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A Return Look at Preseason Irrigation

Alan Schlegel, Loyd Stone, Troy Dumler, and Freddie Lamm
Kansas State University

ABSTRACT

Many of the irrigation systems today in the Central Great Plains no longer have the capacity to apply peak irrigation needs during the summer and must rely on soil water reserves to buffer the crop from water stress. Considerable research was conducted on preseason irrigation in the US Great Plains region during the 1980s and 1990s. In general, the conclusions were that in-season irrigation was more beneficial than preseason irrigation and that often preseason irrigation was not warranted. The objective of this study was to determine whether preseason irrigation would be profitable with today's lower capacity wells. A field study was conducted at the KSU-SWREC near Tribune, Kansas, from 2006 to 2009. The study was a factorial design of preplant irrigation (0 and 3 in), well capacities (0.1, 0.15, and 0.20 in day^{-1} capacity), and seeding rate (22,500, 27,500, and 32,500 seeds a^{-1}). Preseason irrigation increased grain yields an average of 16 bu a^{-1}. Grain yields were 29% greater when well capacity was increased from 0.10 to 0.20 in day^{-1}. Crop water productivity (CWP, grain yield divided by crop water use) was not significantly affected by well capacity or preseason irrigation. Preseason irrigation was profitable at all well capacities. At well capacities of 0.10 and 0.15 in day^{-1}, a seeding rate of 27,500 seeds a^{-1} was generally more profitable than lower or higher seeding rates. A higher seeding rate (32,500 seeds a^{-1}) increased profitability when well capacity was increased to 0.2 in day^{-1}.

INTRODUCTION

Irrigated crop production is a mainstay of agriculture in western Kansas. However, with declining water levels in the Ogallala aquifer and increasing energy costs, optimal utilization of limited irrigation water is required. The most common crop grown under irrigation in western Kansas is corn (about 50% of the irrigated acres). Almost all of the groundwater pumped from the High Plains (Ogallala) Aquifer is used for irrigation (97% of the groundwater pumped in western Kansas in 1995 [Kansas Department of Agriculture, 1997]). In 1995, of 3 billion m^3 of water pumped for irrigation in western Kansas, 1.41 million acre-ft (57%) were applied to corn (Kansas Water Office, 1997). This amount of water withdrawal from the aquifer has reduced saturated thickness (up to 150 ft in some areas) and well capacities.

Considerable research was conducted on preseason irrigation in the US Great Plains region during the 1980s and 1990s (Stone et al., 1983, 1987, and 1994; Lamm and Rogers, 1985; Musick and Lamm, 1990; Rogers and Lamm, 1994). In general, the conclusions were that in-season irrigation was more beneficial than preseason irrigation and that often preseason irrigation was not warranted because overwinter precipitation could replenish a significant portion of the soil water profile. Lamm and Rogers (1985) developed a relationship between fall ASW and over-winter precipitation on spring ASW (Fig. 1). In a review of preplant irrigation, Musick and Lamm (1990) concluded that benefits of preplant irrigation are likely to be greatest when the soil profile is dry and growing season irrigation is reduced. With recent dry conditions in certain areas and diminished well capacities, this creates a situation where preplant irrigation may be beneficial. In a more recent study Stone et al. (2008) used simulation modeling to examine the effectiveness of preseason irrigation. They found the differences in storage efficiency between spring and fall irrigation peaked at approximately 37 percentage points (storage efficiency of approximately 70% for spring and 33% for fall irrigation) when the maximum soil water during the preseason period was at approximately 77% of available soil water.

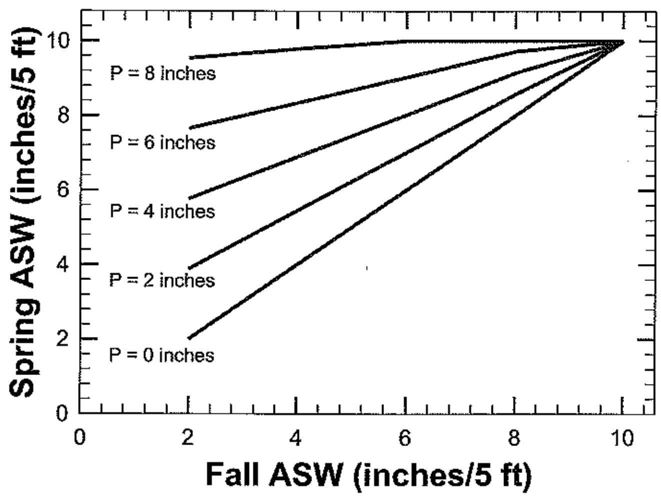

Figure 1. Available soil water in the 5 ft soil profile in the spring (May) as affected by available soil water in the fall (November) and overwinter precipitation (P). Results calculated using an equation from Lamm and Rogers, 1985.

Many of the irrigation systems today in the Central Great Plains no longer have the capacity to apply peak irrigation needs during the summer and must rely on soil water reserves to buffer the crop from water stress. Therefore, this study was conducted to evaluate whether preseason irrigation would be profitable when well capacity is limited and insufficient to fully meet crop requirements.

MATERIALS AND METHODS

A field study was conducted at the KSU-SWREC near Tribune, Kansas from 2006 to 2009. Normal precipitation for the growing season (April through September) is 13.2 in and normal annual precipitation is 17.4 in. The study was a factorial design of preseason irrigation (0 and 3 in), well capacities (0.10, 0.15, and 0.20 in day^{-1} capacity), and seeding rate (22,500, 27,500 and 32,500 seeds

a^{-1}). The irrigation treatments were whole plots and the plant populations were subplots. Each treatment combination was replicated four times and applied to the same plot each year. The irrigation treatments were applied with a lateral-move sprinkler with amounts limited to the specified well capacities. Preseason irrigation was applied in early April and in-season irrigations were applied from about mid-June through early September. The in-season irrigations were generally applied weekly except when precipitation was sufficient to meet crop needs. Corn was planted in late April or early May each year. The center two rows of each plot were machine harvested with grain yields adjusted to 15.5% moisture (wet basis). Plant and ear populations were determined by counting plants and ears in the center two rows prior to harvest. Seed weights (oven-dried) were determined on 100-count samples from each plot. Kernels per ear were calculated from seed weight, ear population, and grain yield. Soil water measurements (8 ft depth in 1 ft increments) were taken throughout the growing season using neutron attenuation. All water inputs, precipitation and irrigation, were measured.

Crop water use was calculated by summing soil water depletion (soil water at planting less soil water at harvest) plus in-season irrigation and precipitation. In-season irrigations were 9.6, 12.6, and 19.0 inches in 2006; 7.2, 10.1, 15.6 inches in 2007; 8.2, 11.0, 14.8 inches in 2008; and 8.8, 11.8, 17.9 inches in 2009 for the 0.10, 0.15, and 0.20 in day^{-1} well capacity treatments, respectively. In-season precipitation was 6.9 inches in 2006, 8.1 inches in 2007, 9.4 inches in 2008; and 14.4 inches in 2009. Non-growing season soil water accumulation was the increase in soil water from harvest to the amount at planting the following year. Non-growing season precipitation was 15.0 inches in 2007, 4.2 inches in 2008, and 8.6 inches in 2009 with an average of 9.3 in. Precipitation storage efficiency (without preseason irrigation) was calculated as non-growing season soil water accumulation divided by non-growing season precipitation. Crop water productivity (CWP) was calculated by dividing grain yield (lb a^{-1}) by crop water use (in). Local corn prices ($3.39, 4.80, 3.96, and 3.46 bu^{-1} in 2006, 2007, 2008, and 2009, respectively), crop input costs, and custom rates were used to perform an economic analysis to determine net return to land, management, and irrigation equipment for each treatment.

RESULTS AND DISCUSSION

Preseason irrigation increased grain yields an average of 16 bu a^{-1} (Table 1). Although not significant, the effect was greater at lower well capacities. For example, with a seeding rate of 27,500 seeds a^{-1}, preseason irrigation (3 in) increased grain yield by 21 bu a^{-1} with a well capacity of 0.10 in day^{-1} while only 7 bu a^{-1} with a well capacity of 0.20 in day^{-1}. As expected, grain yields increased with increased well capacity. Grain yields (averaged across preseason irrigation and seeding rate) were 29% greater when well capacity was increased from 0.1 to 0.2 in day^{-1}. Preseason irrigation and increased well capacity increased the number of seeds ear^{-1} but had little impact on seed weight.

The optimum seeding rate varied with irrigation level. With the two lowest well capacities and without preseason irrigation, a seeding rate of 22,500 seeds a^{-1} was generally adequate. However, if preseason irrigation was applied, then a higher seeding rate (27,500 seeds a^{-1}) increased yields. With a well capacity of 0.2 in day^{-1}, a seeding rate of 32,500 seeds a^{-1} provided greater yields with or without preseason irrigation.

Crop water productivity was not significantly affected by well capacity or preseason irrigation (Table 1), although the trend was for greater CWP with increased water supply. Similar to grain yields, the effect of seeding rate varied with irrigation level. With lower irrigation levels, a seeding rate of 27,500 seeds a^{-1} tended to optimize CWP. It was only at the highest well capacity that a higher seeding rate improved CWP.

Crop water use increased with well capacity and preseason irrigation (Table 2). Soil water at harvest increased with increased well capacity, but this caused less soil water to accumulate during the winter. Non-growing season soil water accumulation averaged 2.7 in (without preseason irrigation). Average non-growing season precipitation was 9.3 in giving an average non-growing season precipitation storage efficiency of 29%. Preseason irrigation (about 3 in) increased available soil water at planting by 1.7 in. Seeding rate had minimal effect on soil water at planting or crop water use but increased seeding rate tended to decrease soil water at harvest and increase over-winter water accumulation.

Preseason irrigation was found to be profitable at all irrigation capacities (Table 3). At the two lower well capacities, a seeding rate of 27,500 seeds a^{-1} was generally the most profitable. However, the highest irrigation capacity benefited from a seeding rate of 32,500 seeds a^{-1}.

CONCLUSIONS

Corn grain yields responded positively to preseason irrigation and increases in well capacity. This yield increase generally resulted from increases in kernels ear^{-1}. Preseason irrigation was profitable at all well capacities. Seeding rate should be adjusted for the amount of irrigation water available from both well capacity and preseason irrigation. At well capacities of 0.10 and 0.15 in day^{-1}, a seeding rate of 27,500 seeds a^{-1} was generally more profitable than lower or higher seeding rates. A higher seeding rate (32,500 seeds a^{-1}) increased profitability when well capacity was increased to 0.20 in day^{-1}.

ACKNOWLEDGEMENTS

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Table 1. Crop parameters of corn as affected by well capacity, preseason irrigation, and seeding rate, Tribune, Kansas, 2006 - 2009.

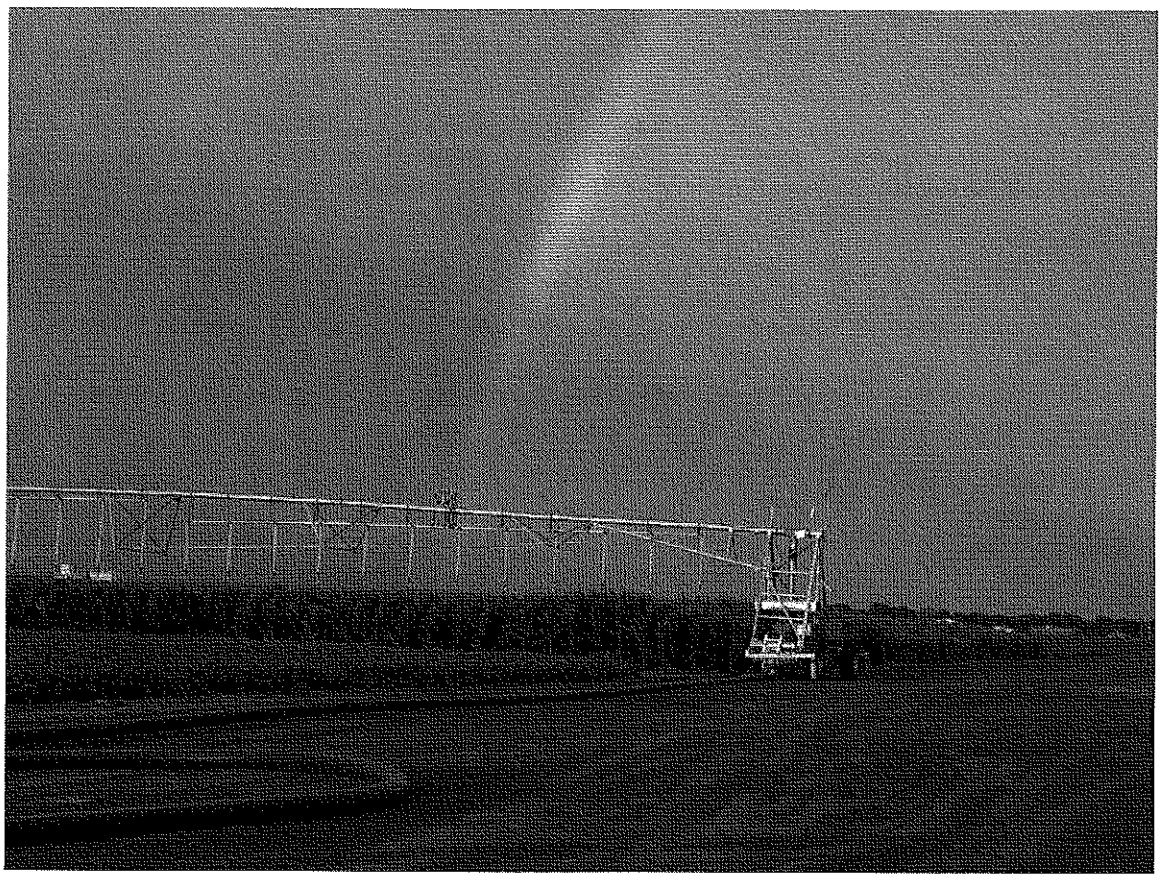
Well capacity	Pre-season irrigation	Seed rate	Grain yield	Crop water prod.	Plant pop.	Ear pop.	1000 seed	Kernel
in day^{-1}		10^3 a^{-1}	bu a^{-1}	lb ac-in^{-1}	- 10^3	acre^{-1} -	oz	# head^{-1}
0.10	no	22.5	153	386	22.4	21.5	13.20	476
		27.5	158	397	26.7	24.7	12.75	442
		32.5	155	389	31.2	28.8	12.46	379
	yes	22.5	171	403	21.9	21.5	13.43	531
		27.5	179	416	26.7	25.3	13.15	478
		32.5	183	419	31.5	29.6	12.80	427
0.15	no	22.5	172	389	22.2	21.2	13.24	543
		27.5	173	395	27.0	25.9	12.93	465
		32.5	171	383	31.1	29.2	12.84	406
	yes	22.5	185	405	22.4	21.9	13.36	563
		27.5	197	431	27.0	26.2	13.08	512
		32.5	201	433	31.4	30.2	12.80	466
0.20	no	22.5	200	404	22.3	22.0	13.29	615
		27.5	211	414	27.0	26.8	13.02	544
		32.5	223	440	31.8	31.3	12.74	503
	yes	22.5	204	396	22.1	21.9	13.59	617
		27.5	218	414	27.0	26.8	13.27	551
		32.5	229	436	31.9	31.2	12.74	517
ANOVA (P>F)								
Well Capacity (WC)			0.001	0.411	0.086	0.001	0.687	0.001
Pre-Season			0.002	0.099	0.659	0.107	0.160	0.001
WC*Pre-Season			0.222	0.297	0.452	0.401	0.752	0.138
Seed Rate			0.001	0.001	0.001	0.001	0.001	0.001
Seed Rate*WC			0.001	0.018	0.012	0.001	0.212	0.176
Seed Rate*Pre-Season			0.018	0.126	0.089	0.345	0.186	0.263
Seed Rate*W*Pre-Season			0.402	0.626	0.427	0.373	0.518	0.295
MEANS	Well cap.	0.10	167	402	26.8	25.2	12.97	456
		0.15	183	406	26.9	25.8	13.04	493
		0.20	214	417	27.0	26.6	13.11	558
		$LSD_{0.05}$	11	25	0.2	0.5	0.35	21
	Pre-season	no	180	400	26.9	25.7	12.94	486
		yes	196	417	26.9	26.1	13.14	518
		$LSD_{0.05}$	9	21	0.2	0.4	0.28	17
	Seed rate	22,500	181	397	22.2	21.7	13.35	558
		27,500	189	411	26.9	25.9	13.03	499
		32,500	194	417	31.5	30.1	12.73	450
		$LSD_{0.05}$	3	8	0.2	0.3	0.09	10

Table 2. Available soil water in 8 ft profile, crop water use, and non-growing season water accumulation for corn as affected by well capacity, preseason irrigation, and seeding rate, Tribune, Kansas, 2006 - 2009.

Well capacity	Pre-season irrigation	Seed rate	Available soil water Planting	Harvest	Water use	Non-growing season accumulation.
in day^{-1}		10^3 a^{-1}	- - in 8 ft. profile^{-1} - -		in	in 8 ft. profile^{-1}
0.10	no	22.5	8.36	5.21	21.28	2.79
		27.5	8.24	4.83	21.55	2.73
		32.5	8.02	4.63	21.52	2.78
	yes	22.5	10.66	5.43	23.36	5.02
		27.5	10.52	4.88	23.78	5.30
		32.5	10.83	4.96	24.00	5.33
0.15	no	22.5	8.78	5.47	24.35	2.71
		27.5	9.17	6.08	24.13	2.56
		32.5	9.06	5.68	24.42	2.98
	yes	22.5	10.51	6.19	25.36	4.05
		27.5	10.46	6.15	25.35	4.77
		32.5	10.71	5.98	25.76	5.05
0.20	no	22.5	10.51	9.07	27.94	2.14
		27.5	9.95	7.86	28.59	3.02
		32.5	10.56	8.53	28.53	2.82
	yes	22.5	13.44	10.82	29.11	3.15
		27.5	13.22	10.13	29.58	3.68
		32.5	12.90	9.85	29.55	3.55
ANOVA (Probability>F)						
Well capacity (WC)			0.010	0.001	0.001	0.001
Pre-season			0.001	0.266	0.001	0.001
WC*Pre-season			0.647	0.587	0.010	0.001
Seed rate			0.779	0.076	0.001	0.002
Seed rate*WC			0.692	0.173	0.059	0.156
Seed rate*Pre-season			0.985	0.820	0.546	0.424
Seed rate*WC*Pre-season			0.389	0.625	0.749	0.303
MEANS	Well capacity	0.10	9.44	4.99	22.58	3.99
		0.15	9.78	5.92	24.89	3.69
		0.20	11.76	9.37	28.88	3.06
		$LSD_{0.05}$	1.49	1.77	0.39	0.38
	Pre- season	no	9.18	6.37	24.70	2.73
		yes	11.47	7.15	26.21	4.43
		$LSD_{0.05}$	1.22	1.44	0.32	0.31
	Seed rate	22.5	10.38	7.03	25.23	3.31
		27.5	10.26	6.65	25.50	3.68
		32.5	10.35	6.61	25.63	3.75
		$LSD_{0.05}$	0.34	0.40	0.18	0.24

Table 3. Net return to land, irrigation equipment, and management from preseason irrigation (0 or 3 in) at three irrigation well capacities and three seeding rates at Tribune, Kansas 2006-2009.

Well capacity in day^{-1}	Preseason Irrigation	Seeding rate (10^3 a^{-1})		
		22.5	27.5	32.5
		Net return, \$ a^{-1} yr^{-1}		
0.10	No	231	238	214
	Yes	285	300	297
0.15	No	290	283	261
	Yes	321	352	357
0.20	No	415	449	485
	Yes	417	458	492



Corn research plots being irrigated with a lateral move sprinkler irrigation system at Kansas State University.

Cropping intensity, fallow efficiency, and field peas and safflower as fallow alternatives

Lucas A. Haag, Northwest Area Agronomist
Northwest Research-Extension Center, Colby, Kansas

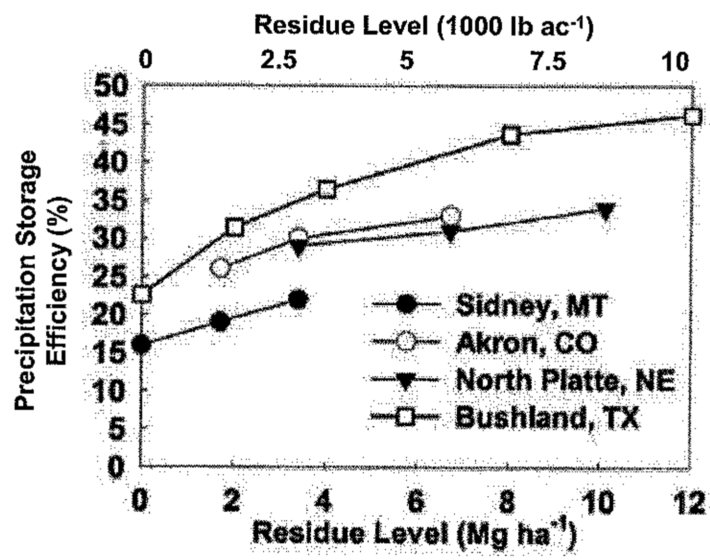
Water is the most limiting factor in Great Plains crop production. Limited amounts of precipitation and erratic patterns led to implementation of the crop-fallow system to help stabilize crop yields as in this region growing season precipitation alone is almost never enough to meet the evapotranspiration (ET) demands of a crop. Significant advances in cropland productivity throughout the region have resulted from improving precipitation use efficiency (PUE) of cropping systems and fallow efficiency or precipitation storage efficiency (PSE) during the remaining fallow periods.

The increase in surface residues and feasibility of a NT cropping system has allowed improvement in PUE and WUE by replacing the summer fallow period with a summer annual crop (Nielsen et al., 2005; Peterson et al., 1996; Schlegel et al., 2002). The addition of a summer annual such as corn, grain sorghum, proso millet, or sunflower improves PUE by using water for transpiration that would have otherwise been lost to evaporation during the fallow period. This intensification provides greater net returns and reduces economic risk (Dhuyvetter et al., 1996; Schlegel et al., 2002). Wheat-summer annual-fallow rotations also provide opportunities to control and reduce seed banks of many weeds (Lyon and Baltensperger, 1995; Holtzer et al., 1996).

Factors Impacting Fallow Efficiency

Fallow efficiency or precipitation storage efficiency is simply defined as the amount of water stored in the soil profile over the fallow period divided by the total precipitation received during that time. Any situation that allows loss of water from the system will thus result in a decreased fallow efficiency. The most notable processes that result in water loss from the system are transpiration of water by weeds, runoff of precipitation into non-crop areas and evaporation of water. Certainly keeping fallow fields weed-free gains much attention due to the visual impact of weedy fallow. Less obvious however are the impacts of runoff and evaporation as they are harder to see and quantify.

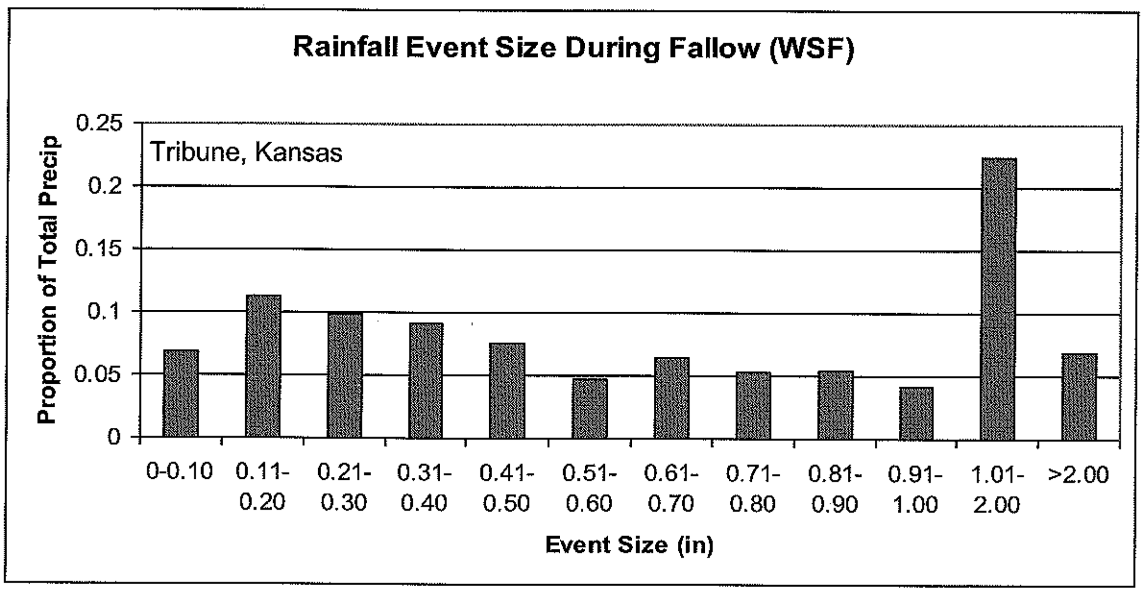
Tillage reduces fallow efficiency (Table 1) through several mechanisms. The immediate evaporative loss that occurs from freshly tilled soil can be significant, especially when the soils contain moisture to the depth of tillage, tillage is intensive (i.e. disk, plot, chisel), and evaporative conditions are high. Tillage also reduces surface residues which can have a large impact on fallow efficiency. Increased



Adapted from Nielsen et al., 2005.

surface residue reduces the impact of falling rain which results in higher infiltration and less run-off of precipitation. Increased surface residues also alter the wind profile near the soil surface and the solar radiation energy balance, both key drivers in evaporation which decreases fallow efficiency.

Maintaining high fallow efficiencies is inheriently difficult in the High Plains due to the nature of precipiation events that occour during the fallow period. During the fallow phase of a W-S-F rotation, nearly 70% of the precipiation comes in events of less than 1", distributed farily evenly by 0.10" increments, with the most events under 1" being 0.11 to 0.20" in size. As the size of a precipiation event decreases the larger percentage of it is lost to evaporation. Maintaining surface residues reduces evaporative losses, especially of the small precipiation events. It is also these smaller events perhaps that a growing crop can make the most use of compared to a loss in fallow if the root architecture is condusive to capturing it.



Crop rotation can also have an impact on fallow efficiency due to the type and amount of residue produced by the previous crops and its rate of decomposition. Data at Tribune, KS has shown follow efficiencies can be nearly double following crops producing high levels of durable residue such as sorghum compared to lower levels of residue that decompose faster such as sunflower and soybean (Table 2). This holds true even when evaluated in more intense four-year rotations where higher levels of durable residue preceded the use of a low residue crop (Table 3). When making cropping decisions it is important to consider the amount and durability of crop residue present when heading into a fallow period. A rotation that places low residue and/or quickly decomposing crops ahead of a long fallow period should be avoided. An extremely bare soil condition due to drought or a low level of residue due to poor crop growth may warrant continuous cropping if possible to reestablish surface residues and improve precipitation storage efficiency. For example, continuous cropping no-till wheat into poor wheat stubble to build residue before returning to row-crop instead of seeding row-crop into poor stubble..

Fallow Alternatives

Research has been conducted in western Kansas looking at crops that could be used either as green fallow (cover crop) or as a cash crop in place of fallow. Growing a crop in place of fallow could possibly improve the PUE of the entire system by transpiring water through a plant that would have otherwise been lost to evaporation during the follow period.

Schlegel and Havlin (1997) evaluated a wide array of species for use as a green fallow crop in a wheat-fallow rotation at Tribune, Kansas. Of the species evaluated, hairy vetch appeared to be the best suited with regard to stand establishment and growth. They evaluated the impacts of hairy vetch on subsequent wheat yields and discovered when the vetch was not terminated until mid-July subsequent wheat yields were reduced by 43%. The impact was much less pronounced when the vetch was terminated in April to mid-May. Vetch was also seeded in the late summer prior to grain sorghum and reduced sorghum yields when allowed to grow until spring.

More recent work as looked at replacing fallow with a forage or cash crop that could further intensify the rotation beyond wheat-summer annual-fallow while generating economic returns (see work by J. Holman in this proceedings). Additionally, in 2010 studies were initiated to look at yellow field pea and safflower as potential, spring seeded short-duration crops that could partially fill the fallow period. Both crops had been grown in the region on an experimental basis at times in addition to some acres planted by producers on a limited commercial basis. Field peas are a fibrous and shallow rooted legume. Although previously evaluated as a nitrogen fixing green fallow crop, field peas are a highly concentrated source of protein and could be a valuable feedstuff to the established livestock feeding (Hinkle et al., 2010) and emerging dairy industry throughout the region as either grain or forage. Safflower is regarded as a drought tolerant crop, gaining that reputation from the deep rooting ability of its tap-root, much like sunflower. It is an oilseed crop, the oil from which is suitable for human consumption.

Both crops were no-till seeded in mid-March into corn or grain sorghum stalks as part of a wheat-corn-fallow or wheat-sorghum-fallow rotation. Peas were seeded at 150 – 180 lbs ac^{-1}, approximately 1.75" deep. Four treatments were evaluated in the peas, May 15 termination, June 1 termination, grain harvest, and green fallow. Safflowers were seeded at four different seeding rates, 15, 25, 35, 45 lbs ac^{-1}, approximately 1" deep. Soil water measurements were taken at planting, through the growing season, and at wheat planting. Field peas tended to use between 1.4 and 3.5" of water compared to fallow while safflower generally used 4.5 – 6" of water compared to fallow. Field pea yields have ranged from 2 to 33.5 bu ac^{-1} while we have struggled in this study to produce economically viable safflower yields. The different fallow alternatives have resulted in vastly different levels of available soil water at wheat planting, typically in the order of No-Till Fallow > Pea > Safflower. This trend was reflected in subsequent wheat yields where wheat after peas was reduced by 13 to 53% and wheat after safflower was reduced by 32 to 86% compared to wheat after no-till fallow. While the water use of safflower is to large to allow its utilization as an alternative to follow, under the proper management, weather and market conditions it may eventually prove useful as a cash crop in a rotation with a longer subsequent fallow period. Field peas may offer an opportunity for intensification of the rotation that is economically positive depending upon the wheat : pea price ratio.

Current limitations to field pea production include susceptibility to heat-stress, especially during flowering which has resulted in the highly variable yields observed in this study. Earlier planting dates and evaluation of available genetics for heat-tolerance may be potential avenues for improvement in this regard.

Table 1. Effect of tillage on fallow efficiency in Wheat-Fallow (WF) rotation. Tribune, Kansas 1993-1998.

Fallow Method	Fallow Accumulation		Fallow Efficiency	
	cm (in)		Percent	
No-Till	16.0 (6.30)	a	23.8	a
Reducted Till	14.0 (5.51)	b	20.9	a
Conventional Till	8.2 (3.23)	c	12.1	b
	ANOVA P>F			
Source of Variation				
Fallow Method	0.011		0.0114	
LSD 0.05	1.6 1.7		0.07	

†Letters within a column represent differences at LSD (0.05)

Table 2. Crop choice effect on surface residues and fallow efficiency. Tribune, Kansas 1998-2008.

Fallow Method	Fallow Accumulation		Fallow Efficiency	
	cm (in)		Percent	
W-S-F	8.3 (3.25)	a	20.1	a
W-SF-F	5.3 (2.08)	b	12.5	b
	ANOVA P>F			
Source of Variation				
Fallow Method	0.0452		0.0346	
LSD 0.05	1.6 (1.14)		6.94	

†Letters within a column represent differences at LSD (0.05)

Table 3. Crop choice effect of fallow efficiency in intensified rotations. Tribune, Kansas, 2001-2006.

Fallow Method	Fallow Accumulation		Fallow Efficiency	
	cm (in)		Percent	
W-C-GS-F	8.3 (3.26)	a	20.4	a
W-C-SB-F	5.8 (2.27)	b	14.1	b
W-C-SF-F	4.2 (1.64)	c	10.0	c
	ANOVA P>F			
Source of Variation				
Fallow Method	0.0002		<0.0001	
LSD 0.05	1.6 (0.54)		2.53	

†Letters within a column represent differences at LSD (0.05)

Field Peas

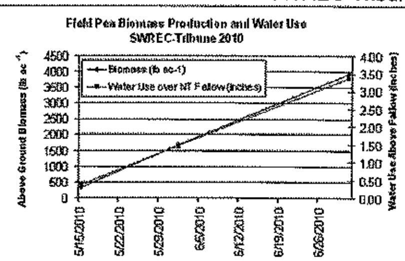
- DS Admiral Yellow Field Pea
- Planted mid March @ 150-180 lbs ac^{-1}
- Four Treatments
  - Terminated 15 May and left as cover crop
  - Terminated 1 June and left as cover crop
  - Allowed to fully mature and left as cover crop
  - Harvested for grain early July
- 2011 Winter wheat failed at Tribune and emerged late at Colby (end of February / early March)
- 2012 Winter wheat was harvested at the Kansas locations

Water Use by Field Peas vs. No-Till Fallow SWREC-Tribune

	Water Use to Date (Inches)		
	15-May Termination	1-Jun Termination	1-Jul Harvest
Peas	2.18	5.42	9.30
Fallow	1.81	3.94	5.92
Fallow Efficiency	23.3%	31.1%	25.9%

Peas effectively used 3.38" of water

Field Pea Biomass Production and Water Use SWREC-Tribune 2010



	15-May	1-Jun	1-Jul
Biomass (lb ac-1)	331	1676	3937
Water Use over NT Fallow (inches)	0.37	1.48	3.38

Pea Grain Yields

Location	2010	2011	2012
		bu ac^{-1}	
Colby	33.5	7.1	2.8
Garden City		-	17.3
Tribune	26.7	-	18.9
Bushland		-	-

Fallow Alternative Impacts on Available Soil Water at Wheat Planting

Table 2. Available soil water at wheat planting as affected by fallow method. NWREC-Colby 2010

Fallow Method	Available Soil Water at Wheat Planting		
	cm	(in)	
NT Fallow	30.6	(12.05)	a
Peas - Green Fallow	27.1	(10.66)	b
Safflower	18.8	(7.42)	c

ANOVA P>F

Source of Variation		
Fallow Method	0.001	
LSD 0.10	3.2	(1.26)

[1]Letters within a column represent differences at LSD (0.10)

Tribune 2010 - Fallow Alternative Impacts on Available Soil Water at Wheat Planting

Table 1. Available soil water at wheat planting as affected by fallow method. SWREC-Tribune 2010 Preliminary Data

Fallow Method	Available Soil Water at Wheat Planting		
	cm	(in)	
NT Fallow	20.4	(8.02)	a
Peas Terminated 6/1	13.9	(5.47)	ab
Peas Harvested for Grain	13.9	(5.47)	ab
Peas Terminated 5/18	13.1	(5.16)	abc
Peas - Green Fallow	12.2	(4.79)	bc
Safflower	6.4	(2.50)	c

ANOVA P>F

Source of Variation		
Fallow Method	0.0951	
LSD 0.10	7.3	(2.87)

[1]Letters within a column represent differences at LSD (0.10)

Haag

Tribune 2011 – Fallow Alternative Impacts on Available Soil Water at Wheat Planting

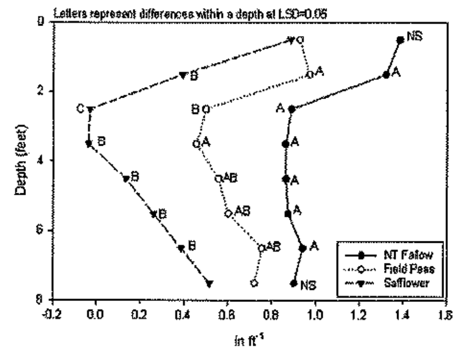
Table 3. Available soil water at wheat planting as affected by fallow method. SWREC-Tribune 2011 Preliminary Data

Fallow Method	Available Soil Water at Wheat Planting		
	cm (in)		
Peas Terminated 5/18	17.1	(6.72)	a
NT Fallow	16.7	(6.58)	a
Peas Terminated 6/1	14.4	(5.68)	ab
Peas Harvested for Grain	11.5	(4.53)	b
Peas - Green Fallow	10.2	(4.02)	b
Safflower	4.2	(1.67)	c
ANOVA P>F			
Source of Variation			
Fallow Method	0.0008		
LSD 0.10	4.2	(1.67)	

†Letters within a column represent differences at LSD (0.10)

Fallow Alternative Study SWREC-Tribune 2010 Available Soil Water at Wheat Planting

PRELIMINARY DATA



2012 Colby Wheat Grain Yields

Table x. Subsequent wheat grain yields as affected by fallow method. NWREC-Colby 2012 Preliminary Data

Fallow Method	Wheat Grain Yield	
	kg/ha (bu/ac)	
Peas Terminated 5/18	(56.59)	a
NT Fallow	(51.22)	ab
Peas Terminated 6/1	(49.19)	ab
Peas Harvested for Grain	(44.50)	bc
Peas - Green Fallow	(40.51)	c
Safflower	(38.44)	c
ANOVA P>F		
Source of Variation		
Fallow Method	0.0099	
LSD 0.10	(7.96)	

†Letters within a column represent differences at LSD (0.10)

2012 Garden City Wheat Grain Yields

Table x. Subsequent wheat grain yields as affected by fallow method. SWREC-Garden City 2012 Preliminary Data

Fallow Method	Wheat Grain Yield	
	kg/ha (bu/ac)	
NT Fallow	(30.16)	a
Peas Terminated 5/18	(20.23)	b
Peas Terminated 6/1	(17.57)	bc
Peas - Green Fallow	(16.93)	bc
Midas Peas for Grain	(14.29)	bc
Admiral Peas for Grain	(13.06)	c
Safflower	(4.14)	d
ANOVA P>F		
Source of Variation		
Fallow Method	0.0003	
LSD 0.10	(6.47)	

†Letters within a column represent differences at LSD (0.10)

2012 Tribune Wheat Grain Yields

Table x. Subsequent wheat grain yields as affected by fallow method. SWREC-Tribune 2012 Preliminary Data

Fallow Method	Wheat Grain Yield	
	kg/ha (bu/ac)	
NT Fallow	(6.61)	a
Peas Terminated 6/1	(6.22)	a
Peas - Green Fallow	(5.84)	a
Midas Peas for Grain	(5.51)	a
Peas Terminated 5/18	(5.29)	a
Safflower	(0.73)	b
ANOVA P>F		
Source of Variation		
Fallow Method	0.0092	
LSD 0.10	(3.62)	

†Letters within a column represent differences at LSD (0.10)

Moving Forward

- Although growing field peas may reduce subsequent wheat yield, the entire system may be more profitable depending on wheat:pea price ratios
- Can we make the decision of planting peas based on profile water at pea planting time
- Are there better genetics available for temperature stress
- Viability of "bin-run" seed grown in the central High Plains
- Planting date, how early can we push it

Fallow Replacement in Western Kansas

John Holman

Scott Maxwell & Tom Roberts

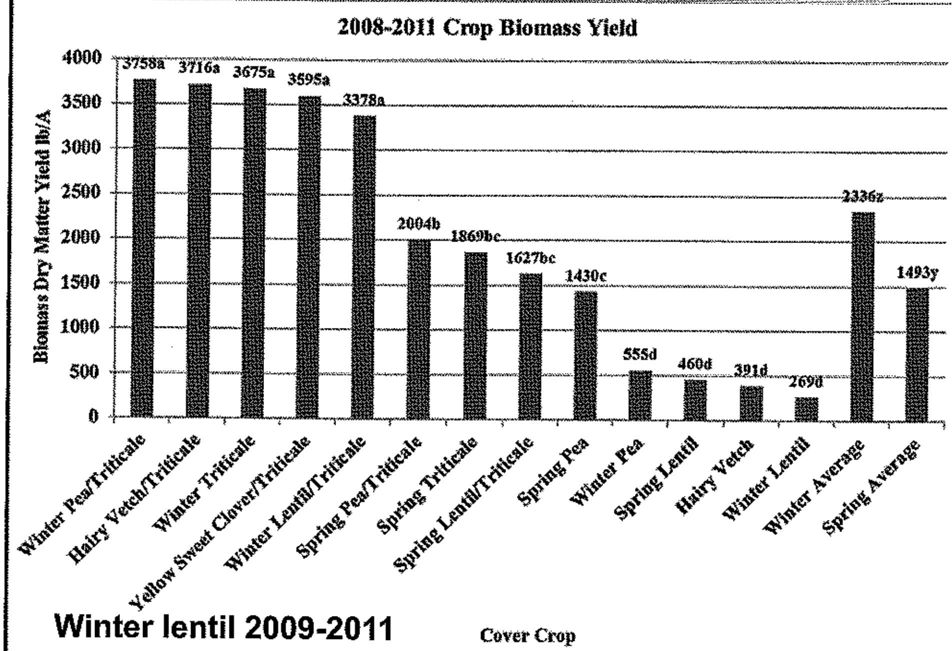
COLLEGE OF AGRICULTURE
KANSAS STATE UNIVERSITY

Fallow Treatments (Cover, Forage, Grain)

Season	Crop	Year Produced 2007	2008	2009	2010	2011
Winter	Yellow sweet clover	x	x			
""	Yellow sweet clover/Winter triticale		x			
""	Hairy vetch	x	x	x	x	x
""	Hairy vetch/Winter triticale		x	x	x	x
""	Winter lentil			x	x	x
""	Winter lentil/Winter triticale			x	x	x
""	Winter pea	x	x	x	x	x
""	Winter pea/Winter triticale		x	x	x	x
""	Winter triticale	x	x	x	x	x
""	Winter pea (grain)		x	x		x
Spring	Spring lentil	x	x	x	x	x
""	Spring lentil/Spring triticale		x	x	x	x
""	Spring pea	x	x	x	x	x
""	Spring pea/Spring triticale		x	x	x	x
""	Spring triticale		x	x	x	x
""	Spring pea (grain)				x	x
Other	Chem-fallow	x	x	x	x	x
""	Continuous winter wheat	x	x	x	x	x

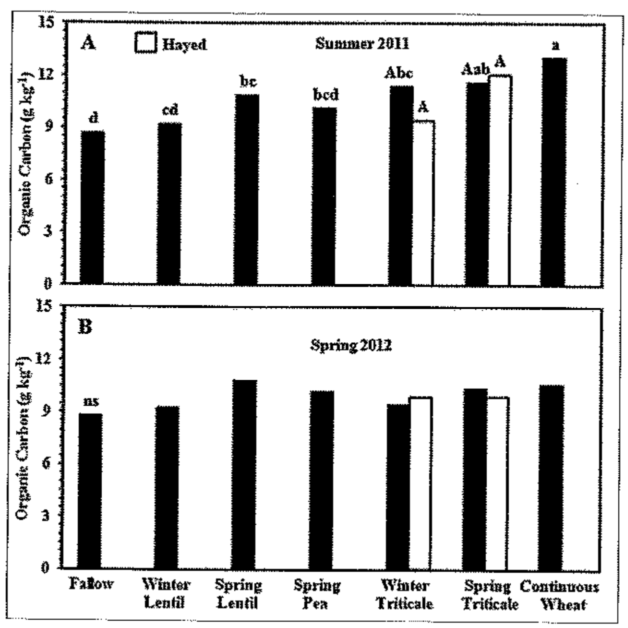
- 18 treatments total

2008-2011, Crop Biomass



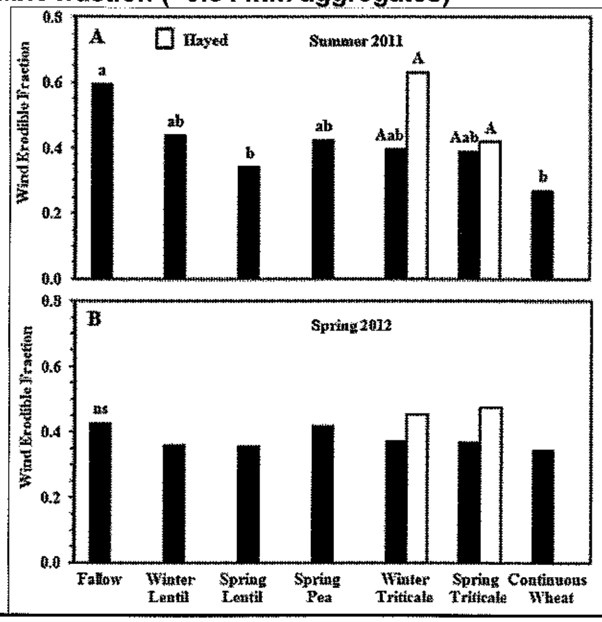
Winter lentil 2009-2011

Soil Organic Carbon

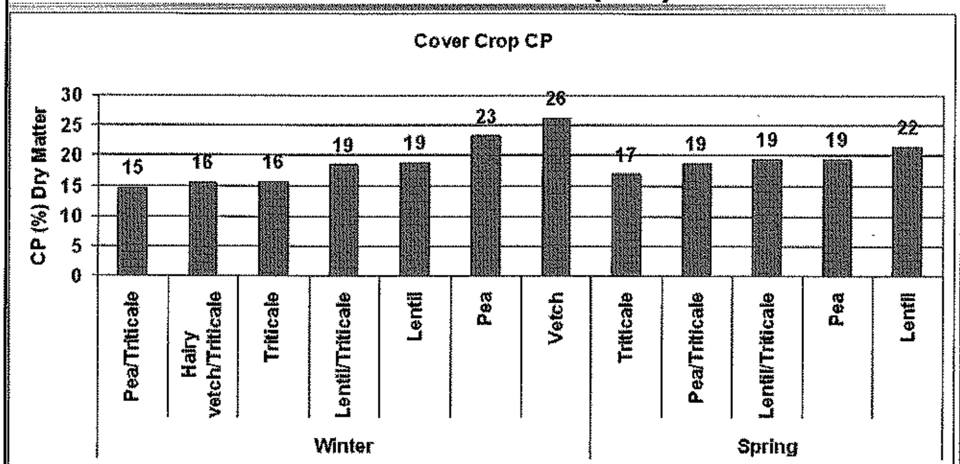


Wind Erosion

- Wind erodible fraction (<0.84 mm aggregates)

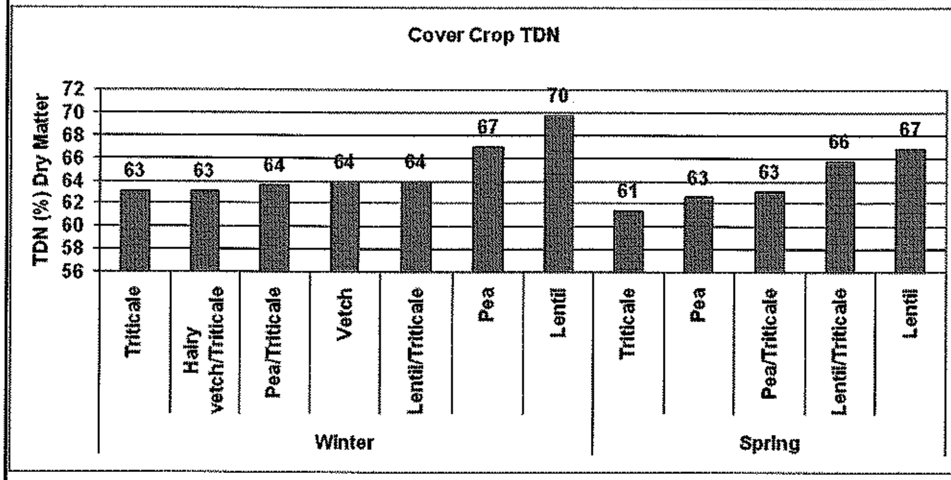


Crude Protein (CP)



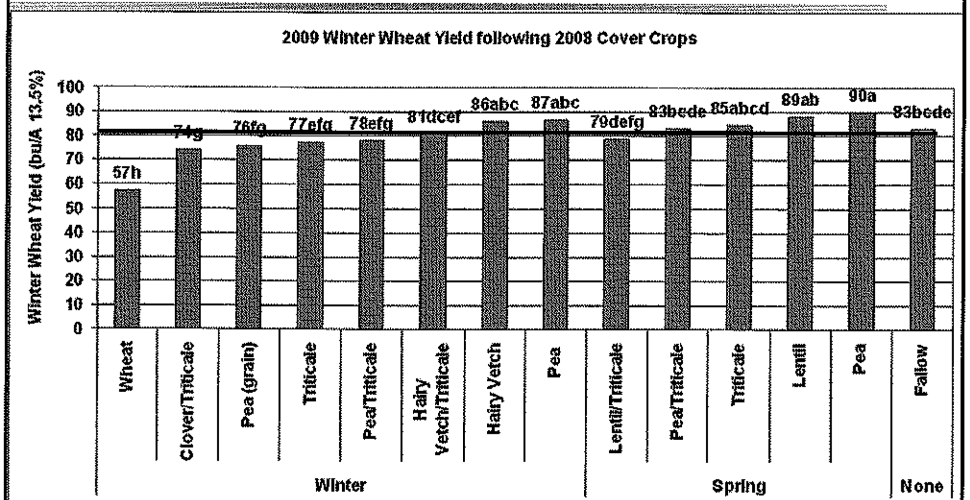
- Microbial protein and amino acid production
- > 13% “premium” nutritive value
- Alfalfa 18-24% CP

Total Digestible Nutrients (TDN)



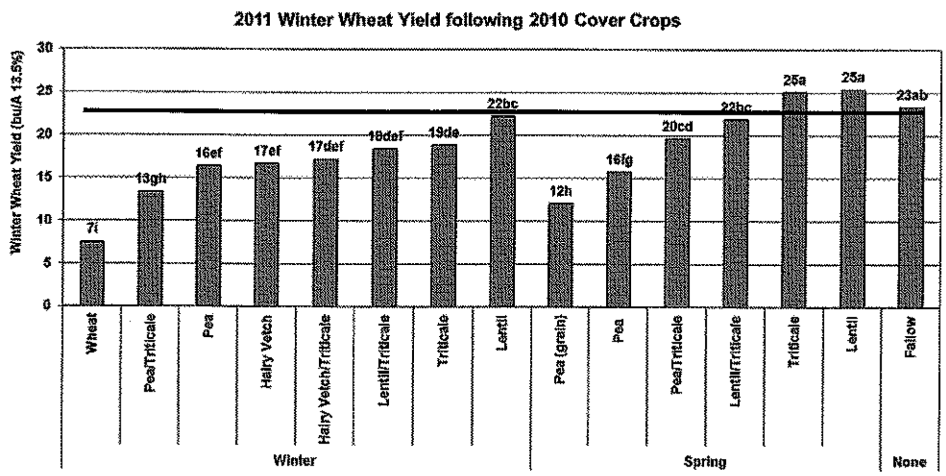
- Energy available
- Alfalfa 61-67% TDN

Yield Results (2008-2010 similar results)



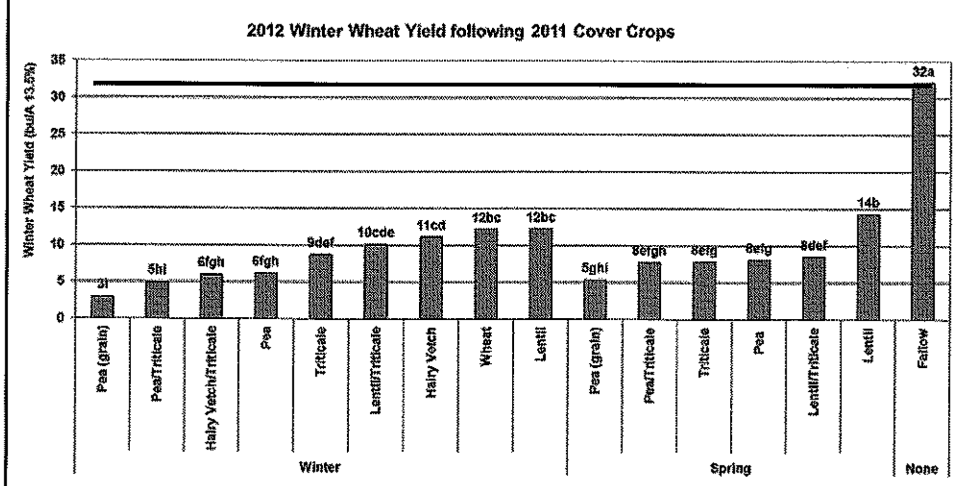
- Good yields: 45 bu/A APH, visual diff with cont. wheat
- No effect of residue management treatment

2011 Yield Results



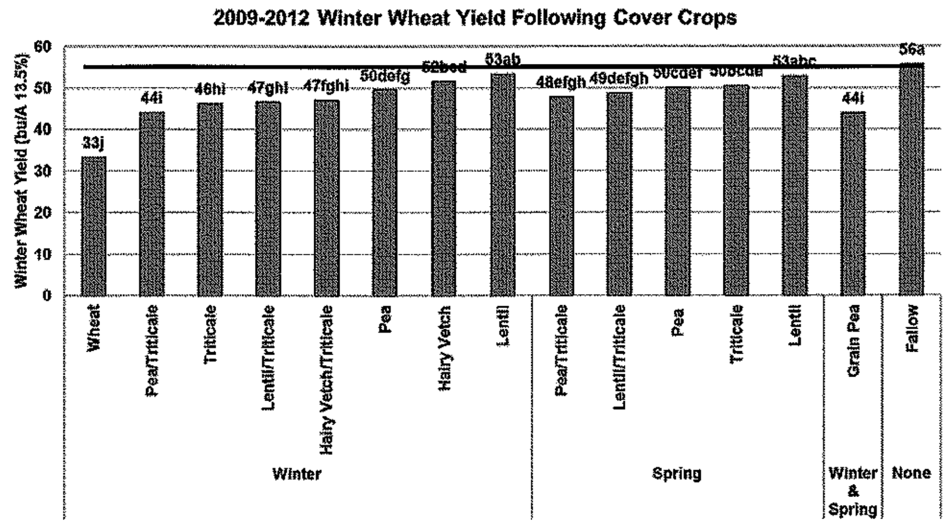
- Very dry year, marginal wheat stands
- No effect of residue management treatment
- On average spring forage reduced yield 3 bu/A

2012 Yield Results



- Very dry year, marginal wheat stands
- No effect of residue management treatment
- All treatments reduced yield compared to fallow

2009-2012 Yield Results



- **2 good years, 2 very poor years**
- **No effect of residue management treatment**

Economic Results

	Winter								Spring						None
	Vetch	Vetch/ Trit	Lentil	Lentil/ Trit	Pea	Pea/ Trit	Trit	Wheat	Lentil	Lentil/ Trit	Pea	Pea/ Trit	Trit	Pea, grain	Fallow
Expenses															
Total seeding cost $/A	69	48	24	26	37	32	27	21	23	26	40	35	30	40	0
Total hay cost $/A	19	64	17	60	21	65	64	0	19	36	33	41	39	0	0
Grain harvesting $/A	0	0	0	0	0	0	0	30	0	0	0	0	0	30	0
Fallow spray cost $/A	36	36	36	36	36	36	36	36	36	36	36	36	36	36	48
In-crop spray cost $/A	0	0	0	0	0	0	0	11	0	0	0	0	0	11	0
Total Expense (cover)	**104**	**83**	**60**	**61**	**73**	**68**	**63**	-	**59**	**62**	**76**	**71**	**66**	-	-
Total Expense (hay)	**123**	**148**	**77**	**121**	**94**	**133**	**126**	-	**78**	**98**	**109**	**111**	**104**	-	-
Total Expense (grain)	-	-	-	-	-	-	-	**98**	-	-	-	-	-	**117**	**48**
Returns															
Yield ton/A or bu/A	0.2	2.2	0.2	2.0	0.3	2.2	2.2	33.0	0.3	1.0	0.8	1.2	1.1	14.0	0.0
Price $/ton or $/bu	110	110	110	110	110	110	110	7	110	110	110	110	110	7	0
Yield Return $/A	25	240	17	219	36	243	238	216	30	105	93	130	121	92	0
N Return $/A	20	20	20	20	20	20	0	0	20	20	20	20	0	0	0
Impact on wheat bu/A	-4	-9	-2	-9	-6	-12	-9	-22	-3	-7	-6	-8	-5	-12	0
Impact on wheat $/A	-26	-59	-13	-59	-39	-78	-59	-144	-20	-46	-39	-52	-33	-78	0
Net Return (cover)	**-111**	**-122**	**-53**	**-100**	**-92**	**-126**	**-121**	-	**-58**	**-88**	**-95**	**-103**	**-98**	-	-
Net Return (hay)	**-124**	**9**	**-73**	**14**	**-97**	**7**	**28**	-	**-68**	**-51**	**-55**	**-47**	**-29**	-	-
Net Return (grain)	-	-	-	-	-	-	-	**-46**	-	-	-	-	-	**-38**	**-48**
Net Return (alt vs fallow)	**-76**	**56**	**-25**	**61**	**-50**	**55**	**75**	**2**	**-20**	**-3**	**-8**	**1**	**19**	**10**	

*Assumption: N contribution from legume 0 when hayed, 50 lbs N add for winter trit. and 25 lbs N add for spring trit.

Economic Results Summary

Return	Winter								Spring						None
	Vetch	Vetch /Trit	Lentil	Lentil /Trit	Pea	Pea /Trit	Trit	Wheat	Lentil	Lentil /Trit	Pea	Pea /Trit	Trit	Pea, grain	Fallow
Cover crop	-111	-122	-53	-100	-92	-126	-121	-	-58	-88	-95	-103	-98	-	-
Hay	-124	9	-73	14	-97	7	28	-	-68	-51	-55	-47	-29	-	-
Grain only	-	-	-	-	-	-	-	-46	-	-	-	-	-	-38	-48
Best alternative	-76	56	-25	61	-50	55	75	2	-20	-3	-8	1	19	10	

- Fallow cost $48/A
- Returns include any reduction of following wheat yield
- Winter and spring triticale hay, grain peas, cont. wheat

Results

- Impact on wheat yield and profitability
  - Depends on wheat yield potential
  - Wet years little to no impact on yield (yield ≥ 70 bu/A)
  - Dry years
    - 2011: dry year (WF yielded 23 bu/A)
      - Spring crops < 1 bu & winter crops < 6 bu
    - 2012: second dry year (WF yielded 32 bu/A)
      - Spring crops < 23 bu & winter crops < 24 bu
  - "Average" year?
  - IF you knew you were going to be in a drought W-F best
  - What is the best choice long-term?
  - How much weight do you put on a record drought year?

Results

- Spring triticale forage
  - 4 years of no yield impact & 1 year yield reduced
    - 2008, 2009, 2010, & 2011 no impact
    - 2012 -24 bu
  - On average wheat yield -2.5 to 5 bu/A (range: +2 to -24)
  - 1 ton forage @ $110/ton
    - Net $19 to 36/A more than chem-fallow long-term
    - Net $54/A more than chem-fallow without 2012
  - Break-even yield reduction of 7.5 bu/A @ $7.00/bu
    - Wheat-fallow yield potential of <25 bu?

Conclusion

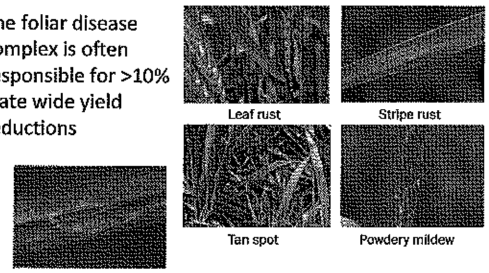
- <u>It is only sustainable if it is profitable</u>
  - Graze it, bale it, or combine it!
  - No difference if grown as forage or cover
- High seed cost, offsets N contribution- grow own seed
  - More economical to apply N
- Select fallow replacement crop adapted to region
- Terminate cover crop prior to June 1 for winter wheat
- If moisture is available consider double-crop after wheat
- Harvesting crop as forage or grain in place of fallow can increase profitability

Leveraging information to maximize wheat yield response to foliar fungicides

Erick De Wolf
Kansas State University
Plant Pathology

Complex of Foliar Diseases

- The foliar disease complex is often responsible for >10% state wide yield reductions

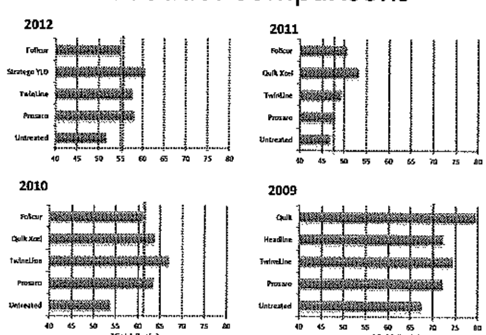


What are the Product Options and Costs of Application?

Fungicide Product Options

- The decision to apply is more important than small differences between efficacy
- Availability, price and PHI may be your determining factors

Product Comparisons



Targeted diseases tan spot and leaf rust

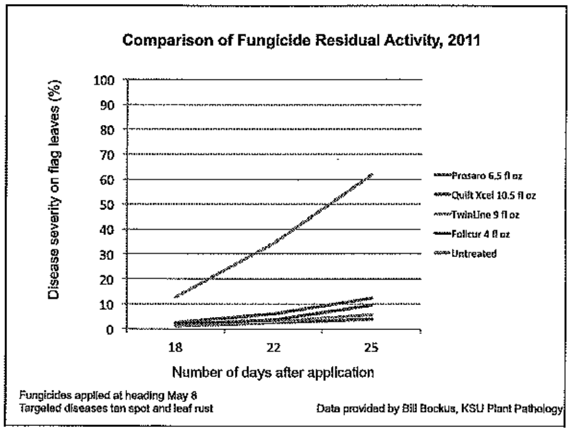
Data provided by Bill Bockus, KSU Plant Pathology

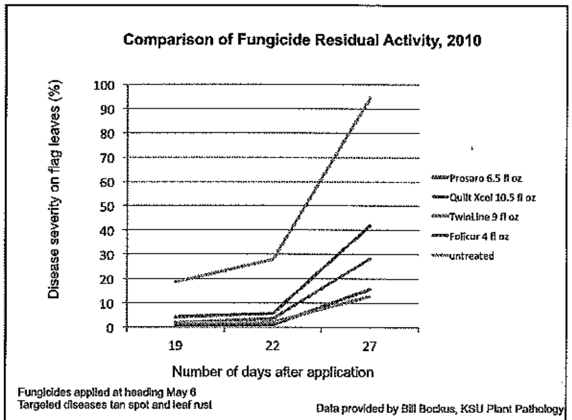
What is the residual activity of the fungicides?

- Fungicides in the fungicide efficacy table will generally last 21 days
- Yes, this includes the generic tebuconazle (Folicur) and propiconazle (Tilt)

Research Backing Fungicide Residual Activity

- Fungicide evaluations in Manhattan 2008-2011
- Primary focus tan spot and leaf rust
- Heavy disease pressure and susceptible wheat variety
- Multiple disease evaluations after application provide evidence of residual activity





What about the preventative and curative activity of the fungicides?

- All fungicides are best applied when disease is still at low levels
  - Severely damaged leaves can not be restored to health
- Triazole fungicides are generally considered to have slightly better curative activity
  - Triazole
    - Tilt, Prosaro, Folicur
  - Mixed mode of action (Triazole + strobilurin)
    - Quilt Xcel, Stratego YLD, TwinLine
  - Curative activity varies with disease targeted

Are these products vulnerable to removal by rain?

- The fungicides listed in the fungicide efficacy publication are adhere well to leaves and are readily absorbed by plants
- Less data to support how long a fungicide needs to be on the plants before a rain
- Generally, the more dry time the better
  - Most recommendations indicate that the fungicide must dry prior to rain
  - This may take several hours in humid conditions

When is the best time to apply a foliar fungicide?

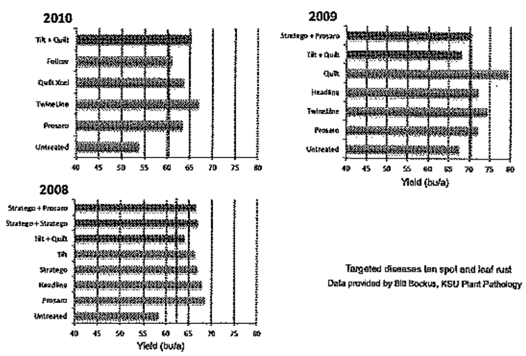
Fungicide Timing

- Single fungicide applications are most effective when applied between flag leaf emergence and flowering
  - Target: disease control on last two leaves

What do you think of early fungicide applications?

- Early applications generally result in only a small yield increase
- Most reasonable when combined with second application at boot or heading
- Most of the yield response comes from 2nd application

Tests of Early Fungicide Applications



Targeted diseases tan spot and leaf rust
Data provided by Bill Bockus, KSU Plant Pathology

Are there potential concerns with early treatments?

- Generally applied at half rate creating potential issues with fungicide resistance
- Limited systemic nature of fungicides means new growth is not protected

What is the Typical Yield Response?

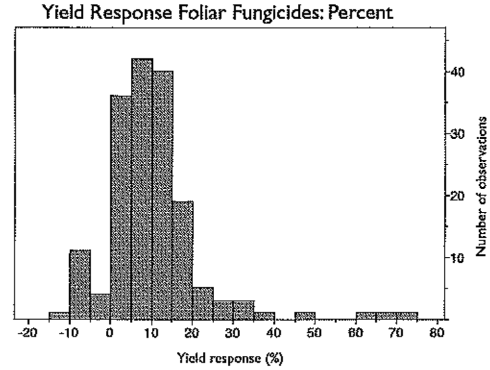
Fungicide Response In Kansas

- K-State Research and Extension fungicide evaluations 1991-2011
- 169 observations
- Locations: Manhattan, Hesston, Hutchinson, Garden City, Colby, and Belleville

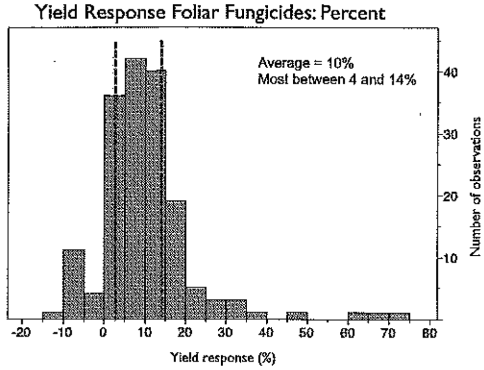
Fungicide Research Details

- Products evaluated include
  - Labeled products (Tilt, Twinline, Stratego, Quilt, Folicur)
  - Susceptible varieties
  - Evaluated in high disease pressure
- Single fungicide treatment applied between flag leaf emergence and flowering

Yield Response Foliar Fungicides: Percent

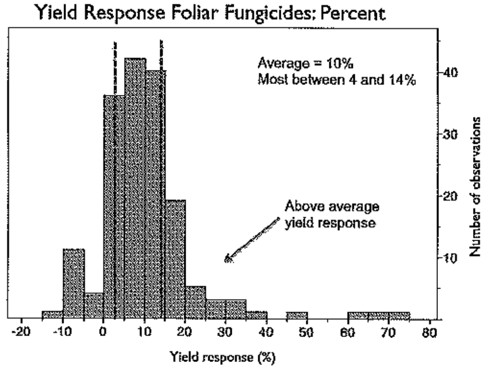


Yield Response Foliar Fungicides: Percent



How can we maximize chances of yield response from fungicides?

Yield Response Foliar Fungicides: Percent



Key Factors Influencing Yield Response

- Strategies for making fungicide decisions
  - Determine which varieties are most likely to respond to fungicide application
    - Susceptibility / Resistance to multiple diseases
  - Correctly identifying the in-season risk of disease loss

Evaluating Susceptibility

- Susceptibility to leaf diseases
  - Stripe rust, leaf rust, tan spot, Septoria tritici blotch, powdery mildew
  - Summarize disease ratings to create a simplified index

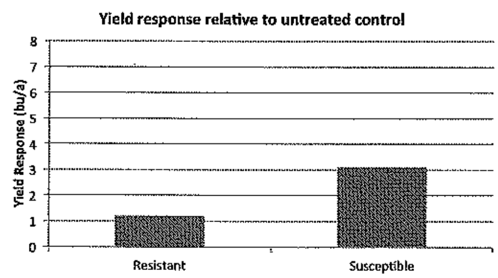
Fungicide Testing Results

- Three central Kansas location
- 2008-2011 with multiple varieties
- Single application of Quilt or Prosaro at heading
- Comparison with untreated control
- 125 observations

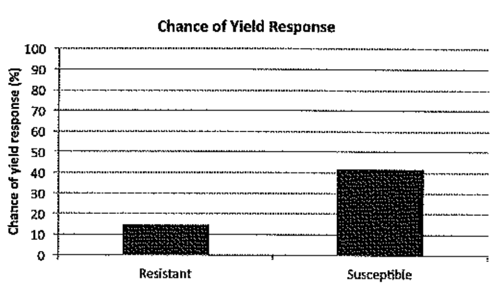
Leaf Disease Resistance Index

Variety	Leaf disease index	Overall disease resistance category
Santa Fe	24	Resistant
Everest	25	Resistant
Art	25	Resistant
Karl 92	25	Resistant
2137	29	Susceptible
Overley	30	Susceptible
Fuller	30	Susceptible
Jagger	30	Susceptible
PostRock	34	Susceptible
Jagalene	38	Susceptible

Decision Based on Variety



Decision Based on Variety



*Based on target of 4 bu/a or more

Identifying Disease Risk

- Variation in disease pressure is normal
  - Between years
  - Among locations
- Factors influencing variation
  - Local weather
  - Pathogen population changes or increases
    - "Race changes" in rust diseases
    - Timing relative to crop growth
    - Cropping practices

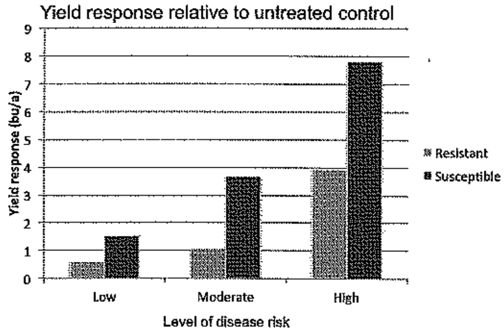
Indicators of In-Season Disease Risk

- Regional outbreaks of leaf rust or stripe rust
- Disease scouting in individual fields

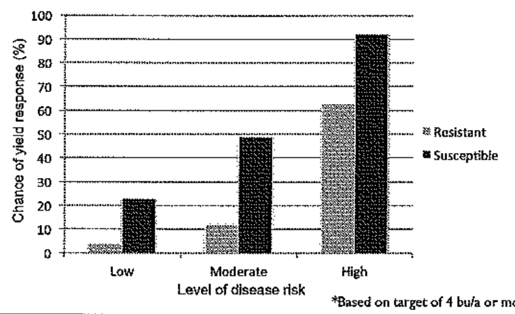
Categories of Disease Risk

- Low: Disease not present at given location and no reports of rust outbreaks
- Moderate: Regional outbreaks reported and disease present in mid canopy at heading
- High: Regional outbreaks reported and disease present on upper leaves at heading

Decision Based on Variety and Disease Scouting

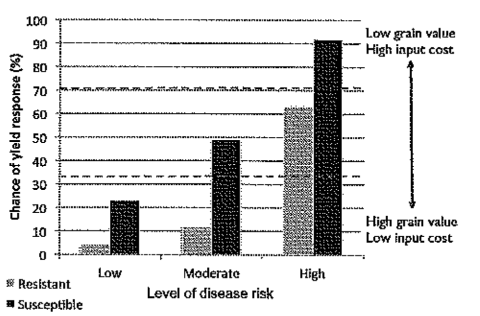


Decision Based on Variety and Disease Scouting



*Based on target of 4 bu/a or more

Integrating Economics



*Based on target of 4 bu/a or more

Questions?

Understanding the Activity of Fungicides

- Two major classes of fungicides labeled for use on wheat
  - Triazole
  - Strobilurin
- These classes of fungicides represent different modes of action

Mode of Action

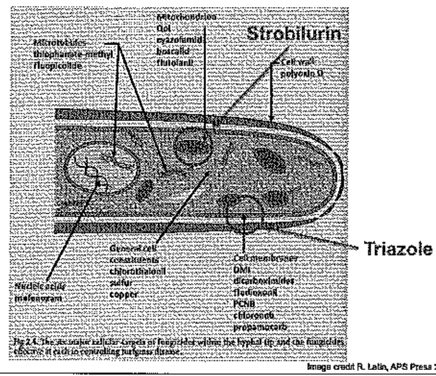
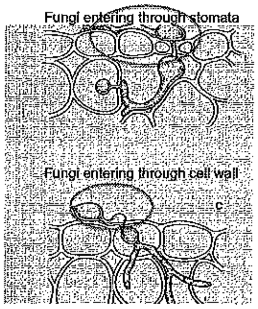


Image credit R. Latin, APS Press 2011

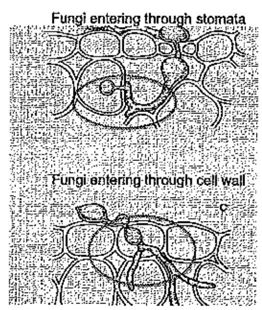
Strobilurin Fungicide



- Interrupts fungal respiration
- Most effective in early stages of fungal infection
  - Spore germination
  - Penetration

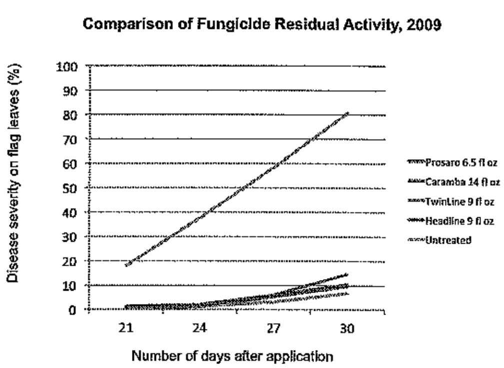
Image: Hartleb et al. 1997

Triazole Fungicides



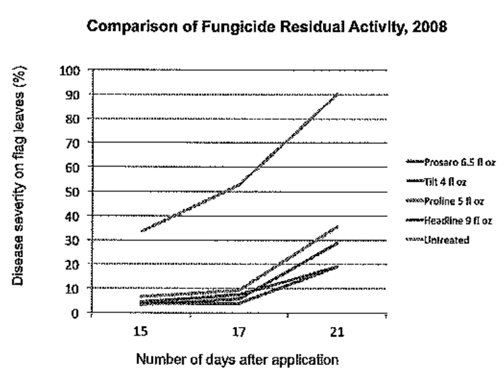
- Disrupts cell membranes and development of new cells
- Most effective during early stages of infection or colonization

Image: Hartleb et al. 1997



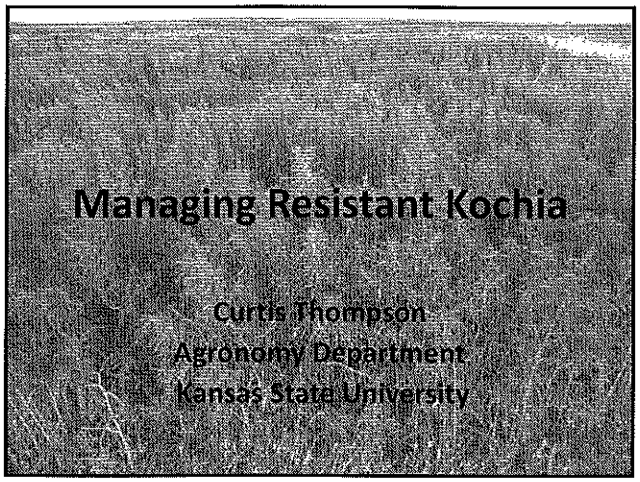
Fungicides applied at heading May 8
Targeted diseases tan spot and leaf rust

Data provided by Bill Bockus, KSU Plant Pathology



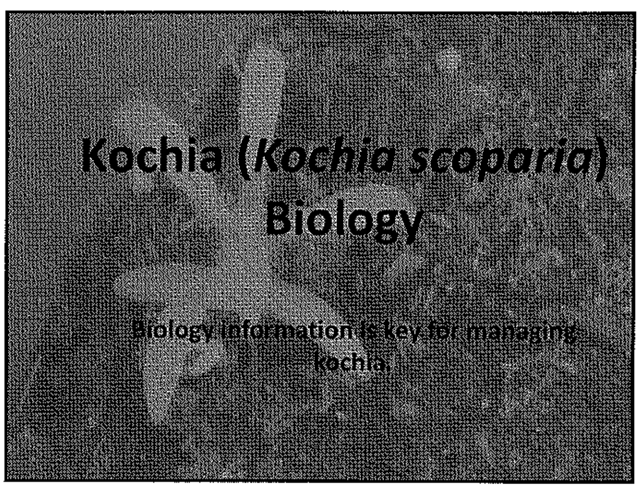
Fungicides applied at heading May 19
Targeted diseases tan spot and leaf rust

Data provided by Bill Bockus, KSU Plant Pathology



History/Background

- Reduced rates of glyphosate controlled kochia in fallow with or with the addition of dicamba (adding dicamba was recommended), early 90's
- As glyphosate prices declined, growers sometimes using straight glyphosate eliminating dicamba because of costs (problematic)
- In addition, in glyphosate resistant crops, often glyphosate was used alone to reduce costs
- Kochia became increasingly difficult to control (2005-2007 and after)



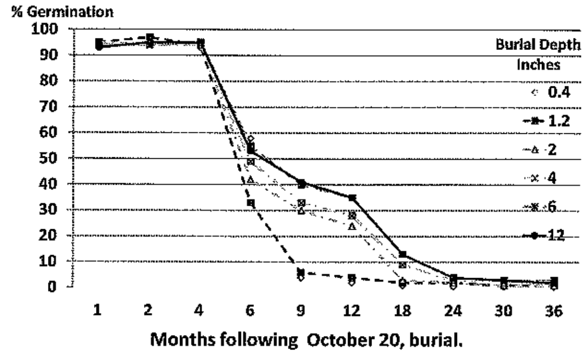
Kochia Biology

- Annual, herbaceous dicot, C4 plant
- Drought and salt tolerant
- Germinates – early spring germinator however can germinate throughout the growing season
- Reported germination at temperatures of 39 to 106 F with lab experiments
- 41 to 77 F being optimum (Everitt et.al. 1983)

Seed longevity

- Nebraska experiments showed 5% viability after one year of burial and 0% after two years, Burnside et.al. 1981
- Colorado experiments showed a very low percentage (1 to 3%) viability after 3 years of burial, Zorner et.al. 1984

Effect of burial depth and time on kochia seed viability, Zorner et.al. Weed Sci. 1984.



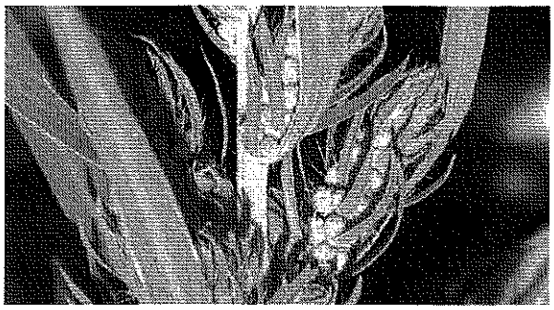
Kochia emergence patterns, Dille etal., 2010.

Location	Site	10% Emerged		90% Emerged	
		GDD	Date	GDD	Date
Lingle, WY	NC	76	3/21	191	4/10
Mitchell, NE	NC	84	3/17	456	5/7
Scottsbluff, NE	NC	69	3/15	415	4/29
Hays, KS	Crop	238	3/18	365	3/24
Hays, KS	NC	137	3/31	173	4/10
Ness City, KS	NC	114	3/11	475	4/18
Garden City, KS	Crop	283	3/31	1056	5/26

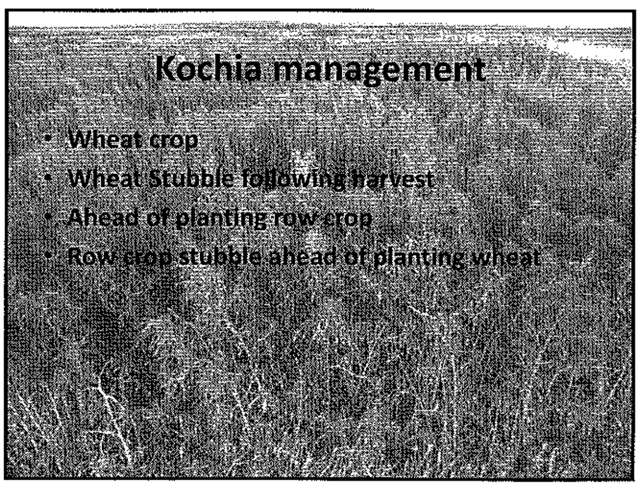
Kochia Reproduction

- Daylength sensitive – critical light period triggering flowering is 13 to 15 hrs depending on biotype, Bell et.al. 1974
- Accessions from New Mexico were reported to have shorter critical light period requirements than accessions from North Dakota
- Begin flowering in July to into August
- Destroy prior to flowering – KEY!

Stigmas present without anthers, proto-gyneous flowering, facilitates cross pollination, however kochia is self fertile.



Kochia pollen



Control kochia in wheat!

Control kochia in wheat!

- Include dicamba in a tank mix prior to wheat jointing.
- Use a Starane containing product. Fluroxypyr can be applied up to early boot. ($10 to 14.00 for Starane product)
- Huskie, 11-16 fl oz, NIS 0.25-.5% v/v, AMS .5 to 1 lb/a on wheat 1 leaf to flag leaf emergence. ($9 to $13.50)
- 2,4-D, MCPA, Aim, Cadet, ALS inhibitors generally not very effective on kochia.

UGA1459291

Kochia management in fallow

- Intended cropping sequence may affect what herbicides that are used
- Heavy kochia pressure following wheat harvest may not be controlled
- Gramoxone SL + atrazine 2qt+1pt - $18.50+4.50
- Gramoxone SL + metribuzin 2qt+.67 lb - $18.50+11
- Gramoxone SL + Linex 4L 2 qt+24 fl oz - $18.50+15
- Glyphosate + dicamba 0.75 lb ae+1pt - $3 + 11
- IF seed is produced in this period, it will be key to use March applications of herbicides.

Postemergence control of kochia in fallow with photosynthetic inhibitors, Tribune 2011.

	Product	Prod. Cost	Kochia control (%)	
Treatment	rate	$	May 30, 16DAT	June 11, 28DAT
Gramoxone SL+atrazine+COC	48 +16+1%	18.50+2.25 + 0.57	94	91
Linex+atrazine+ COC	24+16+ 1%	15+2.25+ 0.57	96	94

Dense stands of kochia were treated May 14th.

Kochia management

- Wheat crop
- Wheat Stubble following harvest
- Ahead of planting row crop
- Row crop stubble ahead of planting wheat

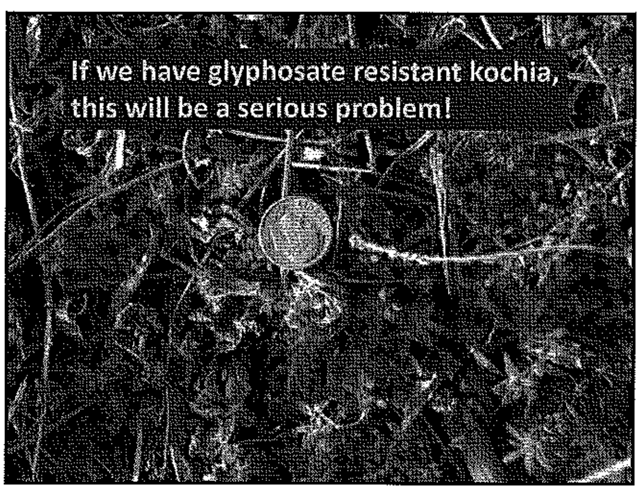
Postemergence control of kochia in fallow with photosynthetic inhibitors, Tribune 2011.

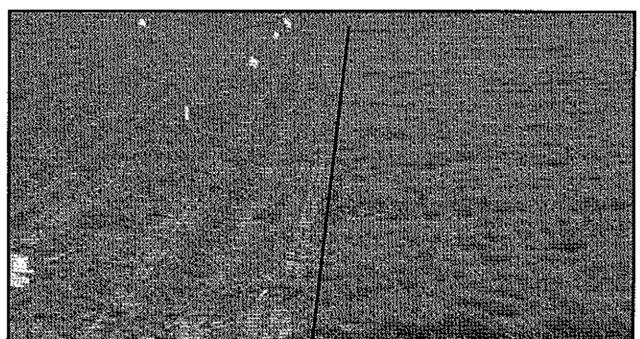
	Product	Prod. Cost	Kochia control (%)	
Treatment	rate	$	May 30, 16DAT	June 11, 28DAT
Gramoxone Inteon+atrazine+COC	48 +16+1%	12.32+2.16 + 0.57	94	91
Linex+atrazine+ COC	24+16+ 1%	13.88+2.16 + 0.57	96	94

Dense stands of kochia were treated May 14th.

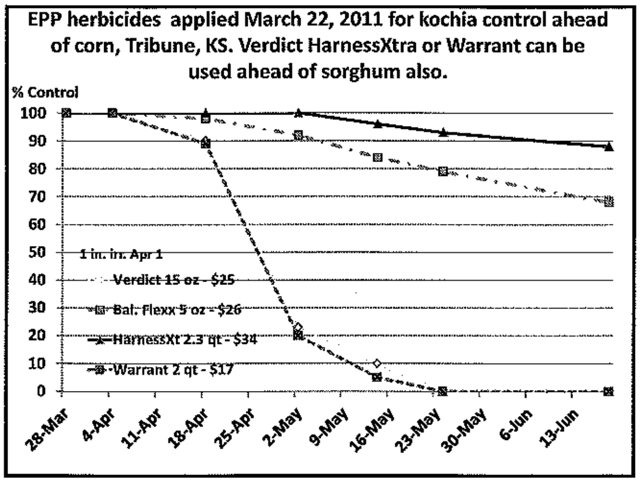
Early Spring applications

- Conventional methods including herbicide selection and timing of application may no longer be successful due to glyphosate resistant kochia
- Herbicides very early PRE may be required?!
- Dense/solid stands of little kochia may not be controlled.
- The larger kochia get, the more difficult it is to control

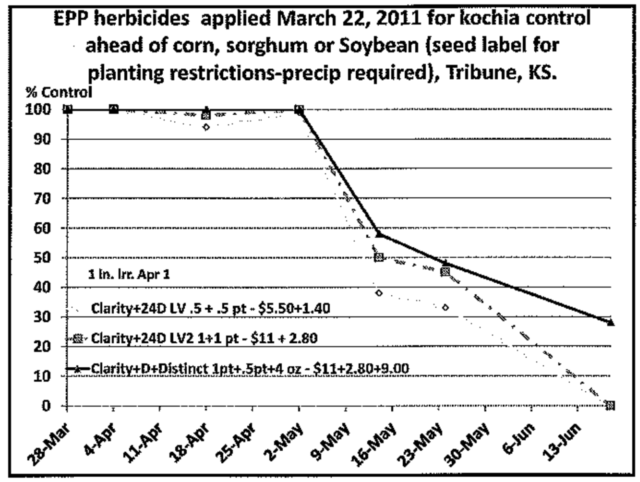




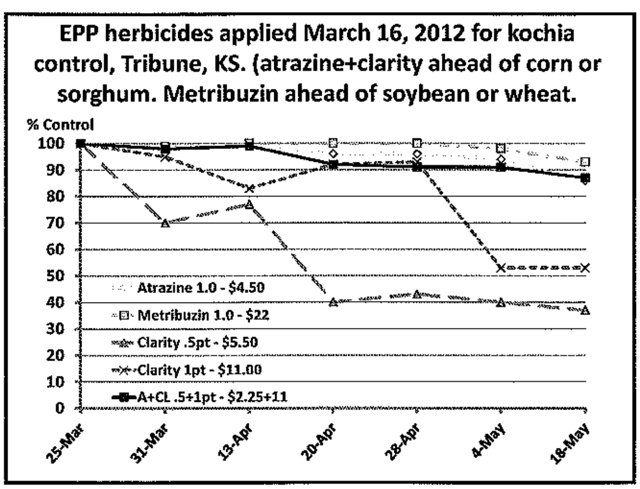
March PRE's!!! Avoid this!!!



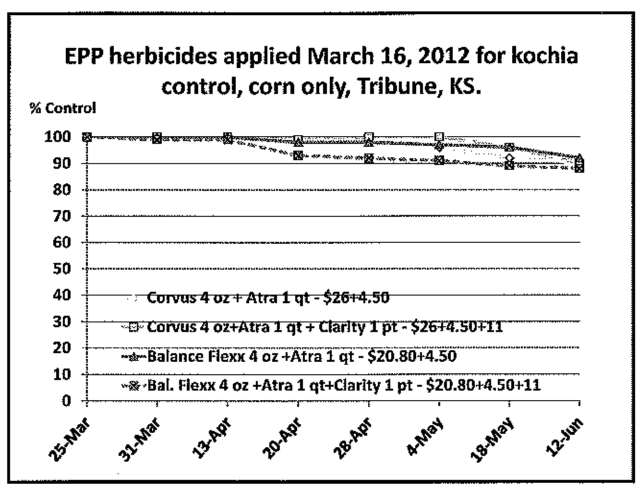
EPP herbicides applied March 22, 2011 for kochia control ahead of corn, Tribune, KS. Verdict HarnessXtra or Warrant can be used ahead of sorghum also.



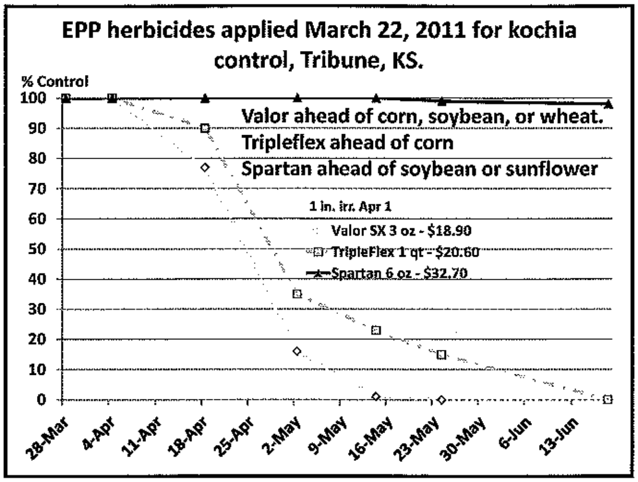
EPP herbicides applied March 22, 2011 for kochia control ahead of corn, sorghum or Soybean (seed label for planting restrictions-precip required), Tribune, KS.

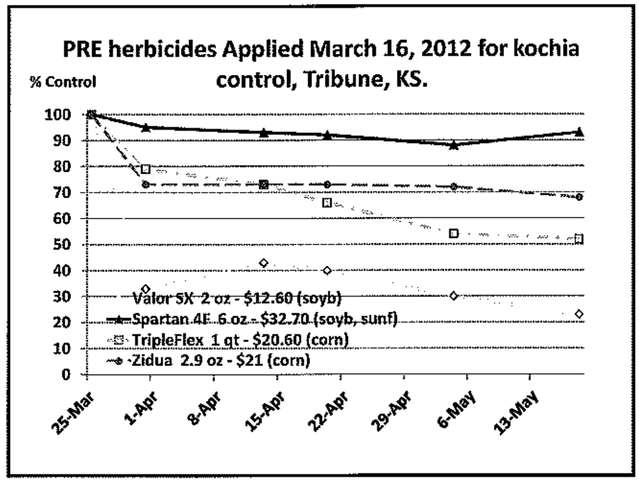


EPP herbicides applied March 16, 2012 for kochia control, Tribune, KS. (atrazine+clarity ahead of corn or sorghum. Metribuzin ahead of soybean or wheat.



EPP herbicides applied March 16, 2012 for kochia control, corn only, Tribune, KS.





Controlling kochia late April or early May??

Postemergence control of kochia in fallow, Tribune 2011.

	Product	Prod. Cost	Kochia control (%)	
Treatment	rate	$	May 30, 16DAT	June 11, 28DAT
Distinct+AMS+NIS	4+17lb+.5%	9+0.75+1.95	61	68
Distinct+2,4-D LV4+AMS+MSO	4+8+ 17lb+1%	9.0+1.40+ 0.75+3.18	55	73
Sharpen+2,4-D LV4+AMS+MSO	1+16+ 17+1%	5.12+2.80+ 0.75+3.18	79	68
Sharpen+atrazine+AMS+MSO	1+12+ 17+1%	5.12+1.70+ 0.75+3.18	86	76
Starane NXT	14	10.50?	79	75
Huskie+AMS+NIS	15+8.5 +0.5%	11.05+0.37+ 1.95	76	65
Huskie+atrazine+AMS+NIS	15+8FL oz+8.5+0.5 %	11.05+1.13+ 0.37+ 1.95	87	80

Dense stands of kochia were treated May 14th.

Postemergence control of kochia in fallow with HPPD inhibitors, Tribune 2011.

	Product	Prod. Cost	Kochia control (%)	
Treatment	rate	$	5/30,16DAT	6/11, 28DAT
Laudis+atrazine+AMS+MSO	3+8+8.5+1 %	16.35+1.13 +.37+3.18	76	60
Callisto+atrazine+AMS+MSO	3+8+8.5+1 %	16.50+1.13 +.37+3.18	80	60
Armezon/Impact+ atrazine+AMS+MSO	0.75+8+ 8.5+1%	13.00+1.13 +.37+3.18	76	66
Armezon/Impact+ atrazine+UAN+MSO	0.75+8+ 2.5% +1%	13.00+1.13 +.35+3.18	82	79
Armezon/Impact+ atrazine+UAN+MSO	1.0+8+ 2.5% +1%	17.35+1.13 +.35+3.18	85	84
Roundup Wmax+AMS	32 FL OZ + 17lb	7.75+0.75	85	85

Dense stands of kochia were treated May 14th.

Kochia management in the row crop following the MARCH PRE

- Burn down before planting if needed
  - Glyphosate or paraquat can be effective
  - Dicamba should not be used ahead of sunflower
  - Dicamba requires precip for breakdown ahead of soybean
- Essential to use an effective PRE herbicide
  - Use sulfentrazone containing product in soybean or sunflower
  - Include atrazine in the mix for corn or sorghum
  - Corvus or Balance Flexx with atrazine for corn
- Be prepared to apply an effective post emergence herbicide
  - Post products for soybean and sunflower may not be effective.
  - Corn – Callisto, Laudis, Armezon, Impact with atrazine and appropriate adjuvants
  - Sorghum – Huskie + atrazine with AMS
- A two past system is very effective

Summary

- Control kochia in the wheat crop
- Early herbicide applications, ie. March, can effectively control germinating kochia and will increase the effectiveness of subsequent in crop or fallow herbicide applications.
- To begin control strategies in mid to late April when kochia are glyphosate resistant is risky and most likely will not be successful.
- The frequency of glyphosate resistant kochia in Kansas is on the RISE! (Godar and Stahlman)
- Glyphosate resistant kochia is manageable!

Questions?

Curtis Thompson
cthompsa@ksu.edu
785-532-5776

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Wheat Fertilization: Simple, Fast, Efficient and Effective

David Mengel, Professor of Agronomy
Kansas State University
Manhattan, KS 66502
dmengel@ksu.edu

For most people the objective of a wheat fertilization program is to provide adequate nutrients to support the growth and development of a high yielding wheat crop, as simply and as cheaply as possible. That is a reasonable objective for most farmers, but like everything else in crop production, especially in dry regions such as western Kansas, western Nebraska and eastern Colorado, the devil is in the details. The objectives of this paper are to:

- Discuss the relationship between key growth stages of wheat and yield;
- Describe how fertilization and nutrient availability can impact these relationships;
- Define some of the important aspects of a timely and efficient fertilization program;
- Discuss some of the new tools, such as crop sensors, which can help add efficiency to a fertilization program.

When planning a fertilization program, it's important to consider how nutrient availability or application will interact with other important management decisions such as seeding rate, planting date and row spacing etc, and influence the three major yield components: number of heads, seeds per head, and seed size/test weight. Also remember that we can over do a good thing, and reduce yield by over fertilizing, especially with nitrogen. Many farmers in SE Kansas learned that the hard way in 2012 as the result of large quantities of carry-over N from a failed 2011 corn crop, combined with high rates of fertilizer N. The result was excess vegetation, high levels of plant disease (even with fungicide application) and lodging which combined to slow harvest, reduce test weight and reduce yield. So, how do we put all this together into a simple system which can be applied over a lot of acres in a reasonable amount of time, at a reasonable cost?

First, let's consider planting time fertilizer practices, and how they can influence the potential number of heads per foot of row through tillering. Ideally, we would like to see 1 to 3 tillers per plant in a high yielding wheat field. We also would like to see many of those tillers produced in the fall. Two key nutrients that can potentially influence the number of fall tillers are nitrogen (N) and phosphorus (P). The wheat plant is very responsive to both nutrients, and we have good, well calibrated soil tests which can help us determine the potential need for fertilization of both N and P. Generally, the first nutrient we think about with fall fertilizer is P. Many farmers in Kansas have traditionally applied P at planting with their drill (or now air seeder) at rates near the amount removed by a "good" crop. Early work in Kansas and other states showed that row application of P, at low soil test P levels, and low rates of fertilizer, was superior to broadcasting. That hasn't changed. We still have a high percentage of the soils used for wheat production, especially dryland wheat production, which test low for P, and drill row application of 11-52-0 (MAP) or 18-46-0 (DAP) is an excellent way to apply that fertilizer. One of the key reasons we see that response to planting time P applications is the positive impact it has on tillering. P placed close to the wheat seed enhances early growth and tillering, and in many cases results in

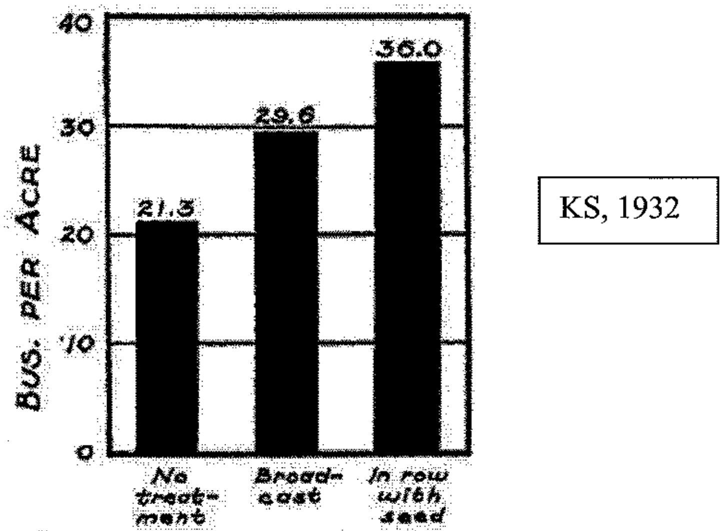


FIG. 18.—Graphs showing effect on yield of wheat of applying superphosphate broadcast and in the row with the seed.

Figure 1. Effect of P placement on wheat yield, KSU research, 1932.

more heads per foot of row. While in corn and sorghum, as soil test P goes up, the response to starter P goes down. But in wheat, that's not as true, since wheat produces the majority of it's tillers, and future heads, in the fall or early spring under cool conditions. The current KSU P fertilizer application rates based on soil test level and yield potential are given below in Table 1.

Soil test ppm		Yield Potential, bushels per acre 30	40	50	60	70
		pounds P_2O_5 per acre				
0-5	Deficient	50	55	60	60	65
6-10	Deficient	35	40	40	45	45
11-15	Deficient	20	25	25	25	30
16-20	Deficient	15	15	15	15	15
21-30	Adequate	0	0	0	0	0
31+	Adequate plus	0	0	0	0	0
Crop Removal		15	20	25	30	35

Table 1. P application rates for wheat: Nutrient Sufficiency Approach

Nitrogen can have a similar effect on tillering, but in many of our wheat production systems we have enough N available, naturally or as carry-over fertilizer, in the system to support early growth. The one key place where this is usually not true is where wheat is planted following sorghum. Sorghum is a terrific scavenger of nutrients, especially late in the season as it produces

Images from "Growth stages of wheat" TAMU publication SCS-1999-16 by Travis Miller

Picture 1, Feekes 2/3 wheat in the fall, with tillers.

"sucker heads". Most sorghum residue also has a very wide C:N ratio. This creates a demand for N by soil organisms responsible for the decomposition of that residue. As a result, wheat planted in sorghum stubble really responds to preplant or at planting N. As a minimum, 30 pounds of N per acre should be applied in the fall prior to or at planting. Total N applications for wheat after sorghum should also be a minimum of 30 pounds per acre higher than for wheat following corn, wheat or soybeans.

The second key growth stage where nutrients can be critical is when the head is being formed. This occurs early in the spring at approximately Feekes 5. It is important to have adequate N and P present to ensure optimum head size and the potential for enough seeds per head. While we can add enough N topdressing to overcome any shortage slightly before this point, it is not really possible to fully correct deficiencies of P at this point. Partial correction is possible but not full correction. So this reinforces the importance of providing adequate P at planting time.

There are several options available to farmers to ensure that they have adequate N in the soil prior to head formation. These would include: Soil testing to determine the N soil supply before planting; Applying all the N prior to planting, for example applying all the N as ammonia prior to planting on medium or heavier textured soils; Applying a significant amount of N, 30-40 pounds per acre in the fall, and topdressing at Feekes 4 or 5; or Topdressing N during the winter or early spring before or at greenup, usually Feekes 3 or before. All of these systems work, but the potential for N loss can increase as N is exposed to the environment for extended periods of time before uptake, while under dry conditions, there is some risk of the N not being moved into the root zone with precipitation, if topdressing is done just prior to Feekes 5, or head differentiation. My personal preferred choices to ensure adequate N for head formation is applying all the N as ammonia preplant on medium textured soils; or applying 30 pounds of N at planting, broadcast or with the drill, and topdressing the balance at Feekes 4/5. I don't personally like winter topdressing due to the potential for high N loss, and the fact I can't make adjustments in N rate based on winter survival and spring moisture conditions.

Picture 2, Feekes 4 stage wheat, tillering complete and head differentiation beginning (assumes adequate vernalization)

One of the problems with all preplant or early topdress decisions is that the amount of N available from residual soil nitrate and mineralization of soil organic matter and crop residue is a guess at best, even when a person takes a profile N test prior to planting. In some soils and climates the potential for N loss over winter is fairly significant some years, but difficult to guess in advance. The amount of N mineralized is impacted by soil temperature and soil moisture. Again, difficult to estimate in advance. For this reason, I am very high on making topdress N applications late, Feekes 5 or 6, jointing, and using of crop sensors such as the Green Seeker or Crop Circle and a fertilized reference strip to estimate the actual available N.

So, how does this system work? The sensor sends out a beam of light in two wavelengths, one in the red wavelengths, absorbed by the pigments responsible for photosynthesis, and one in the near infrared which is not absorbed by plants. A photocell measures the relative amount of each wavelength reflected back off the target plant/soil. This then can tell us how much biomass is present, the amount of growth on the crop, and how much photosynthetic capacity that biomass has. These two pieces of information, together with the growth stage of the crop, can be used to estimate the yield potential and the need of the crop for additional N, particularly when compared to a well fertilized reference strip in the same field of the same variety.

Examples of the relationship between the NDVI index readings from the sensor and measured yield at Feekes 4 and Feekes 6/7 are given in Figures 2 and 3 respectively. Note the big range in NDVI values across the range of yield values obtained at both vegetative growth stages. Also note that the later the measurements are made, the tighter the relationship between NDVI and yield. This simple reflects the shorter period of time for things to go wrong in the field. If the measurements are made even later, at boot for example, the relationship is even tighter, less variable.

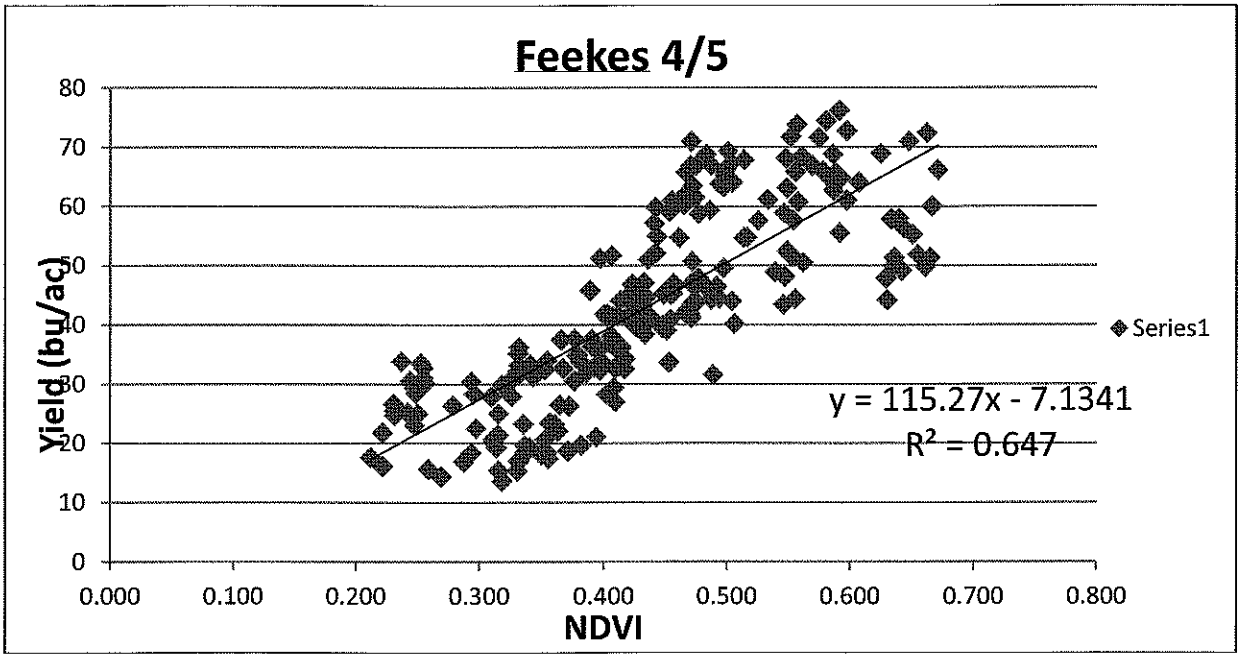


Figure 2. Relation between NDVI and yield of wheat in Kansas, 2007 to 2012.

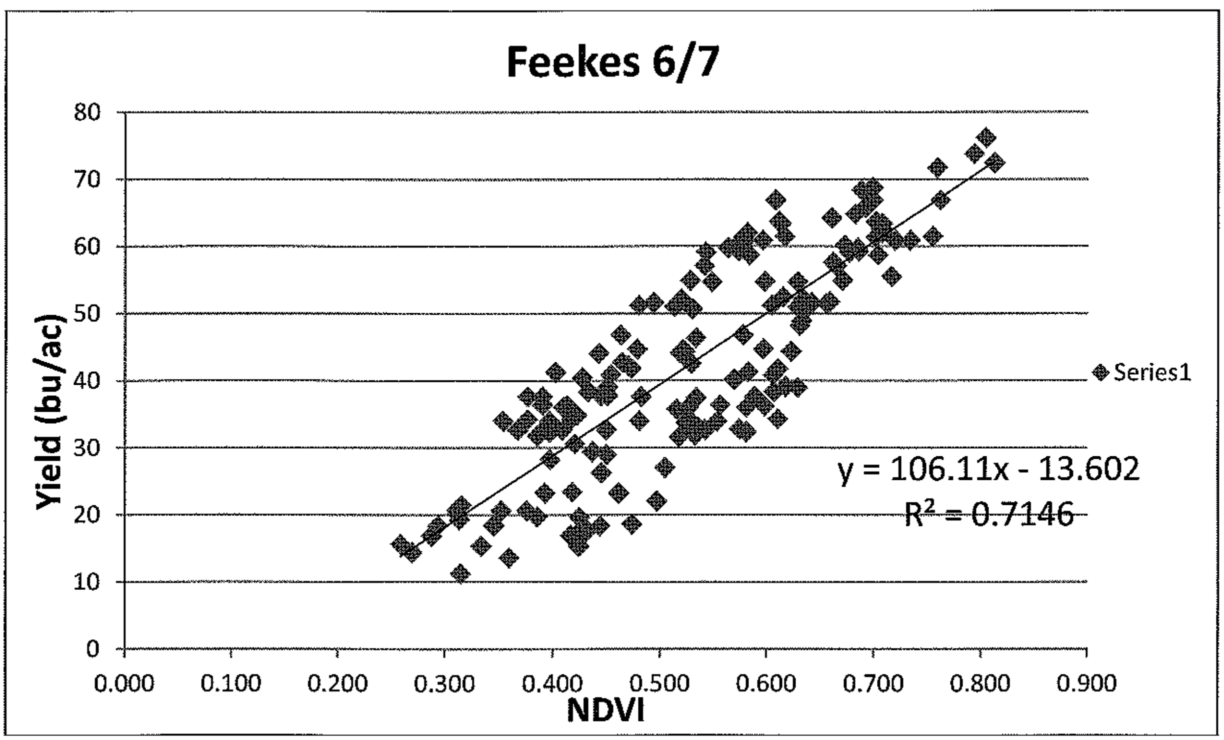


Figure 3. Relationship between NDVI and wheat yield in Kansas, 2007 to 2012.

What about situations where too much N is applied, either as a result of large amounts of unaccounted for carryover N, or just too high of N application? Can this reduce yield? Yes. That is one of the reasons for the high level of variation in the relationship between NDVI and yield shown in Figures 2 and 3. Several things can happen when too much N is available. These include excess canopy development stimulating disease development, lodging, or simply utilizing the available soil water to produce straw and not having adequate amounts available to produce grain. This potentially an advantage to using sensor guided N recommendations.

This idea was tested in 2012 in SE Kansas on a number of farmer fields. Working with a crop consultant, reference strips were established in late 2011 on a number of fields where wheat was planted after failed corn crops. Sensor readings were made in spring 2012 at around Feekes 5/6, or at or near jointing. In only 1 field was any N recommended. The farmers decided if they trusted the sensor or wanted to put on additional N. About half the fields received N and half did not. Those fields which did not receive N yielded in the 70 to 80 bushel range with minimal lodging, while those that did receive N lodged and yielded from 60 to 70 bushel per acre.

So in summary, providing adequate, but not excess, N at key growth stages is important for wheat production. Crop sensors can help manage this process and potential improve yield and reduce risk.

Winter survival of poorly developed wheat
Jim Shroyer, K-State Wheat Specialist

Conditions remain very dry conditions in many areas of Kansas this year. Both the topsoil and subsoil are very dry. Where this is the case, wheat development has typically been poor. Will this make some wheat fields more susceptible more winter die-off or weakening than usual?

Factors to consider

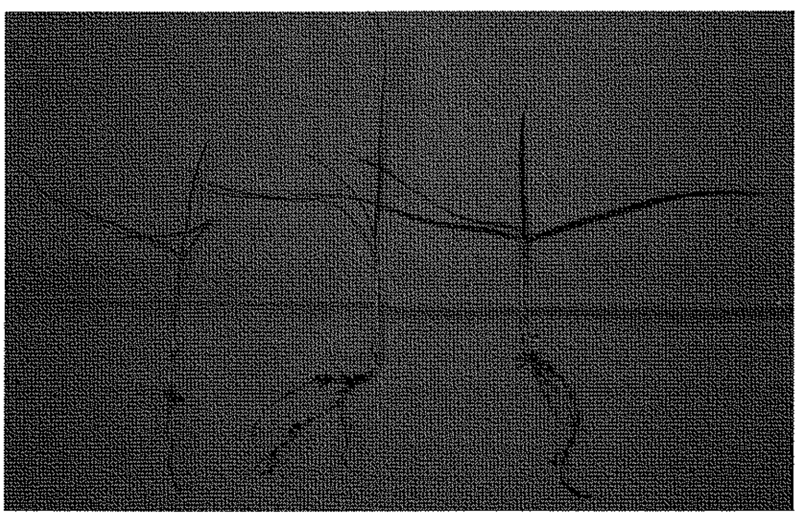
The following are some of the factors to consider when evaluating the outlook for winter survival of wheat:

* How well has the wheat cold hardened?

When temperatures through fall and early winter gradually get colder, that helps wheat plants develop good winterhardiness. When temperatures remain unusually warm late into the fall (which can lead to excessive vegetative growth) then suddenly drop into the low teens, plants are less likely to have had time to cold harden properly and will be more susceptible to winterkill. This fall, temperatures have fallen off gradually. As a result, the wheat should be adequately cold hardened in most cases.

* How well developed is the root system?

Good top growth of wheat doesn't necessarily indicate good root development. Poor root development is a concern where conditions have been dry. Where wheat plants have a good crown root system and two or more tillers, they will tolerate the cold better. If plants are poorly developed going into winter, with very few secondary roots and no tillers, they will be more susceptible to winterkill or desiccation, especially when soils remain dry. Poor development of secondary roots may not be readily apparent unless the plants are pulled up and examined. If plants are poorly developed, it may be due to dry soils, poor seed-to-soil contact, very low pH, insect damage, or other causes.



* How cold is the soil at the crown level?

This depends on snow cover and moisture levels in the soil. Winterkill is possible if soil temperatures at the crown level (about one inch deep) fall into the single digits. If there is at least an inch of snow on the ground, the wheat will be protected and soil temperatures will usually remain above the critical level. Also, if the soil has good moisture, it's possible that soil temperatures at the crown level may not reach the critical level even in the absence of snow cover. But if the soil is dry and there is no snow cover, there may be the potential for winterkill, especially on exposed slopes or terrace tops, depending on the condition of the plants.

* Is the crown well protected by soil?
If wheat is planted at the correct depth, about 1.5 to 2 inches deep, and in good contact with the soil, the crown should be well protected by the soil from the effects of cold temperatures. If the wheat seed was planted too shallowly, then the crown will have developed too close to the soil surface and will be more susceptible to winterkill. Also, if the seed was planted into loose soil or into heavy surface residue, the crown could be more exposed and could be susceptible to cold temperatures and desiccation.

* Is there any insect or disease damage to the plants?
Plants may die during the winter not from winterkill, but from the direct effects of a fall infestation of Hessian fly. Many people are familiar with the lodging that Hessian fly can cause to wheat in the spring, but fewer recognize the damage that can be caused by fall infestations of Hessian fly. Wheat infested in the fall often remains green until the winter when the infested tillers gradually die. Depending on the stage of wheat when the larvae begin their feeding, individual tillers or whole plants can die. If the infestation occurs before multiple tillers are well established then whole plants can die. If the plants have multiple tillers before the plants are infested then often only individual tillers that are infested by the fly larvae will die.

The key to being able to confirm that the Hessian fly is the cause of the dead tillers is to carefully inspect the dead plants or tillers for Hessian fly larvae or pupae. This can be done by carefully removing the plant from the soil and pulling back the leaf material to expose the base of the plant. By late winter all of the larvae should have pupated and thus the pupae should be easily detected as elongated brown structures pressed against the base of the plant. The pupae are fairly resilient and will remain at the base of the plant well into the spring.

Damage from winter grain mites, brown wheat mites, fall armyworm, aphids, and crown and root rot diseases can also weaken wheat plants and make them somewhat more susceptible to injury from cold weather stress or desiccation.

Symptoms of winter survival problems
If plants are killed outright by cold temperatures, they won't green up next spring. If they are only damaged, it might take them a while to die. They will green up and then slowly go "backwards" and eventually die. There are enough nutrients in the crown to allow the plants to green up, but the winter injury causes vascular damage so that nutrients that are left cannot move, or root rot diseases move in and kill the plants. Slow death is probably the most common result of winter injury on wheat.
Direct cold injury is not the only source of winter injury. Under dry conditions, wheat plants may suffer from desiccation. This can kill or weaken plants, and is actually a more common problem than direct cold injury.

Wise Use of Corn Residue for Cattle

Terry Klopfenstein
Animal Science, University of Nebraska-Lincoln

The cattle industry has changed dramatically in the past 10 years. For 50 years the "farm problem" was too much corn. Farm programs were designed to reduce production by idling acres. Then the fuel ethanol industry developed as another market for grain. This was great for corn producers because it increased demand and therefore price. The price spiked in 2006 and this encouraged more acres to be planted to corn. Many of these acres came from pasture and hay land.

The cattle industry has been affected by high corn prices. However, the effect on forage prices may be even more important. We estimate that 85% of the feed that is needed to produce finished beef is forage. This includes use by the cow, replacements, backgrounding calves, etc. The cattle industry is faced with a severe forage deficit. This deficit has been made more apparent with drought conditions in the Plains States the past two years. However, the forage deficit is a continuing challenge for the cattle industry into the future.

The forage resource available in large supply is corn residue. With more acres planted and increasing grain yield per acre, the production of corn residue has markedly increased. The proportion of residue (about 80%) to corn grain has remained relatively constant as grain yields have increased. Kansas has about 4.2 million acres of corn annually and at 140 bu/ac yield, produces about 16.5 million tons of residue. Our emphasis in this report is on corn residue but the residue from wheat and sorghum in Kansas equals another 7.82 million tons of residue. This is a total of 24.32 million tons. If all of the hay and winter grazing in Kansas were replaced with residues, the use would be no more than 7.5 million tons or about 30% of the residue. This level of use is unlikely so residue usage in the range of 15 to 20% is more likely. So is 15 to 20 usage of residues wise and sustainable?

Let's first discuss uses of residues by the cattle industry. Probably the best use of corn residues is by grazing. A five year summary of cow performance in eastern Nebraska shows that cows cam be maintained on cornstalks even without supplement (Table 1). There was some advantage to supplement and it would be recommended. A four year summary of cow performance grazing in western Nebraska at two stocking densities is shown in Table 2. Cow performance was good and somewhat better for cows at the lower stocking density. All cows were supplemented.

Calves or cows grazing cornstalks eat primarily the husk, leaf and residual corn. Corn produces 15 to 16 lb of husk and leaf per bushel of corn grain produced. UNL research measurements suggest about 50% harvest efficiency by the cattle. Therefore, the cattle will consume about 8 lb of dry matter for each bushel (15.5% moisture) corn. At a 200 bu yield, that is 1,600 lb of leaf and husk consumed, which is equivalent to 2.35 AUM. The husk is above 60% digestible and very palatable. The greater the grazing pressure, the more leaf that is consumed and the leaf is much less digestible than corn or husks, (≈ 45%).

The obvious advantage to stalk grazing is the low cost of this grazed forage. Disadvantages are weather risk, potential transportation expense, lack of water and fencing. Unfortunately the stalks may also not be near the cattle enterprise. These grazing options work well when ethanol byproducts are used as the supplement. The byproducts are excellent energy sources and provide good protein and phosphorus for calves (or cows) in addition to the energy. The energy value of distillers grains is about 130% that of corn and for gluten feed at least 120% that of corn in these forage based feeding systems. Distillers grains are currently priced at about the price of corn grain so they are quite economical considering the feeding value. Figure 1 shows the gain responses to levels of DDGS from calves grazing cornstalks.

Harvested residues can be in the form of baled stalks or as corn silage. The harvested residue can be used in the feedlot to substitute for hay and(or) grains. The harvested residue can be used as hay replacement for cows or backgrounded calves. It works especially well when mixed with wet distillers grains.

What are the consequences of corn residue removal? We consider them in three general categories: subsequent crop yields, soil and water.

Numerous studies have been done at the University of Nebraska over the years to determine the effect of grazing crop residue on grain yields in the subsequent years (Table 3). In 1996 a grazing trial was started on a linear move irrigation field in a corn-soybean rotation looking at the time of the year that crop residue is grazed and its effect on subsequent yield. The fall/winter grazing typically is from November till February and is the time that most cattle are on crop residue. The field is typically frozen, and mud and compaction due to cattle in the field are at a minimum. Spring grazing in this field is typically from February through mid-April. This was designed to be the worst possible situation for grazing crop residue as the soil is thawing and spring rains will cause the fields to be muddy and the amount of compaction and trampling should be at its highest.

Fall/winter grazing of corn residue on the linear move irrigation field showed a significant ($P = 0.001$) increase in soybean grain yields of 2 bu/ac due to grazing the year before. Corn residue grazing had no statistical effect ($P = 0.188$) on corn yields, but there was a numerical increase of about 3 bu/ac for the fall/winter grazed treatments (Table 3).

Soybean yields, planted the year following spring grazing of the corn residue, show an increase in grain yield ($P = 0.001$) with a numerical increase of 1 bu/ac. Corn yields the second year of the spring grazing show no significant difference ($P = 0.188$) but a 1.2 bu/ac numerical increase in yield on the grazed treatment.

Irrigated corn grain yields in either a continuous corn or a corn-soybean rotation show no effect of grazing on grain yields and soybeans planted the year following corn residue grazing show a significant increase in yields due to grazing treatment. Timing of grazing, fall grazed or spring grazed, seems to have little effect on grain yields. Since the treatments in the linear move irrigation field have been maintained over an extended period of time any detrimental effects from grazing would have been picked up. With the statistical increase in yields of soybeans, especially in the spring grazing treatment, cattle grazing corn residue actually help the grain yields by working some of the nutrients and residue into the ground and removing some of the excess residue so the ground can warm up faster.

We find that the average digestibility of residue consumed is no more than 55% meaning that the cattle utilize less than 55% of the organic matter and the remaining 45% of the organic matter is returned to the soil surface where it can be reincorporated into the soil supplying organic matter for the soil microbes. Cattle remove less than 20% of residue unless the corn residue is overgrazed.

A 130-acre center pivot irrigated corn field near Brule, NE, was divided into eight paddocks and assigned one of four treatments: ungrazed (UG), baled (B). light grazing (LG, 1 AUM/ac), and heavy grazing (HG, 2 AUM/ac). These treatments have been maintained for four years. Grain yields over the past three years (Table 4) show no difference among treatments (P = 0.93). We measured 15.3 and 18.1 lb of palatable feed (leaf blade, leaf sheaf, and husk) per bushel of grain yield in 2011 and 2012, respectively. An AU is defined as the amount of forage a 1,000 lb animal consumes, 680 lb DM/month or 22.7 lb/day. When the daily intake was multiplied by the number of grazing days, each AU consumed 1,337 lb DM in 2011 and 1,564 lb of DM in 2012. This is the equivalent of 1.9 and 1.0 AUM/ac for HG and LG respectively. By using the grain yields and lb of residue/bu of grain we can calculate 6,092 and 5,839 lb forage DM/acre of HG and LG respectively. Therefore, the cattle consumed an average of 23.4% and 12.6% of the residue for HG and LG respectively. If we assume the diet was on average 55% digestible, 45% of the organic matter consumed is being returned to the field, so cattle are removing 12.9% and 6.9% of the organic matter in the HG and LG treatments, respectively. These values fall within the acceptable range of residue removal. The yields from this field support this as they show no effect of yield due to treatment over a three year period, suggesting that grazing does not have a negative effect on grain yields in continuous corn cropping system.

Two residue removal studies were conducted at the University of Nebraska Agricultural Research and Development Center (ARDC) near Mead, NE (Weinhold et al., 2013 NE Beef Cattle Report). The first study was initiated in 1998 under rainfed (nonirrigated) conditions on a site that qualified for the Conservation Reserve Program. Treatments in this study were residue removed (50%) or retained in no-tillage corn receiving 107, or 160 lb N/ac. The second study was initiated in 2001 under irrigation on a productive soil. Treatments in this study were disk or no-tillage with 0, 40, or 80% residue removal. All treatments received 180 lb N/ac. Removal rates in both studies are more intensive than what would be expected with grazing but less intensive than what would be expected with grazing but less intensive than harvest for silage. Corn grain and residue production were measured annually in both studies.

Under rainfed conditions, annual removal of crop residue resulted in similar 10-year average yields (Table 5). In the irrigated study, grain yields were nearly double those of the rain-fed study. In the irrigated study, grain yields were greater under disk tillage than under no-tillage with no residue removal. In both tillage treatments, grain yields increased as residue removal increased (Table 5).

In rainfed production systems yield is limited by water availability. Under these conditions a layer of crop residue reduces evaporation losses and increases the amount of water that is available for the crop resulting in greater yields where residue is retained. In irrigated systems, production is much greater and crop residue can cause problems with soils warming in the spring and establishment of a uniform stand. In these systems, tillage that incorporates the residue into the soil and residue removal when no-tillage is used improves stand establishment and subsequently yield.

Following is a summary of our observations on corn residue removal:

1. Corn residue offers an opportunity to maintain and grow the beef cattle industry in corn producing states.
2. Even with increased numbers and use of corn residue, the beef industry would use less than 15 to 20% of the state's corn residue.
3. Removal of residue by cattle grazing is less than 15% in most cases.
4. Grazing of irrigated corn residue or harvest of 20 to 30% of the residue likely increases subsequent crop yields if no-till.
5. Tillage is more detrimental to erosion than residue removal up to 20 to 30%.
6. No residue should be removed from highly erodible fields. That is fields with highly erodible soil but with inappropriate management for erosion control. Unfortunately, some of the heaviest removal occurs on fields of highly erodible soil with management inappropriate for erosion control. This is a major concern and where stewardship appears to be moving backward.
7. Light to moderate grazing of non-irrigated fields of low erodability is likely without consequence.
8. Residue harvest should be done primarily on irrigated fields or rainfed fields in higher rainfall areas where conditions and management prevent much erosion.
9. Residue harvest should be minimized to 20% to 30%. Management to obtain this level of removal is problematic and needs further research.
10. Husk and cob removal is of little consequence, especially on irrigated acres.
11. Silage harvest should be accompanied with heavy manure application and(or) cover crops. Sowing of cover crops immediately after harvest needs to be strongly promoted for the ground cover and soil protection but also for grazing or hay, at least for irrigated land.

Table 1. Effects of Supplementation on Corn Residue on Cow and Calf Performance

	Treatment	
Item	Supplemented	Control
October Wt., lb	1263	1265
February Wt., lb	1351	1327
October BCS	5.4	5.4
February BCS	5.6[a]	5.4[b]
Calf Birth Wt., lb	86	85
Pregnancy Rate, %	94	91
Weaning Wt., lb	552	548

5-Year study n=85 head per treatment per year; March calving cows
Supp cows = 2.2 lb/hd/da DM basis, distiller based cube
Oct = pre-corn residue grazing
Feb = post-residue grazing
[ab] differ at $P \leq 0.05$

Table 2. BCS and BW of cattle grazing corn residue

	Heavy grazed	Light grazed	P value
BCS[a]			
Pre grazing	5.27	5.34	0.35
Post grazing	5.05	5.39	<0.01
Body weight			
Pre grazing	920	927	--
Post grazing	972	1005	0.03
[a]On a scale of 1 to 9 with 1 being emaciated and 9 being obese.			

Table 3: Grain Yields

Years of Study[1]	Cropping System[2]	Crop	Grazed Yield	Ungrazed Yield	SEM	P value
93-95	Irrigated Corn-Soybean[3] Rotation	Soybeans	54.6667	55	3.3747	0.7418
93-95	Dryland Strip Cropping[4]	Soybeans	39.3333	42.6667	17.5431	0.8289
93-95	Dryland Strip Cropping[4]	Grain Sorghum	106.33	107	17.5431	0.8289
93-95	Dryland Strip Cropping[4]	Corn	184.67	174.67	17.5431	0.8289
93-95	Irrigated Continuous Corn[5]	Corn	185.33	181.67	27.3272	0.5766
96-11	Fall Grazed Corn-Soybean[6]	Soybeans	62.4	60.4	2.1056	0.001
96-11	Fall Grazed Corn-Soybean[6]	Corn	208.9	205.8	7.8359	0.1808
96-11	Spring Grazed Corn-Soybean[6]	Soybeans	61.7	60.4	2.0156	0.001
96-11	Spring Grazed Corn-Soybean[6]	Corn	207.2	205.8	7.8359	0.1808

[1] Starting and ending year that the study was conducted

[2] Type of cropping system that the field was managed in.

[3] Center pivot irrigation, corn residue grazed and soybean yields reflect impact of grazing on yields.

[4] This field was in a strip cropping study in a rotation where residue from all crops was grazed. Corn followed soybeans, grain sorghum followed corn, and soybeans followed grain sorghum.

[5] Was maintained in a continuous corn system

[6] Fields are from linear move irrigation field and maintained in corn followed by soybean rotation for 14 years.

Table 4. Corn grain yields[1]			
	2009	2010	2011
Control	124	141	166
Light grazing	128	144	160
Heavy grazing	133	141	170
Baled	124	142	166
[1]bu/ac at 15.5% moisture.			

Table 5. Corn grain yield (bu/ac) for rainfed and irrigated crop residue removal studies	
Site-Treatment	Yield
Rainfed – Residue retained – 107 lb N/ac	116.0
Rainfed – Residue removed – 107 lb/N/ac	115.3
Rainfed – Residue retained – 160 lb N/ac	113.9
Rainfed – Residue retained – 160 lb N/ac	115.8
Irrigated – Disk tillage, 0% removal	201.7
Irrigated – Disk tillage, 40% removal	207.5
Irrigated – Disk tillage, 80% removal	212.4
Irrigated – No-tillage, 0% removal	180.9
Irrigated – No-tillage, 40% removal	205.9
Irrigated - No tillage, 80% removal	202.0

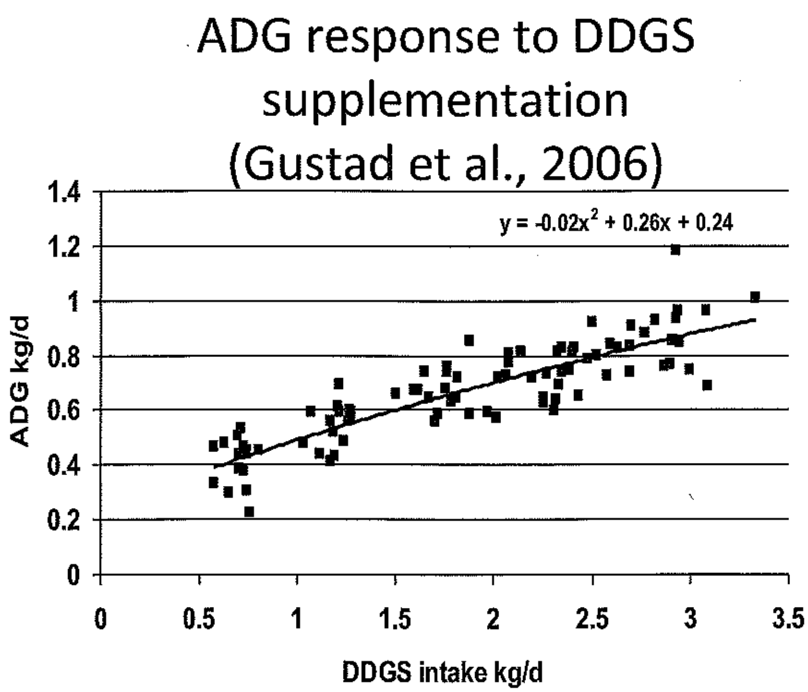


Figure 1.

Here are a few agronomy-related websites that you may find useful:

Weather:	
National Weather Service	www.weather.gov
The Weather Channel	www.weather.com
Weather Underground	www.wunderground.com
Drought Monitor	www.droughtmonitor.unl.edu
Markets:	
Chicago Board of Trade	www.cbot.com
Kansas City Board of Trade	www.kcbt.com
DTN	www.dtnprogressivefarmer.com
Dow Jones	www.dowjones.com
News:	
Ag Web (Farm Journal)	www.agweb.com
Agriculture.com (Successful Farming)	www.agriculture.com
Farm Progress (Kansas Farmer)	www.farmprogress.com
Grass and Grain	www.grassandgrain.com
High Plains Journal	www.hpj.com
University:	
K-State Research and Extension	www.ksre.ksu.edu
K-State Department of Agronomy	www.agronomy.ksu.edu
K-State Ag Economics Extension	www.agmanager.info
K-State Department of Entomology	www.entomology.ksu.edu
K-State Department of Plant Pathology	www.plantpath.ksu.edu
K-State Department of Bio and Ag Engineering	www.bae.ksu.edu
Commodity Groups:	
Kansas Corn Commission	www.ksgrains.com/kcc
Kansas Grain Sorghum Producers Association	www.ksgrains.com/sorghum
Kansas Soybean Commission & Kansas Soybean Assoc	www.kansassoybeans.com
Kansas Sunflower Commission	www.kssunflower.com
Kansas Wheat (Kansas Wheat Commission & Kansas Assoc of Wheat Growers)	www.kswheat.com
Herbicide Labels:	
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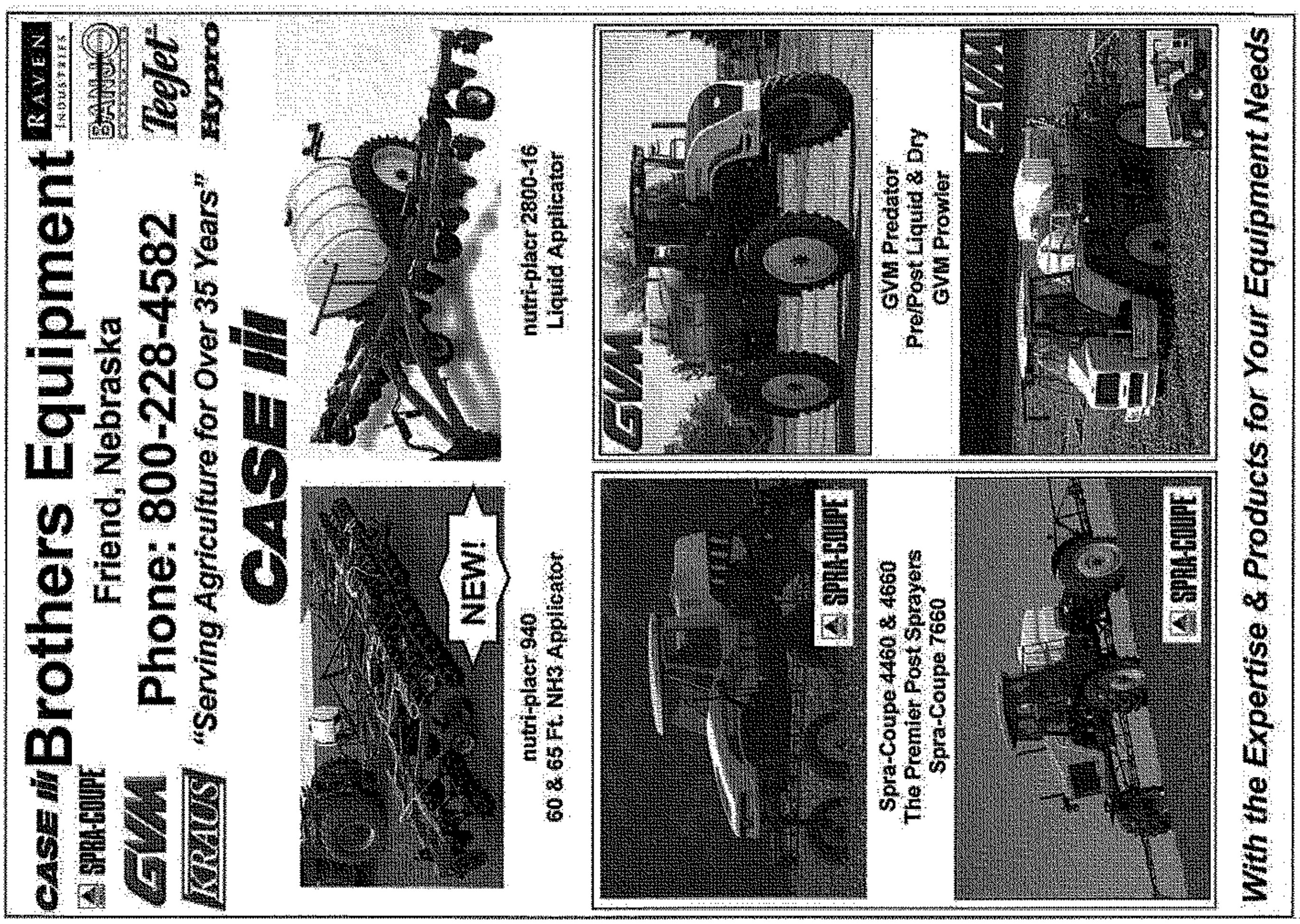
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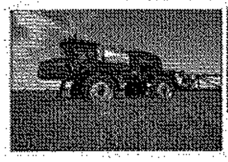

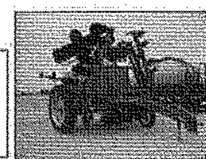

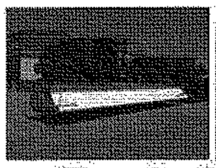

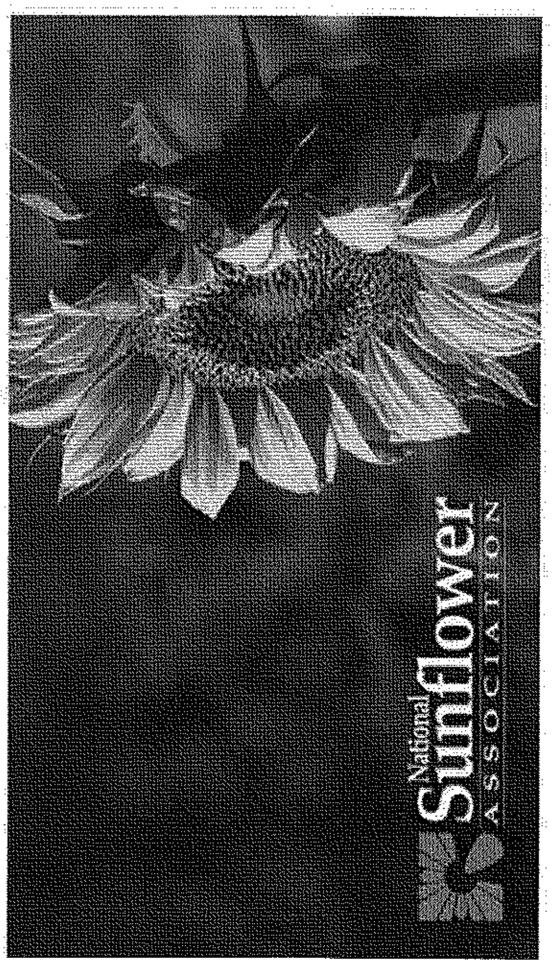
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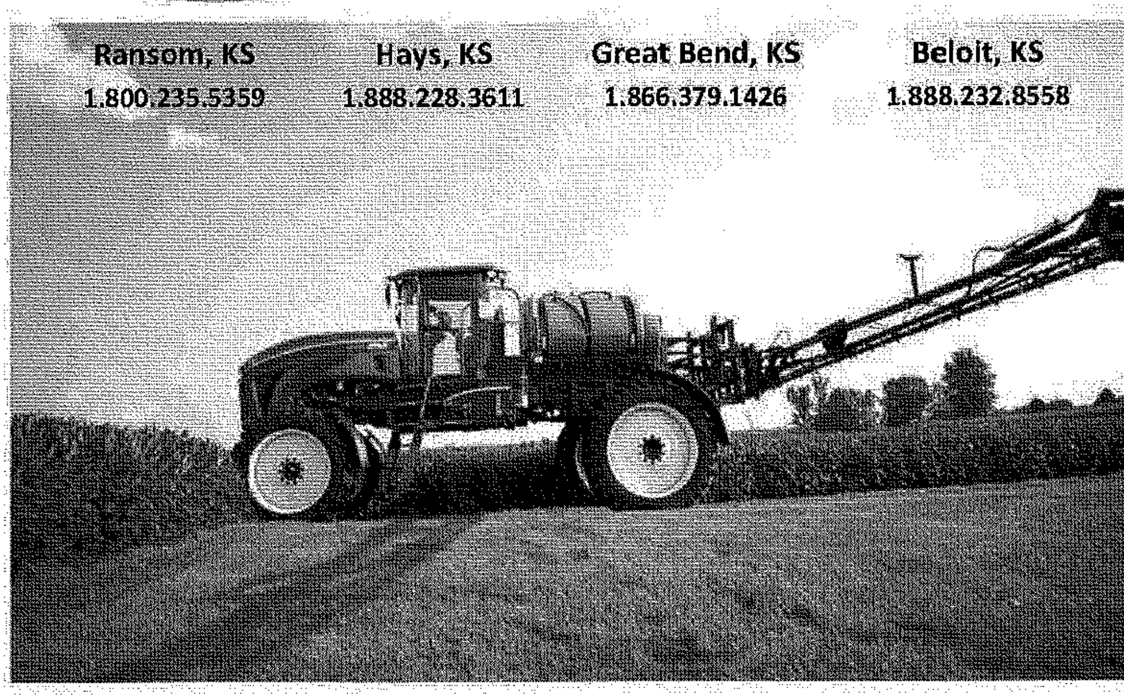

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The plan for the day...

		Room 1	*Room 2*	*Room 3*	*Room 4*
7:45	8:15	*Registration*			
8:15	8:20	*Welcome*			
8:30	9:20	Foliar Fungicide Applications in Wheat[1,2] *(E. DeWolf)*	Fallow Replacements: Cover & Forage Crops[1] *(J. Holman)*	A Return Look at Preseason Irrigation[1] *(A. Schlegel)*	*Sunflower Production Update (Nat'l Sunflower Assoc) (I)*
9:30	10:20	Cropping Intensity, Fallow Efficiency, Peas & Safflower[1] *(L Haag)*	Managing Resistant Kochia[1,2] *(C. Thompson)*	Wise Use of Corn Residue in Cattle[1] *(T. Klopfenstein)*	*Strategies for Weed Control (Sims Fertilizer) (I)*
10:20	10:50	*View Exhibits*			
10:50	11:40	Wheat Conditions[1] *(J. Shroyer)*	Wise Use of Corn Residue in Cattle[1] *(T. Klopfenstein)*	Fallow Replacements: Cover & Forage Crops[1] *(J. Holman)*	*Chloride - the Missing Link (Evans Enterprises) (I)*
11:50	12:40	2013 Grain Market Outlook[1] *(D. O'Brien)*	Cropping Intensity, Fallow Efficiency, Peas & Safflower[1] *(L Haag)*	*Lunch*	
12:50	1:40	Managing Resistant Kochia[1,2] *(C. Thompson)*	Wheat Conditions[1] *(J. Shroyer)*	*Lunch*	
1:50	2:40	Wheat Fertility: Simple, Fast and Effective[1] *(D. Mengel)*	A Return Look at Preseason Irrigation[1] *(A. Schlegel)*	Foliar Fungicide Applications in Wheat[1,2] *(E. DeWolf)*	*Weed Management Solutions (Monsanto) (I)*
2:40	3:10	*View Exhibits*			
3:10	4:00	Producer Panel: Striving for Successful No-till	2013 Grain Market Outlook[1] *(D. O'Brien)*	Financial Trends of NW KFMA Farms[1] *(Wood, Roehl, Milliman)*	*Ag Estate Tax Planning (KS Community Foundations) (I)*
4:10	5:00	Financial Trends of NW KFMA Farms[1] *(Wood, Roehl, Milliman)*	Wheat Fertility: Simple, Fast and Effective[1] *(D. Mengel)*	*Kochia Control Solutions (Bayer CropScience) (I)*	*SoilBuilder Cover Crops (Arrow Seed Co) (I)*
5:00		*Bull Session (Tuesday Only)*			

(I) indicate industry sessions.

[1] Indicate Certified Crop Advisor CEUs applied for.

[2] Indicate Commercial Applicator CEUs applied for.

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