dow Agrisciences, Indianapolis, Ind), 2) Spinosad (0.067 lb a.i./ ac), 3) Spinosad (0.089 lb a.i./ ac), 4) Asana (0.05 lb a.i./ac) (a. i., 8.4% esfenvalerate) and a control. All treatments applied at equivalent of 20 gpa. Each treatment was replicated 5 times. Each replication was 12 ft wide X 35 ft. There were three rows of plastic mulch per plot (54 inches on center). Two rows of corn (18 inches apart) were planted into each row. Seed spacing was 8 inches in row. One line of T-Tape was placed beneath each plastic row. The plots were set up in a complete block design. Each plot was 12 ft X 175 ft. Each plot was split into 5 equal subplots, with each subplot representing one treatment replication. The sweet corn variety planted was *Zea mays* L. "Merlin". The Spinosad and Asana XL treatments were applied on August 6, 1999. There was only one application for both Spinosad and Asana XL.

Results

The number of infested corn ears was not significantly different between the Spinosad treatments and the control. The number of infested corn ears was significantly less in the Asana XL treated plots. As in the Fruita trials, one application is not sufficient for commercial control of corn earworm.

Table 1: Evaluation of 3 rates of Spinosad and 1 rate of Asana XL on corn earworm, *Heliothis zea* in sweetcorn, *Zea mays* L. var. "Merlin".

Treatment	Application date	Corn earworm
Spinosad (0.045 lb a.i./ ac)	August 6	31.2a[b]
Spinosad (0.067 lb a.i./ ac)	August 6	31.2a
Spinosad (0.089 lb a.i./ ac)	August 6	34.4a
Asana XL (0.05 lb a.i./ac)	August 6	9.2b
Control		41.6a

[a] Evaluated on August 28, 1999. 50 ears were picked from each plot (total 250 ears/treatment).
[b] Lower case letters in the same column, if different, denote significant differences ($P \leq 0.05$).

CONTROL OF CORN EARWORM, *Heliothis zea*, WITH SPINOSAD AT FRUITA RESEARCH CENTER, FRUITA, CO 1999

Rick Zimmerman and Bob Hammon

The sweetcorn plots were irrigated on a regular basis using furrow irrigation. Four treatments were applied: 1) Spinosad (0.045 lb a.i./ ac) (DowAgrisciences, Indianapolis, Ind), 2) Spinosad (0.067 lb a.i./ ac), 3) Spinosad (0.089 lb a.i./ ac), 4) Asana XL (0.05 lb a.i./ac) (a. i., 8.4% esfenvalerate) (DuPont Corp, Wilmington, DE) and a control. Spinosad treatments applied at 20 gpa. Asana XL applied at 15 gpa. Each treatment was replicated four times. Each replication was 4 rows wide (rows set on 30 in centers) X 35 ft long. Seed spacing was 8 inches in row. The sweetcorn variety planted was *Zea mays* L. var. "Spring Treat". The spinosad treatments were applied on July 12, 1999. The Spinosad treatments were applied only once. The Asana XL was applied on July 13 and July 19.

Results

The number of infested ears found in all three Spinosad rates was not significantly different than the control. The Asana XL resulted in signifcantly less earworm infestation than the control and Spinosad treated plots. One application of Spinosad is not sufficient for commercial control of corn earworm. Virtually, all of the sweetcorn produced in western Colorado is for fresh market. There is zero tolerance for insect damage. Additionally, the number corn ears infested with sap beetle, *Carpophilus lugubri*s M. (Nitidulidae:Coleoptera) was recorded.

Table 1: Evaluation of 3 rates of Spinosad and 1 rate of Asana XL (a. i., 8.4% esfenvalerate) on corn earworm, *Heliothis zea* in sweetcorn, *Zea mays* L. var. "Spring Treat".

Treatment	Application	Corn earworm	Sap beetle
Spinosad (0.045 lb a.i./ ac)	July 12, 1999	24a[b]	37a[b]
Spinosad (0.067 lb a.i./ ac)	July 12, 1999	13a	38a
Spinosad (0.089 lb a.i./ ac)	July 12, 1999	18.5a	46.5a
Asana XL (0.05 lb a.i./ac)	July 13, July 19	7.5b	45a
Control		13.5a	41a

[a] **Evaluated on July 27, 1999. 50 ears were picked from each plot (total 200 ears/treatment).**
[b] Lower case letters in the same column, if different, denote significant differences ($P \leq 0.05$).

NITROGEN MANAGEMENT UNDER NO-TILLAGE IN A FURROW-IRRIGATED CROP ROTATION OF CORN AND WHEAT IN WESTERN COLORADO

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SUMMARY AND RECOMMENDATIONS

A field experiment was conducted during 1996 and 1997 to evaluate N application rates and timings in a no-till, furrow-irrigated crop rotation of corn (*Zea mays* L.) and wheat (*Triticum aestivum* L.) in western Colorado. The data indicate that various N rate and timing applications can be applied under conservation tillage (CS) in a corn/wheat rotation with furrow irrigation needed to obtain economic yields without causing excessive NO_3-N leaching provided best management practices are used.

INTRODUCTION

Considerable research has been conducted on various aspects of CS under furrow-irrigated conditions (Carter et al., 1991). Yet, most farmers in furrow-irrigated areas of the U.S. have not readily adopted CS for a number of possible reasons (Ashraf et al., 1999). Developing CS for furrow-irrigated cropland has unique challenges that must be understood and overcome before CS will be used by farmers (Pearson, et al., 1998). Little research has been conducted to develop N management practices for CS on furrow-irrigated cropland. The objective of this research was to evaluate N application rates and timings under a no-till, furrow-irrigated crop rotation of corn and wheat in western Colorado.

MATERIALS AND METHODS

A field experiment was conducted during 1996 and 1997 at the Colorado State University Western Colorado Research Center at Fruita. The soil was Billings silty clay loam. The experiment was a randomized complete block design with four replications. Plot size was 9.1 m wide by 10.7 m long. Factorial treatments were four N application rates of 75, 150, 225, and 300 kg N ha^{-1} and three N application timings applied in a crop rotation of corn and wheat. A control treatment was also included in which no N fertilizer was applied. The three application timings were: 1) all N band-applied at planting, 2) 1/3 of the N band-applied at planting and the remaining 2/3 banded in the bottom of the irrigation furrow in wheat before the first node and side-dressed in corn 12 cm to the side of the corn row and 10 cm deep at the five- to seven-leaf stage, 3) all N banded post-emergence in wheat before first node and side-dressed in corn at the five- to seven-leaf stage of development. All treatments were applied to both crops. The corn phase of the rotation was corn (1994), spring wheat (1995), corn (1996), and winter wheat (1997). The wheat phase was spring wheat (1994), corn (1995), winter wheat (1996), and corn (1997).

The experiment was conducted under no-tillage, furrow-irrigated conditions. Conservation tillage crop production practices began by establishing a wheat/corn rotation in the designated plot areas by planting spring wheat on 28 April 1994 and Pioneer® brand corn hybrid 3394 on 27 April 1994. No N fertilizer was applied to wheat or corn in 1994. In 1995, all treatments were applied as per the protocol, and in 1996 and 1997 crop data were collected. After harvest of each crop, the residue was flailed and a Buffalo® no-till cultivator, equipped with ACRA-PLANT® trash tillers, was used to open and shape alternate 76-cm furrows. This operation moved residue out of the irrigation furrow to the top of the bed and somewhat across into the dry furrow. In the spring of each year prior to planting, annual weeds and volunteer wheat in corn plots were controlled by applying glyphosate. Bladex® and Prowl® were applied each year to corn as a broadcast overlay after planting but prior to seedling emergence. Harmony® and 2,4-D were applied for weed control each spring in winter wheat. An application of 98 kg P ha^{-1} was applied in the spring of 1996 and 1997 to corn plots only. Generally, irrigation furrows were shaped again after planting using the Buffalo® no-till cultivator equipped with ACRA-PLANT® trash tillers.

Soil was sampled to a depth of 0.9 m at 0.3 m increments each year (sampling #1- spring 1995, sampling #2 - spring 1996, sampling #3- spring 1997) and after harvest (sampling #4) in December 1997. Nitrate-nitrogen was determined by Hach colorimetric method 8152 using a DR/2000 spectrophotometer.

The experiment was irrigated in alternate, 76-cm furrows in both corn and wheat. The same irrigation furrows in wheat were used throughout the season. When corn was sufficiently tall, the dry furrow was cultivated to move residue from the bottom of the furrow to the top of the bed and around corn plants. For the remainder of the season, corn was irrigated by alternating irrigations between 76-cm furrows. Irrigations were applied as needed and were consistent with practices commonly used in western Colorado.

Winter wheat cv. Stephens was planted 15 Nov 1995 and 13 Nov 1996 and harvested 30 July 1996 and 12 Aug 1997. Wheat was planted at 134 kg ha^{-1} rate using a CS planter designed for use in furrow-irrigated conditions (Pearson et al., 1994). Pioneer® corn hybrid P3394 was planted 2 May 1996 and 6 May 1997 using a Buffalo® no-till planter. Corn was harvested on 24 Oct 1996 and 7 Nov 1997 using a research plot combine. Two, 76-cm rows 7.8 m long were harvested for grain yield for winter wheat and corn. Grain yields were corrected to 15.5% for corn and 12% for winter wheat. Fifty-stem samples were used to determine yield components in winter wheat.

Data for corn and wheat crop traits were analyzed as a randomized complete block, two-factor analysis of variance (without the control) with years as a repeated measure. Means were separated by LSD when the F-test was significant at the 5% level. Data for soil NO_3-N were analyzed separately by depth using SAS proc-mixed using the same model as crop traits.

RESULTS AND DISCUSSION

Generally, differences between years for corn and wheat for most plant traits were significant and year effects were often greater than reps, N rate, N application timing, and their interactions.

Corn grain yield, grain moisture, test weight, and 200-seed weight increased with increasing N rate (Table 1). Only corn grain moisture and test weight were affected significantly by application timing. There was a significant year x application timing interaction for grain yield. In 1997, grain yields responded similarly to N application timing. In 1996, application timings #1 and #3 were lower than timing #2. Corn plant and ear populations were not affected by either N rate or N application timing. The amount of corn residue produced was affected by N rate, but the response was not consistent across N rates beyond the initial increase at the 75 kg N ha^{-1} rate.

Generally, wheat grain yield increased, grain moisture and test weight decreased, kernels/spike increased, and weight/kernel decreased with increasing N rate (Table 2). Only test weight and harvest index were affected significantly by application timing. Year x N rate interactions occurred for both test weight and harvest index. Test weights were similar across N rates in 1997. In 1996, the test weight at the highest N rate was lower than those at the other rates. In 1996, harvest index was similar across N rates, but in 1997, harvest index generally decreased with increasing N rate. Surprisingly, N rate did not have a significant effect on the amount of wheat residue. This may be the result of the small areas used to obtain residue samples.

Soil NO_3-N levels were affected significantly by the main effects of N application timing, N rate, crop rotation, and year, with N rate having the largest effect and application timing having a small effect. As expected, soil NO_3-N increased as the amount of applied N increased. Averaged across other factors, NO_3-N at soil depth 0.6-0.9 m was 38% lower and at 0.3-0.6 m was 31% lower than at the upper soil depth (0-0.3 m). Nitrate-nitrogen levels were higher in the second sampling because the N banded at planting in 1995 adversely affected corn plant stands (data not shown). Average NO_3-N at sampling #4 was only slightly higher, 4 kg N ha^{-1} compared to the initial sampling, though this difference depended to a degree on depth and application timing. Meek et al. (1995) found that NO_3-N leaching was less under no-till than conventional tillage in their furrow-irrigated study.

Many of the two and three-way interactions with N application timing, N rate, sampling depth, crop rotation, and sampling time were smaller than main effects but were significant, with the exception of crop rotation x N rate. The four-way interaction of N application timing x crop rotation x N rate x year was not significant. These interactions indicated that application of N fertilizer in this cropping system was not straightforward (Fig. 1). The analysis also indicated that N rate is an important management consideration. Year effects can also have a big impact, particularly if problems occur with N applications as occurred during sampling #2. The wheat phase of the rotation had similar responses (data not shown) but without the dramatic effect from the application problem experienced in sampling #2 (Fig.1). Our data indicate that growers should be judicious in the N rate they choose when CS is used under furrow irrigation. Yet, our results also indicate that while N management should be carefully considered in furrow-irrigated, no-till cropping systems, as should be the case in any cropping system, growers can apply N rates with confidence using best management practices and expect the crop to respond readily without creating significant risk to the environment.

Weeds were scattered in the field and the area was not as weed-free as would be expected in clean-till fields, but weeds did not appear to have any adverse affects on crop yields. However, the control of perennial weeds under no-till, furrow-irrigated conditions is a concern. Field bindweed (*Convolvulus arvensis* L.) is likely the most widespread and severe perennial weed problem in cultivated conditions in western Colorado and its control should be conscientiously considered when crops are grown under long-term, no-till conditions.

Growing no-till winter wheat following corn presented challenges unrelated to N application. Because corn was grown with irrigation, considerable quantities of residue were produced. Such large quantities of residue created difficulty when planting winter wheat into corn residue. However, once the no-till planter was modified by staggering the gangs of seed openers the corn residue flowed readily through the planter. After making necessary equipment adjustments, planting became routine. Additionally, the large amount of surface corn residue made it difficult for wheat seedlings to emerge and this created problems obtaining a uniform plant stand. Also, if the soil was too wet the slot made by the seed opener did not close properly, leaving the seed exposed and without acceptable seed-to-soil contact. Planting wheat proceeded more smoothly when the soil and residue were dry. No problems were encountered when planting corn into the wheat residue.

Nitrogen leaching at the deeper soil depths increased slightly at the higher N rates. Choosing an N rate appropriate for a realistic yield goal and using best management practices should be a routine approach. A problem was encountered when N was banded too close to the seed and affected plants stands as occurred in 1995 when the treatments were being established. Thus, N not utilized by growing plants was subjected to increased leaching in subsequent years.

These data indicate that N rate and timing applications using CS in a corn/wheat rotation with furrow irrigation can be somewhat flexible without adversely affecting corn yields or creating environmental problems. Obtaining acceptable wheat yields under CS in furrow irrigation may be more a limitation of planting problems following corn than with difficulties related to N management.

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Table 1. Effect of nitrogen rate and application timing on corn grown at Fruita, Colorado under no-tillage conditions during 1996 and 1997.

	Grain yield	Grain moisture	Plant population	Ear population	Test weight	200-seed weight	Residue quantity
	kg/ha	g/kg	plants/ha	ears/ha	g/L	g	kg/ha
Year							
1996	12,059*	180*	75,934*	65,507*	724*	68.5	9,291*
1997	13,652	158	86,193	74,911	774	68.1	12,774
Nitrogen rate							
75	9,192	162	81,793	68,731	740	61.1	9,626
150	12,537	166	80,784	69,319	751	65.6	11,956
225	14,399	172	81,568	71,646	749	71.8	11,017
300	15,295	177	80,111	71,141	757	74.7	11,531
LSD (0.05)	726	31	NS	NS	8	2.0	1431
Nitrogen timing							
At planting	12,532	167	80,454	69,985	745	67.3	11,040
Split	13,270	168	80,643	70,384	755	69.1	10,672
Post-planting	12,765	172	82,094	70,258	747	68.5	11,385
LSD (0.05)	NS	3	NS	NS	7	NS	NS

*, significantly different between years at the 5% level of probability.

Table 2. Effect of nitrogen rate and application timing on winter wheat grown at Fruita, Colorado under no-tillage conditions averaged for two years (1996 and 1997).

	Grain yield	Grain moisture	Test weight	Harvest index	Kernels/ spike	Weight/ kernel	Residue quantity
	kg/ha	g/kg	g//L		no.	g	kg/ha
Year							
1996	8,521*	106	753*	0.48	24.7*	44.0*	5,556*
1997	4,495	108	702	0.50	33.6	36.6	9,291
Nitrogen rate							
75	5,178	110	731	0.51	26.6	42.0	7,023
150	6,362	107	732	0.49	28.0	41.7	8,140
225	7,167	107	728	0.50	29.8	40.5	7,352
300	7,326	104	720	0.47	32.2	36.9	7,179
LSD (0.05)	350	4	6	NS	2.5	2.4	NS
Nitrogen timing							
At planting	6,392	107	722	0.48	28.6	39.4	7,380
Split	6,570	106	731	0.48	28.8	39.8	7,384
Post-planting	6,562	108	729	0.51	30.1	41.7	7,507
LSD (0.05)	NS	NS	5	0.02	NS	NS	NS

*, significantly different between years at the 5% level of probability.

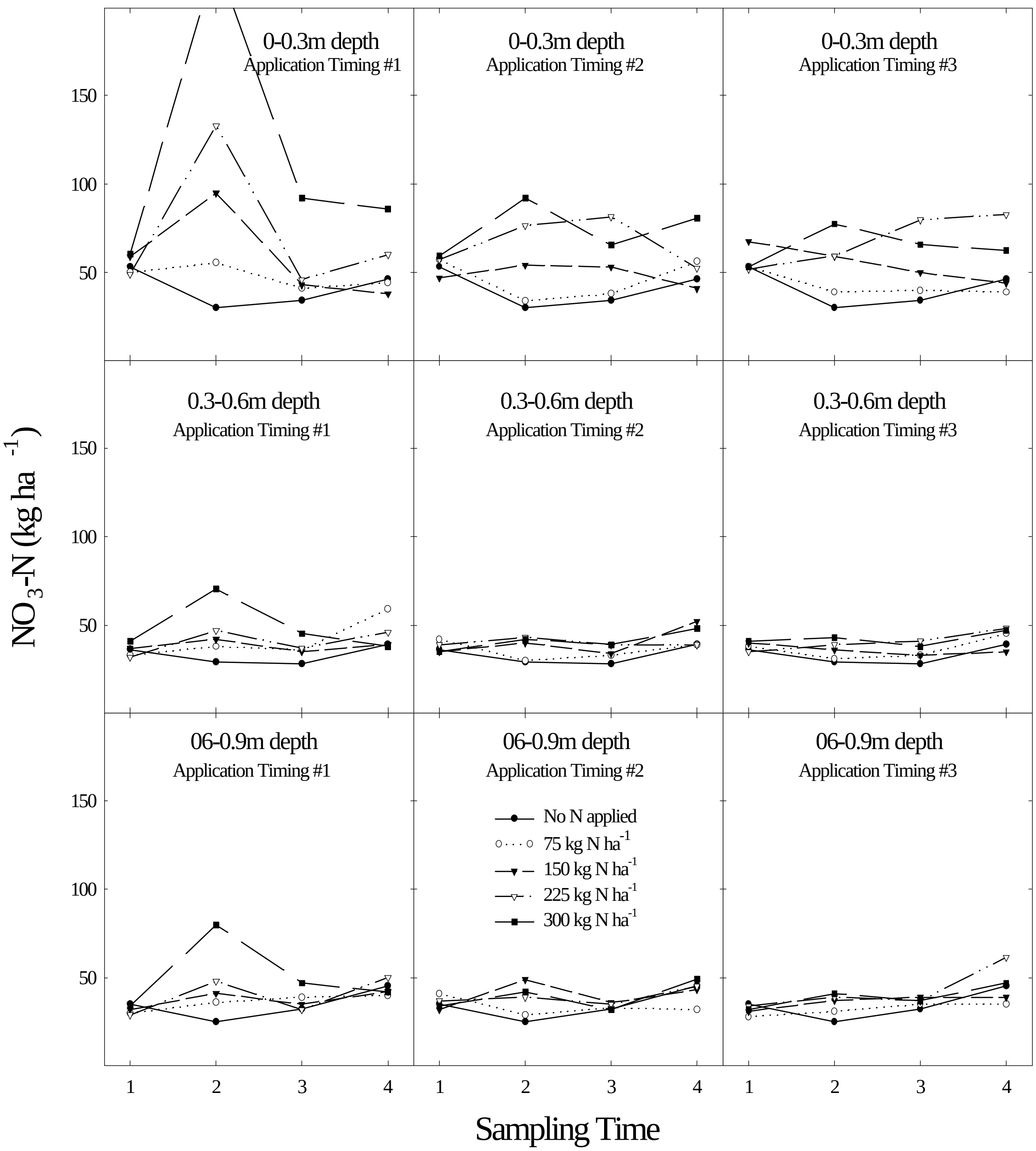

Fig. 1. Effect of soil depth, sampling time (year), N application timing, and N rate on soil NO_3-N at Fruita, Colorado.

CORN SILAGE HYBRID PERFORMANCE TESTS AT FRUITA AND OLATHE, COLORADO 1999

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist; Dr. Jerry J. Johnson, Extension Specialist Crop Production, CSU Fort Collins; and Cynthia L. Johnson, Research Associate, CSU Fort Collins

Summary and Recommendations

Fifteen and twelve corn hybrids were evaluated for silage production at Fruita and Olathe, Colorado during 1999, respectively. Forage production in the silage hybrid performance test at Fruita ranged from a high of 32.5 tons/acre for HYTEST HT7820 to a low of 20.6 tons/acre for Gutwein 2707. The test average at Fruita was 29.0 tons/acre. Forage production in the silage hybrid performance test at Olathe ranged from a high of 29.9 tons/acre for HYTEST HT7820 to a low of 25.2 tons/acre for Grand Valley GVX7937. The test average at Olathe was 27.6 tons/acre.

Introduction and Objectives

Corn hybrid performance tests are conducted by Colorado State University researchers to support corn growers, corn seed companies, breeding companies, and other agribusinesses. This information is collected using unbiased, scientific procedures and assists growers in selecting corn hybrids that will be productive on their farms. This corn hybrid performance information is also useful for seed companies to determine marketing strategies for their hybrids. Breeding companies also use the information in directing their breeding and development efforts. Additionally, other agribusinesses, such as fertilizer and consulting companies, use this information to be informed about new developments in the corn industry. These corn hybrid performance tests have been ongoing for many years and are a valued source of consistent and reputable information.

Corn hybrid entries in this test are selected and provided by seed companies. Participation in the corn hybrid performances tests is voluntary and open to any company that pays the evaluation fee for each hybrid they desire to be tested. These tests are conducted without discrimination or endorsement of any hybrid or company. The objectives are to evaluate corn hybrids grown for grain and determine grain yield and other important plant characteristics. Results of these tests are available to the public.

Materials and Methods

Corn Silage Hybrid Performance Test at Fruita

This study was conducted at the Colorado State University, Western Colorado Research Center at Fruita. The experiment was a randomized complete block with four replications. Plot size was 5-feet wide by 50-feet long. The soil was a Glenton very fine sandy loam. The previous crop was winter wheat. Planting occurred on May 13, 1999 and was seeded at 35,890 seeds/acre. Harvest occurred on September 13, 1999. Herbicide used for weed control was Bladex 4L herbicide applied PPI at 2 qts/acre on May 11, 1999. Fertilizer applied was 36 lbs N/acre and 112 lbs P_2O_5/acre preplant of 18-46-0 on May 6, 1999 and 180 lbs N/acre of 32-0-0 side-dress on June 22, 1999. To control spider mites, dimethoate insecticide (1pt/acre) was applied on June 21, 1999, Comite II (2.25 pt/acre) was applied on July 18, 1999, and Capture 2EC (6.4 fl oz/acre) was applied on August 15, 1999. The field was furrow-irrigated eight times during the season.

Corn Silage Hybrid Performance Test at Olathe

This study was conducted at the Earl Seymour Farm at Olathe, Colorado. The experiment was a randomized complete block with four replications. Twelve corn hybrids were evaluated for silage production. Plot size was 5-feet wide by 50-feet long. The previous crop was sweet corn. Planting occurred on May 11, 1999 and was seeded at 35,890 seeds/acre. The soil was a sandy loam. Harvest occurred on Sept 24, 1999. Herbicide used for weed control was Harness applied PPI at 2.0 pts/acre. Fertilizer applied was 50 lbs N/acre, 50 lbs P_2O_5/acre, and 60 lbs K_2O/acre broadcast and disced in prior to planting. At planting, 15 lbs N/acre and 50 lbs P_2O_5/acre of 10-34-0 was applied. Additional fertilizer was 163 lbs N/acre of 32-0-0 applied side-dressed split between two cultivations. Comite and dimethoate insecticides were applied to control spider mites. The field was furrow-irrigated approximately seven times during the season.

Results and Discussion

Corn Silage Hybrid Performance Test at Fruita

Forage production in the silage hybrid performance test at Fruita ranged from a high of 32.5 tons/acre for HYTEST HT7820 to a low of 20.6 tons/acre for Gutwein 2707 (Table 1). The test average was 29.0 tons/acre. High-yielding corn hybrids were HYTEST HT7820, DEKALB DK679, and HYTEST HTX76221. Forage moistures ranged from a high of 72.1% for Wilson Demand 118 to a low of 57.1% for DEKALB DK641. The test average was 65.5%. Plant populations ranged from a high of 37,072 plants/acre for DEKALB DK647 to a low of 28,453 plants/acre for Wilson E4025. The test average was 34,548 plants/acre.

Corn Silage Hybrid Performance Test at Olathe

Forage production in the silage hybrid performance test at Olathe ranged from a high of 29.9 tons/acre for HYTEST HT7820 to a low of 25.2 tons/acre for Grand Valley GVX7937 (Table 2). The test average was 27.6 tons/acre. Eight of the twelve hybrids were high yielding. Forage moistures ranged from a high of 76.5% for Garst Seed 8314 to a low of 71.3% for Grand Valley GVX7937. The test average was 73.5%. Plant populations ranged from a high of 36,516 plants/acre for Grand Valley SX 1446 (RR) to a low of 33,689 plants/acre for DEKALB DK641. The test average was 34,674 plants/acre.

Acknowledgments

We gratefully acknowledge Earl Seymour for allowing us to conduct this test on his farm. Appreciation is expressed to Lot Robinson and Fred Judson (Western Colorado Research Center staff), and Sara Albertson, Daniel Dawson, and Amy Mannel (part time hourly employees) who assisted with this research.

Table 1. Corn silage hybrid performance test at Fruita, Colorado in 1999.

Hybrid	Yield	Moisture	Density
	tons/acre	%	Plants/acre
HYTEST HT7820	32.5	67.0	36,609
DEKALB DK679	32.0	65.2	35,821
HYTEST HTX76221	31.4	64.8	33,736
Grand Valley SX1564	30.0	65.9	35,635
Grand Valley SX1545	30.0	66.2	31,789
Grand Valley SX1550	29.9	64.0	36,145
Wilson E7004	29.8	66.4	32,530
HYTEST HTX7877	29.4	66.0	35,821
Grand Valley GVX252653	29.4	68.4	36,470
DEKALB DK641	28.8	57.1	36,099
DEKALB DK647	28.2	60.7	37,072
Wilson E4025	27.8	62.2	28,453
Grand Valley SX1600	27.7	66.2	35,172
Wilson Demand 118	27.1	72.1	35,821
Gutwein 2707	20.6	70.1	31,048
Average	29.0	65.5	34,548
LSD (0.30)	2.0		
CV (%)	10.2		

Table 2. Corn silage hybrid performance test at Olathe, Colorado in 1999.

Hybrid	Yield	Moisture	Density
	tons/acre	%	Plants/acre
HYTEST HT7820	29.9	75.9	35,450
Grand Valley GVX4601	29.7	72.2	34,662
DEKALB DK641	28.8	72.6	33,689
Grand Valley SX1445 (RR)	28.3	72.1	34,060
DEKALB DK679	28.0	75.7	33,782
Grand Valley SX1360	27.3	73.8	35,126
Grand Valley SX1446 (RR)	27.1	73.1	36,516
DEKALB DK647	27.0	73.7	36,006
HYTEST HTX7877	26.8	74.6	35,033
Grand Valley SX1356	26.4	70.2	33,735
Garst Seed 8314	26.2	76.5	34,153
Grand Valley GVX7937	25.2	71.3	33,875
Average	27.6	73.5	34,674
LSD (0.30)	3.0		
CV (%)	12.3		

CORN GRAIN HYBRID PERFORMANCE TESTS AT FRUITA AND DELTA, COLORADO 1999

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist; Dr. Jerry J. Johnson, Extension Specialist Crop Production, CSU Fort Collins; and Cynthia L. Johnson, Research Associate, CSU Fort Collins

Summary and Recommendations

Corn grain hybrid performance tests conducted in 1999 at Fruita were a short season hybrid test and a long season hybrid test, and a short season corn hybrid test at Delta. Grain yield in the long season corn grain test at Fruita ranged from a high of 249 bushels/acre for HYTEST HT4138 to a low of 169 bushels/acre for Gutwein 2611. The test average in the long season test was 223 bushels/ acre. Grain yield in the short season corn grain test at Fruita ranged from a high of 255 bushels/ acre for Grand Valley SX1300 to a low of 168 bushels/acre for Grand Valley GVX7977. The test average in the short season test at Fruita was 209 bushels/acre. Grain yield in the short season corn grain test at Delta ranged from a high of 198 bushels/acre for HYTEST HT7512 to a low of 154 bushels/acre for Grand Valley SX1216. The test average at Delta was 180 bushels/acre.

Introduction and Objectives

The information obtained in corn hybrid performance tests conducted by Colorado State University researchers is provided to support corn growers, corn seed companies, breeding companies, and other agribusinesses. This information is collected using unbiased, scientific procedures and assists growers in selecting corn hybrids that will be productive on their farms. This corn hybrid performance information is also useful for seed companies to determine how and where to market seed of their hybrids. Breeding companies also use the information in directing their breeding and development efforts. Additionally, other agribusinesses, such as fertilizer and consulting companies, use this information to be informed about new developments in the corn industry. These corn hybrid performance tests have been ongoing for many years and have become a recognized source of consistent and reputable information.

Corn hybrid entries in this test are selected and provided by seed companies. Participation in the corn hybrid performances tests is voluntary and open to any company that pays the evaluation fee for each hybrid they wish to have tested. These tests are conducted without discrimination or endorsement of any hybrid or company. The objectives of this research are to evaluate corn hybrids for grain yield and other important plant characteristics. Results of these tests are available to the public.

Materials and Methods

Long and Short Season Corn Grain Hybrid Performance Tests at Fruita

The long and short season grain tests were conducted at the Western Colorado Research Center at Fruita. The experiment was a randomized complete block with four replications. Plot size was 5-feet wide by 50-feet long. The previous crop was alfalfa. The soil type was a Youngston clay loam. Planting occurred on May 13, 1999 and was seeded at 35,890 seeds/acre. Harvest occurred on October 26, 1999. Grain yields were corrected to 15.5%. Bladex 4L herbicide was applied PPI at 2 qts/acre on May 11, 1999. Fertilizer applied was 36 lbs N/acre and 112 lbs P_2O_5/acre preplant of 18-46-0 on May 6, 1999, and 180 lbs N/acre of 32-0-0 was applied side-dress on June 22, 1999. Dimethoate insecticide (1pt/acre) was applied on June 21, 1999. Also, Comite II (2.25 pt/acre) was applied on July 18, 1999 and Capture 2EC (6.4 fl oz/acre) was applied on August 15, 1999. The field was furrow-irrigated ten times during the season.

Short Season Corn Grain Hybrid Performance Test at Delta

This short season grain test was conducted at the Wayne Brew Farm, Delta, Colorado. The experiment was a randomized complete block with four replications. Plot size was 5-feet wide by 50-feet long. The previous crop was pinto beans. The soil was a Mesa sandy clay loam. Planting occurred on May 17, 1999 and was seeded at 35,890 seeds/acre. Harvest occurred on Nov. 8, 1999. Herbicides applied for weed control was Lasso (2 qts/acre) at planting, and 6 oz/acre of Clarity plus 12 oz/acre of 2, 4-D applied prior to layby. Fertilizer applied was 20 lbs N/acre plus 77 lbs P_2O_5/acre of 10-34-0 at planting and 185 lbs N/acre of 32-0-0 as a side-dress applications. To control insects, primarily spider mites, 1 qt/acre of Comite was applied at layby.

Results and Discussion

Short and Long Season Corn Grain Hybrid Performance Tests at Fruita

Grain yield in the short season corn grain test ranged from a high of 255 bushels/acre for Grand Valley SX1300 to a low of 168 bushels/acre for Grand Valley GVX7977 (Table 1). The test average was 209 bushels/acre. Grand Valley SX1300 was the highest yielding corn hybrid, yielding 15 bushels/acre more than the second highest yielding hybrid. Grain moistures ranged from a high of 20.3% for Grand Valley SX1300 to a low of 11.0% for HYTEST HT4310. The test average was 15.0%. Test weight in the short season corn grain test ranged from a high of 58.2 lbs/bushel for Grand Valley GVX7977 to a low of 53.6 lbs/bushel for Grand Valley SX1300. The test average was 56.1 lbs/bushel. Plant populations ranged from a high of 35,937 plants/acre for Grand Valley SX1300 to a low of 28,541 plants/acre for Grand Valley GVX 4651. The test average was 33,161 plants/acre. Plant lodging in the short season corn grain test at Fruita in 1999 was low for all hybrids, with the exception of Gutwein 2400, which had 13% lodging.

Grain yield in the long season corn grain test ranged from a high of 249 bushels/acre for HYTEST HT4138 to a low of 169 bushels/acre for Gutwein 2611 (Table 2). The test average was 223 bushels/acre. High-yielding corn hybrids were HYTEST HT4138, Grand Valley GVX4601, and DEKALB DK617. Grain moistures ranged from a high of 27.8% for HYTEST HT7820 to a low of 17.3% for DEKALB DK585. The test average was 23.1%. Test weight in the long season corn grain test ranged from a high of 55.4 lbs/bushel for Gutwein 2611 to a low of 53.7 lbs/bushel for DEKALB DK585. The test average was 54.7 lbs/bushel. Plant populations ranged from a high of 36,663 plants/acre for DEKALB DK585 to a low of 32,580 plants/acre for Gutwein 2611. The test average was 34,818 plants/acre. Plant lodging in the long season corn grain test in 1999 was low.

Short Season Corn Grain Hybrid Performance Test at Delta

Grain yield in the short season corn grain test at Delta ranged from a high of 198 bushels/acre for HYTEST HT7512 to a low of 154 bushels/acre for Grand Valley SX1216 (Table 3). The test average was 180 bushels/acre. High-yielding corn hybrids were HYTEST HT7512, DEKALB DK551, and DEKALB DK537. Grain moistures ranged from a high of 17.8% for HYTEST HT7512 to a low of 11.0% for Garst 8707. The test average was 13.0%. Test weight in the short season corn grain test at Delta ranged from a high of 52.9 lbs/bushel for DEKALB DK477 to a low of 44.5 lbs/bushel for HYTEST HT7512. The test average at Delta was 50.4 lbs/bushel. Plant populations ranged from a high of 38,117 plants/acre for Grand Valley HRX5367 (RR) to a low of 27,700 plants/acre for Grand Valley GVX4651. The test average was 35,071 plants/acre. Most corn hybrids in the short season corn grain test at Delta in 1999 did not have any plant lodging or ear drop, but if any lodging or ear drop occurred it was low.

Acknowledgments

We gratefully acknowledge Wayne Brew for allowing us to conduct the short season corn grain test on his farm at Delta, Colorado. Appreciation is expressed to Lot Robinson and Fred Judson (Western Colorado Research Center staff), and Sara Albertson, Daniel Dawson, and Amy Mannel (part time hourly employees) who assisted with this study.

Table 1. Irrigated short season corn grain hybrid performance test at Fruita, Colorado in 1999.

Hybrid	Yield	Grain moisture	Test weight	Density	Lodging
	bu/acre	%	lbs/bu	plants/acre	%
Grand Valley SX1300	255	20.3	53.6	35,937	2
HYTEST HT7512	240	18.2	55.0	34,395	3
Grand Valley SX1270	236	16.4	57.8	33,170	4
Grand Valley GVX8259 (RR)	224	15.1	57.4	32,307	2
DEKALB DK551	224	13.3	56.4	36,164	4
Grand Valley GVX9258	222	15.1	55.3	31,808	4
Grand Valley GVX4651	221	16.2	56.7	28,541	3
Gutwein 2400	218	14.6	55.4	32,806	13
Grand Valley SX1238	216	14.8	55.6	35,302	0
Grand Valley GVX9256	214	16.0	54.8	28,678	1
DEKALB DK537	208	14.5	57.0	35,620	3
Grand Valley SX1272	189	15.0	54.8	30,855	5
Grand valley HRX5376 (RR)	184	13.4	57.0	33,941	2
DEKALB DK477	184	12.9	57.2	35,030	1
DEKALB DK493	179	14.1	56.4	34,531	1
HYTEST HT4310	170	11.0	55.7	33,623	5
Grand Valley GVX7977	168	13.9	58.2	31,037	2
Average	209	15.0	56.1	33,161	3
LSD (0.30)	12				
CV (%)	16.6				

Table 2. Irrigated long season corn grain hybrid performance test at Fruita, Colorado in 1999.

Hybrid	Yield	Grain moisture	Test weight	Density	Lodging
	bu/acre	%	lbs/bu	plants/acre	%
HYTEST HT4138	249	23.0	55.2	35,075	2
Grand Valley GVX4601	237	26.7	54.4	34,258	1
DEKALB DK585	233	17.3	53.7	36,663	2
DEKALB DK617	230	19.6	55.0	34,349	2
HYTEST HT7820	219	27.8	54.4	35,982	2
Gutwein 2611	169	24.0	55.4	32,580	0
Average	223	23.1	54.7	34,818	2
LSD (0.30)	17				
CV (%)	10.2				

Table 3. Irrigated short season corn grain hybrid performance test at Delta, Colorado in 1999.

Hybrid	Yield	Grain moisture	Test weight	Density	Lodging	Ear drop
	bu/acre	%	lbs/bu	plants/acre	%	%
HYTEST HT7512	198	17.8	44.5	35,796	0	0
DEKALB DK551	196	13.8	48.1	37,454	0	0
DEKALB DK537	195	12.6	50.9	37,643	0	0
Grand Valley SX1238	188	12.3	48.5	36,080	0	0
Grand Valley GVX4651	186	14.1	50.3	27,700	0	1
Grand Valley HRX5376 (RR)	186	14.2	50.9	34,944	0	0
Grand Valley GVX8259 (RR)	185	16.4	49.8	33,334	0	0
Garst Seed 8640	184	12.9	50.9	30,115	0	0
Garst Seed 8707	181	11.0	49.5	36,649	0	0
Grand Valley GVX0313	179	12.8	52.0	36,223	1	0
Grand Valley GVX7236	178	12.2	50.1	31,772	0	0
DEKALB DK493	177	12.0	51.2	36,649	0	0
DEKALB DK477	177	11.5	52.9	36,649	1	0
HYTEST HT4310	176	11.2	51.6	34,897	3	2
Grand Valley SX1215	175	11.8	49.5	37,643	0	0
Grand Valley GVX7977	169	14.4	52.4	33,713	0	0
Grand Valley HRX5367 (RR)	163	11.6	52.0	38,117	1	0
Grand Valley SX1216	154	11.8	51.4	35,892	4	0
Average	180	13.0	50.4	35,071	1	0
LSD (0.30)	8					
CV (%)	5.6					

EFFECT OF METHYL BROMIDE AND GOLDEN HARVEST AND PIONEER CORN HYBRIDS UNDER TWO IRRIGATION MANAGEMENTS ON BLUNT EAR SYNDROME AT FRUITA, COLORADO 1999

Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist, Colorado Agricultural Experiment Station, Western Colorado Research Center - Fruita; and Dr. William E. Brown, Professor/Plant Pathologist, CSU Fort Collins

Summary and Recommendations

These data reinforce the importance of field testing corn hybrids for susceptibility to BES. Corn hybrids found to be susceptible to BES, can be marketed more precisely to minimize the possibility of growing susceptible hybrids in areas where a significant potential for BES exits. As with other agronomic studies, evaluating corn hybrids over several years will provide a more complete picture of hybrid response to BES. These data also indicate irrigation water management may affect the development of BES. Additional research on the effect of irrigation on BES is warranted.

Introduction and Objectives

Blunt ear syndrome (BES), also called "beer-can ears, hand-grenade ears, and stunted ears," is a disorder of corn that is characterized by normal-appearing corn plants having reduced ear lengths and fewer kernels per row. A portion of the ear tip is barren in an otherwise normal-looking husk. Yield losses from BES have ranged from minor amounts to as much as 75%, and farmers have reported that BES is often most severe on productive soils (Pearson and Golus, 1990). Previous research has shown that corn hybrids differ in their susceptibility to BES (Fithian, 1999; Pearson and Golus, 1990). Identifying corn hybrids that are susceptible to BES allows seed companies to more accurately market their seed. We have conducted various studies on BES in the Grand Valley for eight years. The occurrence of BES from year to year in the Grand Valley of western Colorado has been more consistent than any other place in the country, making it the best location in the U.S. to study BES. The objectives of this research were: 1) to determine the effect of methyl bromide on BES symptom development. Previous research has shown methyl bromide used as a soil fumigant reduces BES symptoms in corn, 2) to evaluate Golden Harvest corn hybrids for their susceptibility to BES, and 3) to determine the effect of irrigation on BES development. Previous research conducted in 1997 at the Fruita Research Center indicated that irrigation may affect BES development.

Materials and Methods

<u>Methyl bromide application</u>

Methyl bromide was applied at the Colorado State University, Western Colorado Research Center at Fruita to determine if soil fumigation would affect the development of BES. The experiment was a randomized complete block with three replications. Plot size was 10 feet wide and 30 feet long. Methyl bromide was applied at the rate of 1 lb of methyl bromide per 300 ft² on April 21, 1999. Plastic tents covered the treated area until they were removed on April 26, 1999. Planting occurred on May 14, 1999 with Pioneer brand hybrid 3522. Corn plants were sampled (roots and 6-inch stalk length) on August 4, 1999 and were evaluated for internal bacterial and fungal hosts.

Bladex 4L herbicide was applied PPI at 2 qts/acre on May 11, 1999. Fertilizer applied was 36 lbs N/acre and 112 lbs P_2O_5/acre preplant of 18-46-0 on May 6, 1999, and 180 lbs N/acre of 32-0-0 was applied side-dress on June 22, 1999. Dimethoate insecticide (1pt/acre) was applied on June 21, 1999. Also, Comite II (2.25 pt/acre) was applied on July 18, 1999 and Capture 2EC (6.4 fl oz/acre) was applied on August 15, 1999.

Grain yields were not obtained in this study. Just prior to the scheduled harvest date strong winds caused extensive lodging and ear drop. Yield losses were so severe that harvesting to determine yield was not possible.

<u>Evaluation of Golden Harvest and Pioneer Hybrids for BES</u>

Twenty Golden Harvest brand corn hybrids were evaluated for BES at the Colorado State University Western Colorado Research Center at Fruita in 1999. The experiment was a randomized complete block with four replications. Plot size was 5 feet wide and 50 feet long. The previous crop was corn and the soil type was a Glenton very fine sandy loam. The seedbed was prepared using clean tillage. Bladex 4L was applied preplant incorporated at 2.0 qts/acre on May 11, 1999. Planting occurred on May 14, 1999 with a white air planter that had been modified for planting small plots. Both corn rows of each plot were counted the length of the plot on June 15, 1999 to determine plant populations

Bladex 4L herbicide was applied PPI at 2 qts/acre on May 11, 1999. Fertilizer applied was 36 lbs N/acre and 112 lbs P_2O_5/acre preplant of 18-46-0 on May 6, 1999, and 180 lbs N/acre of 32-0-0 was applied side-dress on June 22, 1999. Dimethoate insecticide (1pt/acre) was applied on June 21, 1999. Also, Comite II (2.25 pt/acre) was applied on July 18, 1999 and Capture 2EC (6.4 fl oz/acre) was applied on August 15, 1999. .

Corn in each plot was evaluated for BES symptoms on Nov. 19, 1999 using our 1 to 9 rating scale (Table 1). Grain yields were not obtained in this study. Just prior to the scheduled harvest date strong winds caused extensive lodging and ear drop. Yield losses were so severe that harvesting to determine yield was not possible.

Results and Discussion

The 1999 growing season was favorable for corn production in western Colorado. Weed control in the field was excellent.

Application of methyl bromide did not affect BES in 1999 (Table 2). Previous studies showed BES severity was reduced by applying methyl bromide (Fithian, 1999). This was not the case in the study at Fruita in 1999. Furthermore, no internal fungal or bacterial hosts were found in corn plants.

Plant populations were significantly different among corn hybrids (Table 3). Average plant population was 37,188 plants/acre. The planter was set to plant 35,890 seeds/acre. If small corn seed is used in the planter, the planter plate cells often pick up more than one seed, resulting in seeding rates that are higher than the seeding rate set on the planter. This situation apparently occurred in this study. Six hybrids had high populations greater than 37, 800 plants/acre and ten hybrids had low plant populations of less than 37,100 plants/acre, as compared to other hybrids. The hybrid with the lowest plant population of 35,680 was EX97735RR.

Blunt ear syndrome symptoms in 1999 at the Fruita Research Center were not as severe as 1997 or 1998. Nevertheless, BES rating scores among corn hybrids were statistically different (Table 3). Hybrid H-7773Bt had the highest BES score of 8.3, which means this hybrid had little to no BES symptoms. Hybrid H-2581 had the lowest BES score of 4.9, and thus, had the highest expression of BES symptoms. BES scores for 16 out of the 20 hybrids were not statistically different. Hybrids with comparatively low scores, 7.0 and lower, were, H-2515, H-2551IMI, and H-2581.

A previous study conducted at Fruita in 1997 indicated that irrigation may affect BES development. In 1999, over irrigation, accomplished by irrigating every 30-inch furrow for 24 hours, decreased BES score by an average of a one numerical score compared to irrigating every other 30-inch furrow for 24 hours (Table 4). In the over-irrigation treatment, BES scores were not significantly different among the three hybrids, but in the normal irrigation the BES-tolerant hybrid (P3514) had the highest score, the moderately susceptible hybrid (P3461) had an intermediate BES score, and the susceptible hybrid (P3522) had the lowest BES score.

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Appreciation is expressed to Lot Robinson and Fred Judson (Wester Colorado Research Center staff), and Sara Albertson and Daniel Dawson (part time hourly employees) who assisted with the fieldwork for this study. We appreciate the funding provided by Wayne Fithian and Golden Harvest, and the interest and support of Golden Harvest and Pioneer Hi-Bred in our efforts to better understand BES.

Table 1. Rating scale for evaluating Blunt Ear Syndrome of corn.

9 - No visible symptoms - normal ear, cob extends the expected full length.
8 - Near normal ear with an abnormal tip.
7 - Between 8 and 6.
6 - Cob at 3/4 of a normal ear with abnormal tip.
5 - Between 6 and 4.
4 - Cob at ½ of a normal ear with abnormal tip.
3 - Between 4 and 2.
2 - Cob shorter than 1/4 of a normal ear with abnormal tip.
1 - Essentially little or no cob within the husk.

Table 2. Effect of methyl bromide on Blunt Ear Syndrome (BES) at Fruita, Colorado 1999.

Methyl bromide treatment	BES score
Methyl bromide	8.2
No methyl bromide	8.3

Table 4. Effect of irrigation on Blunt Ear Syndrome (BES) of three hybrids at Fruita, Colorado 1999.

Corn hybrid	Plant population	BES score
Over irrigation	no./acre	
P3514	33,241	7.6
P3461	36,856	6.7
P3522	36887	7.6
Ave.	35,661	7.3
CV (%)		15.1
LSD (0.05)		NS
Normal irrigation		
P3514	32,036	8.0
P3461	37,474	6.2
P3522	37,288	4.7
Ave	35,599	6.3
CV (%)		13.7
LSD (0.05)		1.1

Table 3. Evaluation of Golden Harvest corn hybrids for Blunt Ear Syndrome (BES) at Fruita, Colorado 1999.

Corn hybrid	Plant population	BES score
	no./acre	
H-7773Bt	37,930	8.3
H-2478	37,070	8.1
H-6726	37,580	8.1
H-7599	37,230	8.1
EX98335RR	37,420	8.1
H-2315	37,230	8.1
H-2382	37,840	8.1
EX97735RR	35,680	8.1
EX99283RR	36,790	8.0
H-2398	39,130	7.9
H-8250	37,070	7.8
H-2552	37,810	7.7
EX98673	36,100	7.7
H-8562	36,190	7.6
H-8874RR	36,700	7.6
H-2547	38,210	7.6
H-9177Bt	38,370	7.5
H-2515	35,960	7.3
H-2551 IMMI	36,470	6.2
H-2581	36,960	4.9
Ave.	37,188	7.6
CV (%)	2.77	7.1
LSD (0.05)	1444	0.8

SMALL GRAIN VARIETY PERFORMANCE TESTS AT HAYDEN, COLORADO 1999

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Summary and Recommendations

Each year small grain variety performances tests are conducted at Hayden, Colorado to identify varieties that are productive and suitable for commercial production in northwest Colorado. Three small grain variety performance tests (winter wheat, spring wheat, and spring barley) were conducted at Hayden in 1999. Grain yield in the winter wheat variety performance test average 3517 lbs/acre (58.6 bushels/acre) with fifteen of the twenty-eight varieties exhibiting high yields. Grain yield in the spring wheat variety performance test averaged 1716 lbs/acre (28.6 bushels/acre) with no statistically significant differences among varieties. Grain yield in the spring barley variety performance test averaged 1236 lbs/acre (25.7 bushels/acre) and half (C37, Moravian 14, 95RWA241, C22, Steptoe) of the varieties were high yielding.

Introduction and Objectives

Growers in northwest Colorado are limited to only a few crops they can grow. The number of crops that are grown in northwest Colorado is limited by environmental constraints created primarily by dryland production conditions, a short growing season, and sporadic and limited precipitation. Farmers are also limited by their isolation from markets for their crops. Growers in northwest Colorado are very supportive of agronomic research that will increase yields of crops and increase grower profits. They are also interested in alternative crops that have potential for production in northwest Colorado. The principle cash crop grown in northwest Colorado is wheat. Alternative small grains, such as malting barley, triticale, and specialty wheats such as hard white wheats are of interest to growers because these crops have potential in specialty markets that often demand a premium price. Alternative crops such as these specialty small grains are also of interest because they can be grown with production practices and equipment growers already have on their farm. During 1999 we conducted winter and spring small grain tests that included not only traditional small grains but also some of these specialty small grain.

Materials and Methods

Winter Wheat Variety Performance Test

Twenty-eight winter wheat varieties and lines were evaluated during the 1998-99 growing season at the Dutch and Mike Williams Farm near Hayden, Colorado. The experiment design was a randomized complete block with four replications. Plot size was 5 feet wide x 40 feet long with eight seed rows per plot. The seeding rate was 56 lbs/acre and planting occurred on October 9, 1998. Herbicides applied were Ally at 0.10 oz/acre and 2,4-D at 1/8 lb/acre on May 10, 1999. Harvest occurred on September 7, 1999 using a Hege small plot combine.

Spring Small Grain Variety Performance Tests

Six spring wheat and ten spring barley varieties and lines were evaluated during the 1999 growing season at the Dutch and Mike Williams Farm near Hayden, Colorado. The experiment design was a randomized complete block with four replications. Plot size was 4 feet wide x 40 feet long with six seed rows per plot. The soil was sampled at planting to determine fertility. The results were pH 6.3, 0.4 mmhos/cm salts, 3.6% organic matter, 5.0 ppm nitrate-nitrogen, 15 ppm phosphorus, 390 ppm potassium, 2.1 ppm zinc, 44.8 ppm iron, 24.1 ppm manganese, and 3.4 ppm copper. Planting occurred on May 12, 1999. Spring wheat and barley were planted at 60 lbs seed/acre. Wheat Ally at 0.10 oz/acre was applied on May 25, 1999 for weed control. No insecticides were applied. Harvest occurred on September 16, 1999 using a Hege small plot combine.

Results and Discussion

Winter Wheat Variety Performance Test

Environmental conditions were very favorable for wheat production in the Hayden area in 1999. Six wheat varieties (Brundage, ID 498, ID535, Lambert, Manning, and Treated Akron) had higher moisture contents than other varieties (Table 1). Fifteen of the twenty-eight varieties were high yielding. Grain yields of the twenty-eight varieties averaged 3517 lbs/acre (58.6 bushels/acre) with a high yield of 68.4 bushels/acre to a low yield of 49.4

bushels/acre. Yields in this trial were some of the highest experienced over many years of conducting test plots in northwest Colorado. Three varieties (UT99847, Akron, UT201971) had high test weights. Two varieties (Presto, Lambert) had low test weights compared to other varieties. The two tallest varieties were Presto and UT199847 and the shortest varieties were Brundage, Boundary, and ID513. Lodging was greatest for Jeff and UT199847. Despite the high yields, most varieties had lodging scores lower than 1.5.

Spring Wheat Variety Performance Test

Plant stands were somewhat sparse and irregular because of crusting that occurred during seedling emergence. Rainfall during the 1999 growing season was sporadic. There were no statistically significant differences among varieties for grain moisture, grain yield, or test weight in the spring wheat trial at Hayden in 1999 (Table 2). Averaged across varieties, grain moisture was 11.3%, grain yield was 1716 lbs/acre or 28.6 bushel/acre, and test weight was 60.8 lbs/bu. Butte 86, Grandin, and Sharp were the tallest varieties. Oxen and 2375 were the shortest varieties. Butte 86 had the highest lodging score, but overall lodging in the spring wheats in 1999 was low.

Spring Barley Variety Performance Test

As in the spring wheat test, plant stands in the spring barley variety performance test were also somewhat sparse and irregular because of crusting that occurred during seedling emergence. Grain moisture was highest for the spring barley entry, 95RWA241, with most varieties having grain moistures lower than 12% in this test (Table 3). Half (C37, Moravian 14, 95RWA241, C22, Steptoe) of the varieties were high yielding compared to other varieties. Six varieties (C37, Moravian 14, C22, 95RWA249, C47, and 95RWA104 had high test weights compared to other varieties. Moravian 14 was the shortest variety and 95RWA241 and 95RWA249 were the tallest varieties. 95RWA82 had the highest lodging score, although overall lodging in the spring barleys in 1999 was low.

Acknowledgments

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Table 1. Winter wheat variety performance at Hayden, Colorado in 1999. Farmer-Cooperators: Dutch and Mike Williams.

Variety	Grain moisture	Grain yield		Test weight	Plant height	Lodging[1]
	(%)	lbs/acre	bu/acre	lbs/bu	inches	0.2-9.0
UT944151	11.32	4105	68.4	58.0	30.8	0.8
ID944158	11.45	4025	67.1	56.5	30.3	1.2
Hayden	11.32	3997	66.6	58.0	32.5	1.2
UT203032	11.50	3874	64.6	58.7	34.7	1.4
Treated Hayden	11.38	3845	64.1	57.6	31.4	1.2
Presto	11.38	3772	62.9	55.1	38.2	1.6
UT199847	11.35	3761	62.7	59.9	38.6	3.0
Brundage	11.85	3727	62.1	54.3	24.9	1.0
ID479	11.23	3687	61.4	58.0	32.0	1.5
ID498	11.55	3681	61.4	57.4	30.2	1.3
ID539	11.43	3638	60.6	57.5	30.2	1.7
Akron	11.50	3571	59.5	59.5	28.6	1.5
ID535	11.55	3569	59.5	57.8	30.0	1.8
UT201971	11.32	3522	58.7	60.3	35.0	1.4
ID537	11.38	3500	58.3	56.5	33.1	1.0
Lambert	11.73	3456	57.6	55.0	28.1	1.2
Blizzard	11.42	3440	57.3	56.8	32.9	1.2
Treated Prowers	11.13	3407	56.8	58.7	34.1	1.9
Manning	11.68	3386	56.4	57.4	27.6	1.2
Treated Akron	11.60	3336	55.6	59.4	28.4	1.4
UT 100	11.38	3290	54.8	58.2	30.4	1.0
Fairview	11.38	3262	54.4	58.9	29.8	1.1
Boundary	11.52	3183	53.0	56.5	24.7	0.8
Promontory	11.45	3170	52.8	58.8	28.7	1.2
ID513	11.40	3164	52.7	57.8	26.4	1.2
Jeff	11.43	3131	52.2	58.1	36.1	4.5
ID511	11.32	3027	50.4	58.5	29.3	1.4
Prowers	11.32	2965	49.4	58.2	34.1	2.5
Ave.	11.44	3517	58.6	57.8	31.1	1.5
LSD (0.05)	0.31	645	10.8	0.8	2.0	0.4
CV (%)	1.95	13.0	13.0	1.0	4.5	20.9

[1]0.2 = no lodging, 9.0 = totally area lodged flat.

.

Table 2. Spring wheat variety performance test at Hayden, Colorado 1999.

Wheat variety	Grain moisture	Grain yield		Test weight	Plant height	Lodging[1]
	(%)	lbs/acre	bu/acre	lbs/bu	inches	0.2-9.0
Butte 86	11.4	1558	26.0	61.0	26.0	2.1
Grandin	11.5	1759	29.3	60.6	25.0	1.2
2375	11.6	1788	29.8	59.6	22.4	1.2
Sharp	11.3	1744	29.1	61.4	24.6	1.4
Oxen	11.8	1756	29.3	60.6	21.7	1.1
Forge	11.2	1629	28.2	61.9	23.6	1.6
Ave.	11.3	1716	28.6	60.8	23.9	1.4
LSD (0.05)	NS	NS	NS	NS	1.5	
CV (%)	5.8	18.9	18.9	1.8	4.2	

[1] Lodging: 0.2 = no lodging, 9 = total area lodged flat.

Table 3. Spring barley variety performance test at Hayden, Colorado 1999.

Barley variety	Grain moisture	Grain yield		Test weight	Plant height	Lodging[1]
	(%)	lbs/acre	bu/acre	lbs/bu	inches	0.2-9.0
C37	11.0	1637	34.1	48.6	15.6	1.2
Moravian 14	10.5	1515	31.6	50.4	13.6	1.2
95RWA241	19.1	1498	31.2	42.8	21.2	1.2
C22	11.8	1379	28.7	47.8	16.3	1.2
Steptoe	10.8	1326	27.6	44.8	16.1	1.4
95RWA249	14.8	1287	26.8	49.0	19.4	1.3
C47	10.6	1202	25.0	49.0	17.9	1.3
C40	10.8	982	20.4	45.0	15.7	1.3
95RWA104	11.2	908	18.9	49.3	17.1	1.6
95RWA82	11.9	626	13.0	43.6	18.4	2.7
Ave.	12.2	1236	25.7	47.0	17.1	1.4
LSD (%)	2.6	322	6.7	3.8	1.8	
CV(%)	14.6	18.0	18.0	5.6	7.4	

[1] Lodging: 0.2 = no lodging, 9 = total area lodged flat.

SMALL GRAIN VARIETY PERFORMANCE TESTS AT FRUITA, COLORADO 1999

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Summary and Recommendations

Each year small grain variety performances tests are conducted at the Western Colorado Research Center at to identify varieties that are productive and adapted for commercial production in western Colorado. Grain yields in the winter wheat variety performance test averaged 7846 lbs/acre (130.8 bushels/acre) and ten of the thirteen entries were high yielding. Grain yield in the winter wheat advanced line evaluation averaged 8712 lbs/acre (145.2 bushels/acre) and five entries were high yielding, one of which was the check variety Stephens. Grain yield in the oat variety performance test averaged 3535 lbs/acre (110.5 bushels/acre) and five oat entries (AbSP 19-9, Rio Grande, 91Ab406, Russell, and Powell) were high yielding.

Introduction and Objectives

Small grains, which includes wheat and oats, have been produced traditionally in western Colorado. The importance of these two small grain crops, in terms of the number of acres planted, varies from year to year. Often, these crops are used for rotational purposes and to meet other farm needs. For example, oats may be planted to feed on-farm animals or winter wheat may be planted so it is harvested in time so the field can prepared for planting alfalfa in late summer or early fall. Farmers also require up-to-date and local, site-specific information to assist them when choosing small grain varieties for planting on their farms. The objective of this research was to evaluate winter wheat varieties, advanced winter wheat lines, and oat varieties for their performance under western Colorado conditions.

Materials and Methods

These studies were conducted at the Colorado State University, Western Colorado Research Center at Fruita. These three experiments were randomized complete blocks with four replications.

Winter Wheat Cultivar Performance Test

Thirteen entries, 6 named varieties and 7 advanced numbered winter wheat lines, were evaluated in 1999. The previous crop was dry beans. Plot size was 2, 30-inch wide beds, 40 feet long with six seed rows per plot. The seeding rate was 120 lbs/acre. Planting occurred on October 14, 1998 and harvest occurred on July 24, 1999. Fertilizer applications were 18-46-0 disced in at 92 lbs P_2O_5/acre and 36 lbs N/acre on October 14, 1998. A top-dressed fertilizer application as ammonium nitrate at 100 lbs N/acre occurred on March 2, 1999. Harmony Extra at 0.4 oz/acre and 0.25 lb/acre of 2,4-D herbicides were applied on March 3, 1999. Five irrigations were applied during the growing season.

Winter Wheat Advanced Line Evaluation

Fourteen advanced winter wheat lines and one check variety were evaluated in 1999. These wheat lines were selected from among 465 lines that were developed at CIMMYT in Mexico and brought into the U.S. by Dr. Jim Quick, CSU wheat breeder, in 1996 for evaluation and screening. All lines were evaluated at Fruita for two years and these fourteen lines were selected for desired morphological traits and yield performance.

The previous crop was dry beans. Plot size was 2, 30-inch wide beds, 25 feet long with six seed rows per plot. The seeding rate was 100 lbs/acre. Planting date was October 14, 1998 and harvest occurred on July 24, 1999. Fertilizer applications were 18-46-0 disced in at 92 lbs P_2O_5/acre and 36 lbs N/acre on October 14, 1998. A top-dressed fertilizer application as ammonium nitrate at 100 lbs N/acre occurred on March 2, 1999. Harmony Extra at 0.4 oz/acre and 0.25 lb/acre of 2,4-D was applied for weed control on March 3, 1999. Five irrigations were applied during the growing season.

Oat Variety Performance Test

The previous crop was dry bean. The plot size was 2, 30-inch wide beds, 40 feet long with six seed rows per plot. The seeding rate was 88 lbs/acre and the planting date was April 8, 1999. Harvest occurred on August 25,

1999. Fertilizer applications were 11-52-0 disced in at 104 lbs P_2O_5/acre and 22 lbs N/acre on March 31, 1999. A top-dressed fertilizer application as ammonium nitrate at 95 lbs N/acre occurred on May 14, 1999. Harmony Extra at 0.4 oz/acre and 6 oz/acre of 2,4-D herbicides were applied on May 12, 1999. Seven irrigations were applied during the growing season.

Results and Discussion

Winter Wheat Cultivar Performance Test

Grain moistures among winter wheat varieties were not statistically significant (Table 1). Grain moisture, averaged across the 13 winter wheat entries, was 9.9%. Grain yields averaged 7846 lbs/acre (130.8 bushels/acre. Grain yields in this test in 1999 were better than average compared to most years. Ten of the thirteen winter wheat entries were high yielding. ID 501 had the highest and ID 455 had the lowest test weight. UT 944158 was the tallest and Garland was the shortest entry. Five winter wheat entries (Stephens, Halt, UT 944158, ID 509, ID510) had high lodging scores compared to other entries. Garland had the lowest lodging score. Madsen required the greatest number of days to heading and ID 501, KS 2137, and Halt required the least number of days to heading.

Winter Wheat Advanced Line Evaluation

Grain moistures among winter wheat varieties were not statistically significant (Table 2). Grain moisture, averaged across the 15 winter wheat entries, was 10.0%. Grain yield averaged 8712 lbs/acre (145.2 bushels/acre). Five entries were high yielding, one of which was the check variety Stephens. Four entries had high test weights. 6011 was the tallest and 6450 and 6451 were the shortest wheats. Most varieties did not lodge in 1999. 6011 had the highest amount of lodging, although lodging for this entry was not severe. Days to heading ranged from 138 days to 145 days. Only one entry had a protein content greater than 12%. The other entries were similar to or lower than the protein content for the check variety Stephens. Four entries were hard wheats, four were soft wheats, and seven were intermediate in hardness.

Oat Variety Performance Test

Provena and Lamont had the highest grain moisture contents (Table 3). Both of these oat varieties are naked-seeded oats. Naked-seeded oats do not retain the lemma and palea (chaff) during harvest. Naked-seeded oats as a harvested grain are more similar in appearance to wheat kernels than they are to barley kernels. Grain yield averaged 3535 lbs/acre (110.5 bushels/acre). Five oat entries (AbSP 19-9, Rio Grande, 91Ab406, Russell, Powell) were high yielding. As would be expected, test weights were highest for the two naked-seeded oat varieties, Provena and Lamont. Six varieties (Rio Grande, 91Ab406, Powell, 90Ab1322, Monida, Colorado 37) had tests weights that were lower compared to other varieties. Russell, Otana, Hytest, and Colorado 37 were the tallest and 90Ab1322 and Ajay were the shortest varieties. Oat varieties lodged considerably during 1999. The average lodging score for the study was 4.8. Ten oat entries had lodging scores greater than 4.5. Five oat entries had lodging scores less than 4.0.

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Appreciation is expressed to Lot Robinson and Fred Judson (Western Colorado Research Center staff), and Sara Albertson, Daniel Dawson, and Amy Mannel (part time hourly employees) who assisted with this research.

Table 1. Winter wheat variety performance test at the Western Colorado Research Center at Fruita, Colorado in 1999.

Variety	Grain moisture	Grain yield		Test weight	Plant height	Lodging[1]	Days to Heading[2]
	%	lbs/acre	bu/acre	lbs/bu	inches	0.2-9.0	no. of days
Malcolm	9.6	9004	150.1	57.6	36.7	1.2	144
Brundage	10.4	8734	145.6	60.2	35.8	0.8	142
ID 501	9.6	8668	144.4	62.3	32.6	1.8	138
OR 850513H	10.0	8631	143.9	61.2	33.3	0.4	139
KS 2137	9.8	8383	139.7	60.4	37.3	1.7	138
Stephens	10.0	8329	138.8	56.8	35.8	4.3	143
Halt	9.5	8164	136.1	59.4	35.8	4.9	138
Madsen	10.0	8037	133.9	58.4	35.2	1.0	147
Garland	9.6	7893	131.6	58.0	27.6	0.2	146
ID 455	10.3	7610	126.8	55.7	30.7	1.2	139
UT 944158	10.0	6507	108.4	58.3	41.0	6.1	146
ID 509	10.2	6130	102.2	57.8	37.4	6.4	143
ID 510	9.7	5909	98.5	59.0	39.2	6.1	142
Ave.	9.9	7846	130.8	58.8	35.3	2.8	142
LSD (0.05)	NS	1707	28.4	1.1	1.6	2.3	1.0
CV (%)	5.8	15.2	15.2	1.3	3.1	58.7	0.5

[1] 0.2 = no lodging, 9.0 = totally area lodged flat.

[2] From January 1.

Table 2. Agronomic performance of advanced winter wheat lines at the Western Colorado Research Center at Fruita, Colorado in 1999.

Variety	Grain moisture	Grain yield	Grain yield	Test weight	Plant height	Lodging[1]	Days to heading[2]	Protein	Hardness[3]
	%	lbs/acre	bu/acre	lbs/bu	inches	0.2-9.0	No.	%	
6417	10.0	9631	160.5	61.8	34.8	0.2	139	9.2	57
6421	10.4	9468	157.8	61.9	36.2	0.2	141	10.2	73
Stephens	10.2	9439	157.4	58.1	36.6	0.9	142	10.5	18
6011	10.3	9130	152.1	61.3	39.8	2.6	143	9.7	37
6115	9.8	9026	150.4	59.4	34.0	1.2	143	12.1	31
6418	10.0	8828	147.1	61.8	36.8	0.8	140	10.1	57
6058	10.3	8739	145.6	59.8	35.3	0.2	144	9.5	80
6114	9.9	8706	145.1	59.0	33.7	0.4	143	11.5	13
6445	10.0	8691	144.9	59.9	32.9	0.2	140	10.5	56
6048	9.8	8595	143.3	60.3	33.2	0.2	145	10.7	44
6017	10.0	8492	141.6	60.0	34.2	0.2	145	9.3	84
6049	9.6	8409	140.2	60.4	33.6	0.2	145	10.4	91
6057	9.6	8370	139.5	59.7	34.2	0.2	145	10.4	62
6450	10.2	7723	128.7	60.2	28.5	0.2	138	10.4	50
6451	10.0	7428	123.8	60.1	29.0	0.2	138	9.6	57
Average	10.0	8712	145.2	60.2	34.2				
LSD (0.05)	NS	648	10.8	1.4	1.6				
CV (%)	4.0	5.2	5.2	1.6	3.4				

[1] 0.2 = no lodging, 9.0 = totally area lodged flat.

[2] From January 1.

[3] Reading of <40 indicates soft wheat and reading of >40 indicates hard wheat.

Table 3. Spring oat variety performance at the Western Colorado Research Center, Fruita, Colorado in 1999.

Variety	Grain Moisture	Grain yield		Test weight	Plant height	Lodging[1]
	(%)	lbs/acre	bu/acre	lbs/bu	inches	0.2-9.0
AbSP 19-9	8.82	5208	162.7	33.1	41.6	3.6
Rio Grande	8.30	4489	140.3	30.1	42.0	5.8
91Ab406	8.22	4104	128.3	27.9	38.1	5.5
Russell	8.28	4101	128.2	31.5	44.7	5.7
Powell	9.10	4001	125.0	29.8	36.8	4.5
Jerry	8.60	3707	115.8	36.0	42.8	6.0
Otana	9.05	3604	112.6	31.0	47.1	5.9
90Ab1322	8.02	3584	112.0	29.1	34.4	3.9
Monida	9.12	3325	103.9	29.9	41.5	5.7
Lamont	9.80	3189	99.6	38.1	40.0	1.2
Ajay	8.28	3044	95.1	31.0	32.3	3.7
HyTest	8.80	2764	86.4	37.5	46.2	5.0
Colorado 37	8.88	2723	85.1	30.4	47.4	5.6
Provena	10.05	2596	81.1	40.8	37.0	3.0
AbSP9-2	8.58	2588	80.9	31.2	39.9	7.0
Ave.	8.79	3535	110.5	32.5	40.8	4.8
LSD (0.05)	0.87	1283	40.1	2.7	3.1	2.8
CV(%)	6.92	25.4	25.4	5.9	5.4	41.4

[1]0.2 = no lodging, 9.0 = totally area lodged flat.

Northwest Colorado Insect Surveys - Hessian Fly and Cereal Leaf Beetle

Robert Hammon, Entomologist

Summary

Surveys for hessian fly were conducted during the 1997, 1998 and 1999 growing season in Rio Blanco, Moffat and Routt Counties. Surveys were done in volunteer and seeded wheat, grass hay and Conservation Reserve Program fields. Early season surveys were directed at finding fall damage and overwintering puparia. Mid season surveys were focused on finding adult Hessian flies and late season searches focused on areas of grain lodging and visibly damaged wheat fields. Surveys in all years were negative for all stages of Hessian fly.

Informal surveys were conducted in 1997 and 1998, and formal survey in 1999 for cereal leaf beetle in Rio Blanco, Moffat, Routt, Mesa, Delta, San Miguel, and Montezuma counties. All cereal leaf beetle surveys were conducted in wheat and oat fields. Both visual surveys and sweep net sampling for adults and larvae were conducted. All surveys were negative for the presence of cereal leaf beetles.

Background

Hessian fly, *Mayetiola destructor* (Say), is a pest of wheat in the eastern and central United States. It is native to the southern Causasus region of Russia, but has been established in the United States since 1778. The range of the pest has been expanding westward , and it is established as far west as Washington state. It is an insect of regulatory concern in grass hay exported to Japan because it will feed on several grass species, including several that are grown for hay. Hessian fly is not established in Japan, and regulations dictate that all grass hay must be fumigated before it is allowed to enter that country, which is an excellent market for this hay. Hessian fly has not been detected in western Colorado with the exception of a single egg found in an inspection of grass hay from Routt County bound for Japan. The USDA-CAPS (Cooperative Agricultural Pest Survey) funded a survey of northwestern Colorado from 1997 through 1999 to determine if Hessian fly was actually established there.

Cereal leaf beetle, *Oulema melanopus* (Linné), is a pest of small grains that has been established in the eastern US in the mid 20^{th} century. Its range has expanded, and it became established in Montana and Idaho in the early 1990's, and in northeastern Utah and southern Wyoming in the mid 1990's. It has not yet been discovered in Colorado. There are regulatory concerns regarding the shipment of small grains from cereal leaf beetle infested areas into California. A survey was funded by USDA-CAPS in 1999 to determine whether the insect is present in small grains in western Colorado.

Methods

Hessian fly surveys were conducted in northwestern Colorado on three dates in 1997, and four in 1998 and 1999 (Table 1). The first survey in each year was done during spring regrowth of wheat, when early planted wheat and fallow fields with early germinated volunteer wheat were inspected. Any plants that appeared abnormal in any way were examined for the presence of the “flax seed” puparia. Mid season surveys were done in June and July, and a sweep net was used to locate adult Hessian flies. Both wheat, CRP grasses and irrigated grass hay were included in the mid season surveys. Late season surveys were done in late July and August, and focused on lodged wheat, CRP and irrigated grass hay. Lodged grain was inspected for the presence of Hessian fly larvae or puparia, and green grasses were sampled with a sweep net to find adults.

Surveys were conducted for the presence of cereal leaf beetles in most of the wheat and oat producing areas of the west slope during the spring and summer of 1999. The survey consisted of both visual survey for adult and larvae, both of which are very distinctive, and sweep net sampling of the crops once they had reached the jointing growth stage. Both wheat and oat fields were checked for their presence. The dates and survey locations are displayed in Table 2.

Results

The results of the Hessian fly surveys are displayed in Table 1. No Hessian fly adults, larvae or puparia were found in any survey. These results indicate that it is not established in northwestern Colorado.

Results from the cereal leaf beetle survey are displayed in Table 2. No cereal leaf beetle adults, larvae or eggs were observed in any field on any date. These surveys confirm informal surveys that have been conducted since 1988, in which none have been found. Cereal leaf beetle, if established in Colorado, is at most in local pockets with very low infestation levels. It is probable that cereal leaf beetle is not yet established in Colorado.

Table 1. Results from hessian fly survey, by year and county. Acreage represents total area of fields in which scouting occurred.

County	1997 [1]			1998 [2]			1999 [3]		
	Fields	Acres	+/-	Fields	Acres	+/-	Fields	Acres	+/-
Rio Blanco	3	85	-	7	850	-	6	40	-
Moffat	15	2650	-	8	1950	-	9	1450	-
Routt	28	3700	-	21	5050	-	24	4600	-

[1] 13 May, 23 Jul, 8 Aug, 1997; [2] 5 May, 20 May, 30 Jun, 19 Aug, 1998; [3] 27 Apr, 18 May, 10 Jun, 28 Jul, 1999

Table 2. Location by county, and date of cereal leaf beetle survey, 1999. Acreage represents total area of fields in which scouting occurred.

County	Sample dates	# fields	Acres	Result +/-
Delta	4/16	2	70	-
Montrose	4/6	3	125	-
Mesa	4/14, 4/22, 5/13, 6/7	11	250	-
Dolores	4/20	2	250	-
San Miguel	4/20, 5/12, 6/8, 6/29	5	355	-
Montezuma	4/20, 5/12, 6/8, 6/29	7	345	-
Rio Blanco	4/27, 5/18, 7/28	6	40	-
Moffat	4/27, 5/18, 6/10, 7/28	9	1450	-
Routt	5/18, 6/10, 7/28	24	4600	-
Ouray	6/24	2	100	-

Chemical Control of Wheat Curl Mite

Robert Hammon, Entomologist

Summary

Five insecticides and an untreated control were included in an insecticide trial against wheat curl mite in wheat at the Fruita Research Center. Treatments were applied in early March, under cool conditions. Furadan 4F (0.5 lb a.i./a.) was the only insecticide to effectively control wheat curl mites. Following the Furadan 4F treatment, some mite activity was noted at 7 and 14 days, but total control was not achieved until the 21 day after treatment sample date.

Background

Wheat curl mites, *Aceria toschiella* Keifer, (WCM) are important agricultural pests when they transmit virus diseases in crops. They are responsible for the spread of wheat streak mosaic in wheat, and high plains disease in small grains and corn. The economic impact of WCM in western Colorado is greatest in the sweet corn crop, where high plains disease can cause economic loss. Sweet corn grown for seed is especially vulnerable to high plains disease. The need to control WCM with foliar sprays in wheat occasionally exists to prevent them from moving into adjacent susceptible high value sweet corn. Only one other insecticide trial of whet curl mite exists (Hammon, R., F. Judson & F. Peairs. 1993. Wheat curl mite control. Insecticide and Acaracide Tests. 18: 294-295) and more data was needed to complete work on a high plains disease management program. A significant wheat curl mite population existed in some early planted wheat at the Fruita Research Center during the spring of 1999, so it was used to screen five insecticides in a replicated trial.

Methods

Wheat (cv. 'Stephens') planted at the Fruita Research Center, Fruita CO, on 17 Aug 1998 was heavily infested with wheat curl mite and used as the site for the trial. Plots were 25 ft. long and 5 ft. wide, arranged as a randomized complete block with four replications. Insecticides were applied with a CO_2 pressured hand-held (pop bottle) sprayer equipped with three LF4 nozzles at 18 in. spacing, calibrated to apply 25 gpa at 35 psi. Plots were sprayed on 10 Mar 1999, under clear skies with an air temperature of 50° F, and winds 0-3 MPH. WCM were counted with the aid of a dissecting microscope on five randomly selected tillers per plot on each sample date. Plots were sampled pre-spray, 7 days after treatment (DAT), 14 DAT and 21 DAT. Analysis of variance of data was done with MSTAT-C after a log (x+1) transformation. Transformed means were separated using the Student-Neuman-Keuls test. Untransformed data means are displayed.

Results

Treatments and WCM counts are displayed in Table 1. Furadan 4F was the only insecticide effective in controlling WCM. Complete control of WCM by Furadan 4F was not achieved until 21 DAT, although activity was evident at both the 7 and 14 DAT sample dates. WCM infested 85% of the pre-spray, 80% of untreated tillers 7 DAT, and 100% of untreated tillers 14 and 21 DAT. There was an average of 73.8 WCM per tiller at the time of insecticide application, which increased to 160.8 WCM per tiller in the untreated plots at 7 DAT, 148.5 WCM per tiller at 14 DAT, and 106.8 WCM per tiller at 21 DAT. Differences among treatments were significant at P=0.10 but not at the P=0.05 level 7 DAT, with lower numbers of WCM in the Furadan 4F treated plots. WCM numbers were significantly lower (P=0.05) in the Furadan 4F plots than any other treatment 14 and 21 DAT. WCM infested 75% of tillers in the Furadan treated plots 7 DAT, 45% 14 DAT and 5% 21 DAT. 100% of tillers in all other treatments were infested 14 and 21 DAT.

Table 1. Experimental treatments, rates and WCM counts. Means within a column followed by the same letter are not significantly different (α=0.05; SNK).

Treatment/ formulation	Rate		Mean no. WCM/tiller		
	lb a.i./a	Pt/a	7 DAT	14 DAT	21 DAT
Furadan 4F	0.5	1.0	33.6	9.9 a	0.2 a
Capture 2EC	0.10	0.4	142.1	171.2 b	165.8 b
Agri-Mek 0.15EC	0.019	1.0	93.8	92.0 b	56.5 b
Sevin XLR	1.0	2.0	57.2	94.5 b	53.8 b
Dimethoate 4EC	0.5	1.0	211.5	168.5 b	124.2 b
Untreated			160.8	148.5 b	106.8 b

SPRING WHEAT PLANTING DATE EFFECT ON RUSSIAN WHEAT APHID AND GRAIN YIELD IN DIFFERING ENVIRONMENTS

Robert Hammon, Entomologist

Summary

Spring wheat planting date effects followed the same pattern observed in 1997 and 1998. Earlier planted spring wheat delivered better yields than later planted spring wheat in the Grand Valley, following a near linear trend. Spring wheat planting date effects on yield were insignificant in plots at Yellow Jacket. The difference in planting date effects on yield between the two environments is probably related to summer temperatures. In 1999, there tended to be more Russian wheat aphid foliar symptoms in the later planting dates at Fruita, but not at Yellow Jacket. During the late season sampling, more Russian wheat aphids were found feeding on wheat heads than on leaves or stems. Head feeding was responsible for some yield loss, but control efforts aimed at Russian wheat aphid earlier in the season tended to reduce the number of aphids found on heads during grain fill.

Background

Previous experiments were conducted during the 1997 and 1998 growing seasons to determine the effect of planting date and Russian wheat aphids (RWA) on spring wheat production in differing environments. They were conducted at the Fruita Research Center (Mesa Co.) and the Southwest Colorado Research Center near Yellow Jacket (Montezuma Co.) These experiments showed that planting date accounted for most of the variability of spring wheat yield at Fruita, but virtually none of it at Yellow Jacket (Figs. 1 & 2). Summer temperatures were used to explain the differences between the two sites, with the Fruita wheat suffering from high temperatures during flowering and grain fill, while southwestern Colorado temperatures never reaching a high enough level to affect production.

The number of RWA extracted from randomly chosen tillers was greatest in the earliest planting dates in the 1997 and 1998 experiment years, but the pattern was greatest in years with intense RWA infestation. The number of RWA symptomatic plants was greatest in the latest planting dates in southwest Colorado, but that pattern was not as evident in the Grand Valley. The discrepancy between RWA numbers and symptoms was attributed to their feeding position. Early season feeding by RWA is concentrated on leaves as they are produced by the plant, and typical symptoms of leaf rolling and streaking are produced. Later season feeding by RWA is on the

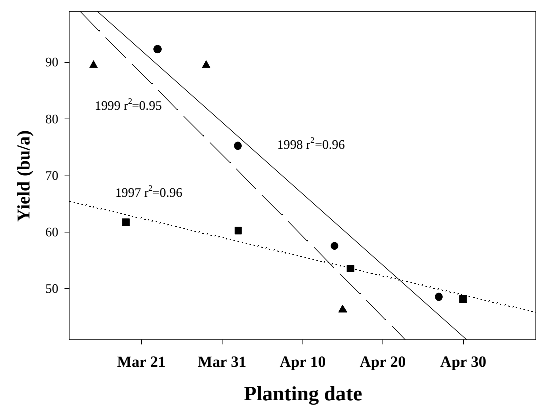

Figure 1. Planting date effect on grain yield at Fruita, 1997-1999.

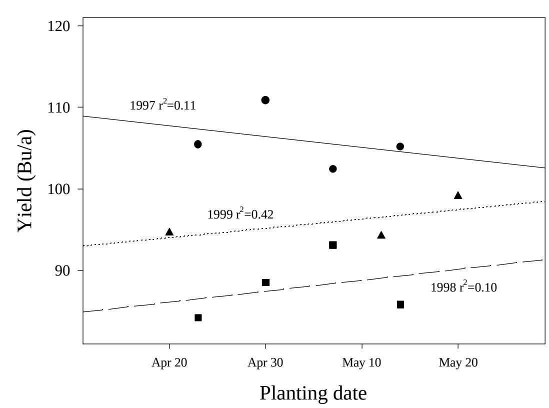

Figure 2. Planting date effect on grain yield at Yellow Jacket, 1997-1999.

plant culm and head, and foliar symptoms are not produced. Determining the effect of these symptomless late season RWA infestations was the objective of the 1999 field research. The experiment also allowed for the determination of planting date effects on yield and agronomic characteristics of spring wheat in differing environments.

Methods

Spring wheat was planted on three dates at the Fruita Research Center (March 15, March 29, April 15) and at the SW Colorado Research Center (April 20, May 12, May 20). The planting dates are typical of the range generally used by local growers. The second and third planting dates at the SW Colorado Research Center were delayed because of rains in late April. Within each planting date there were three chemical treatments: 1) Gaucho 480 FS 1 oz/.cwt; 2) Gaucho 480 FS 1 oz./cwt followed by Lorsban 4E, 0.5 lb a.i./a at anthesis; 3) untreated. The Gaucho 480 FS was intended to control early season RWA, but allow late season infestation. Treatment 2, with the foliar Lorsban spray controlled RWA during the entire season. Treatment 3 provided an untreated control. The experiment was treated as a two factor randomized complete block with four replications. Plot size was 10 ft x 50 ft. RWA were sampled three times, at boot (Z 45), anthesis (Z59) and soft dough (Z85) growth stages. Ten random tillers were chosen per plot and the number with foliar RWA symptoms recorded. The heads were separated from vegetative growth on the last two sample dates to determine the proportion of RWA feeding on different plant parts. The tillers and heads were then placed in Berlese funnels for 24 h to extract aphids, which were then counted under a dissecting microscope. The Fruita plots were harvested on Aug 2, 1999 using a modified Gleaner combine with on board scales. The SW Colorado Research Center plots were harvested on Sep 14, 1999 with a Hege plot combine. Percent moisture and test weight were recorded using a Seedboro grain analysis computer. Five hundred seed weights were calculated from a grain sample taken at harvest.

Results

The data are presented in Tables 1 & 2. The earliest two planting dates had significantly greater yield than the third planting date at Fruita and the regression r^2 value was very high, following the trend observed in the two previous years. The slope of the regression was steep, signifying a strong planting date effect on yield. The r^2 value for the SW Colorado data was higher in 1999 than those observed in previous years, but the slope of the regression was low, signifying only a slight planting date effect on yield. The earlier planting dates had higher test weight at Fruita. The later planting dates had higher test weight in Southwest Colorado.

RWA symptom patterns were different at the two sites. At Fruita, the last planting date had more RWA symptoms than the first two dates. In southwest Colorado, there were no differences in percent symptomatic tillers between planting dates. The later planting dates at both sites tended to have more RWA present, both on the stem and on the head during the boot and anthesis growth stage samples. The number of RWA was approximately equal in the three planting dates on the soft dough sample. There were many more RWA present on the head than on the stem at both sites during the anthesis and soft dough samples.

Gaucho was effective in controlling RWA through heading at both sites, as was the Lorsban in controlling RWA on the heads. The Gaucho only treatment had fewer RWA at soft dough than the untreated plots, while those treated with Lorsban remained relatively aphid free.

Percent yield loss for different treatments is displayed in Table 3. The overall yield loss from RWA was greatest in the third planting date at both sites. Yield loss from RWA head feeding was recorded in only the first planting date at Fruita and the third planting date at Yellow Jacket.

Later planting dates tended to have greater percent RWA symptomatic tillers during the boot and anthesis sampling at both sites, but the differences disappeared at the soft dough sample. There were also more total RWA in the later planting dates during the first two sample dates, which is the opposite of that observed during the 1997 and 1998 experiments. The later planting dates had more head feeding RWA at the anthesis sample at both sites, but these differences had disappeared by the soft dough sample date.

The bulk of the yield loss at either site could have been avoided with a timely application of a foliar insecticide. This application, if made before boot, would probably control RWA whose progeny would feed on heads. RWA symptoms, while not precisely indicating the number of RWA feeding on the plant, are probably sufficient to indicate economic problems with RWA under most situations. The only circumstance under which foliar symptoms would not be sufficient to identify a RWA infestation would be when there was late season immigration into previously uninfested wheat fields. These late season RWA would feed on heads without creating foliar symptoms.

Table 1. Results from Fruita experiment, 1999. Means within a column grouping followed by the same letter are not significantly different. (á=0.05; [1] á=0.10); [2] P-values labeled NS have a value greater than 0.40.

	Yield bu/a	Test Weight	500 seed wt	% Symp. Z45	RWA Z45	% Symp. Z59	Stem RWA Z59	Head RWA Z59	% Symp Z85	Stem RWA Z85	Head RWA Z85
PD 1	84.4 a	57.6 ab	16.9 a	3.3 a	1.5 a	0.0 a	2.0	21.8 a	0.8	0.9 a	72.3
2	83.4 a	58.3 a	17.3 a	0.0 a	1.6 a	3.3 a	9.6	25.6 a	0.0	1.4 a	12.4
3	45.3 b	57.0 b	15.1 b	16.7 b	13.7 b	12.5 b	15.8	52.8 b	1.7	9.6 b	67.0
P-value	<0.0001	0.061	0.004	<0.0001	0.046	0.002	0.158	0.029	0.372	0.023	0.120
LSD	7.36	0.87[1]	1.27	6.5	10.94	0.66		24.38		6.76	
Chem 1	71.4 ab	57.7	16.4 ab	5.8	3.9	4.2	8.2	17.0 a	1.7	2.9 ab	23.8 a
2	75.1 a	58.2	17.3 a	5.0	3.4	5.0	3.5	18.8 a	0.8	0.2 a	0.5 a
3	66.5 b	57.3	15.6 b	9.2	9.3	6.7	15.8	64.4 b	0.0	8.8 b	127.4 b
P-value	0.084	0.261	0.047	NS[2]	NS[2]	NS[2]	0.244	0.0006	0.372	0.041	0.0008
LSD	6.27[1]		1.27					24.38		6.76	66.55
PD1 CH1	82.6	57.7	16.6	0.0	0.8	0.0	1.3 a	9.3 a	2.5	0.5 a	21.0
CH 2	89.5	58.5	18.1	2.5	0.5	0.0	2.5 a	10.8 a	0.0	0.0 a	0.3
CH3	81.0	57.2	16.1	7.5	3.0	0.0	2.3 a	45.5 a	0.0	2.3 a	195.5
PD2 CH1	80.1	58.0	16.8	0.0	2.0	2.5	19.8. ab	32.8 a	0.0	3.0 a	11.5
CH2	89.5	58.3	17.5	0.0	0.5	2.5	1.3 a	12.3 a	0.0	0.5 a	0.0
CH3	80.8	58.7	17.5	0.0	2.3	5.0	7.8 a	31.8 a	0.0	0.8 a	25.8
PD3 CH1	51.7	57.4	15.8	17.5	9.0	10.0	3.5 a	9.0 a	2.5	5.3 a	38.8
CH2	46.3	57.8	16.2	12.5	9.3	12.5	6.8 a	33.5 a	2.5	0.0 a	2.3
CH3	37.8	56.0	13.3	20.0	22.8	15.0	37.3 b	116.0 b	0.0	23.5 b	161.0
P-value	0.419	0.377	0.256	NS[2]	NS[2]	NS[2]	0.097	0.018	NS[2]	0.038	0.174
LSD							20.54[1]	42.23		11.7	

Table 2. Results from Southwest Colorado experiment, 1999. Means within a column grouping followed by the same letter are not significantly different. (á=0.05; [1] á=0.10); [2] P-values labeled NS have a value greater than 0.40.

	Yield bu/a	Test Weight	500 seed wt	% Symp Z45	Stem RWA Z45	% Symp Z59	Stem RWA Z59	Head RWA Z59	% Symp Z85	Stem RWA Z85	Head RWA Z85
PD 1	93.0	56.1 a	17.5	14.2	26.1	8.3 a	5.4	15.6 a	30.0	2.7 a	17.0
2	90.9	57.4 b	16.8	20.8	41.8	20.0 b	18.0	41.5 b	33.3	0.5 b	17.5
3	90.8	58.2 c	17.5	19.2	34.0	11.7 a	19.6	51.8 b	25.8	0.8 b	18.9
P-value	NS	<0.0001	0.288	0.319	NS[2]	0.009	0.108	0.014	NS[2]	0.044	NS[2]
LSD		0.77				0.73		24.0		1.83	
Chem 1	93.9 a	57.5	17.6 a	5.8 a	5.0 a	0.0 a	3.0 a	15.7 a	18.3 a	1.2 ab	15.8 a
2	96.0 a	57.3	18.1 a	5.0 a	4.3 a	1.7 a	1.0 a	4.2 a	20.0 a	0.3 a	1.1 a
3	84.8 b	56.8	16.1 b	43.3 b	92.5 b	38.3 b	39.0 b	89.1 b	50.8 b	2.5 b	36.5 b
P-value	0.004	0.195	0.0008	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.056	0.0014
LSD	6.57		0.93	9.25	40.78	7.30	14.44	24.19	11.7	1.52[1]	17.59
PD1 CH1	94.4	56.2	18.0	2.5	0.5	0.0 a	0.0	3.0 a	17.5	2.0	15.8
2	94.6	56.2	17.9	5.0	2.8	0.0 a	0.8	6.3 a	20.0	0.3	1.0
3	90.1	55.9	16.4	35.0	75.0	25.0 b	15.5	37.5 a	52.5	5.8	34.3
PD2 CH1	96.8	57.5	17.4	5.0	3.8	0.0 a	4.3	19.3 a	15.0	0.8	12.3
2	94.2	57.5	17.5	5.0	3.3	5.0 a	2.3	0.8 a	27.5	0.5	1.5
3	81.7	57.0	15.7	52.5	118.3	55.0 c	47.5	104.5 b	57.5	0.3	38.8
PD3 CH1	90.6	58.8	17.4	10.0	10.8	0.0 a	4.8	24.8 a	22.5	0.8	19.5
2	99.1	58.3	18.8	5.0	7.0	0.0 a	0.0	5.5 a	12.5	0.0	0.8
3	82.7	57.5	16.4	42.5	84.3	35.0 b	54.0	125.3 b	42.5	1.5	36.5
P-value	0.381	NS[2]	NS[2]	NS[2]	NS[2]	0.020	0.181	0.042	NS[2]	0.129	NS[2]
LSD						12.64		41.64			

Table 3. Percent yield loss. Overall yield loss calculated by comparison of untreated control to Gaucho plus Lorsban treatment. Head feeding loss calculated by comparison of Gaucho only to Gaucho plus Lorsban treatments.

Planting date	Fruita % loss from RWA		Yellow Jacket % loss from RWA	
	Overall	Head feeding	Overall	Head feeding
1	9.4	7.7	4.8	0
2	9.8	0	13.2	0
3	18.4	0	16.5	9.4

AGRONOMIC PERFORMANCE OF KENAF VARIETIES IN THE GRAND VALLEY OF WESTERN COLORADO

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist

Summary and Recommendations

A kenaf (*Hibiscus cannabinus* L.) cultivar performance test was conducted in 1998 and 1999 at the Western Colorado Research Center at Fruita. Four kenaf cultivars (7N, Everglades 41, Tainung 2, SF192, and SF459) were planted on May 15, 1998 and six kenaf cultivars (Everglades 41, Everglades 71, SF459, Whitten, Tainung 2, and a Colorado experimental) were planted on June 4, 1999. Harvest occurred on December 17, 1998 and December 13, 1999 from a plot area 1.5 m (5 feet) wide by 14.3 m (47 feet) long using a commercial forage harvester. Plot yields were determined by chopping the sample into a weigh truck. A subsample was collected from each plot to determine moisture at harvest. The only plant characteristic to have significant differences among cultivars in 1998 was plant population. In 1999, there were significant differences among cultivars for plant height, stem diameter, plant population, and moisture at harvest. Plant height averaged 3.1 m (10.3 ft.) in 1998 and 2.0 m (6.7 ft.) in 1999. Stem diameter averaged 22.6 mm (0.89 in.) in 1998 and 12.4 mm (0.49 in.) in 1999. Plant population averaged 201,241 plants/ha (81,389 plants/acre) in 1998 and 339,504 plants/ha (137,396 plants/acre) in 1999. Plant moisture at harvest averaged 26.5% in 1998 and 19.5% in 1999. Dry matter yields averaged 11,180 kg/ha (5.0 tons/acre) in 1998 and 6,775 kg/ha (3.0 tons/acre) in 1999.

Kenaf yields were nearly 4,480 kg/ha (2 tons/acre) higher in 1998 than in 1999. The late planting date in 1999 was likely an important reason for the low yields. Kenaf shows promise as an alternative crop in western Colorado, although more extensive testing is needed to determine how well kenaf would perform in the varied conditions that exist in the mountain valleys of western Colorado. More comprehensive research is also needed to develop best management practices for kenaf production in western Colorado. Other critical aspects of production in western Colorado is identifying suitable markets for kenaf and obtaining accurate, local costs for producing and transporting kenaf to identified markets. Unreliable, distant markets will not be an enticement for kenaf production in western Colorado.

Introduction

Kenaf (*Hibiscus cannabinus* L.) is an annual fiber crop native to east-central Africa where it has been grown for thousands of years for food and fiber (LeMahieu et al., 1991). Kenaf was introduced into the United States when jute imports were affected by World War II. Potential uses for kenaf include paper and newsprint, animal feed, clothing/textile fabrics, thermoplastic composites, animal bedding/litter, phytoremediation and other environmental services, and plant growth media. Research on kenaf since its introduction into the U.S. has been sporadic. Although research efforts on kenaf have increased in recent years, sustained research funding and profitable commercial production of this new crop continues to be uncertain.

Chronic surpluses and low prices of traditional crops over the past several years has again created strong interests from farmers and agriculturists in developing profitable alternative crops. Other people also have strong interests in alternative crops because of their potential for increased sustainability and the opportunity to develop new products, businesses, and industries. One of the first steps in evaluating the potential of an alternative crop is to assess its agronomic potential for production in specific locations. Considerable agronomic research has been conducted on kenaf at various locations across the U.S. to determine its adaptation to local environments and its compatibility to site-specific crop production systems. Kenaf variety performance trials have been conducted in Mississippi (Hovermale, 1995; Baldwin et al., 1998), Florida (Stricker et al., 1998), Texas (Nelson and Cook, 1998), Kentucky (Bitzer et al., 1999), and possibly other locations in the U.S. To the best of our knowledge little, if any, research has been conducted on kenaf in the intermountain west.

In 1997, we planted a preliminary field study to determine kenaf performance in the Grand Valley of western Colorado. Kenaf, cultivar Tainung 2, was planted on May 9, 1997 and harvested on April 10, 1998. Based on the observations and results from the 1997 planting and interest from the public in western Colorado, we determined additional agronomic research on kenaf was warranted. The objective of our study was to determine the agronomic performance of kenaf cultivars in the Grand Valley of western Colorado.

Materials and Methods

A field kenaf cultivar performance test was conducted at the Colorado State University, Western Colorado Research Center at Fruita during 1998 and 1999. The elevation at Fruita is 1371 m (4510 feet). The average annual precipitation is 213 mm (8.4 inches) and the average frost-free days is 181 days. The last spring frost occurred on April 19, 1998 and the first fall frost occurred on October 18, 1998, thus the 1998 frost-free days was 181 days (28EF base). The last spring frost occurred on April 17, 1999 and the first fall frost occurred on October 17, 1999, thus the 1999 frost-free days was 183 days (28EF base).

Four kenaf cultivars (7N, Everglades 41, Tainung 2, SF192, and SF459) were evaluated in 1998 and six kenaf cultivars (Everglades 41, Everglades 71, SF459, Whitten, Tainung 2, and a Colorado selection) were evaluated in 1999. The Colorado selection was out of the 1997 planting from one of a few plants that first flowered on July 2, 1997. The Colorado selection has been identified in this report as 'Fruita-Select.' The experiment was a randomized complete block with three replications in 1998 and four replications in 1999. Plot size was 1.5 m (5 feet) wide by 15.2 m (50 feet) long in both years. Planting rate in 1998 was 33 seeds/m (10 seeds/foot) with one seed row per 76-cm (30-inch) bed. In 1999, the planting rate was 66 seeds/m (20 seeds/foot) of row distributed across three seed rows per 76-cm (30-inch) bed. Fertilizer applications in 1998 were 224 kg/ha (200 lbs/acre) of 11-52-0, applied preplant broadcast. No herbicides were applied in either 1998 or 1999. Planting occurred on May 15, 1998 and June 4, 1999 with a small plot, cone planter. Plots were furrow-irrigated as needed throughout the growing season.

Stem diameters were determined each year near the base of the plant using calipers on ten successive plants in a randomly chosen area of each plot. Plant populations were determined in four areas of each plot along 0.91-m (3-foot) lengths randomly selected within the interior of the plot area. Plant height was measured in four areas of the each plot using a telescoping surveyor's measuring rod.

Harvest occurred on December 17, 1998 and December 13, 1999 from a plot area 1.52 m (5 feet) wide by 14.3 m (47 feet) long using a commercial forage harvester. Plot yields were determined by chopping the sample into a weigh truck. A subsample was collected from each plot to determine moisture at harvest.

Results and Discussion

The only plant characteristic to have significant differences among cultivars in 1998 was plant population. In 1999, there was significant differences among cultivars for plant height, stalk diameter, plant population, and moisture at harvest.

Plant height averaged across cultivars was 3.1 m (10.3 ft.) in 1998 and 2.0 m (6.7 ft.) in 1999. There were no statistically significant differences in plant height among kenaf cultivars in 1998. Whitten and Fruita-Select were the tallest cultivars in 1999. Everglades 41, Everglades 61, SF 459, and Tainung 2 were statistically similar in plant height.

Stem diameter averaged 22.6 mm (0.89 in.) in 1998 and 12.4 mm (0.49 in.) in 1999. There were no statistically significant differences in stem diameter among kenaf cultivars in 1998. In 1999, Whitten had the largest stem diameter, while the other kenaf cultivars were statistically similar in stem diameter.

Plant population averaged 201,241 plants/ha (81,389 plants/acre) in 1998 and 339,504 plants/ha (137,396 plants/acre) in 1999. Differences in plant populations for 7N, Everglades 41, and Tainung 2 were significantly different in 1998. SF 192 and SF 459 had the lowest plant populations among the kenaf cultivars in 1998. In 1999, there was considerable variation among cultivars for plant population. Fruita-Select in particular had a low population, although Everglades 71 and Whitten also had low populations in comparison to other cultivars. Tainung 2 and Everglades 41 had similar, high plant populations, although they did not differ statistically from Everglades 71, SF 459, or Whitten.

Plant moisture at harvest averaged 26.5% in 1998 and 19.5% in 1999. There were no statistically significant differences in harvest moisture among kenaf cultivars in 1998. The cultivars with the lowest harvest moistures in 1999 were Everglades 71, Whitten, Tainung 2, and Fruita-Select. The difference between cultivars with the highest and lowest numerical moisture contents was slightly more than 1%.

Dry matter yields averaged 11,180 kg/ha (5.0 tons/acre) in 1998 and 6,775 kg/ha (3.0 tons/acre) in 1999. There were no statistically significant differences in dry matter yields among kenaf cultivars in 1998 or 1999. In Mississippi, kenaf yields typically range from 4 to 8 tons/acre (Baldwin et al., 1996). The dry matter yields in 1998 in western Colorado were within this range. Our yields in 1998 were also similar to those obtained in Kentucky (Bitzer et al., 1999) and Texas (Nelson and Cook, 1998), but generally lower than those experienced in Florida (Stricker et al., 1998).

In the 1997 preliminary study, kenaf yield was estimated at 12,096 kg/ha (5.4 tons/acre). Harvest of the 1997 planting did not occur until the following spring and plants stood in the field throughout the winter and during early spring. At the time of harvest, considerable lodging of kenaf plants had occurred, creating some difficulty with mechanical harvesting. Lodged plants were not readily picked up by the forage harvester and did not feed evenly into the machine. In 1998 and 1999 we did not observe any lodging and harvesting was accomplished without difficulty. Weed infestations were higher than desired in both years and may have reduced yields. Improved weed control would likely result in increased yields in western Colorado.

Acknowledgments

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Table 1. Field performance of kenaf cultivars at the Colorado State University, Western Colorado Research Center at Fruita in 1998-99.

Variety	Dry matter yield		Moisture at harvest	Plant population		Stem diameter		Plant height	
	tons/A	kg/ha	%	Plants/A	Plants/ha	inches	mm	ft	m
1998									
7N	4.59	10,277	30.9	96,800	239,192	0.84	21.3	10.6	3.2
Everglades 41	4.68	10,485	29.8	86,926	215,273	0.83	21.0	9.9	3.0
Tainung 2	5.83	13,072	23.2	85,184	210,490	0.90	22.8	10.6	3.2
SF 192	4.68	10,475	22.5	73,568	181,787	0.91	23.1	10.4	3.2
SF 459	5.17	11,594	26.2	64,469	159,462	0.97	24.7	10.0	3.1
Ave	4.99	11,180	26.5	81,389	201,241	0.89	22.6	10.3	3.1
LSD (0.05)	NS	NS	NS	18,670	46,115	NS	NS	NS	NS
CV (%)	31.1	31.1	14.9	12.3	12.3	9.4	9.4	6.5	6.5
1999									
Everglades 41	3.22	7,213	20.3	171,699	424,268	0.44	11.4	6.5	1.98
Everglades 71	2.87	6,432	19.5	112,893	278,958	0.49	12.4	6.4	1.95
SF 459	3.43	7,680	19.8	159,357	393,771	0.48	12.4	6.2	1.88
Whitten	3.24	7,267	19.6	141,933	350,716	0.56	14.2	7.4	2.28
Tainung 2	3.08	6,891	19.0	174,240	430,547	0.45	11.4	6.6	2.00
Fruita-Select	2.31	5,166	19.0	64,251	158,764	0.49	12.5	7.4	2.25
Ave.	3.02	6,775	19.5	137,396	339,504	0.49	12.4	6.7	2.05
LSD (0.05)	NS	NS	0.8	81,580	201,503	0.07	1.5	0.6	0.20
CV (%)	28.2	28.2	2.8	15.9	15.9	8.0	8.0	5.9	6.4

DOUBLE-CROPPING PINTO BEAN AFTER WINTER BARLEY IN WESTERN COLORADO

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist

Summary and Recommendations

In temperate climates, crop production is limited to mainly one crop per growing season. Compared to producing only one crop per year, double cropping in temperate locations would be an efficient way to maximize use of the growing season, resulting in increased production and profit potential. A field study was conducted for three years from 1997 through 1999 at the Colorado State University, Western Colorado Research Center at Fruita to develop a double-crop system of winter barley followed by a pinto bean crop for use in the valley areas of western Colorado. Grain yields of winter barley in 1997, 1998, and 1999 averaged 6413, 4398, and 7082 lbs/acre, respectively. Double-cropped pinto bean yields in 1997, 1998, and 1999 averaged 2150, 2657, and 1934 lbs/acre, respectively. In 1997, a pinto bean yield of 2150 lbs/acre at $16.00/cwt and a winter barley crop of CO12554 at 6522 lbs/acre at $6.00/cwt grossed $735.32 per acre. In 1998, a pinto bean yield of 2657 at $16.00/cwt and a winter barley crop of CO12554 at 5140 at $6.00/cwt grossed $733.52 per acre. In 1999, a pinto bean yield of 2138 lbs/acre of Olathe at $16.00/cwt and a winter barley crop of CO12554 at 7031 at $6.00/cwt grossed $763.94 per acre. Growing an early-maturing winter barley and double cropping pinto beans under a clean-till system appears to be a profitable, viable cropping alternative.

Introduction and Objectives

In temperate climates, crop production is mainly limited to one crop per growing season. Compared to producing only one crop per year, double cropping in temperate locations would be an efficient way to maximize use of the growing season, resulting in increased production and profit potential. Double-crop production systems in the U.S. have been developed and routinely used in areas with long growing seasons.

In a winter barley/pinto bean double-crop system in western Colorado, winter barley would be fall-planted, harvested in late June or early July and pinto beans planted as soon as possible. Planting of winter barley instead of winter wheat is preferred because barley matures earlier than wheat. Early harvest of winter barley is important to retain as much of the remaining growing season as possible for pinto beans to reach maturity.

The objective of this study was to develop a double-crop system of winter barley followed by a pinto bean crop for use in the valley areas of western Colorado that have longer growing seasons than many other locations in western Colorado. We also needed to identify an early-maturing winter barley variety that could be harvested in late June or early July and still allow sufficient time to plant and produce a mature pinto bean crop in one growing season. We also evaluated several pinto bean cultivars for agronomic performance in this double-crop system.

Materials and Methods

A field study was conducted for three years from 1997 through 1999 at the Colorado State University, Western Colorado Research Center at Fruita which is located in the Grand Valley of western Colorado. The previous crop was corn for silage in 1997, dry bean in 1998, and sweet corn in 1999. The soil was a Youngston fine sandy loam in 1997 and 1998 and a Youngston clay loam in 1999.

Schuyler is the most widely grown winter barley cultivar in western Colorado, but it is too late maturing for use in a double-crop system with pinto bean. Furthermore, Schuyler is tall and lodges in many years, further delaying maturity and harvest. We evaluated three winter barley cultivars and one experimental in 1999- Barsoy, Post, Schuyler, and CO12554 (experimental). The field was prepared using clean tillage by disking, moldboard plowing, and roller harrowing once. An application of 175 lbs/acre of 11-52-0 in 1997, and 200 lbs/acre of 18-46-0 each year in 1996 and 1998 was made in the fall of each year. The field was roller harrowed once to incorporate fertilizer and furrowed to form 30-inch beds. Winter barley was planted on 10 Oct. 1996, 21 Oct. 1997, and 13 Oct. 1998 in plots 5 feet wide by 25 feet long. Three seed rows of winter barley were planted on top of the beds. In the early spring of each year, 100 lbs N/acre of ammonium nitrate was top-dressed. Harmony Extra was applied at 0.5 oz/acre plus 0.25 lb/acre of 2,4-D plus 2 pts of Penetrate II per 100 gallons water on March 24, 1997. Harmony Extra only was applied at 0.4 oz/acre on 12 Mar. 1998. Harmony Extra at 0.4 oz/acre plus 0.25 lb/acre of 2,4-D plus 1 qt of Activator 90 per 100 gallons of water was applied in a tank mix for weed control on 3 Mar 1999. Winter barley was harvested on 26 June 1997, 1 July 1998, and 20 June 1999 from an area 5 feet wide by 23 feet long. Grain moistures were determined at harvest and corrected to 12%.

Following harvest of winter barley, the straw in the windrows from the combine was baled and hauled from the field. The stubble was disced and the field moldboard plowed. Following plowing, the soil was roller harrowed once and a tank mix application of Frontier (6.0 lb/gallon formulation) at 23 oz/acre plus Eptam 7E at 2 pts/acre was broadcast sprayed. The field area was roller harrowed once immediately after herbicide application to incorporate herbicides and also to smooth the field and complete seedbed preparation. The field was furrowed and planted in separate operations. Plots were planted with a White Air Planter that had been modified for planting small plots. Four pinto bean cultivars were evaluated to determine pinto bean performance when grown as a double crop. Pinto bean cultivars evaluated were Arapaho, Bill Z, Olathe, and Othello. Plots were 10 feet wide by 35 feet long and were arranged as a randomized complete block with four replications. Pinto bean planting occurred on 27 June 1997, 2 July 1998, and 30 June 1999. At maturity, pinto beans were cut and windrowed with a Pickett One-Step™ rod cutter windrower (Pickett Equipment Co., Burley, ID). Yields were determined from a plot area 5 feet wide and 32 feet long. Pinto beans were harvested with a Hege small plot combine equipped to harvest pinto bean. Harvest occurred on 7 Oct. 1997, 6 Oct. 1998, and 11 Oct. 1999.

Results and Discussion

Grain yields of winter barley were higher in 1999 than in 1997 or 1998 (Table 1). Sprinter and Schuyler were high yielding, but they were also late maturing in 1997. Schuyler was late-maturing compared to most other varieties in all three years. Differences in grain yield among winter barley cultivars were not statistically significant in 1998 or 1999; however, numerically CO12554 yielded 18 and 12 bushels/acre more than Schuyler in 1998 and 1999, respectively. These differences have production significance and would be of importance to growers.

Grain moistures among cultivars in 1998 and 1999 were not significantly different. Sprinter had the highest grain moisture at harvest in 1997. Barsoy flowered and headed earlier than other cultivars in all three years. A freeze occurred when Barsoy was flowering in 1997 and 1998, causing yield losses in this cultivar. Freezing temperatures did not occur during flowering in 1999. CO12554 is early maturing but not did not flower so early that it experienced freeze damage during flowering. CO12554 was short-statured, had a low test weight, and small seed size, compared to most other cultivars.

The short stature of CO12554 is an advantage for double cropping for several reasons. Short-statured plants are less prone to lodging. A standing crop matures more evenly across the field, resulting in uniform grain moisture and allowing for an earlier harvest date than lodged fields. Additionally, fields that do not lodge are much easier to harvest. The short plant height of CO12554 also means less straw after harvest. This may permit the field to be worked easier and faster, which could speed planting of pinto bean. It is important to harvest winter barley as soon as possible, prepare a suitable seedbed for pinto beans, and plant. During the years we have studied double-cropping winter barley and pinto bean, we usually harvest the winter barley in late June and plant pinto beans before the 4th of July. Each day planting is delayed, the growing season for the pinto bean crop is shortened, which could result in yield losses for pinto bean.

Double-cropped pinto bean yields were highest in 1998, lowest in 1999, and intermediate in 1997 (Table 2). Yields among double-cropped bean cultivars were not significantly different in 1997 or 1998, averaging 2150 lbs/acre in 1997 and 2657 lbs/acre in 1998. In 1999, Olathe outyielded Bill Z and Othello. In 1999, seeds were similar in size to 1998 but larger than in 1997, pods/plant was lower than the other two years, and seeds/pod were similar to 1998 but slightly lower than in 1997. Arapaho had the largest seed size in 1997 and seed size was similar among pinto bean cultivars in 1998 and 1999. Pods/plant and seeds/pod were not significantly different among pinto bean cultivars in any of the three years.

In 1997, a pinto bean yield of 2150 lbs/acre at $16.00/cwt and a winter barley crop of CO12554 at 6522 lbs/acre at $6.00/cwt grossed $735.32 per acre. In 1998, a pinto bean yield of 2657 at $16.00/cwt and a winter barley crop of CO12554 at 5140 at $6.00/cwt grossed $733.52 per acre. In 1999, a pinto bean yield of 2138 lbs/acre of Olathe at

$16.00/cwt and a winter barley crop of CO12554 at 7031 at $6.00/cwt grossed $763.94 per acre (Crop prices used for calculations are for illustration purposes only and do not reflect current prices.) Growing an early-maturing winter barley and double cropping pinto beans under a clean-till system appears to be a profitable, viable cropping alternative.

Acknowledgments

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Table 1. Plant performance of winter barley cultivars at Fruita, Colorado in 1997, 1998, and 1999.

Cultivar	Grain moisture	Grain	Yield	Test weight	Plant height	Days to heading	Days to maturity	Seed weight	Lodging
	%	lbs/A	bu/A	lbs/bu	in.	no.	no.	mg.	
1997									
Post	4.4	6391	133	53.4	37	209	253	33.7	-
Schuyler	4.6	7110	148	51.5	36	216	257	38.4	-
Barsoy	4.3	4194	87	54.5	30	197	252	36.0	-
CO12554	4.2	6522	136	49.7	24	205	255	31.8	-
Sprinter	7.6	8351	175	50.7	34	216	262	36.7	-
Ave.	5.0	6413	136	52.0	32	209	256	35.3	
LSD (0.05)	1.1	1103	22	0.9	2.5	1.0	1.3	2.4	
CV (%)	3.1	16.5	16.5	1.6	7.4	0.5	0.5	4.4	
1998									
Barsoy	10.0	3555	74	52.6	39	186	239	37.6	1.6
Post	9.5	4282	89	51.1	42	199	249	36.0	3.1
Schuyler	9.8	4293	89	50.4	41	204	253	38.2	2.3
CO12554	9.2	5140	107	47.6	28	194	249	34.8	0.2
Sprinter	9.6	4723	98	51.8	38	211	258	41.5	2.0
Ave.	9.6	4398	91	50.7	37	199	250	37.6	
LSD (0.05)	NS	NS	NS	1.3	6	1.4	5	1.2	
CV(%)	3.8	24.1	24.1	1.6	11.2	0.5	1.2	2.2	
1999									
Barsoy	10.1	7226	147	47.4	33	194	260	29.6	2.0
Post	10.3	6967	143	46.2	41	208	260	27.2	5.2
Schuyler	10.8	7105	144	45.2	44	213	262	29.7	3.7
CO12554	10.6	7031	156	41.6	27	199	259	27.2	1.1
Ave.	10.5	7082	148	45.1	36	203	260	28.5	
LSD (0.05)	NS	NS	NS	2.6	1.7	1.0	2.3	2.0	
CV(%)	3.8	17.1	17.1	3.6	2.9	0.2	0.5	4.4	

Table 2. Agronomic performance of four pinto bean cultivars grown following winter barley at Fruita, Colorado in 1997, 1998, and 1999.

Cultivar	Pinto bean yield	Seeds/lb	Pods/plant	Seeds/pod
	lbs/A	no.	no.	no.
1997				
Arapaho	2074	1242	15.0	4.0
Bill Z	2180	1528	10.7	4.8
Olathe	2220	1488	11.6	4.3
Othello	2126	1495	14.1	4.7
Ave.	2150	1438	12.8	4.4
LSD(0.05)	NS	146	NS	NS
CV(%)	7.8	6.3	22.2	10.0
1998				
Arapaho	2682	1301	15.0	3.8
Bill Z	2665	1328	14.6	3.9
Olathe	2840	1251	14.9	3.6
Othello	2442	1216	11.4	3.3
Ave.	2657	1274	14.0	3.6
LSD (0.05)	NS	NS	NS	NS
CV(%)	7.8	4.9	29.5	7.0
1999				
Arapaho	1977	1237	11.6	4.1
Bill Z	1786	1204	9.0	3.8
Olathe	2138	1309	11.4	3.6
Othello	1834	1270	9.4	3.8
Ave.	1934	1255	10.3	3.8
LSD (0.05)	281	NS	NS	NS
CV(%)	8.1	12.4	16.5	14.1

EVALUATION OF PINTO BEAN VARIETIES AND DRY BEAN UNIFORM NURSERY ENTRIES AT FRUITA, COLORADO 1999

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Summary and Recommendations

Yields in the pinto bean variety performance test conducted at Fruita, Colorado ranged from a high of 3360 lbs/acre to a low of 2372 lbs/acre. Four pinto bean varieties (Buster, USPT-73, CO64000, Cisco) were high yielding. Yields in the dry bean uniform nursery trial ranged from a high of 3572 lbs/acre for UI 259 to a low of 946 lbs/acre for Lassen. Five dry bean entries (UI 259, NW 63, Viva, Matterhorn, 92235) were high yielding. These results are useful to farmers in selecting varieties to plant on their farms, to seedsmen in knowing which varieties to produce, to dry bean companies to determine which varieties to market and in what locations they are best adapted, and to university personnel in developing new dry bean varieties and educating the public about dry bean variety performance and production. For more information and results of dry bean testing in Colorado visit the web site at: http:www.colostate.edu/Depts/SoilCrop/extension/CropVar/index.html

Introduction and Objectives

Field testing of advanced breeding lines and varieties is important in developing new dry bean varieties and for evaluating varieties and screening lines for adaptation and performance under local conditions. Colorado produces more pinto beans than other dry bean market classes and identifying high yielding pinto bean varieties is important to growers. In 1999, we conducted two dry bean trials at the Western Colorado Research Center at Fruita. We participated in the state pinto bean variety performance test in which the same entries are cooperatively evaluated at several locations in Colorado. We also participated in the Uniform Dry Bean Nursery in which the same varieties and advanced breeding lines of several market classes of dry beans are cooperatively evaluated at more than twenty locations across the U.S and Canada.

Materials and Methods

<u>Pinto Bean Variety Performance Test</u>

A pinto bean variety performance test was conducted at the Colorado State University, Western Colorado Research Center at Fruita during 1999. The experiment was a randomized complete block with three replications. The same 25 varieties and advanced breeding lines were evaluated at Fruita and six other locations around Colorado. Plot size was 10 feet wide by 36 feet long. Frontier herbicide (7.0 lb/gal. formulation) at 18 oz/acre and Eptam (7E) at 2 pts/acre as a tank mix was applied preplant broadcast and incorporated by roller harrowing once, followed by spike-tooth harrowing. Planting occurred on June 21, 1999 with a White air planter modified for planting plots. Plots were cut on September 28, 1999 with a Pickett One-Step™ rod cutter windrower (Pickett Equipment Co., Burley, ID) and threshed on October 4, 1999 using a Hege small plot combine equipped to harvest dry bean.

<u>Dry Bean Uniform Nursery</u>

The dry bean uniform nursery was conducted at the Colorado State University, Western Colorado Research Center at Fruita in 1999. The experiment was a randomized complete block with four replications. The same 36 varieties and advance breeding lines were evaluated at Fruita and at numerous other locations across the U.S. and Canada. Plot size was 5 feet wide by 25 feet long. Frontier herbicide (7.0 lb/gal. formulation) at 18 oz/acre and Eptam (7E) at 2 pts/acre as a tank mix was applied preplant broadcast and incorporated by roller harrowing once, followed by spike-tooth harrowing. Planting occurred on June 21, 1999 with a White air planter modified for planting plots. Plots were cut on September 27, 1999 with a Pickett One-Step™ rod cutter windrower (Pickett Equipment Co., Burley, ID) and threshed on October 4, 1999 using a Hege small plot combine equipped to harvest dry bean.

Results and Discussion

Pinto Bean Variety Performance Test

Yields in this trial ranged from a high of 3360 lbs/acre to a low of 2372 lbs/acre. Four pinto bean varieties (Buster, USPT-73, CO64000, Cisco) were high yielding (Table 1). Five varieties (Frontier, Burke, Elizabeth, Chase, and CO46322) were low yielding. USPT-73 had the largest seed size and Chase had the smallest seed size. Complete information about the varieties as to their origin, growth habits, maturity, yield data summary for several years and at other test sites in Colorado, and disease resistance is available in Technical Report TR99-10, entitled, "Making Better Decisions: 1999 Dry Bean Variety Performance Trials," Agricultural Experiment Station, Colorado State University.

Dry Bean Uniform Nursery

Yields in this trial ranged from a high of 3572 lbs/acre for UI 259 to a low of 946 lbs/acre for Lassen. Five dry bean entries (UI 259, NW 63, Viva, Matterhorn, 92235) were high yielding (Table 2). Five entries (Red Hawk, Montcalm, CLERK, Chinook 2000, and Lassen) were low yielding. USWA-70 had the largest seed size and ND 91-076-01 had the smallest seed size. Days from planting to flowering ranged from 33 days for Shiny Crow up to 47 days for Midnight. L94C356 matured the earliest while Vista was late-maturing. Shiny Crow had the longest pod filling period as did five other entries. L94C356 had the shortest pod filling period.

For more information and results of dry bean testing in Colorado visit the web site at: http:www.colostate.edu/Depts/SoilCrop/extension/CropVar/index.html

Acknowledgments

Appreciation is expressed to Lot Robinson and Fred Judson (Western Colorado Research Center staff), and Sara Albertson, Daniel Dawson, and Amy Mannel (part time hourly employees) who assisted with this research.

Table 1. Pinto bean variety performance test at Fruita, Colorado in 1999.

Pinto bean variety	Yield	Seeds/lb
	lbs/acre	no.
Buster	3360	1241
USPT-73	3274	1040
CO64000	3260	1101
Cisco	3189	1126
Vision	2995	1220
Montrose	2989	1176
Poncho	2988	1116
CO64155	2985	1118
CO75714	2957	1182
CO74905	2919	1198
CO75511	2914	1211
CO74630	2907	1055
Kodiak	2863	1226
Buckskin	2820	1184
CO45188	2795	1167
Othello	2764	1135
Bill Z	2754	1231
CO63603	2668	1155
Maverick	2632	1205
CO66032	2613	1244
Frontier	2594	1082
Burke	2486	1111
Elizabeth	2432	1146
Chase	2392	1270
CO46322	2372	1101
Average	2837	1162
LSD (0.30)	229	
CV (%)	9.4	

Table 2. Performance of entries in the Uniform Dry Bean Nursery at Fruita, Colorado in 1999.

Dry bean entry	Market class	Yield	Seed weight	Days to flowering	Days to maturity	Podfill days
		lbs/acre	g/100 seed	no.	no.	no.
UI 259	red	3572	36.34	41	88	47
NW 63	red	3396	36.02	40	89	49
Viva	pink	3150	27.75	40	87	47
Matterhorn	great northern	3110	33.47	42	89	47
92235	pinto	3095	45.45	38	80	42
Shiny Crow	black	2907	22.73	33	88	55
Weihing	great northern	2877	35.58	41	88	47
ND 91-117-05-02	small white	2873	18.62	45	91	47
Vista	small white	2859	19.39	45	94	49
Kodiak	pinto	2839	38.56	44	90	47
ICB 10-5	black	2792	23.19	42	85	43
US 1140	great northern	2776	32.53	38	80	42
ISB 5893	pinto	2768	39.31	42	86	44
Buster	pinto	2752	36.07	42	86	44
Chase	pinto	2730	36.52	42	84	42
UI 465	great northern	2641	36.87	42	84	43
UI 320	pinto	2630	40.13	39	82	43
Mesa	pinto	2626	41.95	40	84	44
AC Compass	small white	2590	20.52	42	87	46
Mackinac	small white	2564	18.06	43	93	49
ISB 1814	small white	2424	20.51	41	92	51
Midnight	black	2390	18.93	47	93	46
Elizabeth	pinto	2256	37.52	39	82	43
AC Pintoba	pinto	2200	40.42	42	91	49
ISB 1256	small white	2198	18.56	43	92	49
ND 91-076-01	small white	2188	16.35	44	93	49
L94C356	pink	2182	33.11	40	76	36
AC Calmont	dark red kidney	2099	48.65	42	93	52
I9606-6	black	2065	20.83	46	87	41
Beluga	white kidney	1758	48.48	40	93	52
USWA-70	white kidney	1521	53.23	42	92	50
Red Hawk	dark red kidney	1414	46.16	40	89	50
Montcalm	dark red kidney	1317	49.51	41	92	52
CELRK	light red kidney	1315	51.42	40	89	50
Chinook 2000	light red kidney	1265	49.53	40	92	52
Lassen	white kidney	946	45.52	40	92	52
Average		2419	34.38	41	88	47
LSD (0.05)		541	2	3.6	2	3.9
CV (%)		15.9	4.1	6.3	1.6	5.9

SUGARBEET VARIETY PERFORMANCE TRIALS IN WESTERN COLORADO 1999

Dr. Calvin H. Pearson, Professor of Soil and Crop Sciences/Research Agronomist
and A. Wayne Cooley, Extension Agronomist

Summary and Recommendations

Sugarbeet variety performance tests were conducted at Fruita and Delta, Colorado during 1999. The same twenty-five varieties were evaluated at both locations. Beet yields at Delta averaged 26.4 tons/acre with 18.14% sugar which produced 9,591 pounds of sugar/acre at a gross return of $1,230.55/acre. Beet yields at Fruita averaged 34.2 tons/acre with 18.25% sugar which produced 12,445 pounds of sugar/acre at a gross return of $1,608.37/acre. Four varieties (HM Bighorn, Beta 8754 LL, Beta 8749, and Beta 8757LL) produced high sugar yields/acre at both locations. These 1999 results from Delta and Fruita are for one year of testing. Additional years of testing will be needed to obtain a more complete understanding of sugarbeet performance in western Colorado.

Introduction and Objectives

Sugarbeets were first produced in 1883 in western Colorado and were an important agronomic crop on the West Slope for almost a century. Sugarbeets had a strong reputation as a reliable cash crop, but were also important for crop diversity and crop rotation needs for the farmers of western Colorado; however, in 1976 Great Western Sugar Company abruptly ended the production of sugarbeets in western Colorado. No sugarbeets have been produced in western Colorado since that time. Interest in sugarbeets was rekindled when discussions about the possibility of growing sugarbeets were held between a local company, Delta Potato Growers, and Western Sugar Company. One of the outcomes of that discussion was to plant two sugarbeet variety trials in 1999 to ascertain how newer varieties would perform in western Colorado since more than twenty years had elapsed since sugarbeets were produced on the West Slope.

Materials and Methods

Two experiments were planted in western Colorado in 1999, one in the Grand Valley and one in the Uncompaghre valley. The site in the Grand Valley was at the Colorado State University Western Colorado Research Center at Fruita, and in the Uncompaghre Valley at the Steve Shea Farm in Delta. The same twenty-five sugarbeet varieties were evaluated at both locations. Plot size was 5 feet wide by 30 feet long with 6 replications.

In early spring prior to planting and fertilizer application, soil samples were taken to a 12-inch depth at both locations. Previous crop at Fruita was corn grain and at Delta was corn silage. Soil test results at Fruita were: pH - 7.9, 0.5 mmhos/cm salts, organic matter 1.5%, nitrate-nitrogen 13 ppm, phosphorus 8.2 ppm, potassium 150 ppm, zinc 3.3 ppm, iron 18.3 ppm, manganese 2.5 ppm, and copper 4.4 ppm. Soil test results at Delta were: pH - 7.7, 0.8 mmhos/cm salts, organic matter 2.4%, nitrate-nitrogen 28.4 ppm, phosphorus 19.4 ppm, potassium 344 ppm, zinc 6.6 ppm, iron 11.8 ppm, manganese 3.8 ppm, and copper 5.2 ppm.

Field preparation at Fruita included fall plowing followed by spring cultivation with an S-tinge implement. During April, the field was roller harrowed and land planed. A broadcast application of 11 lbs N/acre and 52 lbs P_2O_5/acre as 11-52-0 was applied prior to planting. Following broadcast fertilizer application, the field was roller harrowed, spike-toothed harrowed, and beds were formed. To complete bed preparation for planting, the 30-inch beds were smoothed using a single gang, roller-packer. The seedbed at Delta was prepared by disking corn stubble, plowing, roller harrowing, land planing, and forming beds for planting. Planting at Fruita occurred on April 19, 1999 and at Delta the next day on April 20, 1999. Seeding was done by personnel from the Western Sugar Company using their planter. Tractors to operate the planter were obtained from cooperators at each of the test locations.

In preparation for hand-thinning and also for weed control at Fruita, a Sugarbeet Manager™ implement

(Pickett Equipment, Burley, Idaho) was used twice in opposite directions and a cutaway band cultivation was done on June 1, 1999. Hand labor was used to thin beet varieties to a uniform population. Hand-thinning occurred at both Delta and Fruita on approximately June 2-3, 1999. Hand labor was again used on approximately June 21, 1999 at both locations to enhance the thinning operation and for weed control. At Fruita, sugarbeets were cultivated and re-furrowed on June 4, June 15, and June 22, 1999.

On June 3, 1999, 35 lbs N/acre as 34-0-0 was applied side-dress at Fruita when plants were at the 6-inch rosette stage. Herbicide applications at Fruita were two applications of Betamix applied on May 7, 1999 at 1.5 pts/acre and on May 25, 1999 at 2.5 pts/acre. No fertilizer or herbicide were applied to the sugarbeets at Delta. At Fruita, the field of sugarbeets was furrow-irrigated 12 times during the season using 1 1/4-inch siphon tubes. Irrigation set times averaged 16 hours. At Delta, the sugarbeets were irrigated approximately 9 times with irrigation set times of 12 hours.

Harvest occurred on 21 October 1999 at Delta and 22 October 1999 at Fruita. Sugarbeets were dug with a commercial-size harvester modified for small plot research. The harvester belonged to Western Sugar and was pulled with tractors provided by cooperators at each location. Subsamples of beets were obtained from each plot for later laboratory determinations of tare dirt and sugar content.

Results and Discussion

Delta

During the season sugarbeet plants thrived at Delta and no production problems were observed. Six varieties (Beta 8757 LL, Beta 8749, SX Stampede, HM Bighorn, Beta 8754 LL, and Beta 4689) had high beet yields at Delta (Table 1). Five varieties (Beta 8757 LL, SX Stampede, Beta 8754 LL, Beta 4546, and Crystal 9903 LL) had beets with high sugar concentrations.

Five varieties when combined with high yields and high beet sugar concentrations produced high sugar yields per acre. These varieties were Beta 8757 LL, Beta 8749, SX Stampede, HM Bighorn, and Beta 8754 LL, the same varieties that also had high yield in tons/acre. These same varieties produced gross returns/acre of greater than $1300. It is worth noting that two of these five high-yielding varieties had resistance to Liberty herbicide. Sugarbeet varieties containing herbicide resistance may allow for easier weed control and greatly reduce the effect weeds could have on plant performance from year-to-year.

Fruita

During emergence, seedlings experienced two separate hail events at Fruita. The hail was sustained and hard, causing some plant damage and significant soil crusting. The crust was broken using a rotary hoe. A rotary hoe is not the preferred implement to break soil crusts in sugarbeets. There are implements and management techniques that are much more effective in breaking crusts without causing potential damage to small, shallow-rooted sugarbeet seedlings. Nevertheless, during the season plants thrived and no further production problems were observed at Fruita.

Plant stands counts were taken prior to thinning at Fruita. Varieties were overplanted in an attempt to obtain uniform plant stands for all varieties once hand-thinning was completed. We did not check plant stands after thinning to determine if plant populations among the varieties were the same. We did determine plant populations prior to thinning to assess if there were differences in seed germination and seedling emergence. Crystall 9903LL had the highest plant population and Beta 4546LL had the lowest population (Table 2). Most other varieties did not have plant populations that were statistically different.

Seventeen of the twenty-four varieties evaluated at the Fruita location had high beet yields (Table 2). Ten varieties (HM Geyser, Beta 8757, HM Bighorn, Beta 8754 LL, Crystal 9903 LL, Crystal 304, Beta 8757 LL, SX Stampede, HM 118 RR, Beta 4006 R) had beets with high sugar concentrations. Twelve varieties had high sugar yields per acre. These twelve varieties resulted in gross returns/acre ranging from $1841 to $1647.

Four varieties (HM Bighorn, Beta 8754 LL, Beta 8749, and Beta 8757LL) produced high sugar yields/acre at both locations. The 1999 results from Delta and Fruita are for one year of testing. Additional years of testing will be needed to obtain a more complete understanding of sugarbeet performance in western Colorado. The data from 1999 indicated that several varieties of sugarbeet should be highly productive in western Colorado.

Some weeds persisted at both locations but were not considered to have a significant adverse impact on yield. Flower-of-an-hour was the most widespread weed at Fruita. Some redroot pigweed was also scattered throughout the field, along with some foxtail and barnyardgrass. At Delta, there were some pigweed and purslane. Dodder was the weed of most concern at Delta.

Acknowledgments

We wish to thank Western Sugar Company for their support and participation in these two sugarbeet variety performance tests. Special thanks to Steve Godby of Western Sugar and his workers for planting and harvesting the trials at Fruita and Delta and for their technical advice and suggestions on sugarbeet production. We also thank Steve Shea, farmer-cooperator, for taking care of the sugarbeets during the growing season and permitting the plots to be on his farm. We also thank Delta Area Development, Inc. for their support of sugarbeet production in western Colorado. We particularly thank Ray Rubalcaba and the Board of Directors of the Delta Potato Growers for their support of this research. Ray and those at Delta Potato Growers are largely responsible for opening the way for the possible return of commercial sugarbeet production to western Colorado. We thank research associates, Lot Robinson and Fred Judson, (Western Colorado Research Center staff) for their assistance. Also, Sara Albertson and Daniel Dawson (part-time CSU hourly employees) who assisted with this research.

Table 1. Performance of sugarbeets at Delta, Colorado on the Shea Farm in 1999.

Sugarbeet variety	Variety trait[1]	Tons per acre	Sugar (%)	Pounds of sugar/acre	Gross dollar return/acre	Dollars per ton paid[2]
BETA 8757 LL	Liberty®	29.4	18.85	11,077	$1,448.78	$49.28
BETA 8749		30.0	17.93	10,743	$1,375.29	$45.84
SX STAMPEDE		28.1	19.12	10,708	$1,400.42	$49.84
HM BIGHORN		28.9	18.24	10,559	$1,358.03	$46.99
BETA 8754 LL	Liberty®	27.8	18.82	10,444	$1,366.83	$49.17
CRYSTAL 304	Fusarium	27.0	18.26	9,866	$1,270.79	$47.07
HM 118 RR	Roundup®	26.5	18.57	9,855	$1,278.24	$48.24
BETA 4546 LL	Rhiz/Liberty®	26.7	18.24	9,743	$1,254.65	$46.99
BETA 4689	Rhiz	28.0	17.34	9,707	$1,226.73	$43.81
HM GEYSER		26.3	18.48	9,696	$1,259.75	$47.90
CRYSTAL 184	Rhiz	26.6	18.16	9,668	$1,241.89	$46.69
BETA 4546	Rhiz	25.5	18.74	9,542	$1,246.15	$48.87
BETA 8757		26.1	18.26	9,529	$1,228.43	$47.07
HM DILLON		26.9	17.47	9,391	$1,190.86	$44.27
BETA 4006R	Rhizomania	25.3	18.35	9,297	$1,199.39	$47.41
BETA 8757	Check	25.6	18.08	9,260	$1,187.45	$46.38
SX BRONCO		26.7	17.32	9,228	$1,167.89	$43.74
BETA 8754		25.0	18.49	9,228	$1,198.42	$47.94
CRYSTAL 9612		25.3	18.20	9,215	$1,185.03	$46.84
HM 9155	Check/curly top	25.6	17.65	9,041	$1,149.12	$44.89
SX BLAZER		25.5	17.70	9,010	$1,148.98	$45.06
CRYSTAL 9903 LL	Liberty®	23.7	19.01	8,997	$1,167.89	$49.28
SX RANGER	Aphid/curly top	25.1	17.79	8,930	$1,138.67	$45.36
HH 50	Check	25.3	17.61	8,895	$1,132.20	$44.75
HM 1639	Rhizomania	24.3	16.71	8,134	$1,011.31	$41.62
MEAN		26.4	18.14	9,591	$1,230.55	$46.61
CV(%)		7.50	2.14	8.01		
LSD(0.05)		2.3	0.50	878		

[1]Corresponding variety resistant to Liberty® herbicide, resistant to Fusarium fungus, resistant to Roundup® herbicide, resistant to Rhizoctonia (Rhiz) fungus, resistant to Curly Top virus, resistant to root aphids, resistant to Rhizomania disease, and check varieties (industry standards).

[2] Price paid per ton of sugarbeets based on the percent sugar content.

Table 2. Performance of sugarbeets at Fruita, Colorado at the Western Colorado Research Center at Fruita in 1999.

Sugarbeet variety	Variety trait[1]	Plant pop[2]	Tons per acre	Sugar (%)	Pounds of sugar/a	Gross dollar return/acre	Dollars per ton paid[3]
HM GEYSER		13.58	37.1	18.94	14,012	$1,840.66	$49.61
BETA 8757	Check	17.92	36.3	18.57	13,478	$1,750.95	$48.24
HM BIGHORN		15.33	35.9	18.81	13,478	$1,763.74	$49.13
BETA 8754LL	Liberty®	16.83	35.9	18.51	13,193	$1,723.63	$48.01
BETA 8749		14.75	38.0	17.34	13,155	$1,664.84	$43.81
BETA 8757		15.67	37.0	17.83	13,118	$1,683.57	$45.50
CRYSTAL 9903 LL	Liberty®	22.17	34.4	19.07	13,096	$1,695.17	$49.28
CRYSTAL 184	Rhiz	15.42	35.7	18.20	12,991	$1,672.15	$46.84
CRYSTAL 9612		15.92	36.3	17.93	12,975	$1,664.10	$45.84
CRYSTAL 304	Fusarium	14.42	34.6	18.71	12,941	$1,686.99	$48.76
BETA 8757 LL	Liberty®	15.25	34.3	18.74	12,835	$1,676.19	$48.87
HM DILLON		14.25	35.0	18.26	12,766	$1,647.32	$47.07
SX BLAZER		14.33	35.3	18.04	12,679	$1,632.04	$46.23
HH 50	Check	15.58	35.7	17.80	12,639	$1,620.76	$45.40
BETA 8754		16.50	35.5	17.92	12,630	$1,626.22	$45.81
HM 9155	Check/curly top	15.00	34.4	18.11	12,391	$1,599.54	$46.50
SX RANGER	Aphid/curly top	14.33	34.8	17.79	12,337	$1,578.71	$45.36
SX STAMPEDE		12.92	32.8	18.87	12,328	$1,618.77	$49.35
SX BRONCO		15.92	33.7	18.00	12,137	$1,552.96	$46.08
BETA 4689	Rhiz	16.58	33.1	18.00	11,847	$1,525.31	$46.08
HM 118 RR	Roundup®	13.33	30.5	18.73	11,396	$1,489.36	$48.83
BETA 4546 LL	Rhiz/Liberty®	8.83	31.3	18.08	11,288	$1,451.84	$46.38
BETA 4546	Rhiz	14.33	31.2	17.77	11,023	$1,413.27	$45.30
HM 1639	Rhizomania	15.25	30.2	17.30	10,366	$1,318.85	$43.67
BETA 4006R	Rhizomania	17.75	26.6	18.92	10,026	$1,317.73	$49.54
MEAN		15.29	34.2	18.25	12,445	$1,608.37	$47.03
CV(%)		22.8	9.52	3.38	9.28		
LSD(0.05)		3.99	3.7	0.71	1,321		

[1]Corresponding variety resistant to Liberty® herbicide, resistant to Fusarium fungus, resistant to Roundup® herbicide, resistant to Rhizoctonia (Rhiz) fungus, resistant to Curly Top virus, resistant to root aphids, resistant to Rhizomania disease, and check varieties (industry standards).
[2]Number of plants per 3-foot section of plant row. Plant population prior to thinning. Average of two counts along 3-foot sections of the plant row.
[3]Price paid per ton of sugarbeets based on the percent sugar content.

EVALUATION OF MATING DISRUPTION FOR CONTROL OF OBLIQUE-BANDED LEAFROLLERS, *Choristoneura rosaceana* (HARRIS)

Rick Zimmerman

Methods

The increased use of mating disruption for the control of codling moth, *Cydia pomonella*, has resulted in a corresponding increase of oblique-banded leafroller (OBLR) damage in apples. The purpose of this study is to determine the impact of OBLR sex pheromone on adult and larval populations. In June 1999, three different types of experimental oblique-banded leafroller pheromone dispensers (Shin-et-Su Corp.) were placed into three, 20 acre apple blocks in Western Colorado. These apple blocks were located on Rogers Mesa, west of Hotchkiss. The pheromone dispensers were: a) twin dispenser (220 mg oblique-banded leafroller sex pheromone [OBLR] and 220 mg codling moth sex pheromone, b) 80 mg OBLR sex pheromone dispenser and c) 250 mg OBLR sex pheromone dispenser. The dispensers were placed in the orchards at the following rates: a) 80 mg dispensers – 400/acre, b) 250 mg dispensers – 200/acre and c) twin tube dispenser – 200/acre.

The following blocks received the pheromone dispensers: a) twin tube dispenser – Silver Spruce Orchards, dispensers split between standard size romes and semi-dwarf golden delicious (blocks SS9 and SS10), b) 250 mg dispenser- Eastman/Phillips orchards, dispensers were placed into standard sized Golden Delicious, Gala and Jonathan apple trees (blocks DP2 and DP8) and c) 80 mg dispenser- First Fruit Orchards, dispensers were placed into standard sized golden delicious trees and semi-dwarf galas (blocks KK27 and KK33).

Results

Adult and larval OBLR populations were monitored throughout the summer. Adult populations were monitored using delta-wing pheromone traps. Traps were monitored weekly by a scout employed by the Codling Moth Areawide Management Program (CAMP). Larval populations were measured on three dates: June 24, July 30 and August 23. Fruit and leaf clusters were sampled from the upper part of the apple trees using a telescoping pruning shear. On each sample date, 30 samples were taken in a random pattern from the upper third of the tree canopy. Larval sampling was also conducted in organic orchards which did not employ OBLR pheromone disrupters.

OBLR larvae were not detected in any of the orchards on any single sampling date (Table 1). OBLR may not have been detected due to the small sampling size, small larval populations, the use of Spintor (a naturalyte insecticide, DowAgrisciences, Indianapolis, IN) or predation. In addition, earwigs were found in many of the sampled fruit clusters. Earwigs have been observed to feed on codling moth larvae and could possibly be feeding on OBLR larvae. Both earwigs and OBLR larvae share the same type of cryptic daytime habitats.

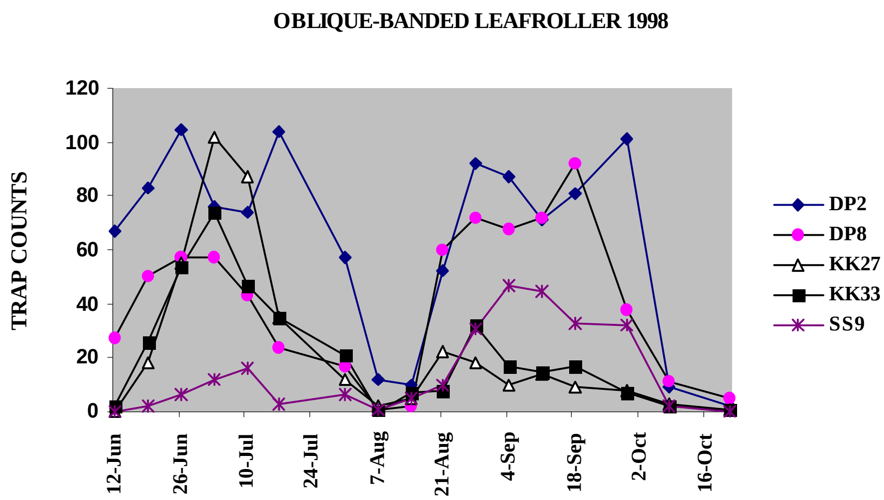
Pheromone trap catches were significantly reduced in the mating disruption blocks (Figure 2 and 3). The number of adult moths was significantly less in 1999 when compared with trap catches for similar dates in 1998 (Figure 1) and total numbers for both growing seasons (Figure 3). OBLR trap catches in nearby apple blocks which did not employ mating disruption were significantly higher than those blocks using mating disruption (Figure 4). Release of the OBLR sex pheromone resulted in pheromone trap shut down in 2 out of the 6 traps monitored in the mating disruption blocks. The totals for the other 4 traps ranged from 1 to 4 moths. Trap catches in non-mating disruption blocks for traps monitored in the CAMP program ranged from 55 to 686 moths/trap, with an average of 282 moths (35 traps). Due to the use of Spintor in several of the blocks, the impact of mating disruption was difficult to assess. Monitoring will continue in the spring of 2000 to determine populations of OBLR larvae in apple blocks employing mating disruptionor standard programs.

Table 1: Numbers of oblique-banded leafroller larvae, *Choristoneura rosaceana* (Harris), found in orchards which employed mating disruption for OBLR during the 1999 growing season.

ORCHARD SITE	Block #	Dispenser Type	June 24[a]	July 30[a]	August 23[a]
Kris Kropp	KK27	80 milligram	0	0	0
	KK23	80 milligram	0	0	0
Silver Spruce	SS9	twin tube[b]	0	0	0
	SS10	twin tube[b]	0	0	0
Eastman/Phillips	DP2	250 milligram	0	0	0
Eastman/Phillips	DP8	250 milligram	0	0	0
Coggins	no trapping	no dispensers	0	0	0
Alvey (North)	TA1, TA2	no dispensers	0	0	0
Alvey (South)	TA11, TA12	no dispensers	0	0	0

[a] 30 samples were taken from randomly selected trees throughout the block. Samples were taken from the upper one-third of tree canopy. Fruit clusters were sampled if available.
[b] Each tube contained 125 milligrams of OBLR sex pheromone and 125 milligrams of codling moth sex pheromone.

Figure 1: Pheromone trap catches of oblique-banded leafroller adults, *Choristoneura rosaceana* (Harris), for the 1998 growing season. Pheromone traps were located in apple blocks near Hotchkiss, Colorado.



Pheromone dispenser types in the different blocks were as follows a) twin tube dispenser – SS9 and SS10, b) 250 mg dispenser- DP2 and DP 8 and c) 80 mg dispenser- KK27 and KK 33.

OBLIQUE-BANDED LEAFROLLER 1999

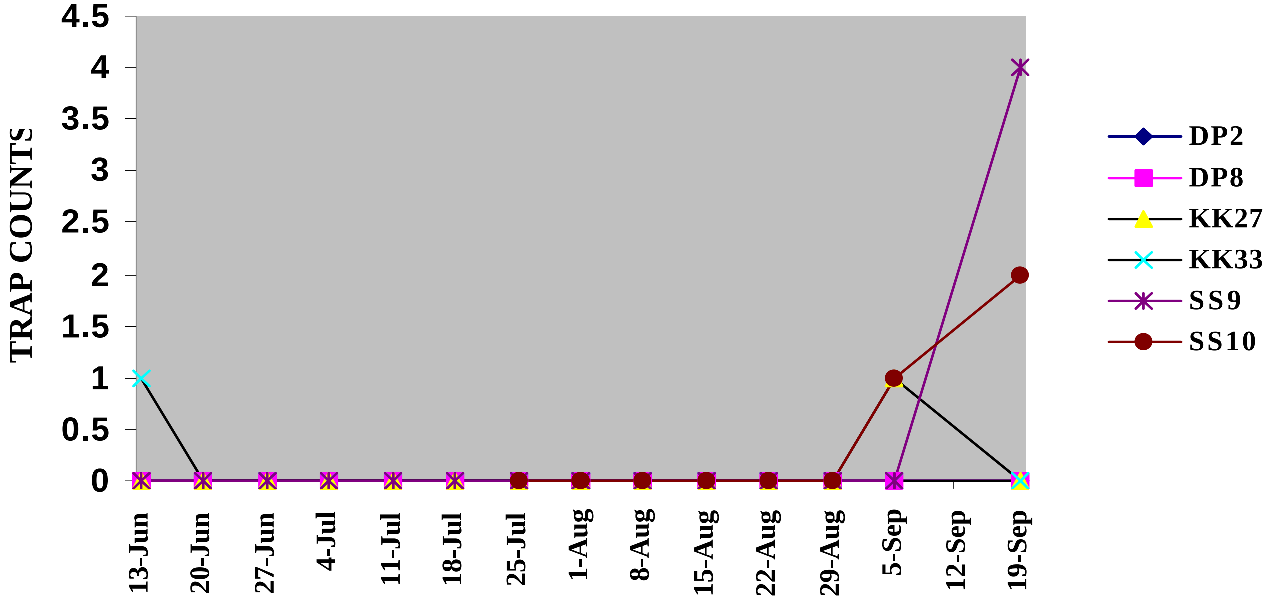


Figure 2: Pheromone trap catches of oblique-banded leafroller adults, *Choristoneura rosaceana* (Harris), mating disruption blocks for the 1999 growing season. Pheromone traps were located in apple blocks near Hotchkiss, Colorado.

Pheromone dispenser types in the different blocks were as follows: a) twin-tube dispenser – SS9 and SS10, b) 250 mg dispenser- DP2 and DP 8 and c) 80 mg dispenser- KK27 and KK 33.

Figure 3: Comparison of total numbers of oblique-banded leafroller adults captured in pheromone traps in the 1998 and 1999 growing season. Mating disruption was used in the same apple blocks only in 1999.
Pheromone dispenser types in the different blocks were as follows a) twin tube dispenser – SS9 and SS10, b) 250 mg dispenser- DP2 and DP 8 and c) 80 mg dispenser- KK27 and KK 33.

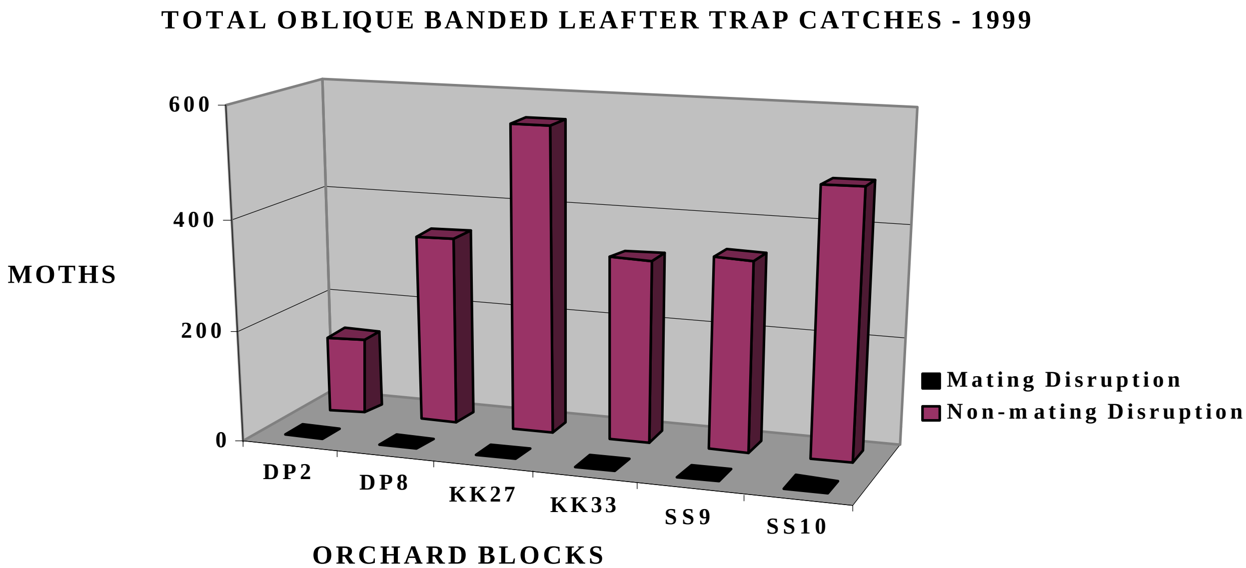
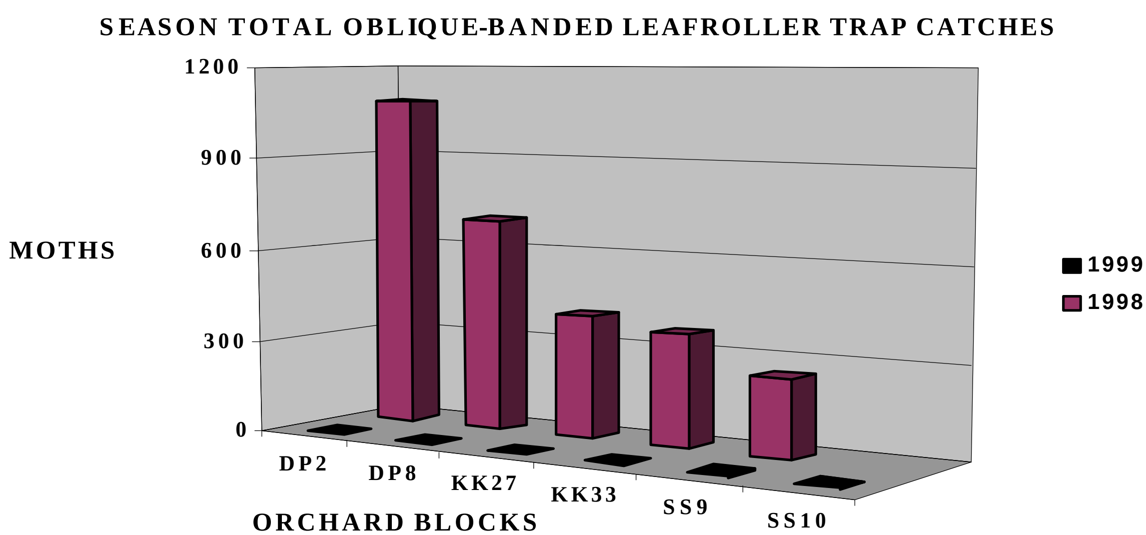


Figure 4: Comparison of total numbers of oblique-banded leafroller adults trapped in pheromone traps in non-mating disruption and mating disruption blocks for the 1999 growing season. Non-mating disruption blocks were adjacent to mating disruption blocks.

Pheromone dispenser types in the different blocks were as follows a) twin tube dispenser – SS9 and SS10, b) 250 mg dispenser- DP2 and DP 8 and c) 80 mg dispenser- KK27 and KK 33.



CONTROL OF WOOLLY APPLE APHID, *Eriosoma lanigerum* , ON APPLES WITH APHISTAR, SILVER SPRUCE ORCHARDS, HOTCHKISS, CO 1999

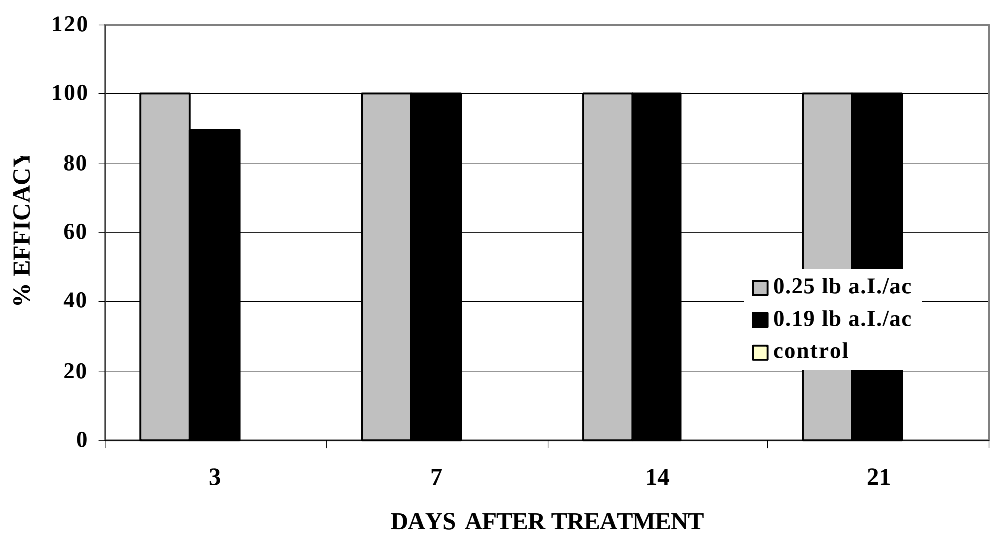
Rick Zimmerman and Steve Ela

The trial was conducted in a block of 2 year-old grafted trees. Scion variety is Gala. Each treatment covered 0.74 acres. The control consisted of 12 trees adjacent to each treated block. Materials were applied on July 21, 1999 with a tractor drawn blast sprayer. All materials were applied at the equivalent of 150 gallons of water carrier per acre. Water pH was adjusted to 7.0. The following treatments were applied 1) Aphistar 50W (0.25 lb a.i./ac) (trade name triazamate, Rohm & Haas Corp., Philadelphia, PA) + 2 qts Leffingwell Supreme 415 Oil /100 gal, (Pace International, Kirkland, WA), 2) Aphistar 50W (0.19 lb a.i./ac) + 2 qts Leffingwell Supreme 415 Oil/100 gal) and a control. Treatments were evaluated 3, 7,14 and 21 days after treatment. Ten colonies were observed in each treatment on each sample date. Efficacy was determined by noting whether there was full mortality, partial mortality or no observable effects. Definitions: 1) all adults and nymphs dead, 2) partial mortality- part of colony (adults and nymphs) were dead, the woolly mass covering the colony was gone, indicating mortality of adult stage. 3) No observable effects- colony was completely covered with woolly mass.

Results

Three days after treatment, there was no living colonies found in the block treated with Aphistar 50W (0.25 lb a.i. / acre). Only one colony was found to be partially intact at the lower rate of Aphistar 50W (0.19 lb a.i. / acre). Those colonies observed in the control were intact and robust. After 7 days no living colony could be found in the plots treated with the high rate of Aphistar 50W (0.25 lb a.i. /acre). Fourteen days after treatment no living colonies could be found in either rate of Aphistar 50W. A survey of the plots 21 days after treatment found that the woolly apple aphid colonies had not returned to the treated plots. The woolly aphid colonies in the control blocks were found to be robust.

FOLIAR APPLICATIONS OF APHISTAR FOR CONTROL OF WOOLLY APPLE APHID



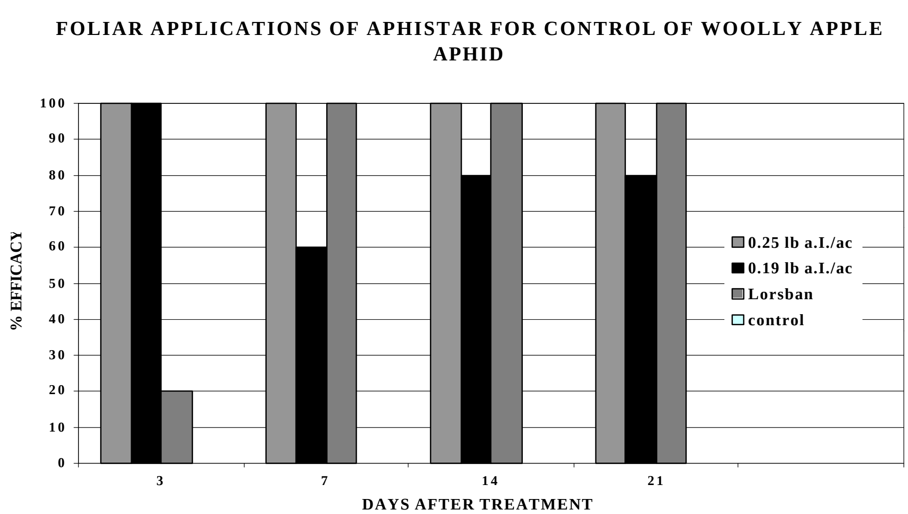
CONTROL OF WOOLLY APPLE APHID, *Eriosoma lanigerum* , ON APPLES WITH APHISTAR, WHITE ORCHARDS, HOTCHKISS, CO 1999

Rick Zimmerman and Bob White

This trial was conducted in a block of mature standard size red delicious trees. Each plot was 0.51 acres. Materials were applied on July 21, 1999 with a tractor drawn blast sprayer. All materials were applied at the equivalent of 200 gallons of water carrier per acre. Water pH was adjusted to 7.0. The following treatments were applied 1) Aphistar 50W (0.25 lb a.i. / ac) (trade name triazamate, Rohm & Haas Corp., Philadelphia, PA) + 2 qts Leffingwell Supreme 415 Oil /100 gal, (Pace International, Kirkland, WA), 2) Aphistar 50W (0.19 lb a.i /ac) + 2 qts Leffingwell Supreme 415 Oil /100 gal and 3) Lorsban 4E (0.19 lb a.i. [chlorpyrifos]/ acre) (Dow AgriSciences , Indianapolis, IN) + 2 qts Leffingwell Supreme 415 Oil /100 gal and 4) control. Lorsban 4E is the standard insecticide used for controlling woolly apple aphids in western Colorado apple orchards. Treatments were evaluated 3, 7,14 and 21 days after treatment. Ten colonies were observed in each treatment on each sample date. Efficacy was determined by noting whether there was total mortality, partial mortality or no observable effects. Definitions: 1) all adults and nymphs dead, 2) partial mortality- part of colony (adults and nymphs) were dead, the woolly mass covering the colony was gone, indicating mortality of adult stage. 3) No observable effects- colony was completely covered with woolly mass.

Results

Three days after treatment, the there was 100% mortality in the aphid colonies treated at both rates of Aphistar 50W. However, on day 7, a few colonies were observed in the trees which received the lower rate of Aphistar. These colonies may have not received direct application of the Aphistar 50W. This was also partial mortality observed among the Lorsban 4E treated colonies 3 days after treatment, however by day 7 no living aphids could be found However, 21 days after treatment with Aphistar 50W (0.19 lb a.i /acre) partial mortality was observed in colonies located in the west perimeter of the plot. Aphid populations in the lower rate of Aphistar never returned to significant numbers.



CONTROL OF WOOLLY APPLE APHID, *Eriosoma lanigerum* , ON APPLES WITH APHISTAR, WHITE ORCHARDS, HOTCHKISS, CO 1999

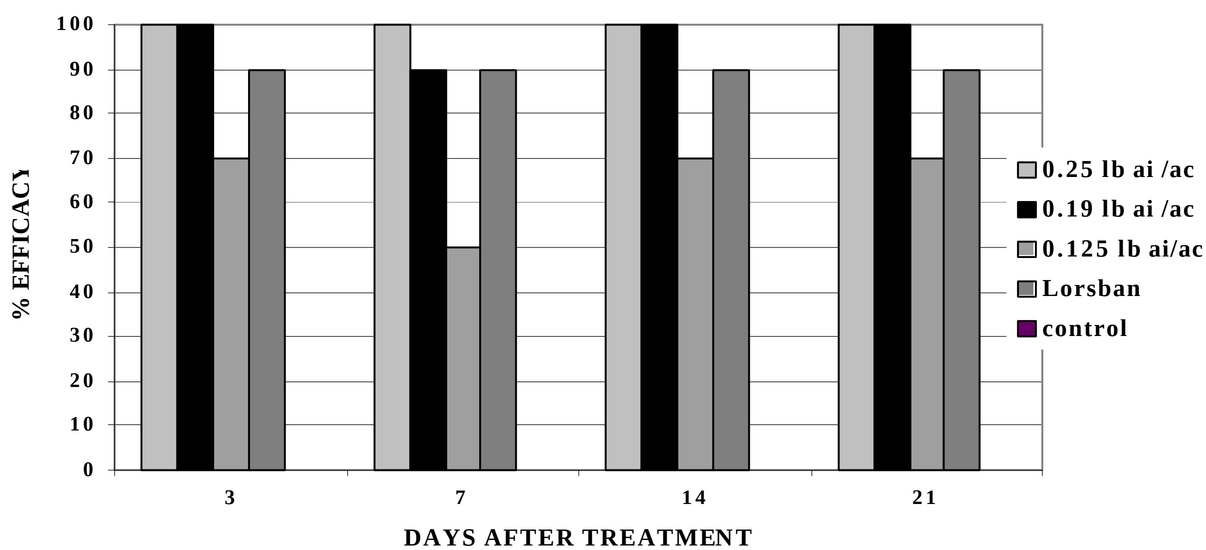
Rick Zimmerman, Brian Braddy and George Osborne

The trial was conducted in a block of mature semi-dwarf red delicious trees. Each plot was 0.20 acres. Materials were applied on July 23, 1999 with a tractor drawn blast sprayer. All materials were applied at the equivalent of 200 gallons of water carrier per acre. Water pH was adjusted to 7.0. The following treatments were applied 1) Aphistar 50W (0.25 lb a.i. /ac)) (trade name triazamate, Rohm & Haas Corp., Philadelphia, PA) + 2 qts Leffingwell Supreme 415 Oil /100 gal (Pace International, Kirkland, WA) , 2) Aphistar 50W (0.19 lb a.i /ac) + 2 qts Leffingwell Supreme 415 Oil /100 gal, 3) Aphistar 50W (0.125 lb a.i./ac) + 2 qts Leffingwell Supreme 415 Oil /100 gal and 4) Lorsban 4E (0.19 lb a.i. [chlorpyrifos]/ acre) (Dow Agrisciences , Indianapolis, IN) + 2 qts Leffingwell Supreme 415 Oil /100 gal and 5) control. Lorsban 4E is the standard insecticide used for controlling woolly apple aphids in western Colorado apple orchards. Treatments were evaluated 3, 7,14 and 21 days after treatment. Ten woolly apple aphid colonies were observed per treatment on each sample date. Efficacy was determined by noting whether there was full mortality, partial mortality or no observable effects. Definitions: 1) all adults and nymphs dead, 2) partial mortality- part of colony (adults and nymphs) were dead, the woolly mass covering the colony is gone, indicating mortality of adult stage. 3) No observable effects- colony was completely covered with woolly mass

Results

Three days after treatment all woolly aphid colonies observed in the Aphistar 50W (0.25 lb a.i. /ac) and Lorsban 4E treated trees suffered complete mortality. In the plot treated with Aphistar 50W at 0.19 lb a.i /ac, mortality of all observed colonies was not achieved until 7 days after treatment. Interesting, at 0.125 lb a.i /ac of Aphistar 50W, woolly apple aphid colonies were either fully dead or exhibited partial mortality. After 21 days, the colonies which were treated with the lowest rate of Aphistar 50W (0.125 lb a.i /acre) had still not recovered to previous populations levels.

FOLIAR APPLICATIONS OF APHISTAR FOR CONTROL OF WOOLLY APPLE APHID



CONTROL OF CODLING MOTH, *Cydia pomonella*, WITH THE INSECTICIDE, AVAUNT WG, ROGERS MESA RESEARCH CENTER, HOTCHKISS, CO 1999

Rick Zimmerman, Brian Braddy and George Osborne

This trial was conducted at the Rogers Mesa Research Center, located near Hotchkiss (Delta County) in western Colorado. The trial was conducted in a block (0.5acre) of semi-dwarf Red Delicious apples (12 ft x 17 ft spacing). Each treatment consisted of 20 trees (4 x 5). The following treatments were applied: 1) AvauntWG (0.11 lb a.i. /ac) (indoxacarb, DuPont Corp., Wilmington, DE) 10 day spray interval, 2) Avaunt WG (0.11 lb a.i. /ac) 14 day spray interval, 3) Avaunt WG (0.11 lb a.i. /ac) + Imidan 70WP (0.53 lb a.i./ac) (phosmet, Gowan Co., Yuma, AZ) and 4) Guthion 50WP (2lb a.i. /ac) (azinphosmethyl, Bayer Corp.). A control was included. Kinetic, a nonionic wetter/spreader/penetrant adjuvant, (Setre Chem. Co., Memphis, TN) was added to all treatments at 8 oz/ 100 gal water. All applications were applied with 100 gal water/acre. For treatment dates and degree days see Table 1. Evaluations were conducted on June 29, 1999.

Results

The trial was terminated after the first generation due to the high levels of infestation. Infestation levels above 0.5 to 1.0% are considered unacceptable in commercial orchards. Treatments of MP062 WG, regardless of spray interval had a significantly higher percentage of infested apples. However, with the addition of Imidan 70WP to MP062 WG resulted in an infestation rate not significantly different than the Guthion treated blocks.

Table 1: Efficacy of Avaunt WG at 10 day and 14 spray intervals, Avaunt WG + Imidan 70 WP and Guthion 50WP on apples for the control of codling moth at Rogers Mesa Research Center, Hotchkiss, Colorado, 1999.

Treatment	Application	#	Total #[b]	% Codling moth
Avaunt WG (0.11 lb a.i. /ac) (10 day spray interval)	May 27, June 4, June 14, June 24	5	600	83.9a
Avaunt WG (0.11 lb a.i. /ac) (14 day spray interval)	May 27, June 10, June 24	5	302	57.9b
Avaunt WG (0.11 lb a.i. /ac) + Imidan 70WP (0.53 lb a.i./ac)	May 27, June 10, June 24	5	481	4.9c
Guthion 50WP[d] (2lb a.i. /ac)	June 4, June 25	5	968	3.9c
Control		5	619	43.8b

[a] 5 trees were randomly selected from each treated block. [b] All apples were removed each tree and counted for codling moth stings. [c] Lower case letters in the same column, if different, denote significant differences ($P \leq 0.05$). [d] Kinetic (8 oz/100 gal) was added to the tank mixture at each application.

CONTROL OF CODLING MOTH, *Cydia pomonella*, WITH THE INSECTICIDE, AVAUNT WG, ROGERS MESA RESEARCH CENTER, HOTCHKISS, CO 1999

Rick Zimmerman, Brian Braddy and George Osborne

This trial was conducted at the Rogers Mesa Research Center, located near Hotchkiss (Delta County) in western Colorado. The trial was conducted in a block (0.5acre) of semi-dwarf Red Delicious apples (12 ft x 17 ft spacing). Each treatment consisted of 20 trees (4 x 5). The following treatments were applied: 1) AvauntWG (0.11 lb a.i. /ac) (indoxacarb, DuPont Corp., Wilmington, DE) 10 day spray interval, 2) Avaunt WG (0.11 lb a.i. /ac) 14 day spray interval, 3) Avaunt WG (0.11 lb a.i. /ac) + Imidan 70WP (0.53 lb a.i./ac) (phosmet, Gowan Co., Yuma, AZ) and 4) Guthion 50WP (2lb a.i. /ac) (azinphosmethyl, Bayer Corp.). A control was included. Kinetic, a nonionic wetter/spreader/penetrant adjuvant, (Setre Chem. Co., Memphis, TN) was added to all treatments at 8 oz/ 100 gal water. All applications were applied with 100 gal water/acre. For treatment dates and degree days see Table 1. Evaluations were conducted on June 29, 1999.

Results

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Avaunt WG (0.11 lb a.i. /ac) (14 day spray interval)	May 27, June 10, June 24	5	302	57.9b
Avaunt WG (0.11 lb a.i. /ac) + Imidan 70WP (0.53 lb a.i./ac)	May 27, June 10, June 24	5	481	4.9c
Guthion 50WP[d] (2lb a.i. /ac)	June 4, June 25	5	968	3.9c
Control		5	619	43.8b

[a] 5 trees were randomly selected from each treated block. [b] All apples were removed each tree and counted for codling moth stings. [c] Lower case letters in the same column, if different, denote significant differences ($P \leq 0.05$). [d] Kinetic (8 oz/100 gal) was added to the tank mixture at each application.

CONTROL OF CODLING MOTH, *Cydia pomonella,* WITH THE INSECTICIDE, AVAUNT WG, ORCHARD MESA RESEARCH CENTER, GRAND JUNCTION, CO 1999

Rick Zimmerman, Rick Gonzalez and John Wilhelm

The trial was conducted in a 1 acre block of semi-dwarf Granny Smith apples (8 ft x 12 ft spacing). Each treatment consisted of 30 trees (6 x 5). The following treatments were applied: 1) Avaunt WG (0.11 lb a.i. /ac) (indoxacarb, DuPont Corp., Wilmington, DE)10 day spray interval, 2) Avaunt WG (0.11 lb a.i. /ac) 14 day spray interval, 3) Avaunt WG (0.11 lb a.i. /ac) + Imidan 70WP (0.53 lb a.i. /ac) (phosmet, Gowan Co., Yuma, AZ) and 4) Guthion 50WP (3 lb a. i. /ac) (azinphosmethyl, Bayer Corp.). A control was included. Kinetic, a nonionic wetter/spreader/penetrant adjuvant, (Setre Chem. Co., Memphis, TN) was added to all treatments at 8 oz/ 100 gal water. All applications were applied with 100 gal water/acre. For treatment dates and degree days see Table 1. Evaluations were conducted on July 9, 1999.

Results

All treatments resulted in infestation rates greater than 50%. Although there were significant differences between the different treatments, the level of infestation was unacceptable. The project was terminated after the first generation. The level of infestation in the Guthion block indicates an undetermined level of resistance. After spray records and procedures were reviewed and it was determined the Guthion to have been properly applied. High levels of codling moth infestation were also observed in other apple blocks on the research station.

Table 1: Efficacy of Avaunt WG at 14 day spray intervals, Avaunt WG + Imidan 70WP and Guthion 50WP on apples for the control of codling moth at the Orchard Mesa Research Center, Grand Junction, Colorado, 1999.

Treatment	Application	#	Total #[b]	% Codling moth
Avaunt WG (0.11 lb a.i. /ac) (14 day spray interval)	May 14, June 4, June 17, June 29	5	250	93.9c
Avaunt WG (0.11 lb a.i. /ac) + Imidan (0.53 lb a.i. /ac)	May 14, June 4, June 17, June 29	5	250	73.8b
Guthion 50WP [d] (3 lb a. i. /ac)	May 14, June 17	5	250	57.2a
Control		5	250	93.0c

[a] 5 trees were randomly selected from each treated block. [b] All apples were removed each tree and counted for codling moth stings. [c] Lower case letters in the same column, if different, denote significant differences ($P \leq 0.05$). [d] Kinetic (8 oz/100 gal) was added to the tank mixture at each application.

CONTROL OF CODLING MOTH, *Cydia pomonella*, WITH ESTEEM, AN INSECT GROWTH REGULATOR, AND DANITOL, A PYRETHROID, AT ROGERS MESA RESEARCH CENTER, HOTCHKISS, CO 1999

Rick Zimmerman, Brian Braddy and George Osborne

Introduction

The trial was conducted in a block (0.5acre) of semi-dwarf Red Delicious apples (12 ft x 17 ft spacing). Each treatment consisted of 20 trees (4 x 5). The following treatments were applied: 1) Esteem 0.86EC (50 gram a. i. / acre) (pyriproxyfen, Valent BioSciences, Corp., Walnut Creek, CA), 2) Esteem 35 WP (50 gram a. i./ acre), 3) Danitol 2.4 EC (0.4 lb a.i. /acre) (fenpropathrin, Valent BioSciences Corp., Walnut Creek, CA) and 4) Guthion 50WP (2lb a.i./ac) (azinphosmethyl, Bayer Corp.). A control was included. Latron B-1956 (12 oz/acre) (Rohm & Haas Corp., Philadelphia, PA) was added to all treatments. All applications were applied with 100 gal water/acre. For treatment dates and degree days see Table 1. Evaluations were conducted on June 23, 1999.

Results

The trial was completed after the first generation due to the high levels of infestation. Infestation levels above 0.5 to 1.0% are considered unacceptable in commercial orchards. All treatments, including the control block, had significantly higher numbers of infested apples than found in the block treated with Guthion 50WP. Although the numbers were high in the Esteem treated blocks, decreasing the interval time to 10 days may make a significant impact on codling moth populations. The spray interval was targeted at 14 days, but was delayed by rain and windy conditions. Danitol 2.4EC looks promising, although the spray interval was probably too long for a pyrethoid insecticide.

Table 1: Efficacy of Esteem 0.86EC, Esteem 35 WP, Danitol 2.4 EC and Guthion 50WP on apples for the control of codling moth.

Treatment	Application	#	Total #[b]	% Codling moth
Esteem 0.86EC[d]	May 21 [103]	5	875	20.36a
Esteem 35 WP[d]	May 21 [103]	5	631	16.52a
Danitol 2.4 EC[d]	May 21 [103] June 9 [332]	5	646	9.84a
Guthion 50WP[d]	June 4 [277]	5	529	0.478b
Control		5	474	15.14a

[a] 5 trees were randomly selected from each treated block. [b] All apples were removed each tree and counted for codling moth stings. [c] Lower case letters in the same column, if different, denote significant differences ($P \leq 0.05$). [d] Latron B-1956 (12 oz/acre) was added to the tank mixture at each application.

CONTROL OF CODLING MOTH, *Cydia pomonella*, WITH INTREPID 80W, AN INSECT GROWTH REGULATOR AT ROGERS MESA RESEARCH CENTER, HOTCHKISS, CO 1999

Rick Zimmerman, Brian Braddy, and George Osborne

The trial was conducted in a block (0.5 acre) of semi-dwarf Gala apples (8 ft x 15 ft spacing). Each treatment consisted of 30 trees (5 x 6). The following treatments were applied: 1) Intrepid 80W (.30 lb a. i. / acre) (methoxyfenozide, Rohm & Haas Corp., Philadelphia, PA), 2) Intrepid 80W (.20 lb a. i./ acre), 3) Intrepid 80W (.30 lb a.i. /acre) + Guthion 50WP (2lb a.i./ac) (azinphosmethyl, Bayer Corp.) and 4) Intrepid 80W (.20 lb a.i. /acre) + Guthion 50WP (2lb a.i./ac) and 5) Guthion 50WP (2lb a.i./ac). A control was included. Latron B-1956 (12 oz/acre) (Rohm & Haas Corp.) was added to all treatments. All applications were applied with 200 gal water/acre. For treatment dates and degree days see Table 1. Evaluations were conducted on August 30, 1999.

All treatments had significantly less codling moth infestations than found in the control. The percent of codling moth infested apples found in the two blocks treated with Intrepid 80W and Guthion 50WP were less than percent infested apples treated with just the standard, Guthion 50WP.

The number of infested apples found in the two blocks treated with only RH-2485 80W was significantly less than the percent of infested apples in the control. Although the number of infested apples is above acceptable commercial levels (1-2%), there appears to be potential for even further reduction in codling moth damage if combined with mating disruption or parasitic hymenoptera. A five-acre block of high-density apples 50 feet to the north of this block employed mating disruption codling moth control. This may have had some influence on the number of codling moth infested apples in the evaluation block. Codling moth catch totaled 31 moths (2 traps) for the growing season in the adjacent five acre high density apple block.

Table 1: Efficacy of two rates of Intrepid 80W, exclusively, and in combination (separate treatment dates) with Guthion 50WP on apples for the control of codling moth.

Treatment	Application Date[Degree Days]	# Trees[a]	Total #[b] apples	% Codling moth infested apples (mean/tree)[c]
Intrepid 80W (0.3 lb a.i./ac)[d]	5-28 [190], 6-22 [545] 7-26 [1292], 8-16 [1702]	5	461	5.98b
Intrepid 80W (0.2 lb a.i./ac)	5-28 [190], 6-22 [545] 7-26 [1292], 8-16 [1702]	5	279	2.42b
Intrepid 80W (0.3 lb a.i./ac) + Guthion 50WP (2lb a.i./ac)[e]	Intrepid 6-22[545], 8-16 [1702] Guthion 6-4 [277], 7-27 [1314]	5	255	0.22b
Intrepid 80W (0.2 lb a.i./ac)+ Guthion 50WP (2lb a.i./ac)[e]	Intrepid 6-22[545], 8-16 [1702] Guthion 6-4 [277], 7-27 [1314]	5	391	1.62b
Guthion 50WP (2lb a.i. / ac)	6-4 [277], 6-28 [674],7-27 [1314], 8-16 1702]	5	331	2.18b
Control		5	233	18.42a

[a] 5 trees were randomly selected from each treated block. [b] All apples were removed each tree and counted for codling moth stings. [c] Lower case letters in the same column, if different, denote significant differences ($P \leq 0.05$). [d] Latron B-1956 (12 oz/acre) was added to the tank mixture at each application.
[e] Separate treatment dates.

CONTROL OF CODLING MOTH, *Cydia pomonella*, WITH INTREPID 80W, AN INSECT GROWTH REGULATOR AT ORCHARD MESA RESEARCH CENTER, GRAND JUNCTION, CO 1999

Rick Zimmerman, Brian Braddy, and George Osborne

The trial was conducted in a 1 acre block of semi-dwarf Granny Smith apples (8 ft x 12 ft spacing). Each treatment consisted of 30 trees (6 x 5). The following treatments were applied:
1) 1 application of Intrepid 80W (.30 lb a.i. /acre) (methoxyfenozide, Rohm & Haas Corp.), Philadelphia, PA + 1 application of Guthion 50WP (3 lb a.i./ac) (azinphosmethyl, Bayer Corp.) and 2) 1 application of Intrepid 80W (.20 lb a.i. /acre) + 1 application of Guthion 50WP (3 lb a.i./ac) and 3) Guthion 50WP (3 lb a.i./ac). A control was included. Latron B-1956 (12 oz/acre) (Rohm & Haas Corp.) was added to all treatments. All applications were applied with 200 gal water/acre. For treatment dates and degree days see Table 1. Evaluations were conducted on July 9, 1999.

Results: The experiment was terminated at the end of the first generation due to the high numbers of codling moth infested apples in all the treatments. The most interesting results of this trial was the breakdown of Guthion as a control agent for codling moth. Codling moth catches in 4 traps adjacent to the Granny Smith block totaled 1228 moths for the months of May and June. Considering that Guthion has been applied at maximum rate for many seasons, one may presume there may be some levels of resistance.

Table 1: Efficacy of Intrepid 80W in combination (separate treatment dates) with Guthion 50WP on apples for the control of codling moth

Treatment	Application Date [Degree Days]	# Trees[a]	Total #[b] apples	% Codling moth infested apples (mean/tree)[c]
Intrepid 80W (0.3 lb a.i./ac) + Guthion 50WP (2lb a.i./ac)[e]	Intrepid 5-20 [210] Guthion 6-17 [698]	5	220	83.5a
Intrepid 80W (0.2 lb a.i./ac)+ Guthion 50WP (3lb a.i./ac)[e]	Intrepid 5-20 [210] Guthion 6-17 [698]	5	152	80.92a
Guthion 50WP (3lb a.i. / ac)	5-20 [210], 6-17 [698],	5	127	57.2b
Control		5	185	93.0a

[a] 5 trees were randomly selected from each treated block. [b] All apples were removed each tree and counted for codling moth stings. [c] Lower case letters in the same column, if different, denote significant differences ($P \leq 0.05$). [d] Latron B-1956 (12 oz/acre) was added to the tank mixture at each application. [e] Separate treatment dates.

APPLE POWDERY MILDEW CONTROL -- 1999, STUDY # 1

H. J. Larsen

Summary

Procure treated fruit was taller and had a higher ratio of height to diameter than that of the Nova treated fruit. However, these differences in fruit height and in height to diameter ratio were insufficient to result in any difference in sales return to the grower. No differences between treatments were found for shoot infection on both observation dates nor for fruit weight, diameter, or % cullable russet. Cullable russet was below economic thresholds for both fungicide programs.

Background

Apple powdery mildew is a disease of apples that requires annual control treatment programs to minimize crop damage and cullage. A number of materials are available for control, including several sterol inhibitor fungicides (known as DMI fungicides). Research in the eastern U.S. has found differing effects on fruit size and shape between fruit treated with Procure (Uniroyal Chem. Co.) and Nova (Rohm & Haas Co.). Fruit treated with Procure tended to be significantly larger and taller than fruit treated with Nova in that area. The study was done to assess comparative impacts of these two DMI fungicides on apple size and shape under Colorado conditions.

Methods

Royal Gala apple cultivar in four different blocks (three locations) were used with each block divided to include the two treatments. The specified rates per acre were applied by air blast sprayer. Sprays were applied according to phenological development (½ inch green tip, pink, petal-fall, and at 10-14 days thereafter until shoot growth stops). Standard insecticide/ miticide materials were used to control insect and mite pests. The last two fully expanded leaves on 100 actively growing terminals per tree were examined for mildew infection 13 - 21 da after the petal fall treatment and in early- to mid-June. Fruit russet, fruit weight, fruit height, fruit diameter, and fruit height/diameter ratio data for 50 fruit/tree were collected after harvest for three blocks (fruit from location 4 was harvested and sold before fruit samples could be taken); fruit were classified as russeted if >9% of the fruit surface is damaged by mildew-induced russet. All data were subjected to two-way analysis of variance. Means were separated by Duncan's Multiple Range Test only where the ANOVA demonstrated significant differences between treatments ($p < 0.05$).

Flag	Treatment (materials)	Rate (ai/A)	Dilution (formulated amt./acre)	Dilution (formulated amt./acre)
Blue	1. Nova 40W	0.125 lb.	5.0 oz.	
	+Latron B-1956	+ 0.008% V/V		+ 1.0 fl.oz.
Blue-Stripe	2. Procure 50WS	0.3125 lb.	10.0 oz	
	+Latron B-1956	+ 0.008% V/V		+1.0 fl. oz.

Loc. 1: Colo. St. Univ. – Orchard Mesa Research Center. Block 11-B, Royal Gala / EMLA 9, planted 1997. Spacing 6 ft in-row X 14 ft between rows, 5 rows of 61 trees/row (305 trees total; 0.59 acres). Block split East/West with East two rows as treatment 2 (Blue-Stripe) & West two rows as treatment 1 (Blue). Center row sprayed from E with treatment 1 (Blue) and from West with treatment 2 (Blue-Stripe) to avoid drift onto treatment rows.
Spray Dates: 3/20, 4/6, 4/27, 5/12, 5/27. Rate: 200 gal./acre.

Loc. 2: Colo. St. Univ. – Rogers Mesa Research Center. Two blocks with Royal Gala apples:

Block 34 – two West rows of Royal Gala (treatment 1, Blue) + two East rows of Royal Gala (treatment 2, Blue-Stripe);
Block 52 – four West rows of Royal Gala (treatment 2, Blue-Stripe) + four East rows of Royal Gala (treatment 1, Blue).
Spray Dates: 3/26, 4/12, 5/5, 5/18, 6/7. Rate: 200 gal./acre.

Loc. 3: Dan Williams Orchard. (Coord. through L. Traubel). Royal Gala apple block (3.8 acres), split ½ :½ . Block DO4. East rows (treatment 1, Blue) + West rows (treatment 2, Blue-Stripe).

Spray Dates: Not available. Fruit data not collected; fruit harvested and sold before samples could be collected.

Results

Procure treated fruit was taller and had a higher ratio of height to diameter than that of the Nova treated fruit. However, these differences in fruit height and in height to diameter ratio were insufficient to result in any difference in sales return to the grower. No differences between treatments were found for shoot infection on both observation dates nor for fruit weight, diameter, or % cullable russet. Cullable russet was below economic thresholds for both fungicide programs.

Trt. No.	Materials	% Shoot Infection		Fruit				
		5/26, 5/27	6/9, 6/19	Height (cm)	Diam. (cm)	Ht:Diam Ratio	Wt. (g)	% Russet
1	Nova 40W + Latron B-1956	19.0	8.25	55.6 A	69.0	0.805 A	128	1.00
2	Procure 50WS + Latron B-1956	19.5	7.50	58.4 B	69.8	0.837 B	136	1.58

APPLE POWDERY MILDEW -- 1999, STUDY # 2

H. J. Larsen,

Summary

Two Sovran/Nova spray sequence programs (Nova/Nova/Sovran/Sovran/Nova & Nova/Sovran/Sovran/Nova/Sovran) provided excellent mildew control equivalent to that provided by a Nova only program. This was despite very high mildew pressure beginning late April / early May 1999. Shoot infection differences with the non-sprayed control were the most dramatic differences. Fruit russet percentages were low for the non-sprayed control trees despite the high shoot infection levels. This likely reflected the fact that early season mildew pressure was not as high as later in the spring; later season fruit infections generally produce only slight russet in contrast to early season (pink to petal fall period) infections.

Background

Apple powdery mildew damages shoots, buds and fruit of susceptible apple cultivars. In so doing, it reduces shoot growth and health, reduces winter hardiness of infected buds (and therefore return bloom), and reduces pack-out of affected fruit if the lesions are large enough and severe enough (percentage of fruit surface damaged must be less than 10% in order to meet the grade standards for US # 1). Fruit with severe russeting also will have reduced storage life due to increased water loss through the damaged skin areas.

Several effective mildewcide chemistries are available and include sterol inhibitors (DMI fungicides such as Nova, Procure, Bayleton, and Rubigan), sulfur products, and the new strobilurin fungicides (Sovran & Flint). One of the concerns about use of a single chemistry on a non-rotational basis is the potential for development of resistance to that chemistry by the powdery mildew fungus. Rotational programs are routinely recommended to avoid this problem and potential loss of control chemistries, but they need to be evaluated before recommendation to the growers. This study was done to evaluate efficacy of two Sovran/Nova rotational spray sequence programs in comparison with a Nova only program and a non-sprayed control.

Methods

Treatments were applied at 0.735 gal/tree (=200 gal/acre) by Rears Miniblast sprayer at 100 psi to six five-tree replicates of UltraRed Gala / EMLA 26 (planted 1995) in a randomized complete block design. Orchard spacing within the block was 16 ft in-row with 20 ft aisles (136 trees/acre). Sprays were applied according to phenological development (½ inch green tip, pink, petal-fall, and at 10-14 days thereafter until shoot growth stopped). Standard insecticide/ miticide materials were used to control insect and mite pests. The last two fully expanded leaves on 100 actively growing terminals per tree were examined for mildew infection 13 da after the petal fall + 2 weeks treatment and 9 da after the final spray (6/4/1999). Fruit russet data for 50 fruit/tree were collected after harvest; fruit were classified as russeted if >5% of the fruit surface was damaged by mildew-induced russet. All data were subjected to two-way analysis of variance. Means were separated by Duncan's Multiple Range Test only where the ANOVA demonstrated significant differences between treatments ($p < 0.05$).

Flag	Treatment	(Materials)	Rate (ai/A)	Dilution (formulated amt./ acre)	(formulated amt. /100 gal)[1]
Blue	1.	Nova 40W	0.10 lb.	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
Red	2.	Spray Sequence: (Sovran/ Sovran/ Nova/ Nova/ Sovran)			
		a. Sovran 50WG	0.125 lb	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
		b. Sovran 50WG	0.125 lb	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
		c. Nova 40W	0.10 lb.	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
		d. Nova 40W	0.10 lb.	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
		e. Sovran 50WG	0.125 lb	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
Red-Str		3. Spray Sequence: (Nova/ Sovran/ Sovran/ Nova/ Sovran)			
		a. Nova 40W	0.10 lb.	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
		b. Sovran 50WG	0.125 lb	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
		c. Sovran 50WG	0.125 lb	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
		d. Nova 40W	0.10 lb.	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
		e. Sovran 50WG	0.125 lb	4.0 oz.	2.0 oz.
		+ Latron B-1956	+ 0.008% V/V	+ 3.0 fl.oz.	+ 1.0 fl.oz.
Wht	4.	Non-sprayed Check	---	---	—

[1]Based on 200 gal / acre.

Spray application dates:

Spray #	Spray Date	Phenological Stage
1	3/20/1999	½ inch green tip
2	4/6/1999	pink
3	4/26/1999	petal fall
4	5/12/1999	2 wk post petal fall
5	5/27/1999	4 wk post petal fall

Results

Mildew pressure was very high beginning late April / early May during 1999. However, both Sovran/Nova spray sequence programs provided excellent mildew control equivalent to that provided by the Nova program. Shoot infection differences with the non-sprayed control were the most dramatic differences. Fruit russet percentages were low for the non-sprayed control trees despite the high shoot infection levels. This likely reflects the fact that early season mildew pressure was not as high as later in the spring; later season fruit infections generally produce only slight russet in contrast to early season (pink to petal fall period) infections.

Trt. No.	Materials	% Shoot Infection		Fruit	
		5/26	6/4	Ave. Wt. (lbs)	% Russet
1	Nova 40W only (+ Latron B-1956)	14.3 A	6.5 A	0.33	1.0 A
2	Spray Sequence 1: (+ Latron B-1956) (Sovran/Sovran/Nova/Nova/Sovran)	15.2 A	7.5 A	0.32	2.5 A
3	Spray Sequence 2: (+ Latron B-1956) (Nova/Sovran/Sovran/Nova/Sovran)	13.7 A	7.7 A	0.33	2.2 A
4	Non-sprayed Check	49.7 B	54.0 B	0.31	4.3 B

CYTOSPORA CANKER CONTROL, STUDY # 1

H. J. Larsen,

Summary

Red Globe peach trees with pre-existing cankers caused by *Cytospora persoonii* were treated in late dormancy with different fungicides in a carrier liquid consisting of 50% alcohol (denatured) and 5% white latex paint. Fungicides tested for curative efficacy included Benlate (benomyl), Nova (myclobutanil), Procure (imidazole), and Elite (tebuconazole). No differences were found in tree mortality, canker severity or canker incidence in trees treated.

Background

Cytospora canker (also known locally as "gummosis") is one of the major diseases of stone fruits in western Colorado. Its impact is especially severe in peach and nectarine, and Cytospora canker is the primary factor in removal of peach and nectarine blocks in this region by the time they reach 20 years of age. Many peach orchards fail to reach production potential each year because of loss of secondary limbs, primary scaffold limbs, or even entire trees within the orchard, and growers often try to carry the orchard block as long as possible with such missing production structures. Identification of means to protect against or to cure this disease once it occurs would reduce tree and associated crop loss.

One grower has reported that topical treatment of existing canker infections on peach with Benlate 50W @ the rate recommended (2 Tablespoons / pint of carrier liquid) in the current Colorado Tree Fruits Pest and Crop Management (Spray) Guide has been extremely effective if 50% ethanol (denatured) + 5% white latex paint was used as the carrier liquid for the treatment. The current study is designed to assess the efficacy of the carrier liquid alone and of other DMI fungicides in combination with this carrier liquid for control of existing canker infections on peach.

Methods

The study used a randomized complete block (RCB) design with 7 individual tree replicates (matched with regard to canker severity within each replicate) and 6 treatments. Red Globe peaches (at the Orchard Mesa site of the W. Colorado Research Center, Block 8-A, planted 1993) were used; individual trees with preexisting Cytospora cankers within the two rows were matched according to canker severity to provide the six matched sets of replicates. Canker incidence and severity and tree mortality information collected 12/24/1998 was used for this matching, with a final assessment to double check the matches prior to treatment application in the spring of 1999. The six treatments included: 1) carrier liquid alone consisting of 50% ethanol (denatured) + 5% white latex paint only; 2) Nova 40W @ 3.59 g product / liter of carrier liquid; 3) Procure 50WS @ 14.4 g product / liter of carrier liquid; 4) Benlate 50W @ 28.8 g product / liter of carrier liquid; 5) Elite 45DF @ 3.4 g product / liter of carrier liquid; and 6) water + 5% white latex paint only. All treatments were applied by pump-up hand sprayer to flagged treatment tree cankers by March 10, 1999 by H. Larsen (peach development was at 1st swell to early calyx green). All trees were evaluated again for canker incidence and severity and for tree mortality 12/22/1999.

Results

No significant differences were found in tree mortality, canker severity or canker incidence in trees treated during late dormancy. Slight non-significant reductions in canker severity were observed for all treatments except for the water and paint control (see table below). It is possible that these changes might become significant in the second year of observation with a repeated treatment in spring of 2000.

Trt. #	Treatment	Canker Severity Rating[1]		Change in Severity (1 yr)[2]	Mortality[3]
		Initial (12/'98)	Yr 1 (12/'99)		
1	Carrier only	5.14	4.29	9.14	1.00
2	Nova 40W @ 3.59 g/l	4.86	4.72	9.87	1.16
3	Procure 50WS @ 14.4 g/l	4.86	4.00	9.14	1.14
4	Benlate 50W @ 28.8 g/l	5.14	4.57	9.43	1.00
5	Elite 45DF @ 3.4 g/l	5.43	3.71	8.29	1.00
6	Water + paint only	5.71	5.71	10.00	1.14

[1]Canker Severity Rating: 0 = Healthy; 2 = dried up gum (inactive canker); 4 = slight gumming (slight canker activity; 6 = moderate gumming (moderately active canker); 8 = severe gumming (strongly active canker); 10 = scaffold / trunk almost dead or dead (severely active canker).

[2]Change in canker severity rating. Calculated as follows: Change = (initial rating - Yr 1 rating) + 10

[3]Mortality: 1 = Living; 2 = Dead at latest observation

1994 PEACH ROOTSTOCK TRIAL (NC-140)

Alvan G. Gaus*, Research Scientist and Extension Specialist - Fruit
Harold Larsen, Extension Specialist-Fruit Pathology

Summary

This is the end of the 6th year of the planting. The trees are very similar in all growth aspects. It is too early in this planting to draw conclusions. No recommendations should be made at this time.

Background

The best choice of rootstock could make the difference between an economically viable orchard and one that loses money for the orchardist. This trial was initiated in the NC-140 committee is composed of tree fruit researchers across the U.S. and Canada that do research on tree fruit rootstocks) to see how these relatively new peach rootstocks would perform over a range of climates.

Methods

This trial was done in Block 8B at the Orchard Mesa site. The trial consisted of 17 peach rootstock clones and seedlings. The scion variety chosen was Redhaven. It was planted in a randomized complete block design with 10 replications. Trees were trained to an open-vase system. Trees were watered by furrow irrigation. Similar plantings are replicated at 17 other sites across the U.S.

Results

The 1999 crop was completely lost to frost. Only tree growth could be measured.

Rootstock	No. still alive	Yield 1999 (lb)	Trunk dia. 1999 (in)	Average Rootsuckers (#/tree)
Lovell	2	< 1	4.6 ab	0.0
Bailey	8	< 1	4.1 bc	0.0
Tenn. Natural	6	< 1	4.4 bc	0.1
GF 305	6	< 1	4.3 bc	0.0
Higama	7	< 1	4.5 bc	0.0
Montclar	8	< 1	4.5 bc	0.0
Rubira	7	< 1	3.9 bc	0.0
Ishtara	5	< 1	3.9 bc	0.0
Myran	1	< 1	5.4 a	0.0
S 2729	7	< 1	4.5 abc	0.0
Chui Lum Tao	4	< 1	3.7 c	0.3
Tzim Pee Tao	4	< 1	4.3 bc	0.0
H 7338013	7	< 1	4.5 abc	0.0
H 7338019	4	< 1	4.3 bc	0.0
BY 520-8	6	< 1	4.6 abc	0.0
BY 520-9	8	< 1	4.6 abc	0.3
Ta Tao 5	6	< 1	4.3 bc	0.0

Values within columns are significantly different if not followed by the same letter.

Making recommendations after only 6 years worth of data is not wise. After 6 years, the rootstocks seem to be very similar in yield, growth, and root sucker. Most of the apparent death (No. still alive) is due to lack of trees from the beginning of the experiment. The Lovell rootstock apparently had some problems at the supplying nursery and most died the first year.

Acknowledgments

Colorado Agricultural Experiment Station funds supported data collection and analysis. Rick Gonzalez for data collection help.

1990 APPLE CULTIVAR-ROOTSTOCK TRIAL (NC-140)

Alvan G. Gaus, Research Scientist, Extension Specialist - Fruit

Summary

This is the 10-year report of this multi-year study. Using only one year's worth of data may lead to false conclusions. The rootstock with the most rootsuckers was Ottawa 3, while M.26 EMLA, M.9 EMLA, and B.9 had the fewest. This suckering combined with virus susceptibility (as reported elsewhere) would lead to the recommendation not to plant Ottawa 3 rootstock. One thing that is clear is that Mark is one of the smallest trees in the study. This is mainly due to a runting out of the tree after soil-line swelling of the trunk began. Mark is known to start this soil-line swelling after a water stress event, and Colorado was no exception. Mark has shown significant soil line trunk swelling and should not be planted in Colorado. Based on 10 years worth of data, for Empire, use either M.26 or B.9; for Golden Delicious, use M.26 (M.9 EMLA and B.9 not tested); for Jonagold, M.26 EMLA or M.9 EMLA; for Rome, use M.26 EMLA or B.9. Initial interpretation of yield data would indicate that one should choose a rootstock based on total yield. However, extrapolating the data out to yield per acre creates a different set of conclusions and recommendations. Using a semi-dwarf spacing of 605 trees per acre (12' x 6') and a dwarf spacing of 907 trees per acre (12' x 4'), the dwarf trees actually yield more per acre. Jonagold on Ottawa 3 yielded 213 lbs per tree cumulative yield that translates to 3068 bushels per acre. However, Jonagold on M.9 EMLA and Bud.9 yielded 190 and 175 cumulative bushels per tree, respectively. This translates to 4098 and 3775 bushels per acre, respectively. Taking this yield per land area into account, now the recommendations would be for M.9 EMLA and B.9; for Empire, Jonagold and Rome. Remember that Golden Delicious was not tested on the dwarf rootstocks.

Background

The best choice of variety and rootstock could make the difference between an economically viable orchard and one that loses money for the orchardist. This trial was initiated in the NC-140 committee (NC-140) is composed of tree fruit researchers across the U.S. and Canada that do research on tree fruit rootstocks) to see how these cultivars and rootstocks would perform over a range of climates.

Methods

This trial was done in Block 35 at the Rogers Mesa site. The initial trial was to include 4 varieties (Empire, Smoothee Golden Delicious, Nicobel Jonagold, and Rome) on 5 rootstocks (M.9 EMLA, M.26 EMLA, Ottawa 3, Mark and Budagovski 9). However, Golden Delicious on Bud.9 and M.9 EMLA were not available. It was planted in a randomized complete block design with 6 replications. Trees were supported and trained to a combination of slender spindle/central leader training system. Trees were watered by furrow irrigation. This same planting is replicated at 13 other sites across the U.S.

Results

Cultivar	Rootstock	Trunk Diameter (in)	Yield per tree (lb.)	Cumulative Yield / tree (lb.)	Average Fruit size (oz.)	Average Rootsuckers (# per tree)
Empire	B.9	2.9 c	3 b	94 ab	4.0 a	3 b
	M.9 EMLA	3.2 bc	4 ab	122 a	3.8 a	6 b
	M.26 EMLA	4.3 a	7 a	123 a	4.0 a	0 b
	Mark	2.1 d	0 b	79 b	3.5 a	5 b
	O.3	3.5 b	3 b	112 ab	3.9 a	14 a
Golden Del.	M.26 EMLA	4.6 a	88 a	332 a	4.9 a	0 a
	Mark	2.5 b	7 b	159 b	4.3 b	3 a
	O.3	3.8 a	24 b	334 a	4.2 b	3 a
Jonagold	B.9	3.4 a	28 bc	175 a	5.9 ab	1 a
	M.9 EMLA	3.8 b	25 bc	190 a	6.0 ab	0 a
	M.26 EMLA	4.9 a	61 a	216 a	6.4 a	1 a
	Mark	2.6 c	11 c	121 b	5.4 b	3 a
	O.3	3.8 b	43 ab	213 a	6.0 ab	1 a
Rome	B.9	2.6 c	50 b	271 b	4.4 b	2 ab
	M.9 EMLA	3.4 b	87 a	368 a	5.6 ab	1 b
	M.26 EMLA	4.2 a	124 a	424 a	5.6 ab	0 b
	Mark	2.7 c	33 b	233 b	5.5 ab	2 ab
	O.3	3.5 b	114 a	412 a	4.9 a	4 a

Acknowledgments

Colorado Apple Administrative Committee funding that supported data collection and analysis. George Osborn, Bryan Braddy, Diane Cridler, and Juanita Ensley for data collection help.

CODLING MOTH RESISTANCE STUDY

Eugene E. Nelson
Orchard Mesa Research Center, Rogers Mesa Research Center, CO, 1999.

Treatments of Guthion 50W were applied to apples beginning at model predicted first egg hatch and then every 21 days until harvest time (four total sprays at each location).

PERCENT DAMAGED FRUIT*

RATE GUTHION 50W	ORCHARD MESA RESEARCH CENTER	ROGERS RESEARCH CENTER
2 x = 24 oz./100 gal.	43.0	12.9
1 x = 12 oz./100 gal.	72.4	19.3
0.5 x = 6 oz./100 gal.	88.1	28.9
0.25 x = 3 oz./100 gal.	89.0	32.5
Check	98.7	50.8

*Injury reflects seasonal as well as harvest time evaluations.

A study to determine if local populations of codling moth (i.e., the worm in the apple) have developed resistance to the insecticide Guthion was completed and evaluated during this growing season. Knowing the status of Guthion treatments is important to local apple and pear growers since it has been the most often used insecticide in local fruit production for over 30 years. Recently however, growers have complained about a lack of performance. That triggered this study to determine if poor performance resulted from poor coverage, improper timing, incorrect rates or insect resistance.

Fruit evaluations at harvest time indicated that Guthion treatments in an orchard where it had been used sparingly over the years (sparingly exposed population) resulted in significantly better control than in an orchard where it had been applied 4-6 times each year (highly exposed population) for many years. The sparingly exposed population had 19.3 percent of the fruit damaged by worms whereas the highly exposed population 72.4 percent of the fruit damaged. Both locations received the same treatments.

From these preliminary data, it seems that poor insecticide performance is related to the codling moth ability to tolerate spray applications in locations with a long history of intense spraying. However, these studies need to continue before drawing strong conclusions and changing pest management recommendations.

Two-Step Blossom Thinning Method for Organic Apple Production

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Summary and Recommendations:

There is clear evidence for effectiveness of the two-step blossom thinning method obtained from experiments conducted in Colorado and New Zealand. The potential of this method as a tool for organic crop load management has been demonstrated. Colorado data indicate that the fruit set of trees treated with the two-step method, on average, was 73 per cent of the fruit set of trees treated with water. It was evident from the Colorado portion of the work that the thinning activity of vinegar needed to be increased. This was accomplished in the New Zealand experiments by incorporating a horticultural oil into the thinning (vinegar) treatments. Further development of the method is suggested, especially in the area of optimization of vinegar activity and documentation of the ability of this method to protect late blooming flowers. The two-step shows great promise both for conventional and organic fruit production, its commercial application would be premature at this time.

Background:

Thinning, especially blossom thinning, has a major impact on cropping consistency, fruit size, and quality. Approximately 10% of flowers are required to set a full crop of apples. As a general rule, in order to achieve the return bloom, half of the spurs need to be "resting" (no fruit present). The timing of thinning is critical, with the earlier removal of young fruit giving the greatest benefits of thinning. That is why the blossom thinning is such an effective cultural practice.

The mode of action of the two-step thinning method is based on the buffering/neutralizing properties of sodium bicarbonate (the first step) and thinning effect of acidic thinner (the second step). The coating of sodium bicarbonate protects treated flowers from phytotoxic properties of acidic thinner (vinegar) which is applied several days later following application of bicarbonate. The unprotected flowers, opened after application of sodium bicarbonate treatment, are removed readily by acidic thinner. Most flowers opened prior to sodium bicarbonate treatment and flowers that remained closed during acidic thinner application survive and some develop into fruit.

During the 1998 and 1999 growing season this novel blossom thinning method has been tested on peaches and apples. This two-step method has a potential to alter the current thinning practice in western Colorado and in other fruit growing districts. This method overcomes a major problem of acidic blossom thinners: either these thinners are not effective or they become phytotoxic to fruit and/or trees. There is a strong indication that the two-step method preserves late blooming flowers. These flowers are, of course, especially important in the years when crop loss occurs due to spring frost.

Three experiments were conducted during the 1999 year: a preliminary pretest experiment to evaluate phytotoxic properties of vinegar and two experiments of the two-step thinning method itself. The first two of these experiments were conducted in western Colorado. The third experiment is currently in progress in New Zealand.

Method:

The blossom thinning method tested is a two-step procedure. Application of a buffering/neutralizing agent - aqueous solution of sodium bicarbonate - is the first step. The concentration of sodium bicarbonate (a food grade of baking soda) was 10 lb per 100 gal of water. This solution is applied when approximately 20% flowers have been pollinated. The acidic thinner (30% dilution of food grade vinegar) was applied several days later when more flowers open (the second step). In the New Zealand experiments the vinegar treatment and bicarbonate treatment contained 1% of horticultural oil. The fruit set was determined by counting flower clusters at bloom and counting corresponding fruit following a June drop in Colorado and a December drop in New Zealand. The Golden Delicious was used in Colorado experiments and Braeburn in New Zealand experiments. The fruit set is presented as a ratio of fruit number following the June drop (December drop in New Zealand) to the corresponding number of flower clusters. The return bloom will be determined next Spring in Colorado and next Fall in New Zealand.

Results / Discussion:

The pretest conducted to evaluate the phytotoxic properties of vinegar to apple flowers was hampered by spring frost. In spite of confounding effect of frost, it was evident that the highest concentration of vinegar tested, the 15% dilution of vinegar (0.75% acetic acid) was judged to be insufficient to damage flowers in order to prevent pollination.

The thinning experiment conducted in Colorado indicates that the treated trees, on average, set 73% of control trees (Table #1). This level of thinning though significant is not sufficient as a stand alone thinning treatment. It was evident from the Colorado portion of the project that the thinning activity of vinegar needed to be increased. This was accomplished in the New Zealand experiments by incorporating a horticultural oil with the vinegar treatments.

The thinning experiment conducted in New Zealand, presently in progress, also indicates significant level of fruit set reduction (Table #2). In this experiment the thinning effectiveness was evaluated in two ways. The first was to compare fruit set of trees treated with the two-step thinning method to trees treated with water. A 74% reduction in fruit set was observed. The second evaluation method was to compare it to the bicarbonate control - in this case a 50% reduction in fruit set was observed. This difference between the two controls was not expected and needs to be further investigated as it may provide valuable insight into the two-step thinning method itself.

The key attributes of the two-step blossom thinning method is its predictability and its capability of protecting unopened flowers. Preservation of late blooming flowers removes the major impediment to blossom thinning in frost prone orchard sites.

The two-step blossom thinning method has initially been developed with the commercial blossom thinner, Wilthin (a conjugate of sulfuric acid and urea), during the 1998 growing season. Both apples and peaches were tested. The treatment effectiveness exceeded expectations. The addition of vinegar into the two-step thinning method presented a challenge as was expected. The phytotoxic (thinning properties) of acetic acid are considerably lower than Wilthin but were judged to be adequate.

Impact of these findings is potentially far-reaching: increase of cropping reliability, decrease in thinning costs, and improvement of fruit quality and size. Colorado organic fruit growers will be able to apply blossom thinning with predictable results, without fear of overthinning. In areas of United States such as western Colorado where spring frost is sometimes a problem, the late blooming flowers survive frost and become the crop. Traditional blossom methods remove these flowers. The two-step blossom thinning method is likely to preserve these commercially important, late blooming flowers.

Table 1 Fruit Set - Colorado Experiment

Tree Number		Water Control	Bicarbonate Control	Vinegar Control	Bicarbonate/ Vinegar (Two-step Method)	Reduction in fruit set due to two-step method (Compared to water control)	
	Cluster	37	63	70	41		
1	Fruit	49	79	72	47		
	Fruit set	132	125	103	115	87	
	Cluster	42	133	89	102		
2	Fruit	51	94	69	102		
	Fruit set	121	71	78	100	82	
	Cluster	87	88	94	82		
3	Fruit	75	100	94	72		
	Fruit set	86	114	100	88	102	
	Cluster	71	112	117	110		
4	Fruit	88	98	80	69		
	Fruit set	124	88	68	63	51	
	Cluster	80	110	126	166		
5	Fruit	73	49	124	75		
	Fruit set	91	45	98	45	50	
	Cluster	63	66	38	96		
6	Fruit	73	78	69	81		
	Fruit set	116	118	182	84	73	
Average Fruit Set		112	93	105	82	74	

Table 2 Fruit Set - New Zealand Experiment							
Reduction in fruit set due to the two-step method							
Tree Number		Water Control	Bicarbonate Control	Vinegar Control	Bicarbonate/ Vinegar (two-step method)	Compared to water control	Compared to Bicarbonate control
	Cluster	203	223	143	175		
1	Fruit	176	226	134	162		
	Fruit set	87	101	94	93	107	92
	Cluster	330	214	254	263		
2	Fruit	196	203	187	173		
	Fruit set	59	95	74	66	111	69
	Cluster	359	205	247	335		
3	Fruit	269	176	91	193		
	Fruit set	75	86	37	58	77	34
	Cluster	224	321	245	200		
4	Fruit	193	168	248	104		
	Fruit set	86	52	101	52	60	31
	Cluster	242	220	418	239		
5	Fruit	101	168	207	29		
	Fruit set	42	76	50	12	29	12
	Cluster	412	396	263	464		
6	Fruit	296	197	162	173		
	Fruit set	72	50	62	37	52	51
	Cluster	367	237	342	225		
7	Fruit	286	173	142	121		
	Fruit set	78	73	42	54	69	72
	Cluster	215	251	304	188		
8	Fruit	183	192	105	78		
	Fruit set	85	76	35	41	49	48
	Cluster	265	205	184	233		
9	Fruit	167	176	95	169		
	Fruit set	63	86	52	73	115	41
Average Fruit Set		72	77	60	54	74	50

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Prevention of Russeting of Golden Delicious Fruit with Protective Coatings of Sodium Bicarbonate and Starch

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Summary Recommendation:

It was found that the modified starch coating was effective in reducing the russeting of Golden Delicious apples. Consistent differences were observed among treatments and a clear conclusion can be drawn from the 1999 growing season experiments. This treatment also had another effect, the improved visual appeal of the Golden Delicious fruit. As the modified starch coating was effective in reducing the incidence of russeting in two orchards where it was tested, the company manufacturing this food grade starch will be encouraged to consider marketing this product to fruit industry. The effectiveness of bicarbonate coating needs to be further investigated - it is evident from the data and field observations that the sodium bicarbonate concentration tested was too high and resulted in some marking of fruit. Another coating tested, consisting of a combination of starch and bicarbonate increased the incidence of russeting and marking of fruit. The effectiveness of starch coating in improving the fruit quality of Goldens is likely to carry to other high value varieties such as Gala and Fuji. The work is planned to further evaluate these coatings during the 2000 growing season.

Background:

The outstanding fruit quality and its unique cosmetic finish of the western Colorado Golden Delicious apples are considered a trademark of the industry. Incidence of russeting of apples produced in Colorado is reported to have increased in recent years. Golden Delicious is otherwise very well adapted to the western Colorado growing conditions. It is known for cropping reliability as related to spring frost damage. This cultivar is known to bear a crop following severe frost when other varieties fail. Elimination or significant reduction of the incidence of fruit russeting will improve fruit pack-out and thus will improve returns to the grower.

This project focused on the effectiveness of protective properties of sodium bicarbonate and modified food grade starch coating on prevention of apple fruit russeting. The mode of action of the bicarbonate coating is based on the buffering properties of baking soda. The likely mode of action of the modified starch coating is its ability to form a physical barrier on the fruit surface. It is also possible that these carbohydrate molecules are becoming incorporated into the cuticle itself, thus improving the fruit ability to resist russet causing agents.

The outstanding, unique quality of Colorado Golden Delicious apples is the industry’s competitive strength. The extensive plantings of Golden Delicious in western Colorado warrant a major effort in improving quality attributes to further increase the distance of Colorado Golden Delicious from the commodity type Golden Delicious apples produced by our competitors.

Methods:

Three sites for this experiment were chosen in Delta county. The two sites were located at two grower orchards in the Cedaredge area. The third site was situated at the Western Colorado Research Center's Rogers Mesa station.

The Cedaredge area sites received four treatments. The first treatment was water control, the second treatment was baking soda (1% solution of food grade of sodium carbonate). The third treatment was a commercially modified starch (1% suspension in water). The fourth treatment consisted of a combination of baking soda and bicarbonate treatment. The Rogers Mesa site received three treatments: water, sodium bicarbonate at the rate of 3 lb per 1000 gal and sodium bicarbonate at the rate of 10 lb per 100 gallons.

The test units consisted of a partial tree row at the Rogers Mesa site, to individual vertical axis trees in the first Cedaredge experiment, and individual major scaffolds on mature central leader trees in the case of the second Cedaredge experiment. The treatments were applied in approximately 2 week intervals between early June and early September in the case of the Cedaredge area experiments.

The incidence of russeting was recorded at harvest and expressed as a cumulative score, indicative of fruit quality. The higher the numerical russet score, the more serious the russet problem is for this particular group of apples.

Results / Discussion:

The results from the two experiments conducted at commercial orchards in Cedaredge area are very interesting. Clearly the starch coating is effective in reducing the incidence of russeting (Table *1 and Table #2). When russet scores of fruit from individual trees are examined in all but three instances starch treatment outperformed other treatments. Even in these three cases the starch treatment russet scores were similar to the ones of control.

The overall incidence of russeting was low in the blocks where the treatments were applied. This was somewhat surprising as frost events occurred during the spring of the 1999. The conventional wisdom is that the frost causes an increase in the incidence of fruit russeting. This pattern was definitely not evident in the 1999 growing season. Typical frost induced russeting such as frost rings was not observed. It appears that these commercial orchards were also under low pesticide application program - this might have contributed to the low russet incidence.

The starch coating had also another observable effect, above that of reduction of russeting, even at the time of harvest. The best way to describe this qualitative trait is to say that the apples treated with starch exhibited shiny surface. This made them more appealing to the eye. This promising effect needs to be further investigated. The experiments conducted in the 1999 focused on the russeting and not on the visual appeal of the fruit.

The effectiveness of bicarbonate coating needs to be further investigated. It was evident from field observations later in the growing season and the data collected at harvest that the sodium bicarbonate concentration tested was too high or the coating was applied at high ambient temperatures. The symptoms were similar to bitter pit like markings at the calyx end of the fruit.

Another coating tested, a combination of starch and bicarbonate, increased the incidence of fruit marking above that of bicarbonate treatment alone. As the russet score includes other fruit marking, the russet scores for this treatment were the highest of all treatments.

The work is planned to further evaluate these coatings. The starch coating looks especially promising and interesting. It appears that this coating has potential multiple beneficial effects: reduction of russeting incidence, improvement of eye appeal of fruit (above that of russeting itself), and mechanical protection of fruit from abrasion type injury. This line of research looks very promising and will be pursued in future.

Acknowledgment:

The funding for this project provided by the Research Subcommittee of Colorado Apple Administrative Committee is greatly appreciated. In opinion of the author of this report the project was productive and will result in improvement of Colorado Golden Delicious fruit quality and appearance. The technology developed here is very likely applicable to other high value cultivars such as Gala and Fuji.

Table 1	Russet Scores - Site 1						
Block Number	Treatment	Stem Cavity	Side - - Sun	Side - - Shade	Calyx	Marks	Total
1	Control	64	3	7	3	4	81
	Bicarbonate	67	2	3	0	12	84
	Starch	65	0	4	0	1	70
	Bicarbonate/ Starch	66	0	0	0	8	74
2	Control	58	4	11	4	1	78
	Bicarbonate	53	0	4	0	8	65
	Starch	48	0	0	2	5	55
	Bicarbonate/ Starch	74	0	11	5	15	105
3	Control	68	8	6	0	0	82
	Bicarbonate	61	5	4	0	12	82
	Starch	55	0	6	2	3	66
	Bicarbonate/ Starch	59	1	6	0	21	87
4	Control	70	4	5	3	0	82
	Bicarbonate	64	2	6	2	5	79
	Starch	51	0	1	0	0	52
	Bicarbonate/ Starch	69	1	5	1	15	91
5	Control	56	3	9	1	7	76
	Bicarbonate	58	8	3	3	13	85
	Starch	47	0	2	1	5	55
	Bicarbonate/ Starch	61	1	9	7	20	98
6	Control	61	3	3	1	6	74
	Bicarbonate	62	2	7	8	1	80
	Starch	61	4	7	3	1	76
	Bicarbonate/ Starch	60	0	6	0	16	82
7	Control	70	8	4	2	3	87
	Bicarbonate	68	2	5	0	8	83
	Starch	65	1	3	3	3	75
	Bicarbonate/ Starch	70	4	4	5	11	94
8	Control	60	2	7	0	2	71
	Bicarbonate	56	3	3	2	13	77
	Starch	63	8	2	1	0	74
	Bicarbonate/ Starch	66	2	6	0	19	93
9	Control	49	3	16	2	1	71
	Bicarbonate	54	3	5	0	13	75
	Starch	52	3	5	0	4	64
	Bicarbonate/ Starch	44	6	1	0	4	55
Average	Control						79
	Bicarbonate						79
	Starch						65
	Bicarbonate/Starch						91

Table 2	Russet Scores - Site 2						
Block Number	Treatment	Stem Cavity	Side - - Sun	Side - - Shade	Calyx	Marks	Total
1	Control	27	0	0	0	6	33
	Bicarbonate	24	0	5	0	16	45
	Starch	31	0	0	0	3	34
	Bicarbonate/Starch	31	0	5	0	32	68
2	Control	33	0	2	0	5	40
	Bicarbonate	37	0	2	0	44	83
	Starch	25	0	2	0	1	28
	Bicarbonate/Starch	34	0	3	0	30	67
3	Control	38	0	0	0	3	41
	Bicarbonate	37	0	1	0	23	61
	Starch	32	0	0	0	0	32
	Bicarbonate/Starch	30	0	2	0	29	61
4	Control	24	0	3	4	0	31
	Bicarbonate	24	0	2	2	11	39
	Starch	28	0	0	3	5	36
	Bicarbonate/Starch	33	0	0	0	35	68
5	Control	29	0	2	3	0	34
	Bicarbonate	40	0	0	0	18	58
	Starch	19	0	0	1	0	20
	Bicarbonate/Starch	31	0	0	0	46	77
6	Control	39	0	0	2	1	42
	Bicarbonate	20	0	0	0	42	62
	Starch	35	0	2	0	1	38
	Bicarbonate/Starch	23	0	3	2	15	43
7	Control	38	0	1	3	0	42
	Bicarbonate	28	0	0	6	0	34
	Starch	29	0	0	0	1	30
	Bicarbonate/Starch	31	0	5	0	23	59
8	Control	26	0	2	1	0	29
	Bicarbonate	37	0	2	0	7	46
	Starch	27	3	0	0	0	30
	Bicarbonate/Starch	32	0	0	0	36	68
Average	Control						37
	Bicarbonate						52
	Starch						31
	Bicarbonate/Starch						64

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