from the ground up

Agronomy News

2008 Eastern Colorado Winter Wheat Variety Performance Trials

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Colorado State University provides unbiased and reliable information to Colorado wheat producers to help them make better wheat variety decisions. Colorado State University provides excellent research faculty and staff, a focused breeding program, graduate and undergraduate students, and dedicated agricultural extension specialists. However, wheat improvement in Colorado would not be possible without the support and cooperation of the entire Colorado wheat industry. On-going and strong support for a public breeding program is critical because variety development and testing is a long process, especially under the highly variable climatic conditions in Colorado.

Our wheat variety performance trials, and collaborative on-farm testing, represent the final stages of a wheat breeding program where promising experimental lines are tested under an increasingly broad range of environmental conditions. Variation in precipitation, as well as variable fall, winter, and spring temperature regimes, hail and spring freeze events, interact with disease and insect pests and variety maturity to affect wheat yields. As a consequence of large environmental variation, Colorado State University annually conducts a large number of performance trials, which serve to guide producer variety decisions and to assist our breeding program to more reliably select and advance the most promising lines toward release as new varieties.

Planting and emergence conditions in the 2008 trials were unfavorable at some locations due to light, scattered, untimely, and isolated rainfall events. Poor emergence, often combined with continued dry fall weather conditions and wind erosion, led to low and variable stands in many dryland trials. The Uniform Variety Performance Trial (UVPT) locations at Walsh, Bennett, and Lamar never recovered from poor or no fall emergence and the results from these trials could not be reported. The dryland trials at Sheridan Lake and Burlington had acceptable-to-good stand establishment but a combination of drought, hail, spring freeze, and brown wheat mite infestations created highly variable yields. The results from these trials are reported on the CSU Crops Testing website, but the yield data had too much unexplained variability to be useful for making variety decisions and could not be combined with trial data from the other six acceptable trials.

The results from the UVPT at Akron, Arapahoe, Genoa, Julesburg, Orchard, and Yuma were included in the summary of variety performance for the 2008 season. Drought stress affected yield variability at Orchard and Genoa. Adequate spring moisture was received at Akron, Arapahoe, Julesburg and Yuma but hail affected the yields in the Yuma trial and leaf rust, stem rust, tan spot and bacterial blight affected yields at Julesburg. Unlike 2006 and 2007 when trial results from all eleven dryland trials contributed to the annual summary of variety performance, in 2008 there was not a single trial that was not affected by one or more combinations of the following: fall drought and poor emergence, wind erosion, hail, insect or disease infestation, spring freeze, or spring drought.

The growing conditions in the Irrigated Variety Performance Trial (IVPT) at Fort Collins, Haxtun, and Rocky Ford were generally favorable for high yields. Yields at Rocky Ford were affected by a combination of high temperature during pollination and spring freeze in early kernel development. The growing conditions at Haxtun were excellent but led to lush late spring vegetation and severe lodging of many varieties. Yields were reduced for heavily lodged varieties. The Fort Collins irrigated trial yields were reduced by spring drought conditions due to inadequate early season irrigation which culminated with the destruction of the linear move irrigation system by a tornado on May 22.

2008 Trials

There were 40 different entries in the dryland performance trials (UVPT) and 32 entries in the irrigated performance trials (IVPT). In the UVPT, the varieties RonL (KSU) and Avalanche (CSU), were planted but could not be used. KSU mistankenly sent Danby seed instead of RonL (we already had Danby in the trials) and the Avalanche seed had very poor germination. All trials included a combination of public and private varieties and experimental lines from Colorado and surrounding states. All dryland and irrigated trials were planted in a randomized complete block design with three replicates. Plot size was approximately 160 ft^2 and all varieties were planted at 500,000 viable seeds per acre for dryland trials and 1.2 million viable seeds per acre for irrigated trials (viable seed was determined by a germination test prior to planting). Yields are corrected to12% moisture. Eight dryland and three irrigated variety performance trials were harvested but only six dryland trial results could be used for yield. Test weight information was obtained from cleaned grain samples of one or two replicates at all trials except Arapahoe and Yuma which were measured on the combine equipped with a Harvest Master measuring system.

Complete trial performance result tables were published on the Crops Testing website, www.csucrops.com, the CSU Wheat Breeding program website at http://wheat.colostate.edu/vpt.html, and the CWAC, CAWG, and CWRF website at http://www.coloradowehat.org.

2008 Collaborative On-Farm Test (COFT) Results

Jerry Johnson, Extension Colorado State University

Much of Colorado's 2008 wheat acreage was planted to winter wheat varieties that have been tested in the COFT program which is in its 10th year of operation. In the fall of 2007, twenty- three eastern Colorado wheat producers planted COFT trials in Baca, Prowers, Kiowa, Kit Carson, Washington, Phillips, Logan, Adams, and Weld counties. Each collaborator planted five varieties in side-by-side strips (approximately 1.25 acres per variety) at the same time and at the same seeding rate as they seeded their own wheat.

The objective of the 2008 COFT was to compare performance and adaptability of popular and newly-released CSU varieties (Hatcher, Ripper, and Bill Brown), and promising commercial varieties (Keota and NuDakota) under unbiased testing conditions. The COFT trial results are intended to be interpreted based on the average across all tests within a year and not on the basis of a single variety comparison on a single farm in one year. Interpreted as an average of 21 test results, the 2008 COFT results can be extremely useful to farmers making variety decisions. Grain yields of all five varieties in 2008, averaged over a wide range of agroclimatic conditions, were about the same, which is not overly surprising as all five varieties have passed through rigorous selection processes and were chosen because of strong

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Summary of 2008 Dryland Variety Performance Results

Origin[1] Release Year	Variety[2]	Yield 2008	Test Weight 2008
		bu/ac	lb/bu
NE 2008	Settler CL	49.0	60.4
CSU 2006	Ripper	48.9	59.9
CSU exp	CO03W054	48.0	60.6
AP 2005	NuDakota	47.4	59.1
OK 2004	Endurance	46.2	61.1
WB 2007	Winterhawk	46.2	61.6
CSU 2007	Bill Brown	45.8	61.1
CSU-TX 2001	Above	45.5	60.2
KSU 1999	Trego	45.2	62.0
CSU 2004	Hatcher	44.9	61.2
AP 2006	Hawken	44.9	61.2
TX/W 2005	TAM 112	44.7	60.8
CSU exp	CO03064	44.7	59.3
NE 2004	Infinity CL	44.5	60.6
WB 2006	Smoky Hill	44.5	61.3
NE 2008	Camelot	43.8	60.9
KSU 2006	Fuller	43.5	61.1
CSU exp	CO03W043	43.4	60.2
OK 2006	Duster	43.3	60.6
WB 2006	Aspen	43.0	60.1
TX/A 2002	TAM 111	42.9	61.0
CSU 1998	Prairie Red	42.9	60.1
WB 2005	Keota	42.7	59.7
CSU 2004	Bond CL	42.6	60.2
KSU 1994	Jagger	42.6	59.9
CSU 1991	Yuma	42.4	60.9
CSU 1994	Akron	41.9	60.6
AP 2001	Jagalene	41.2	61.2
NE 2006	Overland	41.2	60.5
CSU exp	CO03W139	41.2	61.0
OK 2008	OK Rising	41.0	59.8
KSU 2005	Danby	40.9	62.4
OK exp	OK05737W	40.9	59.8
AP 2005	Postrock	40.8	60.9
NE 2002	Goodstreak	40.2	61.1
CSU exp	CO02W237	39.8	61.3
CSU 2002	Ankor	39.6	60.1
CSU exp	CO03W239	39.4	60.5
	Average	43.5	60.6

[1]Variety origin code: CSU=Colorado State University; CSU-TX=Colorado State University/Texas A&M University; WB=WestBred, LLC; AP=AgriPro® COKER®; TX/A=Texas A&M release, marketed by AgriPro® COKER®; TX/W=Texas A&M release, marketed by Watley Seed Co.; KSU=Kansas State University; NE=University of Nebraska; OK=Oklahoma State University.

[2]Varieties ranked according to average yield in 2008.

Summary of 2-Yr and 3-Yr Dryland Variety Performance Results

2-Yr Average[1]			3-Yr Average[1]		
Variety[2]	Yield 2007-08	Test Weight 2007-08	Variety[2]	Yield 2006-08	Test Weight 2006-08
	bu/ac	lb/bu		bu/ac	lb/bu
NuDakota	56.9	58.2	NuDakota	45.5	57.3
Hatcher	55.5	60.0	Hatcher	44.1	59.2
Hawken	53.4	59.5	Ripper	42.8	57.7
Fuller	52.8	59.6	Infinity CL	42.5	58.6
Ripper	52.6	58.3	Endurance	42.5	59.1
Endurance	52.4	59.7	Bill Brown	42.3	59.4
Smoky Hill	52.4	59.8	Keota	42.1	59.3
Infinity CL	52.3	59.3	Bond CL	41.6	57.9
Bill Brown	52.2	60.0	CO03W239	41.6	58.4
TAM 112	52.1	59.3	Jagger	41.5	58.5
Keota	51.9	59.9	Above	41.1	58.3
TAM 111	51.9	59.8	Yuma	41.1	58.7
Bond CL	51.8	59.0	TAM 111	41.0	59.4
Duster	51.8	60.0	Danby	40.3	60.9
Jagger	51.4	59.2	Trego	40.2	60.2
Above	51.2	58.8	Akron	39.7	58.6
Overland	50.9	59.3	Jagalene	39.6	59.7
Yuma	50.7	59.5	Ankor	39.1	58.1
CO03W239	50.6	59.3	Prairie Red	39.1	58.1
Danby	50.0	61.4	Postrock	39.0	59.5
Jagalene	49.4	60.4	Goodstreak	38.0	59.6
Trego	49.3	60.6	Average	41.2	58.9
Postrock	49.2	60.1			
Akron	48.7	59.1			
Prairie Red	48.5	58.6			
Ankor	47.5	58.7			
Goodstreak	44.9	60.2			
Average	51.2	59.5			

[1]2-yr and 3-yr average yield and test weight are based on six 2008 trials, eleven 2007 trials, and eleven 2006 trials.
[2]Varieties ranked according to average 2-yr yield and according to average 3-yr yield.

performance records in Colorado dryland variety trials. Ripper and NuDakota proved to be statistically slightly higher yielding than Bill Brown, Hatcher, and Keota.

Both Ripper and NuDakota had significantly lower test weight than Bill Brown and Hatcher, which in turn, had lower test weight than Keota. Seemingly small differences in average test weight for different varieties resulted in remarkably large differences in the probability of obtaining at least 60 lb/bu test weight: Keota 57%, Bill Brown 49%, Hatcher 48%, Ripper 28%, and NuDakota 21%.

The largest differences in 2008 COFT yields were from farm to farm (three tests averaged below 10 bu/ac and four tests averaged above 60 bu/ac) which was indicative of highly variable climatic conditions. This variability resulted from wide differences in stand establishment due to dry seeding conditions, variable winter and spring moisture availability, duration of drought conditions, wind erosion, and hail. In 2008, farmers who practiced no-till farming were able to capture and keep more moisture in the soil. Yields from no-till fields were sometimes far superior to those from tilled fields.

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Winter Wheat Variety Selection in Colorado for Fall 2008

Jerry Johnson, Extension Colorado State University

Choosing a variety is a personal decision made by every farmer for every field before planting every year. Variety performance summary tables from CSU are intended to provide reliable and unbiased information to farmers, seed producers, and wheat industry representatives. This section is designed to provide guidance to farmers so they can weigh the advantages and disadvantages of different varieties and choose the variety that best fits their farm conditions.

Producers should consider multiple-year summary yield results

- Over time the best buffer against making bad variety decisions has been to select varieties based on three year average performance and not on performance in a single year, especially not to select a variety based upon performance at a single location in one year.
- Our testing system is designed to predict variety performance of one variety relative to performance of other varieties but not to predict actual expected differences in grain yield. It is designed to provide relative variety performance information for the whole state so an individual farmer should not expect to have the exact same results on their farms each year.
- It is really not possible to predict the general or region-specific climatic conditions for next year and in some years trials are able to predict relative variety performance with more precision than in other years.
- Yield is difficult to measure exactly, and to predict, compared to other traits like test weight, protein content, height, disease tolerance or resistance and insect resistance.

Producers should not use yield as the sole criteria for variety selection

- Wheat is part of a cropping and livestock system and non-yield traits may be more important to individual farmers than yield, because each farmer has a different combination of crop rotation, tillage system, risk of wheat pests, expected rainfall, manure, residue, etc. Non-yield traits that might complement individual Colorado cropping systems include maturity, plant

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2008 Collaborative On-Farm Tests Results

	2008 Varieties										Test Average	
	Ripper		NuDakota		Bill Brown		Hatcher		Keota			
	Yield	Test Wt	Yield	Test Wt	Yield	Test Wt	Yield	Test Wt	Yield	Test Wt	Yield	Test Wt
County/Town	bu/ac[1]	lb/bu	bu/ac[1]	lb/bu	bu/ac[1]	lb/bu	bu/ac[1]	lb/bu	bu/ac[1]	lb/bu	bu/ac[1]	lb/bu
Adams/Bennett N.	39.5	58.3	35.4	55.5	31.7	57.8	29.4	57.6	33.0	58.5	33.8	57.5
Adams/Brighton E.	45.3	57.8	48.2	55.8	50.8	59.0	50.8	59.0	51.0	60.2	49.2	58.4
Adams/Last Chance	6.2	55.7	6.4	56.4	11.3	59.3	8.1	58.7	6.4	58.6	7.7	57.7
Baca/Walsh	5.2	55.8	4.7	55.7	4.8	58.2	2.7	56.3	4.5	57.9	4.4	56.8
Kiowa/Haswell	4.9	59.1	6.7	57.4	7.1	60.7	8.3	60.1	4.3	59.3	6.3	59.3
Kit Carson/Burlington	42.7	61.0	39.9	60.0	44.0	60.0	45.2	60.0	41.4	61.3	42.6	60.5
Kit Carson/Stratton	24.0	55.1	17.4	55.9	21.3	56.9	12.4	58.3	14.0	59.9	17.8	57.2
Logan/Fleming	46.6	61.0	42.3	60.6	45.7	63.2	39.9	62.4	37.9	62.8	42.5	62.0
Logan/Peetz	28.0	55.8	31.8	57.0	21.1	55.6	33.6	59.5	26.9	58.9	28.0	57.4
Logan/Sterling W.	21.7	59.4	24.3	58.9	17.9	60.3	18.9	60.2	21.8	60.9	20.9	59.9
Phillips/Haxtun S.	71.9	60.8	71.7	61.3	66.6	61.3	65.3	61.3	71.7	61.3	69.4	61.2
Phillips/Paoli	70.0	56.3	77.2	58.0	58.4	53.9	64.2	57.1	65.9	57.4	67.1	56.5
Prowers/Lamar	25.6	60.2	27.6	59.3	27.5	62.2	25.7	62.3	23.0	61.6	25.9	61.1
Prowers/Two Buttes	56.0	62.5	53.2	61.1	55.8	63.9	53.4	62.6	51.9	62.6	54.0	62.5
Washington/Akron	32.0	60.3	30.7	59.8	30.6	61.7	29.4	60.9	29.2	61.1	30.4	60.8
Washington/Woodlin	31.3	58.8	37.7	59.5	37.7	60.6	33.3	58.5	35.5	60.0	35.1	59.5
Washington/Woodrow	65.3	58.8	70.0	58.0	68.1	61.0	65.2	59.9	60.6	60.4	65.8	59.6
Washington/Yuma	64.5	61.0	67.5	60.3	58.1	60.0	61.0	59.9	62.8	59.5	62.8	60.1
Weld/Hudson E.	35.3	57.5	28.4	56.7	29.4	58.5	31.0	59.0	29.7	59.2	30.8	58.2
Weld/New Raymer	34.6	58.8	33.5	58.3	31.2	60.4	35.8	60.2	32.1	60.9	33.5	59.7
Weld/Nunn	30.1	58.8	28.2	57.8	29.8	61.0	27.9	61.1	26.3	61.1	28.5	60.0
Average yield	**37.2**	**58.7**	**37.3**	**58.3**	**35.7**	**59.8**	**35.3**	**59.8**	**34.7**	**60.2**	**36.0**	**59.3**
Significance Yield	**a**		**a**		**b**		**b**		**b**			
Significance Test Wt		c		d		b		b		a		

LSD $_{(0.30)}$ for yield = 1.0 bu/ac   LSD $_{(0.30)}$ for test weight = 0.3 lb/bu

Comparison of Hatcher and Ripper Yield Performance in 2-yr Combined COFT (2007 & 2008, 43 tests)

Avg Hatcher yield	41.1	bu/ac	
Avg Ripper yield	40.1	bu/ac	LSD $_{(0.30)}$ is 1.05 bu/ac which indicates no significant difference in yield between Hatcher and Ripper

[1]Yield corrected to 12% moisture

Summary of 2008 Irrigated Variety Performance Results

Origin[1] Release Year	Variety[2]	Yield 2008	Test Weight 2008	Heading days different from trial average at Ft. Collins[3]	Lodging Haxtun 2008
		bu/ac	lb/bu	days +/- ave	1-9[4]
AP 2005	NuDakota	99.5	60.3	-1	5
CSU exp	CO03W239	97.3	60.2	0	3
CSU exp	CO04393	95.3	61.0	1	8
CSU exp	CO04W210	94.9	60.5	0	9
AP 2001	Jagalene	94.8	61.2	1	7
CSU exp	CO04W320	94.8	61.5	0	6
CSU 2004	Bond CL	93.1	58.4	-1	7
CSU 1991	Yuma	91.7	60.1	1	7
WB 2005	Keota	91.4	60.2	1	9
CSU 2004	Hatcher	91.3	60.5	2	8
OK 2008	Ok Rising	91.2	60.7	0	2
CSU exp	CO04551	91.2	60.1	-2	6
CSU exp	CO04W369	91.2	59.8	1	6
CSU 1998	Prairie Red	91.1	60.1	-2	7
TX/A 2002	TAM 111	91.0	61.1	2	6
AP 2006	Hawken	90.6	60.8	-2	7
CSU exp	CO04W323	90.6	61.1	0	6
CSU exp	CO04575	89.6	61.5	-2	9
CSU exp	CO03W054	88.6	60.2	1	9
CSU exp	CO02W237	88.2	61.3	1	8
OK exp	OK05737W	87.9	60.4	0	6
CSU exp	CO04025	87.0	59.9	-1	9
CSU 2007	Bill Brown	86.9	60.0	0	7
CSU exp	CO04499	85.4	61.1	-1	8
CSU exp	CO03W139	85.0	60.6	0	8
CSU exp	CO04448	84.1	60.3	2	7
NE 2008	Anton	84.0	62.0	1	1
CSU exp	CO04549	82.7	60.8	-3	9
WB 2006	Aspen	82.6	58.4	-1	8
TX/W 2005	TAM 112	82.5	62.2	-2	9
CSU exp	CO03064	82.1	59.2	2	8
NE 2008	Camelot	81.0	60.6	-2	9
	Average	89.3	60.5	0	7

[1]Variety origin code: CSU=Colorado State University; WB=WestBred, LLC; AP=AgriPro® COKER®; TX/A=Texas A&M release, marketed by AgriPro® COKER®; TX/W=Texas A&M release, marketed by Watley Seed Co.; NE=University of Nebraska; OK=Oklahoma State University.

[2]Varieties ranked according to average yield in 2008.

[3]Negative differences indicate heading before trial average heading date, positive differences indicate later than trial average.

[4]Lodging score: 1=completely erect, 9=completely lodged.

Summary of 2-Yr and 3-Yr Irrigated Variety Performance Results

2-Yr Average[1]			3-Yr Average[1]		
Variety[2]	Yield 2007-08	Test Weight 2007-08	Variety[2]	Yield 2006-08	Test Weight 2006-08
	bu/ac	lb/bu		bu/ac	lb/bu
NuDakota	97.1	59.0	Bond CL	89.3	58.1
CO03W239	94.4	59.7	NuDakota	87.9	57.7
Bond CL	94.3	59.1	TAM 111	87.6	60.0
Yuma	92.9	59.5	Bill Brown	87.6	59.7
Bill Brown	91.3	60.0	Keota	86.7	59.6
TAM 112	91.0	61.5	Yuma	85.9	59.0
Hatcher	90.4	60.3	CO03W239	85.8	59.1
Jagalene	90.2	60.5	Jagalene	84.0	60.0
TAM 111	89.0	60.4	Hatcher	83.9	59.7
Keota	88.5	60.1	Prairie Red	79.8	59.3
Hawken	88.3	60.3	Average	85.9	59.2
Prairie Red	84.1	59.6			
Aspen	81.8	58.5			

[1]2-yr and 3-yr average yield and test weight are based on three 2008 trials, three 2007 trials, and three 2006 trials.
[2]Varieties ranked according to average 2-yr yield and according to average 3-yr yield.

height, test weight, lodging, herbicide tolerance, disease resistance, insect resistance and wheat quality for milling and baking.

- Non-yield traits that are meaningful to your farm are useful to spread your risk due to the unpredictability of next year's climatic conditions and pest problems, or especially if two varieties under consideration are expected to be about equal yielding.
- Variety selection can be constrained by practical considerations like seed availability and the timing of seed delivery.
- All varieties available for planting this fall are susceptible to prevalent races of RWA and thus resistance to the original RWA biotype should not be a consideration for fall of 2008.

Although many new varieties possessing valuable traits and with high potential are in the breeding and selection process, emphasis here is placed on variety yield performance over the past three years, specific traits they possess, and whether they were planted on a significant number of acres in Colorado this last fall. Only six of eleven 2008 dryland trials are included in the three-year summary, so three-year variety averages depend more upon 2006 (eleven trials included) and 2007 (eleven trials included). Hard red (HRW), hard white (HWW), and Clearfield* varieties are identified as such but listed together by their yield performance rank in the three year UVPT summary table. We recognize that HWW varieties, and to some degree, Clearfield* varieties, will need to be competitive with HRW varieties for yield and other non-yield traits in order to gain acceptance by Colorado farmers.

Dryland winter wheat varieties to consider

NuDakota (HWW) – A medium-maturity 2005 Agripro hard white wheat (HWW) variety that has high yield, excellent resistance to both leaf and stripe rust, but is a shorter variety and has low test weight. NuDakota has not yet been planted on many Colorado acres.

Hatcher – This medium maturing, high yielding 2004 CSU HRW variety was planted on more Colorado wheat acres in Fall 2007 than any other variety. It has good stress tolerance, good test weight and resistance to stripe rust but is a shorter variety.

Ripper – An early maturing HRW 2006 CSU release that is high yielding in low yield environments, taller than Hatcher, and has excellent baking quality. It has low test weight, and is susceptible to both leaf and stripe rust. Certified seed will be available for planting this fall for the first time.
Infinity CL – A later maturing, taller HRW variety released in 2004 from the University of Nebraska that has, in addition to the Clearfield* herbicide tolerance trait, a good combination of high yield, average test weight, and good stripe rust resistance. Although later maturing than Above, it is taller, has much better stripe rust resistance, and is similar to Above for yield.

Bill Brown – The latest CSU HRW release (2007) can be compared to Hatcher and Ripper: It is earlier maturing than Hatcher and later maturing than Ripper. Like Ripper it is slightly taller than Hatcher. It has good resistance to stripe rust like Hatcher, which is much better than Ripper, and also very good resistance to leaf rust. It has superior test weight to Hatcher and other varieties, especially Ripper (low). It has better baking quality than Hatcher but not quite as good as Ripper. Certified seed will be available for planting in fall 2009.

Bond CL –A medium maturing taller HRW CSU release (2004) with high yields and good baking quality in addition to the Clearfield* trait. It has lower test weight and is susceptible to stripe rust and wheat streak mosaic virus. It was planted on 2% of Colorado's acres last year and we expect it to become increasingly popular, especially under irrigation where it has been tough to beat.

Above – This HRW (2001) release and Ripper are the earliest maturing varieties on this list. In addition to the Clearfield* trait it is the same height as Ripper and has better test weight than Ripper but has not yielded as well as Ripper and Hatcher. It is susceptible to leaf and stripe rust and has low baking quality. It was planted on 5% of Colorado acreage in 2007 and 2008 but may become less popular as Bond CL becomes more widely adopted.

TAM 111 – A later maturing HRW variety released in 2002 by Texas A&M University marketed by AgriPro. It has yielded less than Ripper and Hatcher in Colorado trials but is as tall as Ripper with good stripe rust resistance and better test weight. Grown on 9% of Colorado acres last year.

Danby (HWW) – A KSU 2005 release is a later maturing variety with good test weight, good stripe rust resistance, and good sprout tolerance. It was planted on more than 1% of Colorado acreage in fall 2007.

Jagalene – HRW has been a popular variety to plant in Colorado although Jagalene acreage decreased by 3% last fall. Yield performance has dropped as well over time and it has a tendency to shatter but it has excellent test weight and good resistance to stripe rust.

Dryland varieties to watch in the future that have been in Colorado variety trials for two years

Hawken – A HRW 2006 early maturing release from AgriPro with high yields, good test weight, and good leaf and stripe rust resistance.

TAM 112 - A HRW 2005 release from Texas A&M and marketed by Watley Seed Company was planted on 2% of Colorado acreage last year, concentrated in Baca and Prowers counties. It has good dryland adaptation and is distinguished by excellent wheat streak mosaic virus tolerance, long coleoptile, early maturity, and good test weight and baking quality. It is susceptible to leaf and stripe rust.

Irrigated winter wheat varieties to consider

The most important variety selection criteria for irrigated varieties are yield, straw strength, and stripe rust resistance. Varieties to consider are ranked by performance in the IVPT trials in the 3-yr summary. Note that all of the varieties listed below for consideration as irrigated varieties have been listed for consideration as dryland varieties above.

Bond CL – highest yielding irrigated variety. Low test weight is more manageable and less of a concern in irrigated conditions. It has average straw strength but lodged significantly in the high yielding IVPT trial at Haxtun this year. It is susceptible to stripe rust.

NuDakota (HWW) – high yielding irrigated variety with better straw strength than Bond CL. It has low test weight that is more manageable and less of a concern in irrigated conditions. Good resistance to both leaf and stripe rust.

TAM 111 – high yielding irrigated variety with good straw strength , excellent resistance to stripe rust, and good test weight.

Bill Brown – high yielding irrigated variety with good straw strength, good resistance to leaf and stripe rust, and good test weight.

Upcoming Events:

Rocky Mountain Compost School:
April 17-17, 2009
Information and Registration online at
www.rockymountaincompostschool.info

Description of winter wheat varieties in eastern trials.

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL	WH	SR	LR	WSMV	TW	MILL	BAKE	Comments
Above Hard red winter TAM 110*4/FS2	CSU-TX 2001	S	3	4	3	7	4	9	9	5	5	4	7	CSU/Texas A&M release (2001). Clearfield* winter wheat. Early maturing semidwarf, excellent dryland yield in CO. Leaf and stripe rust susceptible. Marginal baking quality.
Ankor Hard red winter Akron/Halt//4*Akron	CSU 2002	R*	6	5	3	5	3	8	9	9	5	6	5	CSU release (2002). Backcross derivative of Akron with slightly higher grain yield under dryland conditions and improved straw strength. Leaf and stripe rust susceptible.
Anton Hard white winter WA691213-27/N86L177//Platte	NE-USDA 2008	S	6	2	1	4	--	7	6	--	3	7	7	University of Nebraska-USDA release (2008), first entered in CSU irrigated trials in 2008. Short semidwarf, medium maturing, hard white winter wheat (HWW). Excellent straw strength, best adapted to irrigated production conditions
Aspen Hard white winter TAM 302/B1551W	Westbred 2006	S	4	2	1	6	--	4	2	5	7	6	6	Westbred release (2006). Hard white winter wheat (HWW), excellent sprouting tolerance. Short semidwarf, good leaf and stripe rust resistance. First tested in CSU irrigated trials in 2007 and dryland trials in 2008.
Avalanche Hard white winter KS87H325/Rio Blanco	CSU 2001	S	5	5	4	5	4	8	8	5	2	2	5	CSU release (2001). Hard white winter wheat (HWW), sister selection to Trego. High test weight, excellent dryland yield in CO and Western KS. Leaf and stripe rust susceptible.
Bill Brown Hard red winter Yumar/Arlin	CSU 2007	R*	4	4	3	2	5	4	2	6	2	4	3	CSU release (2007). Excellent dryland and irrigated yield record in CSU trials High test weight, good leaf and stripe rust resistance. Stem rust susceptible. Good baking quality, short coleoptile.
Bond CL Hard red winter Yumar//TXGH12588-120*4/FS2	CSU 2004	R*	5	5	4	5	4	8	5	8	7	7	3	CSU release (2004). Clearfield* winter wheat. Slightly later, slightly taller thar Above. Excellent dryland yield in CO, very high irrigated yields, excellent baking quality, lower test weight. Leaf and stripe rust susceptible.
Camelot Hard red winter KS91H184/Arlin SIB//KS91HW29/3/NE82761/Redland/4/VBF0168	NE 2008	S	4	7	7	6	--	--	2	--	5	6	6	Nebraska release (2008). Medium-early, taller. Good leaf rust resistance. Firs entered in CSU dryland trials in 2008.
Thunder CL Hard white winter KS01-5539/CO99W165	CSU EXP	R*	5	4	3	5	5	3	5	4	5	5	2	CSU release fall 2008 (to be named). Hard white Clearfield* wheat. Excellent dryland yield in CO, excellent baking quality, moderate resistance to stripe rust and wheat streak mosaic virus, moderate sprout susceptibility.
Danby Hard white winter TREGO/JGR 8W	KSU 2005	S	6	4	5	4	4	4	5	5	2	2	7	KSU-Hays release (2005). Hard white wheat (HWW), similar to Trego, with improved stripe rust resistance and preharvest sprouting tolerance.

Russian wheat aphid resistance (RWA), heading date (HD), plant height (HT), straw strength (SS), shatter potential (SH), coleoptile length (COL), winterhardiness (WH), stripe rust resistance (SR), leaf rust resistance (LR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), protein content (PC), milling quality (MILL), and baking quality (BAKE). Rating scale: 0 - very good, very early, or very short to 9 - very poor, very late, or very tall. * RWA rating denotes resistance to the original biotype (biotype 1) of RWA. All available cultivars are susceptible to the new biotype of RWA

Description of winter wheat varieties in eastern trials.

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL	WH	SR	LR	WSMV	TW	MILL	BAKE	Comments
Duster Hard red winter WO405D/HGF112//W7469C/HCF012	OK 2006	S	6	5	--	2	--	8	2	7	5	3	5	Oklahoma State release (2006). Good yield performance in western Plains breeder trials, first tested in CSU trials in 2007. Leaf rust resistant, stripe rust susceptible.
Endurance Hard red winter HBY756A/Siouxland//2180	OK 2004	S	5	5	2	5	4	7	2	--	4	5	5	Oklahoma State release (2004). Dual-purpose (grain and grazing) wheat, excellent re-growth following grazing. Moderately susceptible to stripe rust, resistant to leaf rust. Good performance in CSU dryland trials.
Fuller Hard red winter Bulk selection (Jagger type)	KSU 2006	S	5	2	--	4	--	2	2	5	4	6	5	KSU-Manhattan release (2006). First tested in CSU trials in 2007. Average test weight, good leaf and stripe rust resistance.
Goodstreak Hard red winter SD3055/KS88H164//NE89646 (=COLT*2/PATRIZANKA)	NE 2002	S	7	8	3	9	5	5	5	8	3	2	8	Nebraska release (2002). Tall, long coleoptile, medium-late maturing. Good test weight, marginal baking quality.
Hatcher Hard red winter Yuma/PI 372129//TAM-200/3/4*Yuma/4/KS91H184/Vista	CSU 2004	R*	5	3	5	5	4	4	8	8	4	2	4	CSU release (2004). Medium maturing semidwarf. Good test weight, good stripe rust resistance, leaf rust susceptible. Excellent dryland and irrigated yield across the High Plains, good milling and baking quality.
Hawken Hard red winter Rowdy/W96-427	Agripro 2006	S	3	4	2	5	--	2	4	7	3	5	6	Agripro release (2006). Targeted for northeast Colorado and further north, first tested in CSU trials in 2007. Good yields in 2007 and 2008, average test weights. Good leaf and stripe rust resistance.
Infinity CL Hard red winter Windstar/3/NE94481//TXGH125888-120*4/FS2	NE 2004	S	6	5	4	6	2	4	3	--	4	--	--	Nebraska release (2005). Clearfield* winter wheat. Good dryland yield in CSU trials, better baking quality than Above.
Jagalene Hard red winter Abilene/Jagger	Agripro 2001	S	5	4	2	4	3	3	9	4	3	2	5	Agripro release (2001). Good test weight, good stripe rust resistance. Good dryland and irrigated yield in CO, has been observed to shatter in CO and KS trials. Very leaf rust susceptible.
Jagger Hard red winter KS82W418/Stephens	KSU 1994	S	2	5	5	5	8	2	9	4	5	5	3	KSU-Manhattan release (1994). Early maturing semidwarf, excellent baking quality, good WSMV tolerance and stripe rust resistance, very leaf rust susceptible. Breaks dormancy very early in the spring.
Keota Hard red winter Custer/Jagger	Westbred 2005	S	6	6	4	5	5	2	9	5	5	6	6	Westbred release (2005). First tested in CSU trials in 2005. Good stripe rust resistance, leaf rust susceptible. Good dryland yields in CSU trials. Slightly taller plant stature, maintains height under stress.

Russian wheat aphid resistance (RWA), heading date (HD), plant height (HT), straw strength (SS), shatter potential (SH), coleoptile length (COL), winterhardiness (WH), stripe rust resistance (SR), leaf rust resistance (LR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), protein content (PC), milling quality (MILL), and baking quality (BAKE). Rating scale: 0 - very good, very early, or very short to 9 - very poor, very late, or very tall. * RWA rating denotes resistance to the original biotype (biotype 1) of RWA. All available cultivars are susceptible to the new biotype of RWA

Description of winter wheat varieties in eastern trials.

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL	WH	SR	LR	WSMV	TW	MILL	BAKE	Comments
NuDakota Hard white winter Jagger/Romanian	Agripro 2005	S	5	3	3	4	3	2	2	4	8	7	5	Agripro release (2005). Hard white wheat (HWW), excellent dryland yield record in CSU dryland trials, low test weight. Good leaf and stripe rust resistance. Moderate sprouting susceptiblity.
OK Rising Hard white winter KS96WGRC39/Jagger	OK 2008	S	4	5	1	3	--	3	4	--	5	2	2	Oklahoma State release (2008). Hard white reselection from OK Bullet. Excellent straw strength and quality, first entered in CSU dryland and irrigated trials in 2008.
Overland Hard red winter Millennium 'S'/ND8974	NE 2006	S	6	7	--	5	--	3	2	--	6	5	8	Nebraska release (2006) as "Husker Genetics Brand Overland", tested in NE trials as NE01643. First tested in CSU trials in 2007. Moderate stripe rust resistance, good leaf rust resistance. Poor baking quality.
Postrock Hard red winter Ogallala/KSU94U261//Jagger	Agripro 2005	S	4	4	3	5	5	2	2	4	3	3	4	Agripro release (2005), first tested in CSU trials in 2006. Good leaf and stripe rust resistance, good test weight. Below average yields in CSU dryland variety trials.
Prairie Red Hard red winter CO850034/PI372129//5*TAM 107	CSU 1998	R*	3	3	3	6	4	9	9	5	6	4	7	CSU release (1998). Backcross derivative of TAM 107. Excellent stress tolerance, poor end-use quality reputation.
Ripper Hard red winter CO940606 (PI 220127/P5//TAM-200/KS87H66)/TAM107R-2	CSU 2006	R*	3	4	3	7	4	9	9	7	6	2	2	CSU release (2006). Excellent stress tolerance, high dryland yields in CO, excellent milling and baking quality. Leaf and stripe rust susceptible, lower test weights. Resistant to Ug-99 race of stem rust from Africa.
RonL Hard white winter Trego/CO960293	KSU 2006	S	6	2	--	4	--	7	9	2	2	2	2	KSU-Hays release (2006). Hard white wheat (HWW), first tested in CSU trials in 2006. High test weight, excellent resistance to wheat streak mosaic virus. Very drought susceptible.
Settler CL Hard red winter N95L164/3/MILLENNIUM SIB//TXGH125888-120*4/FS2	NE 2008	S	5	4	--	6	--	--	4	--	5	4	6	Nebraska release (2008). Clearfield* winter wheat. First entered in CSU dryland trials in 2008.
Smoky Hill Hard red winter 97 8/64 MASA	Westbred 2006	S	6	2	--	4	--	2	2	8	5	5	2	Westbred release (2006). First tested in CSU trials in 2007. Good yield in 2007 CO dryland trials, average test weight. Good leaf and stripe rust resistance.
TAM 111 Hard red winter TAM-107//TX78V3630/CTK78/3/TX87V1233	TX 2002	S	6	6	3	6	5	2	9	5	3	3	4	Texas A&M release (2002), marketed by Agripro. High test weight, good straw strength, good milling and baking quality characteristics. Leaf rust susceptible, good stripe rust resistance. Best adapted to irrigated production conditions.

Russian wheat aphid resistance (RWA), heading date (HD), plant height (HT), straw strength (SS), shatter potential (SH), coleoptile length (COL), winterhardiness (WH), stripe rust resistance (SR), leaf rust resistance (LR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), protein content (PC), milling quality (MILL), and baking quality (BAKE). Rating scale: 0 - very good, very early, or very short to 9 - very poor, very late, or very tall. * RWA rating denotes resistance to the original biotype (biotype 1) of RWA. All available cultivars are susceptible to the new biotype of RWA

Description of winter wheat varieties in eastern trials.

Name, Class, and Pedigree	Origin	RWA*	HD	HT	SS	COL	WH	SR	LR	WSMV	TW	MILL	BAKE	Comments
TAM 112 Hard red winter U1254-7-9-2-1/TXGH10440	TX 2005	S	4	5	7	7	--	9	9	2	3	6	6	Texas A&M release (2005), marketed by Watley Seed. Good dryland performance in Western KS trials, first tested in CSU trials in 2007. Susceptible to leaf and stripe rust, very good WSMV tolerance.
Trego Hard white winter KS87H325/Rio Blanco	KSU 1999	S	6	3	4	5	4	8	9	5	2	2	6	KSU release (1999). Hard white winter wheat (HWW), medium-late maturity, semidwarf, high test weight. Susceptible to both leaf and stripe rust.
Winterhawk Hard red winter 474S10-1/X87807-26//HBK0736-3	Westbred 2007	S	4	5	--	--	--	--	5	5	2	2	4	Westbred release (2007). First tested in CSU dryland trials in 2008. Good yield and test weight in western Plains in regional breeder trials. Good leaf rust resistance.
Yuma Hard red winter NS14/NS25//2*Vona	CSU 1991	S	5	3	3	2	4	6	4	6	5	7	3	CSU release (1991). Medium maturity, semidwarf, short coleoptile, good baking quality characteristics. Good yields under dryland conditions and especially under irrigation.

Russian wheat aphid resistance (RWA), heading date (HD), plant height (HT), straw strength (SS), shatter potential (SH), coleoptile length (COL), winterhardiness (WH), stripe rust resistance (SR), leaf rust resistance (LR), wheat streak mosaic virus tolerance (WSMV), test weight (TW), protein content (PC), milling quality (MILL), and baking quality (BAKE). Rating scale: 0 - very good, very early, or very short to 9 - very poor, very late, or very tall. * RWA rating denotes resistance to the original biotype (biotype 1) of RWA. All available cultivars are susceptible to the new biotype of RWA

Wheat Seed Issues for Fall 2008

Brad Erker, CSU Extension and Colorado Seed Growers Association

Loose smut

The Colorado Seed Growers Association wheat inspectors noticed a higher level of loose smut in fields this summer. Loose smut is a seed borne disease, and although it is commonly present at low levels, this year it seemed to escalate in some areas. Plant pathologists report that with the proper weather conditions, loose smut can increase ten-fold from one year to the next. Seed fields with moderate to high levels of loose smut are required to be treated in order for the certified seed to be sold.

The causal organism of loose smut is *Ustilago tritici*. All cultivated wheats as well as rye, triticale, and barley are cereal hosts of the pathogen. Grass hosts include some species of the *Aegilops, Agropyron, Elymus, Haynaldia*, and *Hordeum* genera. A similar loose smut (*Ustilago avenae*) occurs on oats. *Ustilago tritici* overwinters as dormant mycelium in the embryo of infected seed. Seed carrying the fungus appears normal and its ability to germinate is unaffected. The milling and feed quality of the seed is also unaffected. Mycelium of *Ustilago tritici* is activated by seed germination. The fungus grows intracellularly to the growing point of the seedling. It continues to grow into the developing spikelet. All developing spikelet tissue except the rachis is invaded. The mycelium then fragments into thick walled brown teliospores. Formation of the mass of teliospores occurs before the head emerges from the boot. Smutted heads emerge sooner than healthy heads. Teliospores are held together by a thin membrane of host tissue which easily ruptures. Spores are wind blown or rain splashed to the flowers of healthy heads, thereby establishing the disease in the embryos of the next generation of the crop. The infection period is restricted to one week beginning at flowering. Environmental conditions that favor infection are humid conditions and moderate temperatures (60-70^{o}F).

Farmers who noticed loose smut in their fields and wish to treat their seed should consult with their local chemical providers. Systemic fungicides are effective in controlling loose smut. Compounds labeled for control include **carboxin** and **difenoconazole,** which go by various brand names.

Calculating your seeding rate

Wheat producers are becoming increasingly aware of the advantages of planting by seeds per acre, rather than pounds per acre. Wheat seed can vary dramatically in the number of seeds present in a pound. Smaller seed may give you a thicker stand if all of the seeds come up; however, larger seed may have more vigor and come up better if planted deep. Also, date of planting should be a consideration for how many seeds you want to drop. Early planted wheat will have some long fall days to start tillering. Wheat planted later in the fall may require more seeds to get the desired number of tillers.

How do you know how many seeds you are planting? You must know the number of seeds per pound. If buying Certified seed, ask you seed dealer to provide the information. All of their seedlots must be tested for germination and purity, and the seed count is an easy additional test to request. You can also send in a sample to the Colorado Seed Lab to request your own seed count. You can determine seeds/pound yourself if you have access to a gram scale, either at home or at your local Co-op. First count 500 seeds, and weigh them in grams. Then divide 500 by the sample weight in grams. Multiply this by 453.6 (the conversion factor). This number equals your seeds per pound. An example:

500 seeds weigh 15.0 grams
500 / 15.0 grams = 33.33
33.33 x 453.6 = 15,120 seeds per pound

In this case, if you're planting 50 pounds to the acre, you're planting about ¾ of a million seeds per acre. The appropriate amount to plant, of course, depends upon the unique conditions present on your farm.

Certified seed reminders

Since 1929, the Colorado Seed Growers Association (CSGA) has provided seed quality assurance. CSGA includes 40-50 wheat seed growers who act as the link between wheat breeding programs and the wheat producers who plant over two million acres of wheat each year. As new varieties are released, only a tiny amount of seed is initially available. Through the production of the Foundation, Registered, and Certified classes of seed, these new varieties are made available in sufficient quantities for farmers. CSGA promotes rapid adoption of new varieties as well as maintaining seed of popular older varieties.

All Certified seed is field inspected.

Trained CSGA inspectors walk each field to look for varietal purity and problem weeds in the fields. CSGA's Standards are used by inspectors as the basis for a pass/fail recommendation on every field.

Also available at www.seeds.colostate.edu.

All Certified wheat seed is laboratory tested.

A two-pound seed sample is analyzed for germination and purity. Seeds are germinated in wet paper towels and the germination percentage must be listed on the tag. If a single prohibited noxious weed seed, jointed goatgrass seed, or feral rye seed is found, the seedlot is rejected and can't be sold as seed. Certified seed should come with a tag or bulk sales certificate that lists the lab information and a certification number.

All recent new wheat varieties are protected by the Plant Variety Protection Act (1994 PVPA) or by plant patent laws. Seed of PVPA protected varieties cannot be sold unless it goes through the certification process, but farmers can save seed to plant on their own farms. Selling the seed, even to a neighbor, constitutes a violation of the PVPA and State Seed Law. Protection lasts 20 years on most varieties under the 1994 PVPA. Seed of plant patent protected varieties, like Clearfield wheat (Above and Bond CL) cannot be saved and replanted; new certified seed must be purchased each year.

Maximum permitted ratio of plants			
Factor	Foundation	Registered	Certified
Other varieties	1: 3,000	1: 2,000	1: 1,000
Inseparable other crops	1:10,000	1:10,000	1: 2,000
Rye in wheat, triticale, barley and oats	None	None	None
Noxious weeds seeds (inseparable)	None	None	None

Precision Guidance Systems: Is Now the right time?

Dr. Raj Khosla
Associate Professor and Extension Specialist of Precision Agriculture
Cooperative Extension, Colorado State University.

Recently, the 9th International Conference on Precision Agriculture (ICPA) culminated in Denver, Colorado. The ICPA conference is the largest gathering of Precision Agricultural scientists and practitioners from around the world. One of the keynote speakers at the inaugural plenary session of the ICPA conference, Dr. Simon Blackmore, talked about the "Robotics in Agriculture". Dr. Blackmore is an international authority in the area of Precision Technologies and is currently the Project Manager of the European Union's Future Farm project. In his talk, he presented numerous video-examples or robotic applications in agriculture and their various stages of development. While the thought of "robotics in agriculture" sounds Utopian and far-fetched, Dr. Blackmore's presentation over and again suggested otherwise. Robots will be on farm probably sooner than we would imagine (Figure 1).

Figure 1. Visualisation of seeding robots. [Adapted from Blackmore et al., 2008]

Not too long back, people around the world felt the same for sitespecific farming and precision agricultural technologies. Some of the initial thoughts were, that it would be "expensive", "not-practical", "will not work or pay for itself", etc. Today it is a reality. The 13th annual Precision Agricultural Survey[1] conducted by CropLife Media Group and Purdue University that came out earlier this year (Questionnaires were sent to 2500 retail agronomy dealers across the US) indicates "GPS Guidance with Manual Control/ Lightbar" to be at 73% while two notches behind that was the "GPS Guidance with Auto Control/Auto Steer" at 37% (See figure 2). There is clear indication that adoption of precision guidance technologies are at an all time high, since they first came out in 1990s.

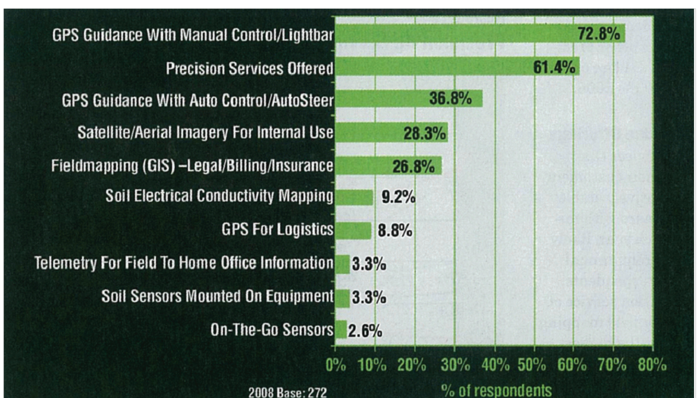

Figure 2. Use of GPS Guidance is all time high

What are these Precision guidance systems? Precision Guidance system for agricultural operations refers to the activity of operating farm equipment (tractors, combines, etc) with the aid of a positioning system such as Global Positioning System (GPS). There are primarily two types of guidance systems: (i) in which a farmer is actually the driving the tractor and he is aided with a sensor or suite of sensors to maintain his driving pattern referred to as "Manual Control/Lightbar" and (ii) in which a farmer is primarily supervising the tractor in its "auto-steer" or "hands-free" mode referred to as fully auto-mated "Auto Control/ Auto Steer" system.

[1] See the complete copy of the survey at https://www.agecon.purdue.edu/cab/research_articles/results.asp?cat=CropLifeSurvey

Either system has numerous economic, agronomic and personal advantages. These include but are not limited to:

(i) Reduction in stress and fatigue after a day-long work behind the wheels in a tractor, making it safer and a more productive operation

(ii) Less over-laps or gaps when applying fertilizer or spraying pesticides

(iii) Can cover more acres in less time, there is about 10 percent advantage with reference to the speed of operation compared to manually operated systems

(iv) Can be operated for longer hours when in need such as, at the time of planting or harvesting, since night time operation is feasible and is as accurate as daytime.

(v) Does not require a skilled person behind the wheels (a novice drives an auto-steer system just as good as a skilled engineer)

(vi) Can be operated day or night, hence a farmer can spray herbicide in an afternoon when the winds are calm, or on a foggy day, or driving against the setting-sun, without compromising with agronomic accuracy or safety.

(vii) Additional savings with no need to purchase foam markers or row-markers

(viii) Could assist in precision cultivation and tillage operations such as tilling ground with drip tapes, or installation of drip tapes for drip irrigation system

(ix) Additional advantages include, precision mapping and levelling, etc.

So how much does it cost? Well the cost of the system varies greatly like with most products/ equipment in agricultural market. It depends on which particular system you want to purchase and what components would you need to get started. There are over a dozen guidance systems on the market. The price of these guidance systems has significantly come down in the last three years and may range anywhere from $3000 to $15000, with a decent system costing somewhere around $8000. A quick "back-of-the-envelope" math indicates that in Colorado, where the average farm size is about 990 acres (CASS 2008), purchase of a decent guidance system would translate into a cost of slightly over $8/acre. While that would be a significant investment, advantages associated with such a system, i.e., agronomic, economic and personal advantages, are numerous. Like one farmer said it all "*My guidance system paid off in one year simply by relieving stress*" (Reeder, 2002).

Precision Guidance System is a sound investment for your farm. We are going through resurgence in agriculture when crops are expected to be grown not only for food, feed and fiber but also for "fuel" purposes. This may be an appropriate time to consider looking into a guidance system suitable for your operation.

For more information please contact Dr. Raj Khosla via email: raj.khosla@colostate.edu.

References:

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Reeder, R. 2002. Guidance Systems: Show me the benefits: Online publication at http://precisionag.osu.edu/resources/GuidanceReeder.pdf Last visited September 2008.

Figure 4. A Lightbar for Semi-Auto Guidance System

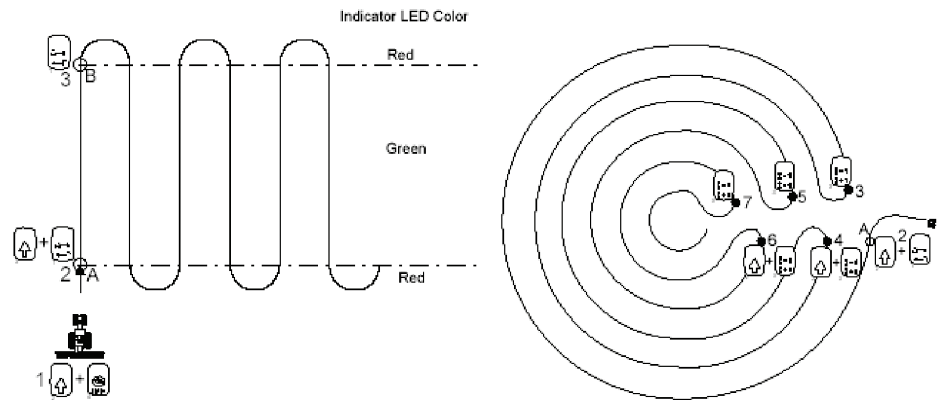

Figure 3. A Schematic showing a parallel swath of operation on a rectangular field and a circular center pivot irrigated field using a precision guidance system.

Links and Resources:

Golden Plains Area Extension: http://goldenplains.colostate.edu

Rocky Mountain Compost School: http://www.rockymountaincom-postschool.info

CSU Crops Testing Programs: http://www.csucrops.com

Colorado Seed Programs: http://www.seeds.colostate.edu

Institute for Livestock and the Environment: http://www.livestockan-denvironment.info