Cover Your Acres Winter Conference

8th Annual

January 18 and 19, 2011

Gateway in Oberlin, KS

Discussing Conservation Crop Production Practices

for the High Plains

K-State Research and Extension &

Northwest Kansas Crop Residue Alliance

Schedule for Conference

Time	Room 1	Room 2	Room 3	Room 4	Exhibit Hall
7:45 - 8:15 a.m.	Registration				
8:20 – 8:27	Welcome in Exhibit Hall				
8:32 – 9:20	Fertilizing for no-till (D. Leikam)[1]	Compaction and crop yields (D. Presley)[1]	Monsanto update - seeds, traits, and weeds (I)	The good & the ugly of growing safflower (I)	
9:20 – 9:50	View Exhibits				Sponsor Displays
9:57 – 10:45	What is your problem (D. Beck)[1]	Alternative crops (K. Roozeboom)[1]	Strip-till: a seed bed preparation practice (I)	Corn refuge fertility & management (I)	
10:52– 11:40	No-till machinery innovations[4]	Tools to cover your acres for less (I)	Tools to maximize your yields and profit (I)	What is your problem (D. Beck)[1]	
11:47 – 12:35	Fertilizer placement (R. Ward)[1]	Sunflower management (I)	Lunch		
12:43 – 1:31	K-State wheat breeding program (A. Fritz)[1]	Spray application technology (R. Wolf)[1, 2]			
1:38 – 2:26	No-till crop rotations (A. Schlegel)[1]	Technology and hardware solutions for you (I)	Planning for the future: ensuring your legacy (I)	Wheat varieties (J. Shroyer & E. De Wolf)[1]	
2:33 – 3:21	DC wheat behind soybeans and corn (J. Shroyer)[1]	Plant nutrition (I)	United Sorghum Checkoff progress report (I)	Fertilizer placement (R. Ward)[1]	
3:28 – 4:16	Stripper heads and stubble height (L. Haag)[1]	Fertility on high pH soils (D. Ruiz-Diaz)[1]	Marketing plans and financing (I)	Strip-till: a seed bed preparation practice (I)	Sponsor Displays
4:16 – 4:46	View Exhibits				
4:53 – 5:41	Q&A with D. Beck[1]	Wheat varieties (J. Shroyer & E. De Wolf)[1]	Spray application technology (R. Wolf)[1,2]	State of fertilizer in 2011 (I)	
	Bull Session				

[1]CEU credits for CCAs have been applied for.
[2]CEU credits for 1A for Commercial Pesticide Applicators have been approved.
[3]Industry sponsored sessions indicated with an (I) will have no CEU credits offered.
[4]No CEUs for CCAs will be offered for the "No-till machinery innovations" sessions

Coordinated by:
Brian Olson, K-State Extension Agronomist – Northwest
Please send comments or suggestions to bolson@ksu.edu
To become a member of the Northwest Kansas Crop Residue Alliance,
please call Dan Skrdlant at 785-877-5814.

PLEASE TURN ALL CELL PHONES OFF OR TO VIBRATE. If you need to talk on your phone, please leave the meeting room. THANK YOU

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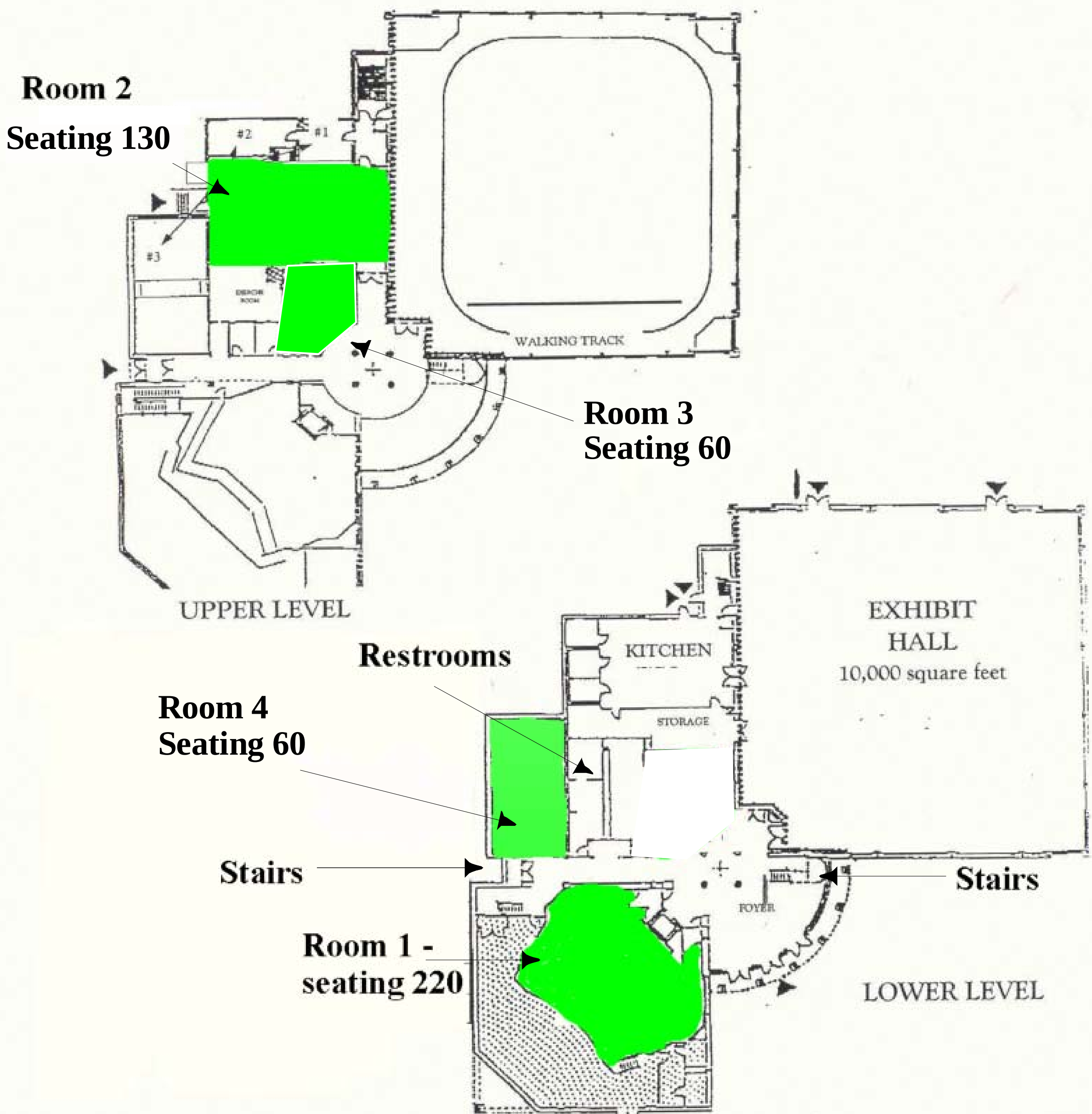
GATEWAY

Oberlin, Kansas

The Premiere Exhibition, Meeting & Conference Center
for the Tri-State Area



#1 Morgan Drive, Oberlin, Kansas 67749 785.475.2400 Fax 785.475.2925

Industry Sessions	Company Presenter
State of fertilizer	Cargill AgHorizons
Plant nutrition	Crop Production Services
Cover your acres for less	Sims Fertilizer
Corn refuge fertility and management	Pioneer
Monsanto update – seeds, traits, and weeds	Monsanto
Strip-till: a seed bed preparation practice	Brothers Equipment
Sunflower management	High Plains National Sunflower Association
United Sorghum Checkoff progress report	United Sorghum Checkoff
Tools to maximize your yields and profit	BASF
Marketing plans and financing	McCook National Bank w/ Market Data Inc.
The good and ugly of growing safflower	Dreamland Industries
Tools to cover your acres for less	Sims Fertilizer
Technology and hardware solutions for you	SureFire Ag Systems
Planning for the future: ensuring your legacy	Thomas County Community Foundation Scott Community Foundation Greater NW Kansas Community Foundation

Nutrient Management In No-Till Systems

Dale F. Leikam

With the continued adoption of no-till production systems over the past several decades, there has been much discussion about how nutrient management programs for continuous no-till systems might differ from production systems that include the use of tillage somewhere in the rotation. While some things are certainly different for nutrient management in no-till systems, not everything changes. And while research has not answered every question related to nutrient management in no-till systems, many questions have been researched. Additionally, the principles underlying our knowledge of soil fertility apply to everything from full tillage systems to reduced/conservation tillage systems to no-till – but how these principles are applied may be different.

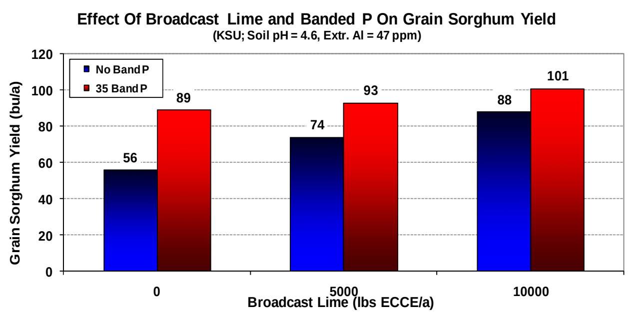
For some nutrients, no-till systems often require greater amounts of nutrient inputs and/or more intensive management than for systems employing some tillage. In general, no-till soils are typically cooler than tilled soils. As a result, certain microbial processes may be reduced and/or delayed which alters the amounts of some nutrients that become available to the plant early in the season. Cool soils also reduce the overall energy level of the seedling and active nutrient uptake by plant roots is similarly reduced. Wet soils tend to be cold soils – leading to reduced nutrient uptake by the plant. And if the soil tends to become saturated more frequently with no-till, low oxygen levels in the soil further reduces the energy level of the plant which leads to diminished active nutrient uptake.

In certain areas, the increase in no-till has been accompanied by significant increases in cropping intensity – which greatly increases crop nutrient removal. Instead of one crop every two years (e.g. wheat/fallow) many moved to two crops in three years (e.g. wheat/corn/fallow) and then to one crop every year if conditions allowed. With this progression, the average annual removal of all crop nutrients with the crops increased significantly. Eventually for most nutrients, nutrients removed will need to be nutrients replaced.

Soil Sampling & Soil Testing. Consistent sampling depth is very important for minimizing year-to-year variability and estimating the likelihood of obtaining crop response to added nutrients. In general, suggested soil sampling depth is the same for no-till systems as for traditional tillage systems. For pH, soil organic matter, P, K and Zn soils should be sampled to a 6 or 7-inch depth since this depth still relates best to potential crop responses. However, for soil pH in no-till systems, it is suggested that the surface 2-3 inches be closely monitored since this is the soil depth that accumulates residual acidity from the nitrification process (microbial conversion of ammonium-N to nitrate-N). Soil testing for residual nitrate-N and chloride is most reliable for soil samples collected to a depth of 24 inches.

Soil pH and Liming. No-till systems require more intensive monitoring (more frequent soil sampling/testing) than for systems that includes tillage. Most soil acidity change in soils is a result of the nitrification process which produces residual acidity (H^+ ions). Soil acidity is the most tightly held soil cation on the CEC complex and accumulates where it forms in soils - in the surface inch or two for many no-till systems. Tillage mixes this acidity with the large amount of soil in the tillage depth and only slowly reduces soil pH in this depth. With no-till systems, the residual soil acidity from surface broadcast applications of N fertilizers (and manure) remains in the surface inch or two of soil and may quickly reduce the soil pH of the surface inch or two of soil. Since most lime recommendations from university and commercial laboratories assume lime incorporatin to a depth of 6-7 inches, these recommendations need to be adjusted to reflect the reduced amount of soil volume that the lime will react with (~ 2 inches).

For areas where ag lime is not readily or affordably available, annual, row-applied phosphate has been shown to substitute for lime by eliminating the toxic effects of aluminum in very acid soils.



Equivalent P Concentration In Band	
7" Row Spacing	30-40 lbs P_2O_5/a
10" Row Spacing	21-28 lbs P_2O_5/a
20" Row Spacing	10-14 lbs P_2O_5/a
30" Row Spacing	7-9 lbs P_2O_5/a

Nitrogen (N). Nitrogen management is generally thought to be impacted the most when comparisons are made to systems that include tillage – but not everyone agrees completely about how much and to what degree. Following are some of my thoughts relative to N management in no-till systems.

Especially in no-till systems, uniform distribution of crop residues at harvest is an absolute must. Uneven residue distribution causes seed placement/stand establishment problems in areas with very high levels of residue. Additionally, tie-up of soil and/or applied N with these increased crop residues may result in severe N deficiencies.

Mineralization of N is the conversion of plant unavailable, organic-N to plant available, inorganic-N by soil microbes. This process occurs when the organic material being broken down by soil microbes has a relatively high N content (C:N ratio less than about 20:1, soil organic matter, legume residues, etc.). *Immobilization* of N is the conversion of plant available, inorganic N to plant unavailable, organic N by soil microbes. This process occurs when the organic material being broken down by soil microbes has a relatively low N content (C:N ratio greater than about 30:1, corn stalks, wheat straw, sorghum stubble, etc.).

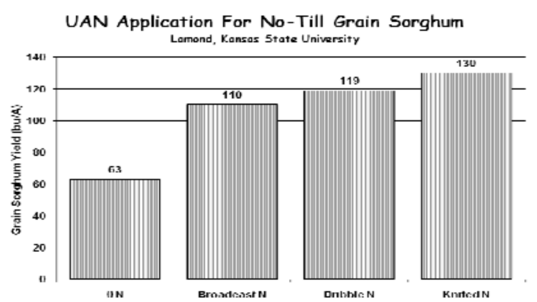
While immobilization is typically viewed as being 'bad' and mineralization is typically viewed as 'good' – this is not necessarily true. Soil organic matter is about 5% N and amounts to about *1,000 lbs. N/a* for each 1.0% soil organic matter to a 6-inch soil depth. As soil organic matter was declining after prairie was initially broken out for crop production, very large amounts of N were mineralized. Since increasing soil organic matter is a stated benefit/goal of adopting no-till systems, it becomes apparent that large amounts of N will need to be immobilized (invested) to increase stable soil organic matter. This is the reason that most institutions and practitioners suggest that more N is initially required for a given crop/yield level if a no-till system is adopted. Some suggest that additional N is not required after 5-10 years of no-till – while others suggest that optimum N rates will actually *drop* after 5-10 years in no-till. As long as soil organic matter continues to increase, even slightly, additional N will need to be invested.

As noted earlier, no-till soils tend to be cooler than tilled soils and this reduced temperature will slow microbial activity and ultimately slow mineralization of soil organic matter. As a result, it is generally suggested that at least a portion of applied N be in place for the developing seedling since soil nitrate-N levels in the seedbed tend to be lower for no-till as compared to tilled soils.

Volatilization generally refers to the loss of ammonia from the soil surface resulting from manure, anhydrous ammonia or urea applications. It is the potential for N loss from surface applied urea that has garnered the most press. After application to soils, urea is initially converted to ammonia (before conversion to ammonium) if proper conditions exist and the enzyme *urease i*s present. Kansas State University conducted much of research leading to an understanding of the mechanisms involved and the factors affecting urea N volatilization. The most important factors were found to be *unincorporated surface urea application to warm, moist, drying soils with crop residues (source of urease enzyme)*. While the potential for loss is certainly greater for no-till systems as opposed to tilled soils, *actual measured field losses* in the Plains have been shown to be much less than what is often presented – even when everything is done to artificially encourage N loss. In addition to managing the time and method of application to minimize potential N volatilization losses, there are several products currently in the marketplace that have been demonstrated to help manage these losses.

There is little doubt that method of N application can have significant effects on N use efficiency. From strictly an agronomic perspective, the best single way to maximize N use efficiency in no-till systems is to subsurface band the needed nitrogen. It is not necessary to place the N deep since it is the placing of the N below the soil surface and away from crop residues that is important. By placing the N below the soil surface and crop residues, immobilization is minimized and the potential for volatilization is eliminated. While subsurface banding is the best agronomic method of N application in no-till systems, there are legitimate management and logistical reasons why growers do not subsurface band apply all of the needed nitrogen. Surface banding (dribble application) is typically accomplished by directing coarse streams of UAN solution on the soil surface. Surface dribble applications are typically made on 15-30 inch centers for row crops and 10-15 inch centers for smallgrains and forage grass. Broadcast applications are often utilized by growers in no-till systems since these applications require no special application equipment, they are time efficient in that large acreages can be covered in short amount of time and the inclusion of herbicides in the broadcast N application is of great benefit.

Differences among subsurface band, dribble and broadcast applications do not occur in every field every year. However, if there is a difference the advantage will most likely favor a subsurface band which often performs better than surface dribbling or broadcasting. Likewise, if there is a difference, surface bands (dribble) will likely outperform broadcast applications. Subsurface banding performs more consistently than surface dribbling which performs more consistently than broadcasting.



<u>Phosphorus (P), Potassium (K) and Zinc (Zn).</u> Stratification of P and K was a major concern in the early years of no-till adoption since it was widely noted that these nutrients were generally considered immobile in soils. It was thought that these nutrients would be 'positionally unavailable' to plants if broadcast on the soil surface since that was what was observed for systems utilizing tillage. Certainly stratification of these nutrients occurs, but it has not generally caused as many problems as was initially anticipated.

In response to these initial concerns there has been a very strong focus on encouraging growers to only band apply these nutrients since they are relatively immobile in soils. In hindsight, there has likely been too much of an emphasis placed on banding. As a result of this focus, many growers have strived to include all of their P, K and Zn fertility program in the planting operation.This resulted in nutrient application rates that were frequently reduced from what had previously been broadcast applied in tilled systems. As a result soil test values typically declined.

Since 2X2 starter application was not a good option for many growers for row crops (too much soil disturbance, expensive equipment, too much weight on large planters, etc.), 'pop up' applications which places the fertilizer in direct seed contact was commonly adopted. The equipment needed for these applications was relatively inexpensive and did not add a lot of iron to the planter. However the drawback to this system is that fertilizer application rates are necessarily limited since too much fertilizer placed in direct seed contact can delay or prevent germination and stand establishment. The result of depending only on low rates of row fertilizer is a decline in soil test levels to the low or very low range which has both short and long term ramifications.

As a result of colder and wetter soils early season in the growing season with no-till systems, the uptake of nutrients such as P, K and Zn may be hampered. The uptake of these crop nutrients requires the expenditure of energy by the plant. Anything that affects the overall energy of the plant will affect nutrient uptake. Wet soils often limit aeration of the soil which reduces respiration in plant roots - which in turn reduces energy production. And cold soils also reduce energy production in the plant roots. As a result, the probability of crop response to starter application of these nutrients is greater than for tilled soil systems – even at soil test levels generally thought to be adequate. Remember, nutrient uptake is a completely different issue than nutrient availability (i.e. soil test). If you have starter attachments, you should strongly consider using tem.

Over the past decade, a different type of starter treatment has been quickly adopted by many growers. First researched by KSU researchers in the late 1990's, a surface dribble NP (and NPKS) application 1-2 inches to the side of seed placement has been surprisingly effective. Additionally, this surface dribble starter application allows for adding additional N at planting in a way that satisfies early season plant N needs as well as stimulating P uptake. Also, and contrary to earlier thinking, research has also indicated that surface broadcast application of P and K can be effective in no-till systems. Research in Kansas has shown that surface applications of both P and K in no-till systems has been surprisingly effective, most likely a result of root proliferation in no-till systems nearer the soil surface than for more traditional tillage systems.

Starter Effects On No-Till Corn

B. Gordon, KSU

NPK Starter	With Seed	2x2	Dribble Over Row
No Starter = 159 bu/A	- - - - - - Bu/A - - - - - - -		
5-15-5	164	190	185
15-5-5	172	191	194
30-15-5	166	213	209
45-15-5	166	211	209
60-15-5	159	211	209
Average	167	202	201

Instead of the discussion centering on if P and K should be band applied or broadcast applied - *band applications of P and K should be used to complement broadcast applications (and vice versa).* A combination of both might be better long-term.

Sulfur (S). The importance of including S in no-till fertility programs is greater than for production systems that include tillage. Similar to N, most soil S is contained in soil organic matter and the same mineralization and immobilization processes that influence N fertilizer availability will also be true for sulfur. In addition, continued higher yields and cropping intensity has drammatically increased S removal from the soil system.

Chloride (Cl). Chloride needs will likely not be influenced by tillage system except for continueld higher yields and cropping intensity.

State of the KSU Wheat Breeding Program

Cover Your Acres Conference
January 18 and 19, 2011
Oberlin, KS

The Pipeline

- Potential 2012 Release
  - KS020319-7-2
- Promising Lines (Could be released in 2013)
  - KS020822-M-5
  - KS020665-M-3
  - KS020633-M-13
  - KS020735-NT-2 and KS020735-M-9

KS020319-7-2

Overley 'S'/Karl 92//Cutter

	BA	BE	CW	GY	K	SU	C KS
KS08HW39-5	51.4	59.8	51.5	57.8	50.3	55.0	54.3
Everest	46.7	55.2	60.5	54.2	49.0	56.2	53.6
KS020319-7-2	**47.3**	**54.5**	**56.9**	**56.9**	**50.8**	**50.6**	**52.8**
Armour	46.8	53.3	56.9	50.4	52.7	56.2	52.7

	FO	H	OS	PN	GC	CO	W KS
KS08HW35-1	54.7	83.3	65.6	70.4	67.2	98.7	73.3
KS08HW39-5	54.6	79.3	60.7	72.4	68.2	96.4	71.9
Armour	52.8	83.6	58.1	68.9	69.8	90.6	70.6
HATCHER	55.7	71.9	57.0	71.1	71.3	85.1	68.7
TIGER	48.9	79.7	53.6	68.3	64.0	87.6	67.0
RonL	48.1	72.0	55.6	72.7	62.8	88.0	66.5
KS020319-7-2	**47.0**	**77.1**	**60.8**	**58.6**	**64.5**	**88.6**	**66.1**
TAM 112	45.9	68.7	51.8	69.1	61.3	83.2	63.3
DANBY	47.7	71.8	54.6	64.7	56.0	74.5	61.5

2010 Central Kansas AYN2

		BA	GY	SU	K	BE	c avg
Everest		37.9	50.1	55.3	51.3	59.7	50.9
KS020665-M-3	KS940748-2-2/JAGALENE//OVERLEY	42.9	55.4	46.6	48.9	53.6	49.5
Armour		33.2	44.8	53.7	55.5	59.7	49.4
KS020822-M-5	KS950409-P-4/KS940786-17-3//KS920709-B-5-2-2	43.0	56.0	51.4	45.8	46.9	48.6
KS020633-M-13	KS920709-B-5-2-2/U3650-3-4//OVERLEY	41.5	49.0	50.5	41.1	58.7	48.2
Art		43.5	51.6	53.8	38.5	49.4	47.4
KS020735-M-9	G97380/OVERLEY//TREGO	44.6	44.4	49.6	42.9	49.6	46.2
CJ		38.3	44.1	47.9	39.2	51.5	44.2
Hitch		38.4	45.5	51.5	32.0	52.5	44.0
KS020735-NT-2	G97380/OVERLEY//TREGO	40.9	37.9	47.1	40.4	52.0	43.7
Fuller		38.7	42.7	50.7	32.2	52.8	43.4
GRAND MEAN		39.1	43.9	47.9	37.6	44.3	
CV		9.6	9.9	7.6	11.3	8.4	
LSD		6.4	7.5	6.2	7.2	6.4	

2010 Western Kansas AYN2

		GC	Hays	Colby	w avg
Armour		70.0	64.8	92.6	75.8
Tiger		64.3	59.4	86.7	70.1
Hatcher		64.9	54.9	87.6	69.1
KS020735-NT-2	G97380/OVERLEY//TREGO	63.1	64.2	75.4	67.6
KS020735-M-9	G97380/OVERLEY//TREGO	63.6	57.7	81.2	67.5
Danby		57.6	63.1	81.5	67.4
KS020822-M-5	KS950409-P-4/KS940786-17-3//KS920709-B-5-2-2	67.0	60.8	73.1	67.0
KS020633-M-13	KS920709-B-5-2-2/U3650-3-4//OVERLEY	58.8	49.9	80.7	63.1
KS020665-M-3	KS940748-2-2/JAGALENE//OVERLEY	64.4	47.1	75.4	62.3
GRAND MEAN		57.6	53.5	71.4	
CV		7.4	10.1	5.2	
LSD		6.9	8.8	6.2	

Overall Status

- Strong foundation of "minor gene" resistance for rust
  - 21 of 36 lines in 2011 AYN2
  - Should provide durable resistance in future varieties
- Full pipeline with multiple strong performers in each generation
- Competing better in western Kansas
- Expanded testing for 2011
  - McPherson Co., Ellsworth Co., Scott Co. Irrigated

Priorities

Focus of recent years

- Durable rust resistance
  - Good progress
- Heat and drought
  - Hard work with much left to do
- Hessian fly
  - Good progress
- Shattering/Western adaptation
  - Good progress
- FHB
  - Some progress

Newer focal points

- Heat and drought
  - Long term issue
- FHB
  - Increasing importance
- Nematode
- Flood tolerance
- Stem rust resistance
  - Ug99 threat
- Special quality traits
- BYDV

Flood Tolerance

- Adaptive trait for eastern Kansas
- Low lying areas around Salina and in south central Kansas
- Could be planted in terrace channels
- Four synthetics reported to have flood tolerance have been crosses to Kansas material.

Flood tolerance

Susceptible Tolerant

Alternative dwarfing genes

- We are also initiating an effort to evaluate other dwarfing genes
- Rht1 and Rht2 are "gibberellin insensitive" which results in shorter coleoptiles and reduced cell elongation
- Gibberellin sensitive reduced height genes would have longer coleoptiles and more vigorous early season growth
  - Need to see impact on productivity

Implementation of Advanced Breeding Technologies

- Marker assisted selection, HPI's doubled haploid lab, and tools for genomic selection (GS) allow us to move to another level of breeding
- Aimed at long term competitiveness
  - These technologies are the foundation of rapid advances in corn yield and are the tools private industry intends to employ in wheat breeding as well
  - Public programs will need access to these tools to remain competitive over time

Marker Assisted Selection

- USDA Genotyping Lab
- Access to Monsanto seed chipper by next summer
  - Marker assisted selection on steroids
- Target traits include…
  - Rust resistance
  - Hessian fly
  - Quality traits
  - FHB resitance
  - A number of other traits

Genomic Selection

- Think of wheat varieties as towns that are all laid out the same. They all have the same streets, and therefore, the same street addresses.
- The houses on the streets are different and can be identified by certain markings (DNA marker differences)
- The streets are like chromosomes and the houses on the streets can be thought of as genes.
- In genomic selection (GS) we measure traits to try to find good neighborhoods

Powdery Mildew as an example

- Let's say 1501 Elm Street is important for powdery mildew.
- Over all of the towns (varieties), there are three types of houses at 1501 Elm Street.
- In Jagalene and Abilene, 1501 Elm Streets have Type A houses
- In Jagger and Fuller, 1501 Elm Streets have Type B houses
- In 2174 and Aspen, 1501 Elm Streets have Type C houses

Genomic Selection, cont'

- Appraisal values are determined for each type of house (we'd look at 250-300 "towns" or varieties to do this type of analysis)
- Our analysis reveals "A" houses at 1501 Elm have a value of $5000, "B" houses have a value of $25,000 and "C" houses have a value of $500,000
- Now we know we want to select for a Type C house at 1501 Elm Street

Powdery mildew example

House at 1501 Elm in Jagalene and Abilene

House at 1501 Elm in Aspen and 2174

House at 1501 Elm in Jagger and Fuller

Genomic Selection, cont'

- The same concept can be applied to any trait we can measure, including yield, disease resistance, quality traits and many others.
- Required a very detailed map of each town (variety) and appraisal data (yield data, for example)
- Associate the map data and appraisal data to see if a given street address is important for a given trait.

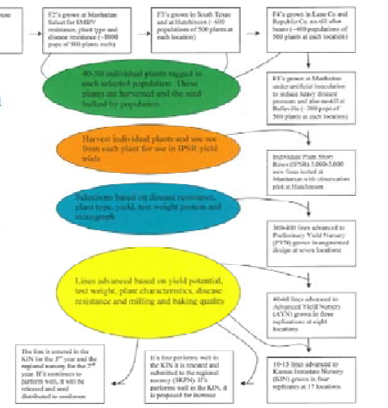
Genomic Selection (cont')

- In theory, we could eventually identify the "perfect"combination of genes for a given environment
- GS is a continuous process that uses field testing data and marker information to continue to refine complex statistical models
- Powerful when combined with doubled haploid technology

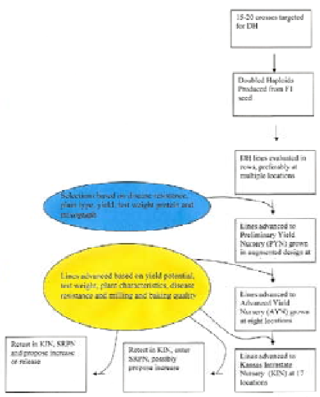
Doubled Haploids

- Cut years off varietal development time
- Increase rate of genetic gain when combined with Genomic Selection
- Vital part of the program, but traditional breeding will also continue

Flow Diagram of the KSU Wheat Breeding Program at Manhattan Using Traditional Breeding



Flow Diagram of the KSU Wheat Breeding Program at Manhattan using Doubled Haploids



Scope of GS and DH efforts

- We will use data/lines from both the Manhattan and Hays programs for the GS effort
  - Already engaged with CSU in working together on various aspects of GS
- DH populations targeting development of hard red wheats for western Kansas are included in current and planned submissions to HPI

Public-Private partnerships

- Monsanto agreement in place
- Discussion with other potential private partners continue
- Primary objectives are strengthen the K-State program, securing future access to biotech traits and identifying opportunities for increased return to the producer based on quality

Public-Public Partnerships

- KSU-CSU-OSU collaboration already occurring
- Uniform MTA for exchange of experimental lines
- Public-Public partnerships are at least as important as Public-Private partnerships

One Vision of the Future

- Public Wheat Breeders, Inc.
  - The idea is that the public programs would work closely together, sharing germplasm and testing materials by production zones rather than state boundaries

Public-Public collaboration

- Efficiency rather than duplication
  - Take advantage of one another's "trait-pertise"
  - Complement one another's strengths rather than compete
  - CSU has good facilities for drought testing, K-State does FHB, rusts well, OSU has excellent facilities for grazing and remote sensing, Nebraska has good stem rust screening and winterhardiness screening

Public-Public Collaboration

- Combined resources are formidable
  - Strong expertise in all areas of wheat research and production
  - More locations/data for making genomic selection work than any private entity
  - Capable of developing better recommendations for areas of adaptation of new varieties

Challenges

- Human nature
- Institutional barriers
- Managing varying levels of interaction with private industry amongst public programs

Fertilizer Placement in the Soil

Ray Ward, President

Ward Laboratories, Inc, Kearney, NE

Nutrient Uptake

To understand fertilizer placement we need to think about how plants take up nutrients. Roots grow at the tips of the roots. There is a root cap at the tip of the root that secretes a gelatinous compound that lubricates the root as it moves through the soil. There are cells just behind the root cap (root meristem) that divide and then the cells elongate. The cell division and cell elongation at the tip is the way the roots grow. Once the cells have elongated there are root hairs that are lateral extensions of the epidermal cells (outside edge of the root). These root hairs increase the sorption capacity for nutrients and water by about 20 times. The root hairs live 24 to 48 hours and then the root becomes a conduit for taking nutrients and water to the leaves and bringing sugars to the root for energy for root growth. Maximum uptake of water and nutrients occurs just above the root tip. Root length with root hairs is 1/16 to 3/8 of an inch. Nutrient uptake depends on how fast the root grows and how many nutrients are available as in the vicinity of the root.

One of the root structures that develop after cell elongation is called the Pericarp. These specialized cells are capable of initiating new root branches that have root tips. These branches continue to develop and are more prevalent where the soil has more organic matter and where nutrient levels are higher, like in a fertilizer band. The soil must be moist for root growth to advance. Roots do not grow in dry soil and will not grow through dry soil to reach moist soil.

The diagram shows the concepts of root growth I have described above. Xylem is the vascular bundle that moves water and nutrients up to the leaves of the plant and phloem is the vascular bundle that moves photosynthate sugars down to the root tips. Roots absorbed oxygen and release carbon dioxide (respiration). Good soil structure is needed so oxygen can get in the

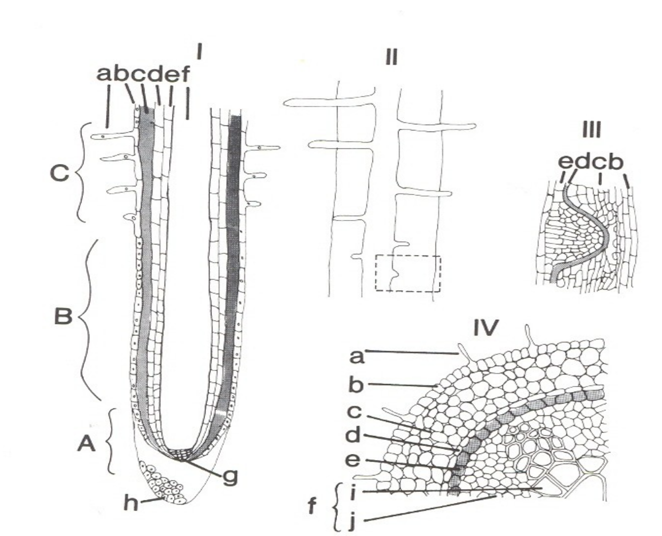


Fig. 10.2. Longitudinal section of herbaceous dicot root. *I.* Root tip with regions of cell division (*A*), elongation (*B*), and maturation (differentiation) (*C*). *II.* Section of mature root with lateral roots in varying stages of development. *III.* Meristem of a lateral root arising from the pericycle. *IV.* Cross section of a young root. Differentiated tissues: root hair (*a*), epidermis (*b*), cortex (*c*), endodermis (*d*), pericycle (*e*), central cylinder or stele (*f*), meristem with quiescent center (*g*), root cap (*h*), xylem (*i*), phloem (*j*).

From: "Physiology of Crop Plants"; Gardner, Pearce, and Mitchell: Iowa State University Press soil and carbon dioxide can get out to the atmosphere. When the soil is low in oxygen, root cell division slows or stops causing water and nutrient uptake to slow or stop. Sometimes it appears plants are lacking nutrients but the real problem is the lack of oxygen which reduces nutrient uptake.

Nutrient uptake is in greatest demand when the plants are growing at the most rapid rate. The idea is to apply needed nutrients just before the large demand for the nutrients. We could increase nutrient efficiency if we applied the nutrient at the time the plant demanded the greatest amount of the nutrient.

Nitrogen Fertilizer Placement

There are a number of methods of applying nitrogen (N) fertilizer. For preplant applications it is most desirable to knife-in, inject, band, etc. In other words the N should be applied below the residue for best results. The chances of N loss from N volatilization off of residue are small but it can happen and that is the reason to get the N below the residue. If rain or irrigation occurs within two days loss will be minimal. When 46-0-0 (urea) or 28-0-0/32-0-0 (UAN) are applied to residue, urease breaks the urea molecule to ammonia and carbon dioxide. The ammonia combines with water and is held as the ammonium ion. If the residue dries out with a dry, hot wind the ammonium ion changes back to gases ammonia ion and is lost to the atmosphere. Therefore, N volatilization happens. Table 1 shows that UAN coulter banded was 12 bushel better than UAN surface banded. Surface banded was 10 bushels better than UAN broadcast on the residue. Dry urea with ESN produced the greatest yield.

Table 1. Response to UAN Placement in No-till Corn, Manhattan 2008 & 2009

Treatment	Yield, bu/a
No N	91
UAN on surface	132
UAN surface banded	142
UAN coulter banded	156
UAN surface banded + SU	157
Urea/ESN blend	169 KSU

Table 2 demonstrates the importance of an N stabilizer if urea is broadcast on residue. Agrotain, Super U, Agrotain plus bacteria inhibitor (SU), and ESU were successful in improving yield and N use efficiency.

Table 2. Response to Surface Applied N in No-till Corn, Manhattan 2008 & 2009

Treatment	Yield, bu/a
No N	91
UAN on surface	132
Urea on surface	149
Urea + Agrotain	163
Urea + SU	168
Urea/ESN blend	169 KSU

Table 3 demonstrates the potential loss of N from urea broadcast in February without ESN stabilizer. Note the greater advantage of applying N after corn has emerged. This information demonstrates the importance of applying N while the crop is growing.

Table 3. Response to Time of Application, Controlled Release Fertilizers and Nitrification Inhibitors in No-till Corn, Manhattan, 2009

Treatment	Yield, bu/a
No N	120
February urea on surface	159
February ESN on surface	179
Urea V-2	191
Urea V-2+ Agrotain + DCD	201
Urea/ESN blend bdcst at V-2	201 KSU

Table 3 points out that there are other methods of applying N besides preplant N. Side-dressing N for row crops often times improves yield or N use efficiency or both. Side-dressing should be considered as any application after crop emergence. Top-dressing refers to applying N to wheat, grass, and alfalfa. When top-dressing and side-dressing are done at crop canopy, potential N volatilization is very much reduced. For growers in areas where soils are very wet in the spring it is a good idea to apply N when crop is growing and using water. Delaying N application will reduce the chances of losses by denitrification.

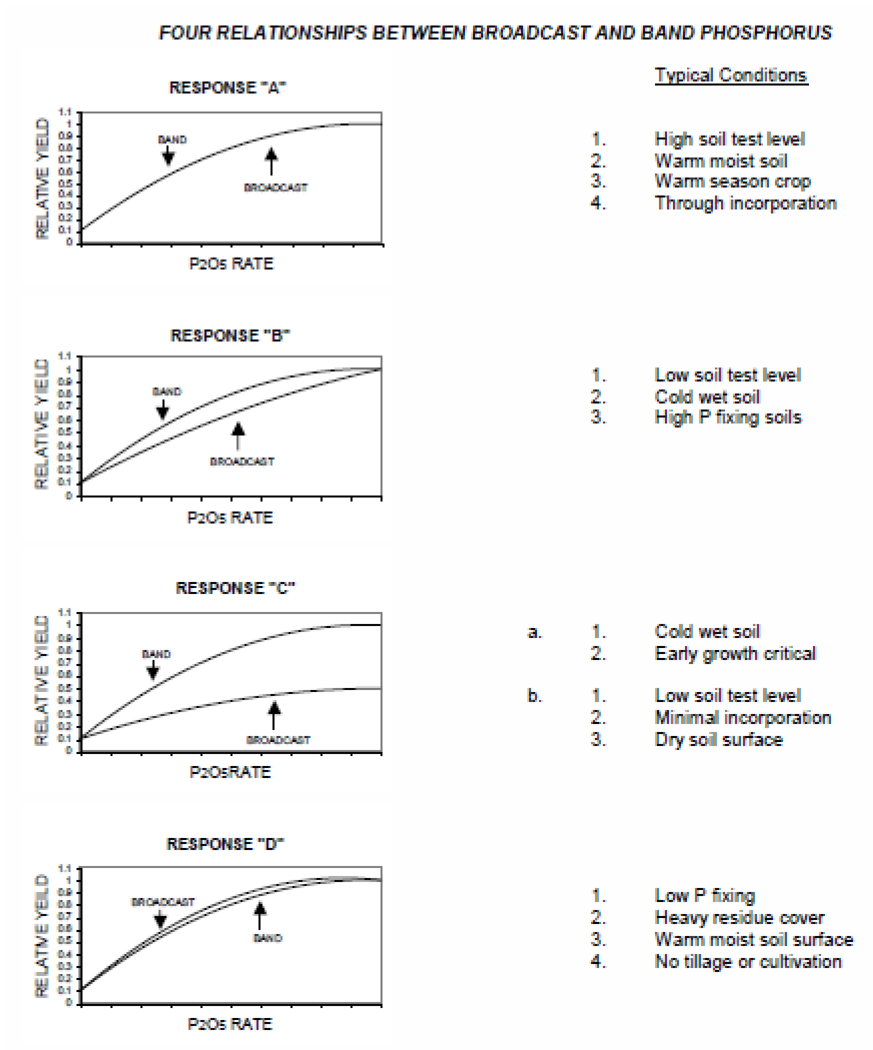
Sulfur (s) fertilizer should be applied at or with the N application time. Many of our no-till fields are showing some need for sulfur. Most N is used to make plant proteins and S is also needed to make proteins. So it is natural to apply S with N application if possible.

Nitrate and sulfur leaching is a problem in many areas, but not very likely to be a problem in Western Kansas. However, in higher rainfall areas N and S should be applied at crop demand time to avoid potential leaching.

Phosphorus Fertilizer Placement

Phosphorus (P) attaches to soil clays and other soil minerals. Phosphorus availability is more dependent on placement than the soluble N and S sources. To get plants started quickly in cold soils it is a good idea to have some phosphate close to the seed or with the seed. Fertilizer with the seed for row crops is pretty risky. Be sure the N plus K2O total is less than 8 lbs per acre for 30-inch rows. Do not apply thiosulfate with seed. Starter should be placed 2 inches to the side of the seed or dribbled behind the press wheel. Starter fertilizer applied behind the press wheel seems to work very well according to research and farmer reports.

Remainder of the needed P2O5 should be applied as a broadcast application. The residue will keep the soil moist early in the season so phosphate will be available. New root tips are growing into the high organic matter soil during the season as rainfall or irrigation is received. The diagrams below describe types of response to P for different conditions. In our soils phosphate will remain for many years. Only so much phosphate is available the first year because the roots cannot get to all of the soil particles where phosphate is located. However, as future crop roots explore the soil the phosphate will be taken up.



Other Nutrients

Zinc is another nutrient that needs to be considered. A recommended broadcast zinc treatment will increase zinc soil tests to adequate level for 6 to 10 years. Otherwise apply zinc with the phosphate starter. Liquid 10-34-0 will sequester zinc and keep it in solution. The zinc mix is critical. Polyphosphate will hold 1 lb of zinc with 30 lbs of P2O5 or 1 lb of zinc with 7 gallons of 10-34-0. Do not make the mix more concentrated.

Chloride fertilizer must be considered in Kansas and Nebraska. KSU has shown good response to chloride applications in Kansas. Chloride is soluble and can be applied with N or K2O. Another nutrient that may be needed is manganese (Mn). It appears Mn soil tests are getting lower. A broadcast application of manganese seems to improve crop growth on calcareous soils (high soil pH and excess lime).

NO TILL AND CROP ROTATIONS IN WESTERN KANSAS[1]

Alan Schlegel, Troy Dumler, John Holman, and Loyd Stone[2]

SUMMARY

Grain yields of wheat and grain sorghum increased with decreased tillage intensity in a wheat-sorghum-fallow (WSF) rotation. Averaged over the past 10 years, no-till (NT) wheat yields were 6 bu/a greater than reduced tillage and 9 bu/a greater than conventional tillage. In 2010, grain sorghum yields were 58 bu/a greater with long-term NT than short-term NT. Averaged across the past 10 years, sorghum yields with long-term NT have been twice as great as short-term NT (57 vs. 26 bu/a). Grain yield of recrop wheat averaged about 80% of the yield of wheat following sorghum in a 4-yr rotation of wheat-wheat-sorghum-fallow. Grain yield of continuous wheat averaged about 70% of the yield of wheat grown in a 4-year rotation following sorghum. Wheat yields were similar following one or two sorghum crops. Similarly, average sorghum yields were the same following one or two wheat crops. Yield of the second sorghum crop in a wheat-sorghum-sorghum-fallow rotation averaged about 70% of the yield of the first sorghum crop.

PROCEDURES

Research on different tillage intensities in a WSF rotation at the Kansas State University (KSU) Southwest Research-Extension Center at Tribune was initiated in 1991. The three tillage intensities in this study are conventional (CT), reduced (RT), and no-till (NT). The CT system was tilled as needed to control weed growth during the fallow period. On average, this resulted in four to five tillage operations per year, usually with a blade plow or field cultivator. Beginning in 2001, the RT system uses no-till from wheat harvest through sorghum planting (short term no-till) and conventional tillage from sorghum harvest through wheat planting. The NT system exclusively used herbicides to control weed growth during the fallow period. All tillage systems used herbicides for in-crop weed control. The 4-yr rotations of wheat-wheat-sorghum-fallow (WWSF) and wheat-sorghum-sorghum-fallow (WSSF) and continuous wheat (WW) were all grown in a NT system.

RESULTS AND DISCUSSION

Since 2001, wheat yields have been severely depressed in 5 of 10 years primarily by lack of precipitation. Reduced tillage and no-till in a WSF rotation increased wheat yields (Table 1). On average, wheat yields were 9 bu/a higher for NT (25 bu/a) than CT (16 bu/a). Wheat yields for RT were 3 bu/a greater than CT even though both systems had tillage prior to wheat. In only 1 of the 10 years has NT yields been less than CT or NT (although not significant).

The yield benefit from reduced tillage was greater for grain sorghum than wheat. Grain sorghum yields for RT averaged 10 bu/a more than CT, whereas NT averaged 31 bu/a more than RT (Table 2). For sorghum, both the RT and NT used herbicides for weed control during fallow so the difference in yield could be contributed to short-term compared with long-term no-till. In 2010, sorghum yields were 58 bu/a greater with long-term NT than short-term NT. This consistent yield benefit with long-term vs. short-term no-till has been observed since the RT system was changed in 2001. Averaged across the past 10 years, sorghum yields with long-term

[1] This research project was partially supported by the Ogallala Aquifer Initiative
[2] Kansas State University Department of Agronomy, Manhattan, KS

NT have been twice as great as short-term NT (57 vs. 26 bu/a).

For the 4-yr rotations in 2010, wheat yields were above average for wheat following fallow (after sorghum) while slightly below average for wheat following wheat (Table 3). Averaged across 14 years, recrop wheat (the second wheat crop in a WWSF rotation) yielded about 83% of the yield of first-year wheat in WWSF. Before 2003, recrop wheat yielded about 70% of the yield of first-year wheat. In 2003 and 2009, however, recrop wheat yields were much greater than the yield in all other rotations. For the 2003 recrop wheat, this is possibly a result of failure of the first-year wheat in 2002 , which resulted in a period from 2000 sorghum harvest to 2003 wheat planting without a harvested crop. However, this was not the case for the 2009 recrop wheat. Generally, there has been little difference in wheat yields following one or two sorghum crops. In most years, continuous wheat yields have been similar to recrop wheat yields; however, in several years (2003, 2007, and 2009), recrop wheat yields were considerably greater than continuous wheat yields.

Sorghum yields in 2010 were greater than average for sorghum following wheat while about average for sorghum following sorghum (Table 4). Sorghum yields were similar following one or two wheat crops, which is consistent with the long-term average. The second sorghum crop typically averages about 70% of the yield of the first sorghum crop, but in 2010, recrop sorghum yields were only about 50% of the yield of the first sorghum crop.

Table 1. Wheat response to tillage in a WSF-fallow rotation, Tribune, 2001-2010.

	Tillage				ANOVA (P > F)		
Year	Conventional	Reduced	No-Till	LSD $_{0.05}$	Tillage	Year	Tillage x Year
	bu/a						
2001	17	40	31	8	0.002		
2002	0	0	0	---	---		
2003	22	15	30	7	0.007		
2004	1	2	4	2	0.001		
2005	32	32	39	12	0.360		
2006	0	2	16	6	0.001		
2007	26	36	51	15	0.017		
2008	21	19	9	14	0.142		
2009	8	10	22	9	0.018		
2010	29	35	50	8	0.002		
Mean	16	19	25	2	0.001	0.001	0.001

Table 2. Grain sorghum response to tillage in a WSF-fallow rotation, Tribune, 2001-2010

	Tillage				ANOVA (P > F)		
Year	Conventional	Reduced	No-Till	LSD $_{0.05}$	Tillage	Year	Tillage x Year
	bu/a						
2001	6	43	64	7	0.001		
2002	0	0	0	---	---		
2003	7	7	37	8	0.001		
2004	44	67	118	14	0.001		
2005	28	38	61	65	0.130		
2006	4	3	29	10	0.001		
2007	26	43	62	42	0.196		
2008	16	25	40	20	0.071		
2009	19	5	72	31	0.004		
2010	10	26	84	9	0.001		
Mean	16	26	57	6	0.001	0.001	0.001

Table 3. Wheat response to rotation, Tribune, 1997-2010

	Wheat yield														
Rotation[1]	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
	---bu/acre--														
Wssf	57	70	74	46	22	0	29	6	45	28	75	40	37	63	42
Wwsf	55	64	80	35	29	0	27	6	40	26	61	40	39	60	40
wWsf	48	63	41	18	27	0	66	1	41	7	63	5	50	29	33
WW	43	60	43	18	34	0	30	1	44	2	41	6	24	23	26
LSD (0.05)	8	12	14	10	14	—	14	2	10	8	14	5	15	9	3

[1] W, wheat; S, sorghum; F, fallow; capital letters denote current year crop.

Table 4. Grain sorghum response to rotation, Tribune, 1996-2010

	Grain sorghum yield															
Rotation[1]	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
	---bu/acre--															
wSsf	58	88	117	99	63	68	0	60	91	81	55	101	50	89	98	75
wsSf	35	45	100	74	23	66	0	41	79	69	13	86	30	44	52	51
wwSf	54	80	109	90	67	73	0	76	82	85	71	101	57	103	105	77
LSD (0.05)	24	13	12	11	16	18	—	18	17	20	15	9	12	53	24	4

[1] W, wheat; S, sorghum; F, fallow; capital letters denote current year crop.

Alternative Crops
Increasing Crop Diversity in No-till Cropping Systems

Kraig Roozeboom
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Introduction

Crop rotation and diversity are key components of successful no-till crop production. A long-term study near Manhattan, KS documented average yield increases of 13% to 230% for soybeans when rotated with wheat or sorghum compared to continuous soybeans, depending on yield potential and rotational crop (Peterson and Roozeboom 2007). The same study documented yield increases up to 19% for no-till grain sorghum rotated with soybeans compared to continuous no-till grain sorghum. Similar long-term responses with these and other crops have been documented at Hesston and Tribune (Claassen and Roozeboom 2007).

The predominant crops in central and western Kansas have included wheat, sorghum, corn, soybeans, and sunflower. Wheat and sorghum acres have trended downwards in recent years, while corn and soybean acres have been increasing (USDA-NASS 2011). This is likely an indication of the increasing adoption of reduced tillage and no-till cropping systems that facilitate greater cropping intensity and more frequent row crop production. Corn, soybeans, or sunflowers may be an untried alternative in some operations, but they will not be discussed here because they are fairly widely grown, and seed, production information, and markets should be readily available in most locations.

Identifying alternative crops to add to the rotational sequence can enhance crop diversity, break disease and insect pest cycles, and spread risk across different growing seasons and markets. Several criteria are necessary for a successful alternative crop:

1. Seed of adapted varieties/hybrids
2. Production system components - planting and harvesting equipment, fertility recommendations, seeding rate and date recommendations, herbicides/weed control options, etc.
3. Market(s) - often via pre-plant contracts
4. Crop Insurance? - may have some protection in contract stipulations

This presentation will discuss a few possible crop alternatives that may have a fit in no-till cropping systems in the Central Great Plains (primarily central and western Kansas). It is not an exhaustive list, and may not include the best alternatives for your situation. However, they are crops that have some kind of track record in Kansas (or that we have fairly good information for) and that have most or all of the criteria necessary for success, making them worth consideration for diversifying no-till cropping systems.

Mention of company names is for information purposes only and does not imply endorsement by Kansas State University.

Possible Aternative Crops

Winter Canola

This crop has been investigated for 20 years or more in this area, but acreage has not taken off the way some had hoped. Recent advances in genetics and production systems make this a good time to take another look at canola.

Seed/varieties	Several new varieties released in recent years Some glyphosate tolerant Some tolerate residual SU herbicides Winter hardiness better than 10-15 years ago Both OP varieties and hybrids available Multiple sources - Monsanto, CroPlan Genetics, K-State, etc.
Production System	Progress has been made with planting dates and fertility, but challenges remain for NT production (not insurmountable)
Market(s)	Producers Cooperative Oil Mill (PCOM), Oklahoma City; often will arrange pickup; others?
Insurance	Available in some areas; early sign up date

Strengths	Developing market, strong domestic demand Easy rotation to and from wheat Allows control of grass weeds that may be a problem in wheat
Weaknesses	Winter stand loss may be a concern in no-till May require additional harvest equipment if swathing or pushing Herbicide/rotation restrictions
Production Info.	*Great Plains Canola Production Handbook*
Fit in rotations	Similar to wheat - fall planted, June/July harvest Good rotational crop with wheat every 3 to 4 years
Adaptation area	Least risk in South Central Kansas, but viable in most of state with right conditions and management. Dryland production most reliable with 20" or more of annual precipitation. Good success with limited irrigation to establish crop and support fall growth. Yields have ranged from 1,200 to more than 3,000 pounds/acre for top-yielding varieties in recent years

Spring Canola

Similar to winter canola but planted in early spring rather than in the fall. Yield potential is usually less than for winter canola, but it may be a viable alternative in NW KS, eastern CO, NE panhandle where winter canola becomes more risky. Yields have ranged from 800 to 1,500 pounds per acre in successful tests at Colby, KS (Aiken 2010).

Camelina

There is some interest in this crop, but there has not been extensive work with it in Kansas. Recent research has shown that it is a viable alternative.

Seed/varieties	Several available, but few specifically selected for this area
Production System	Similar to that for winter and spring canola
Market(s)	Great Plains-The Camelina Company Sustainable Oils
Insurance	Developing

Strengths	Low water requirement
Weaknesses	Yield potential is less than for canola
Production Info.	camelinacompany.com
Fit in rotations	Summer annual (early summer); easy to rotate back to wheat if sufficient moisture
Adaptation area	Montana, Oregon; possibly NW, W KS, eastern CO, and NE panhandle; possible alternative where winter canola is too risky because of limited water availability or winter survival problems. Yields of 800 to more than 2,000 pounds per acre have been documented at Colby and Garden City, KS in recent years (Aiken 2010).

Sesame

Seed/varieties	Limited number available; Non-Dehiscent (ND) and Improved Non-Dehiscent (IND) varieties available
Production System	Well developed for Texas and Oklahoma, developing for southern Kansas
Market(s)	Sesaco, Texas; delivery points at Anthony, KS; several in OK, TX
Insurance	?, Working on it

Strengths	Tolerates heat well
Weaknesses	Relatively few weed control options Difficult to plant wheat in fall after Sesame crop in some areas (late maturation) Herbicide sensitivity/rotation restrictions
Production Info.	Sesaco.com; *Sesame Producer Guide* sesamegrowers.org
Fit in rotations	Summer annual (late summer); typically needs 130 days from time soil temperatures reach 70°F
Adaptation area	South central, southeast Kansas; Oklahoma (similar to cotton) Yields of 1,100 to 1,400 achieved at Manhattan in 2010 (late June replanting, poor stands due to heavy rains with early June planting). Yields as good or better in south central Kansas.

Safflower

Seed/varieties	Dick Auld, Texas Tech., developing varieties for southern High Plains
Production System	Being developed for southern High Plains
Market(s)	?
Insurance	?

Strengths	Heat and drought tolerant
Weaknesses	Not well developed market, herbicide/rotation restrictions
Production Info.	Texas Tech
Fit in rotations	Summer annual
Adaptation area	Western Kansas, eastern Colorado, TX and OK panhandles

Summary

Increasing crop diversity has been documented to be a key component of successful no-till cropping systems. Introducing new crops into your rotation should be approached with care.

- Be sure to identify trusted market(s) before planting the crop
- Have a valid contract in hand before planting
- Be aware of herbicide rotation restrictions
- Be sure current planting and harvesting equipment will work or appropriate equipment is readily available
- Don't assume planting/harvesting/crop management will be similar to that for traditional crops
    - Many alternative crops are small seeded and need additional attention to get good stands
    - Insect and/or disease management may need more attention with alternative crops
    - Fertility requirements may be different than for traditional crops (e.g. sulfer with canolas and camelina)

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Improving Efficacy and Reducing Drift

Robert E. Wolf
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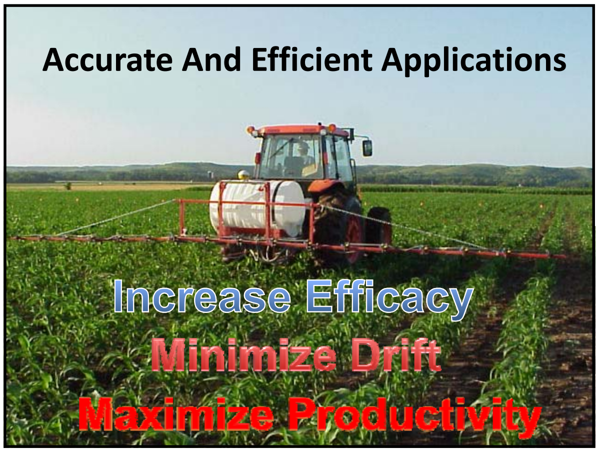
Bio & Ag Engineering
Kansas State University

The latest sprayer technology involves the incorporation of various electronic controls designed to improve the efficiency of the application process. GPS technology is allowing for the incorporation of various components including auto-steer, automatic boom height control, automatic boom swath control, and field mapping for prescription/variable rate applications. In addition, over the last several years there has been an increased emphasis by nozzle manufacturers to engineer spray nozzles that will effectively reduce the volume of driftable fines found in spray droplet spectrums. Concern has been expressed that this increased emphasis in designing nozzles to minimize drift is compromising field efficacy for some herbicide products. Most recently, nozzle manufactures have introduced nozzle types that while maintaining a drift reduction theme, are providing better coverage. More information about how to use the latest equipment and nozzle technologies to apply crop protection products is paramount for achieving optimum control of undesired pests while minimizing drift.

This presentation will provide information on the latest nozzle designs as well as the research done in evaluating field performance. The latest information on calibrating sprayers for label directed spray quality requirements to meet the revised ASABE droplet spectra classification standard, S-572.1, will also be presented. Also, the latest information regarding the influence of various tank mix adjuvants on droplet size will be presented. An update on the status of the EPA’s upcoming National Pollutant Discharge Elimination System (NPDES) permitting process and Drift Reduction Technology (DRT) program will be given.

As future application guidelines regarding increased efficacy and spray drift minimization are established, more technologies will be developed and adapted regardless of cost. These developments will require sound research to support adaptation.



SpotOn Electronic Calibration Tool

Successful Farming Sponsored and will publish findings.

Scott Bretthauer - U of I
Jim Wilson - SDSU
Randy Taylor - OSU
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Calibration!!!!

The next phase!

A new concept for applicators!

Ensuring that the spray droplet spectrum is what it is supposed to be to maximize efficacy while minimizing drift!

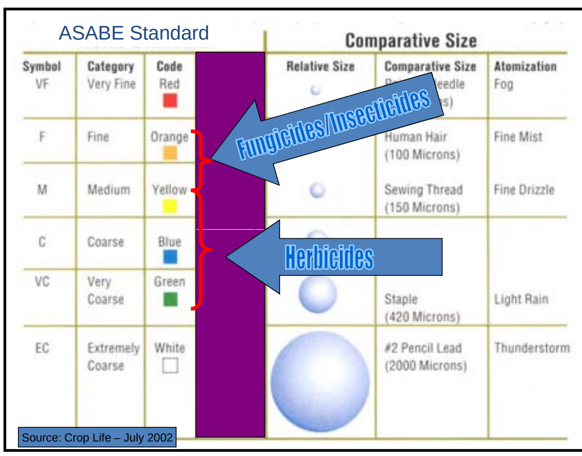
Spray Quality Categories	
ASABE Standard S-572.1	
Category (symbol)	**Color Code**
Extra Fine (XF)	Purple
Very Fine (VF)	Red
Fine (F)	Orange
Medium (M)	Yellow
Coarse (C)	Blue
Very Coarse (VC)	Green
Extra Coarse (XC)	White
Ultra Coarse (UC)	Black

2009

NEW

S572

NEW



Bayer CropScience

OLYMPUS™ FLEX Herbicide

For Post-emergence Control of Certain Grasses and Broadleaf Weeds in Fall-sown or Winter Wheat.

ACTIVE INGREDIENTS:

Propoxycarbazone-sodium (CAS No. 181274-15-7)	6.75%
Mesosulfuron-Methyl (CAS No. 208465-21-8)	4.50%
INERT INGREDIENTS	88.75%

Contains petroleum distillates.

Protected by U.S. Patent Nos. 5,648,315 and 5,688,745 **TOTAL:** 100.00%

This product is a water dispersible granule containing 6.75% Propoxycarbazone-sodium and 4.50% Mesosulfuron-methyl, by weight.

EPA Reg. No. 264-833 **EPA Est.**

GROUND APPLICATION

OLYMPUS™ FLEX Herbicide can be applied broadcast in 10 or more gallons of water per acre. For weed control in dense weed canopies, use 15 or more gallons of water per acre. Weed infestations should be treated before they become competitive with the crop.

The use of 80-degree or 110-degree flat-fan nozzles is highly recommended for optimum spray coverage and canopy penetration. To achieve uniform spray coverage, use nozzles and pressure that deliver MEDIUM spray droplets as indicated in nozzle manufacturer's catalogs and in accordance with ASAE standard S-572. Use screens that are 50 mesh or larger.

AERIAL APPLICATION

OLYMPUS™ FLEX Herbicide should be applied in a minimum of 5 gallons of water per broadcast acre. Weed infestations should be treated before they become competitive with the crop.

To achieve uniform spray coverage, use nozzles and pressure that deliver MEDIUM spray droplets as indicated in nozzle manufacturer's catalogs and in accordance with ASAE standard S-572. DO NOT use raindrop nozzles.

Aerial applications with this product should be made at a maximum height of 10 feet above the crop with low drift nozzles at a maximum pressure of 40 psi. Avoid application under conditions where uniform coverage cannot be obtained or where excessive spray drift may occur.

Flagmen and loaders should avoid inhalation of spray mist and prolonged contact with skin.

See the ***SPRAY DRIFT MANAGEMENT*** section of this label for additional information on proper application of OLYMPUS™ FLEX Herbicide.

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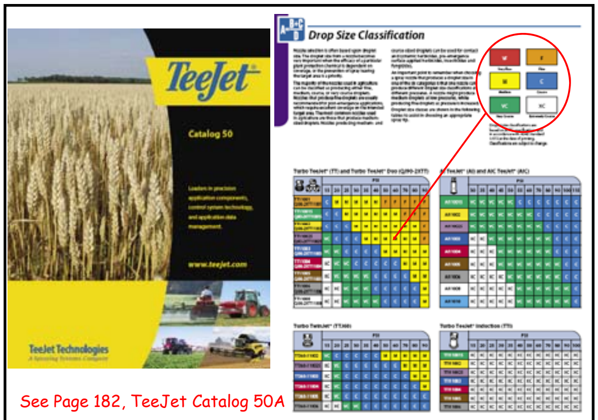
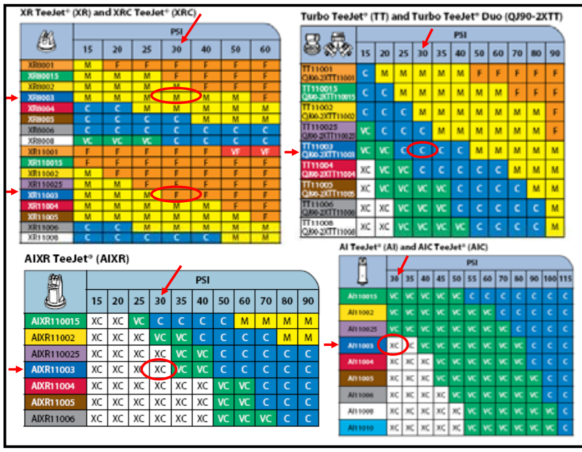


See Page 182, TeeJet Catalog 50A

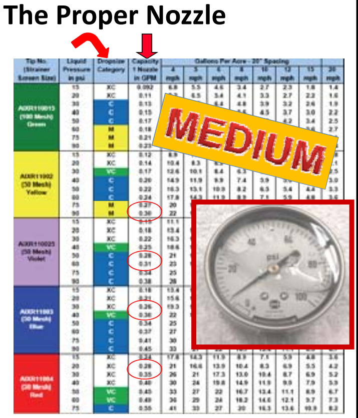


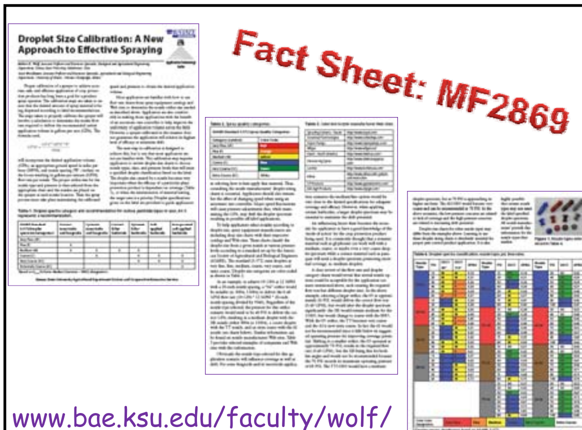
Selecting The Proper Nozzle

Page 9, 12, 14, 15

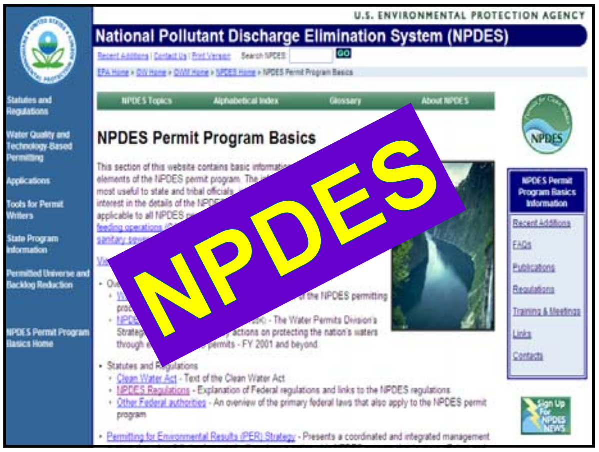
- Calculate GPM (formula)
- Look under GPM column
- Choose the size needed
- Match pressure(psi) and Droplet Classification
- Operate at given pressure and speed used in formula to achieve GPA and the desired droplet size

0.30 gpm





www.bae.ksu.edu/faculty/wolf/



NPDES: The implications

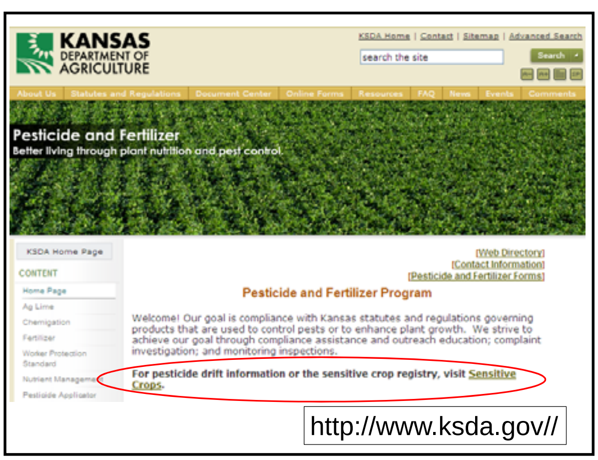
- Permits will be required for:
  - pesticides applied directly to water to control pests
  - pesticides applied to pests that are in or over, including near waters.
  - Could mean 'any pesticide' on or near waters!
- What will be considered waters of the US?
- Pesticide spraying?
- Agricultural fertilizer applications?

NPDES: The Details

- National Pollutant Discharge Elimination System.
  - Clean Water Act permit to control 'Point source discharges' of pollutants in the 'waters' of the US.
    - Factories, feedlots, etc.
  - Excluded pesticide applications on or near water – EPA 2006
- Jan. 7, 2009 – the 6th Circuit Court vacated the 2006 EPA rule.
  - Sprayers would now be considered point source pollutant.

NPDES: Current Status

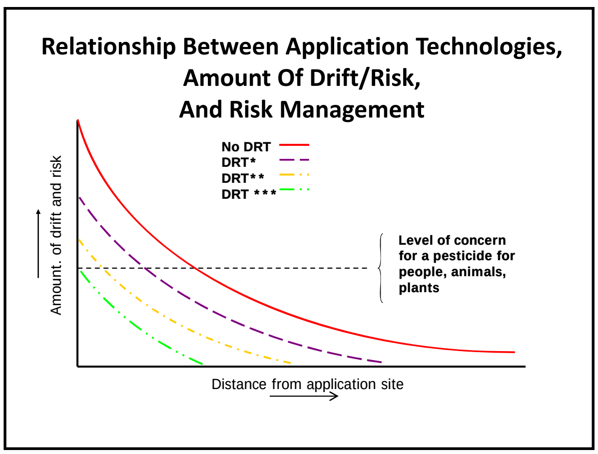
- June 8, 2009 - Court granted the EPA a two-year stay of the mandate to have a permit.
- EPA currently working to develop their NPDES permit.
  - General permit for covered pesticide applications.
  - Assist states in developing similar permits.
  - Must work closely with state water permitting programs.
- Final General NPDES permit - by April 9, 2011

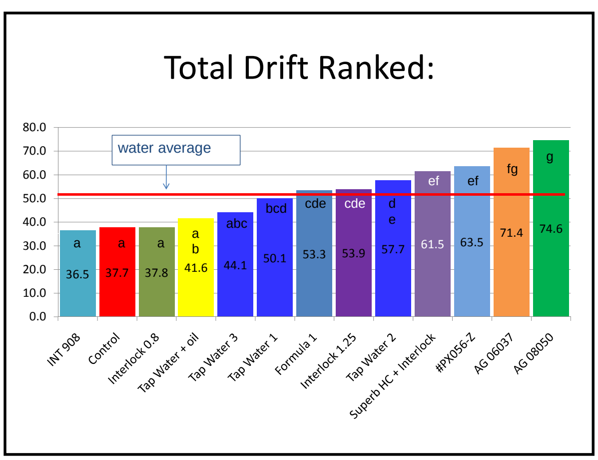


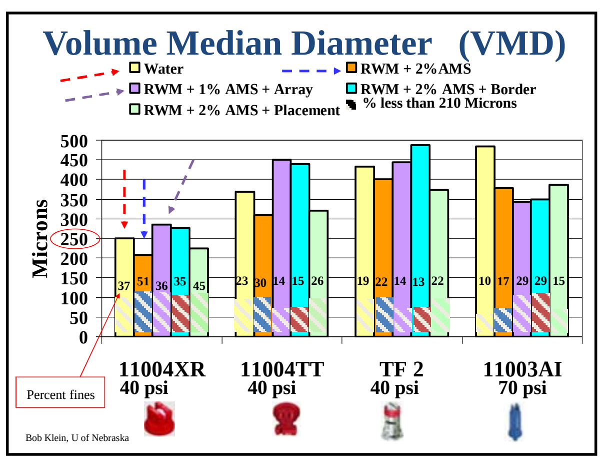
EPA's New Emphasis With Spray Drift Reduction

- Drift Reduction Technology Program – DRT (2006)
  - Encourage the adoption of technology designed to reduce drift.
  - Use of a testing approach to generate high quality peer-reviewed data for DRTs, including test design and quality assurance (QA).
- Example technologies:
  - Spray nozzles – reduce fines
  - Sprayer modifiers – shields, hoods
  - Spray delivery assistance – air-assist
  - Spray property modifiers – formulations, drift control
  - Landscape modifications – hedges, shelterbelts

Rating







Fertility Considerations on High pH Soils

Dorivar Ruiz Diaz, Assistant Professor, Kansas State University

Soil pH is usually higher in regions where the potential evapotranspiration is higher than rainfall. Conditions that are naturally found in western regions of Kansas with less than roughly 20 inches of precipitation per year. Minimal leaching of cations like Ca^{+2}, Mg^{+2}, K^{+}, and Na^{+} from the soil contributes to the high pH. However, the use of chemical fertilizers and other factors like organic matter decomposition can contribute to a significant decrease in soil pH creating areas of low pH particularly in the soil surface in the case of no-till system. Figure 1 shows a summary of eight locations across western KS with pH values for the 0-6 and 6-12 inch depths. The 0-6 inch sampling show in average lower pH values however the variability (indicated by minimum and maximum values) is higher than the 6-12 in sampling. Fields with history of N fertilizer application may show significantly lower pH values (may be the case of locations 1 and 4), and usually with significantly higher variability.

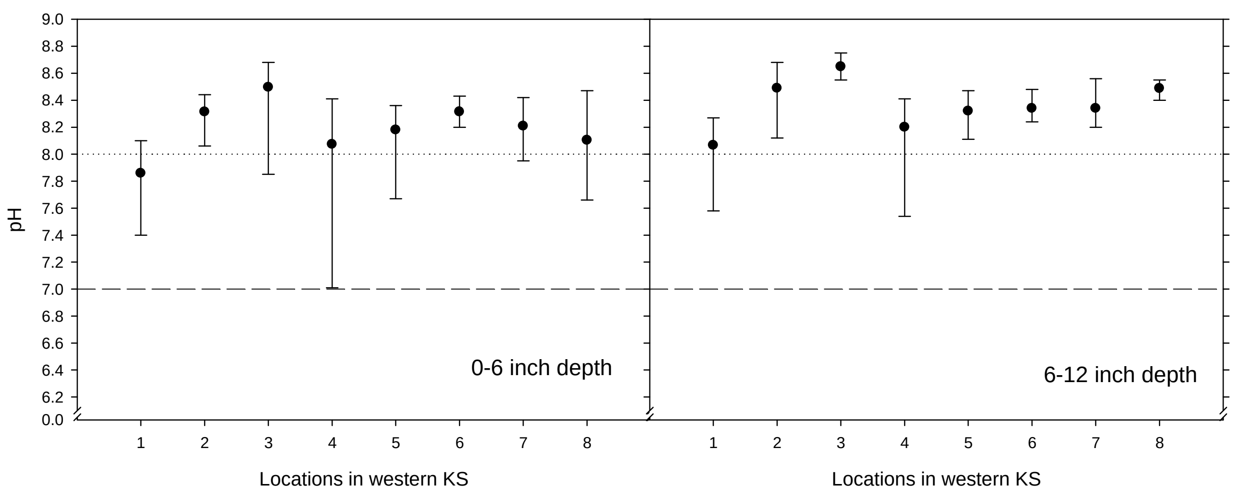


Fig 1. Soil pH values for eight locations in western KS at the 0-6, and 6-12 inch depth. Values are the average, minimum and maximum (indicated by the bars). pH value of 7 is neutral, alkaline is above 7.

One common characteristic of alkaline soils is the accumulation of calcium carbonate (free lime) that is termed calcareous soils (Fig. 2). These conditions of carbonate presence in the soil can generate severe micronutrient deficiencies and are usually noticeable in areas where the topsoil has been eroded or removed for leveling.

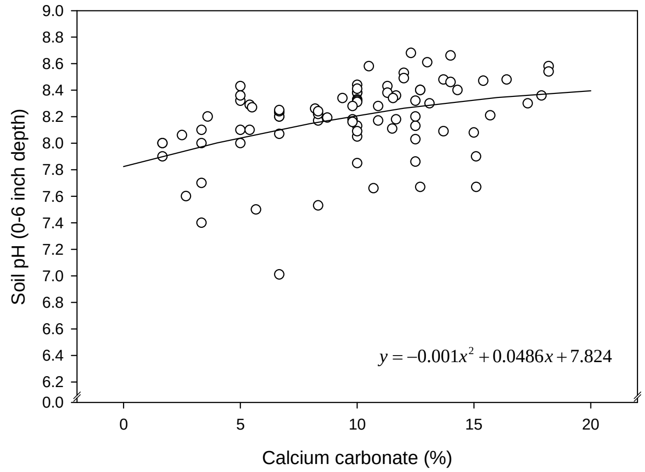


Fig 2. Soil pH and calcium carbonate (free lime) at the 0-6 inch depth.

The availability of most nutrients are influenced by soil pH. Metallic micronutrients like zinc, iron, copper, and manganese are usually highly available in acid soils. However the solubility of these nutrients is significantly lower in alkaline soils. Perhaps the most common nutrient deficiency found in alkaline soils is iron deficiency. Calcareous soils may contain high levels of total Fe, but in forms unavailable to plants. The solubility of this nutrient as determined by extractable DTPA-Fe is significantly lower at high pH values (Fig. 3). Significant limitation in plant growth is common in crops like soybean and sorghum due to iron deficiency. Iron is usually considerably less soluble than Zn or Mn in soils with a pH value of 8 or more. Therefore, inorganic Fe contributes relatively little to the Fe nutrition of plants in calcareous soils, and most of the soluble Fe in the soil is complexed by natural organic compounds, making organic matter the main source of iron for crop uptake under this condition.

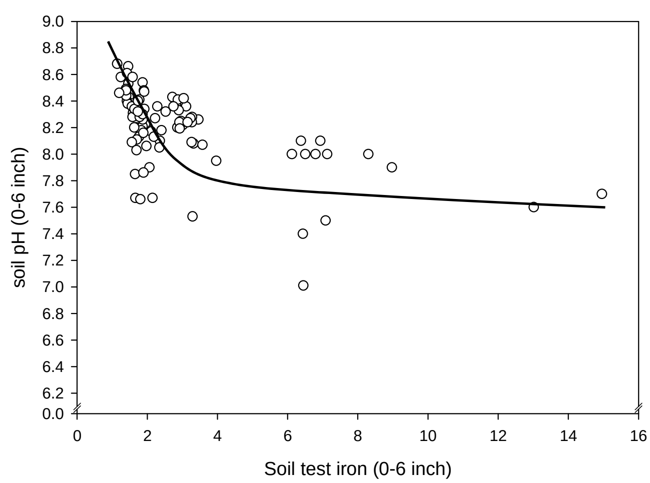


Fig. 3 Soil pH and extractable DTPA iron (Fe) under alkaline soils conditions.

In areas with high levels of calcium carbonate (calcareous soils) the solubility of some nutrients (particularly micronutrients) can be significantly reduced, generating severe nutrient deficiencies (Fig 4).

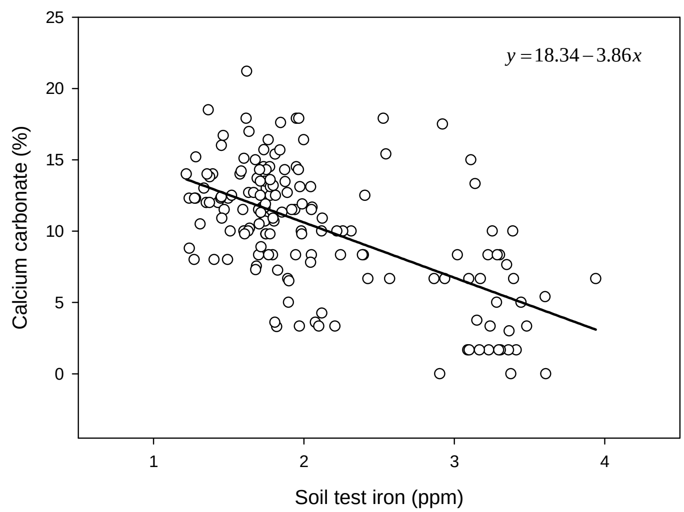


Fig 4. Effect of free calcium carbonate on extractable soil iron.

Under alkaline conditions, macronutrients like phosphorus would be associated primarily with calcium to form calcium phosphate. However, these calcium phosphates can be easily attacked by acids including organic acids excreted by plant roots to release phosphorus for uptake. The high-pH, calcium-rich conditions of alkaline soils may require special considerations for fertility management particularly of micronutrients. The solubility of soil-applied nutrients like iron can be reduced significantly shortly after application and before plant uptake. In-furrow application, in direct contact with the seed is particularly important for plant uptake under alkaline or calcareous soil conditions.

Soil Compaction

DeAnn Presley
Extension Specialist
Soil Management
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Outline

Presentation to include:

- Types of compaction
- Tires vs. tracks
- Is subsoiling effective at alleviating compaction? Does it pay?
- Is no-till less compactable?
- What effect does grazing have on soil?

Country	Soil texture	Crop	Yield reduction %
Canada	Clayey	Corn	70
Finland	Mollic gley	Oat, wheat, barley	1-4
Morocco	Clay loam	Wheat	23
Netherlands	Sandy	Corn sliage	38
Spain	Loam	Seed cotton	28
Sweden	Loam	Wheat	11
USA	Clayey	Corn	24
USA	Clayey	Sorghum	39
USA	Clayey	Oat	31
USA	Silt loam	Barley	14
USA	Silt loam	Pea	28
USA	Silt loam	Corn	14
USA	Clay loam	Corn	30

Ishaq, Ibrahim, and Lal, 2006

Top 10 Reasons to Avoid Soil Compaction

- Causes nutrient deficiencies
- Restricts root development
- Reduces soil aeration
- Decreases soil available water
- Reduces infiltration rate
- Increases bulk density
- Increases sediment and nutrient losses
- Increases surface runoff
- Damages soil structure
- Reduces crop productivity
  - Quantity depends on degree of compaction
  - Root restriction

Limiting bulk density

- Depends on soil texture
- Remember that soil texture can, and usually does, change with depth
- Most KS silty soils: have a zone of higher clay below the soil surface

Texture	Bulk Density g/cc
Sandy	1.77-1.80
Sandy loam	1.75
Loam, sandy clay loam	1.70
Clay loam	1.65
Sandy clay	1.60
Silt, silt loam	1.55
Silty clay loam	1.50
Silty clay	1.45
Clay	1.40

Surface compaction: 0-6”

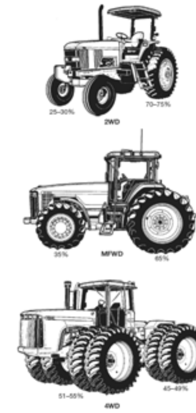
- Caused by wheel traffic, animals
  - Cattle: 30 to 60 psi, affect upper 2--8” of soil
- Can be controlled by “spreading out” a load, either by using a larger tire, more tires, proper inflation
- Tire pressure: 1-2 lbs greater than inflation pressure of the tire
- Usually removed with subsequent tillage operations or, usually by freeze-thaw and wet-dry cycles
  - How well this works depends on the weather, climate, on the cropping system, residue management, soils, etc.

Tillage-induced compaction: Depth of tillage

- Tillage implements that shear the soil, such as moldboard plows, disks, and sweep-type tools
- When continuously operated at the same depth, tillage implements orient soil particles in the same direction
- Potential to cause a tillage pan is greater under wet soil conditions than under dry conditions.

Sub-surface compaction: >6”

- Caused by heavy loads
  - 10 tons reduced corn yield by 17% in 3 out of 4 yr in a silt loam in Pennsylvania (Duiker, 2006)
- Only reduced by adding axles or decreasing load weight
- Axles not always equal



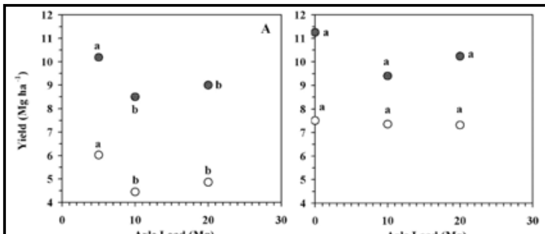


Fig. 5. Corn grain and stover yield in a (A) clay loam and (B) silt loam managed under different compaction levels in Ohio. Mean values of grain and stover followed by the same letter are not significantly different. The black circles represent grain yield whereas the white circles represent stover yield.

Blanco and Lal, 2009, Agronomy Journal

1 Mg = 2200 lbs, i.e., about 1 ton

Several properties measured, but only one that caused yield declines was infiltration (consistent with other papers)

Heavy equipment

- What does a 1050-bu grain cart weigh?
  - Empty: 19,700 lbs
  - Grain: 1050 bushels of grain @ 56 lbs per bushel = 58,800 lbs
- Subtract 8,000 lbs transferred to tractor
- Total: 65,800 lbs
- Axle load = 35 tons (1 axle)

Specs: Kinze 1050 Row Crop Wagon

Tires: 520/85R38 (20.8" x 38")
7000 lbs at 23 psi, flat plate is 443 in^2

So surface pressure is 25 psi,
Axle load is 35 tons

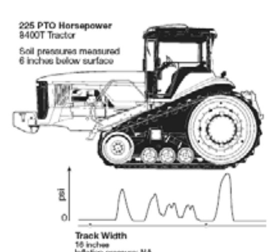
Approximate axle loads for field equipment

Equipment	Axle Load (Tons/axle)
Manure slurry tanker, 4,200 gal.	10-12
Manure slurry tanker, 7,200 gal.	17-18
12-row combine, empty	18
12-row, full with head	24
720 bu grain cart, full, 1 axle	22
Grain cart, 1,200 bu., 1 axle	35-40
Grain cart, 1,200 bu., 2 axles	17-20
4WD Tractor, 325 HP, front axle	13
4WD Tractor, 200 HP, front axle	7.5
MFWD Tractor, 150 HP, rear axle	6.5

If less than 10 tons per axle, compaction is generally restricted to the upper foot or less of soil.

http://www.extension.umn.edu/

Weight distribution on tracks



Still have to watch how weight is distributed!

Tires vs. Tracks?

- Properly inflated duals usually cause less compaction than tracks
- But, tracks better than over-inflated duals
- Tracks cost more
- Tracks improve traction and rideability

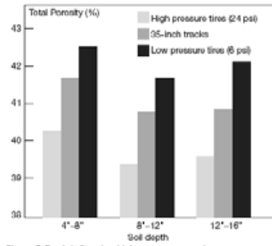


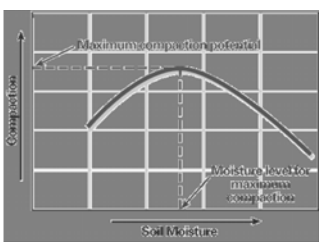
Figure 7. Duals inflated at high pressure caused more compaction than tracks, whereas the same duals caused less compaction if inflated at low pressure. From R. G. Hoeft, E. D. Nafziger, R. R. Johnson, and S. R. Aldrich. 2000. *Modern Corn and Soybean Production*. Champaign, IL: MCSP Publications.

Controlling traffic is great for yield and soils (but efficient?)

Location	Corn Yield (bu/ac)
Untracked	166
Wheel	130
Track	148

Hanna and Al-Kaisi, 2002, Iowa

Moisture matters



www.extension.iastate.edu

Wheel traffic—Key point

- First pass of a wheel causes 70 to 90% of the total compaction (Gill, 1967)

Addressing compaction

- Besides prevention…
- Diverse crop rotation is one of the best solutions
  - Including any kind of taproot is beneficial
- Maintaining adequate residue protects surface, builds structure
- Does tillage work or does the benefit last?

Cover crops and roots

Cover Root Channels May Alleviate Soil Compaction Effects on Soybean Crop (Williams and Weil, 2004, SSSAJ)

- Two possible reasons
  1. Forage radish provided low-resistance paths into the subsoil (biodrilling)
  2. Rye provided a mulch that limited evaporation from the soil surface and increased infiltration early in the growing season.

Does no-till make soil less compactible?

- Well known that NT-induced increases in SOC concentration enhance the formation and stability of aggregates by providing organic binding agents
- BUT, does that translate into the ability to resist compaction?
- NT management-induced increase in SOC improves the soil's ability to resist compaction
- Because OM has low density, high specific surface area, elastic properties, and high water absorbency
- Graphs on following slides from Blanco et al., SSSAJ, 2009, recent research from Great Plains

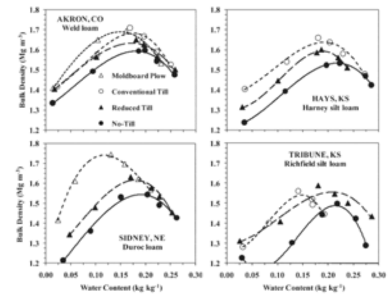


Fig. 1. Relationship between dry bulk density and soil water content using data from the Proctor test for four soils under various long-term tillage systems in the central Great Plains.

Lowest line—means that max bulk density was lower
Shifted right—means that was wetter
Practically speaking: No-till resists compaction more, and in theory could be trafficked when wetter

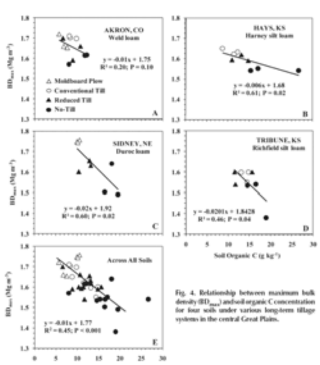


Fig. 4. Relationship between maximum bulk density (BD_{max}) and soil organic C concentration for four soils under various long-term tillage systems in the central Great Plains.

Higher OC =
Less compactable

Very significant,
Four sites in Great Plains

No-till soils less compactable

- Plowed soils would become more easily compacted than NT soils under the same compactive force and water content.
- Plowed soils become compacted at lower water contents than NT soils.
- NT soils can be trafficked at relatively higher water contents and have less susceptibility to compaction than tilled soils at the same water content.

Tillage to address compaction

- Surface smoothing of ruts, rills, etc,
  - Most farmers currently using multiple passes with field cultivator
  - Vertical tillage implement (<2")
- Surface (<8") treat with a chisel plow
- Deep tillage defined as 16 to 20"
  - Straight-shanked ripper causes least disturbance

What about deep ripping, or rotational tillage, or one-time tillage of NT?

- Mechanical operations such as subsoiling and rotational tillage that are used to ameliorate excessive compaction in NT soils actually disturb and degrade soil structure, interrupt SOC accumulation, and increase the risks of rapid recompaction and consolidation (Blanco et al, SSSAJ, 2009)
- Stratification of soil test P, SOC and bulk density, and water stable soil aggregates not different between one-time tilled NT and continuous NT 5 years after tillage. Grain yield was generally not affected by tillage treatment. (Wortmann et al, AJ, 2010, 2 sites in Nebraska)

What about deep ripping, or rotational tillage, or one-time tillage of NT?

- One-time tillage of NT can generally be done without a negative or positive effect on long-term yield or on the soil properties measured.
- Take-away message: Tillage not needed in NT, unless you have a reason (like tracks, or erosion…) and might want to avoid, since presents risks

How long does the benefit last?

- Depends on the producer
  - Traffic on field
  - If they work in wet conditions

Most studies, about 2 years (up to 5)

In 2 years, will have trafficked across 75% to 90% of that field in a conventional tillage system

(Reeder, 2006)

Subsoiling facts

- Subsoiling when it is too wet will only move the compaction zone deeper
- Must wait until very dry (right after harvest?)
  - If this fall is too wet, have to wait for the next dry opportunity
- Cause fracturing
- Only go 1" below the current zone
- Power requirement quadruples as depth is doubled
- Shank spacing and type: No research data

Ottawa, KS study (Keith Janssen, Agronomist)

Tillage system and frequency	*Corn 6 yr avg*	*Soybean 6 yr avg*
No-till	98	35.4
Chisel every year	100	36.6
Subsoil every year	103	37.0
Subsoil every other year	99	37.3
Subsoil every third year	105	37.9

Note: These yields are not statistically different.

Chisel: 5 to 7 inches
Subsoil: 8-14 inches

Averaged across all six years, which included both average and below average moisture years

Does tillage pay?

- Bly (2002) analyzed 169 site years of subsoil tillage data in U.S.
- Subsoiling increased crop yield <u>only when a defined restrictive layer was observed</u>
  - 18 bu corn
  - 7 bu soybeans
  - 10 bu wheat
- Not economical if there was no compaction
- More economical in SE U.S. (low o.m. soil)

Table 4. Assumptions used for a two year net economic analysis for 1000 acres.

Assumptions	**Unit**		**Total $**
Equipment rental	$/acre	5.00	5,000
Fuel cost per acre	$/acre	6.00	6,000
Time to zone till	Hrs	222	
Labor cost	$/hr	12	2,664
Reduction in planting speed	Mph	2	
Additional planting time	Hrs	83	994
Total additional cost			**14,658**
Corn yield benefit	Bu/acre	0	0
Soybean yield benefit	Bu/acre	2.2	2,200
Additional Soybean income	$/bu	6.00	13,200
Total increase in income			**13,200**
Net farm gain			**-$1,458**

Costs for deep tillage on 1,000 acres
Courtesy Jodi DeJong-Hughes, MN

No-till Machinery Innovations

Case IH

AGCO

John Deere

What is the problem?

By Dwayne L. Beck PhD; Dakota Lakes Research Farm; Pierre, SD

The United Nations-Food and Agriculture Organizaiton in 2008 developed a list of factors that they felt were primary constraints to the adoption of "Conservation Agriculture" (no-till) especially as it relates to the non-industrial (G20) countries.

They summarized the list as follows:

- **The mind-set of the plow**.
- **Competition for crop residues.**
- **Social issues.**
- **Weed control**. (PEST CONTROL)
- **Sufficient fertility amendments.**
- **Input market linkages.**
- **Knowledge intensity.**
- **Land tenure.**
- **Equipment**
- **Excess soil water**.
- **Time.**
- **Policies.**

At first blush it is easy to think these restraints do not apply to the developed world. But on closer examination it becomes clear that the opposite is true. "Conservation Agriculture " in their definition refers to farming systems that mimic the local native vegetation in terms of diversity and in how water and nutrients are cycled. It includes having livestock integrated with crop farming while it conserves soil resources and protects water and air quality. This session will analyze these issues as they pertain to the United States and suggest ways these constraints can be mitigated. Using no-till seeding techniques while growing only continuous monoculture grain crops would not be considered "Conservation Agriculture".

Constraints to Adoption of Conservation Agriculture (we need to find a better term because the terms No-till and Conservation Agriculture are both too broad in terms of their common definition in the US.)

Comments by Dwayne Beck

The comments listed below should be viewed as one man's embellishment of the good concepts listed in this paper. They are at times directed most specifically at some of the issues in play in the US, but most have applicability in other places as well. The important thing is that I think the time has finally arrived when No-till is recognized for the ecological services it performs when done properly. Getting control of the myriad of issues facing or economy and ecosystems will take more than no-till **but** it most likely cannot happen without no-till. My good friend Rolf Derpsch always said that the problem in the US is that there was no uniform message. I maintain that has been true in most of the world. The uniform message is starting to appear.

 The mind-set of the plough. The plough has become the symbol of agriculture and many, Including farmers, extension agents, researchers, university professors and politicians have difficulty in accepting that agriculture is possible without tillage.

This is by far the most important of the constraints. In this paper the term CA is used because by UN-FAO definition it is far more restrictive than terms like no-till or zero-till. In the US the term Conservation Tillage was used in order to have a "bigger tent" but many of the systems that people call conservation tillage involve practices that are not acceptable. In the US no-till and zero-till are too broad because they do not define adequately the need for crop diversity and the requirement that surface residues be maintained. There has been some use of adjectives like diverse, low-disturbance, continuous, no-till to better define the optimum systems but this becomes convoluted. One term we have used is regenerative agriculture. Our reasoning is that terms like sustainable and conservation are too broad and do not define the job to be done. The ecosystems are already degraded in most cases. It is not enough to sustain them or conserve them, they must be regenerated.

Lack of commitment to this principle is evident throughout the entire spectrum of agriculture. In the US we have Universities and ARS centers that to some degree acknowledge the benefits of no-till while they continue to manage most of their farms using conventional tillage. There also is a strong propensity within the research community to feel that tillage variables need to be included in any experiment that is being done using no-till. The lead farmers in areas influenced by the Dakota Lakes Research Farm have long ago accepted the notion that TILLAGE IS NOT AN OPTION under any circumstances. They call that attitude having "their brain transplant". If all of the effort that has been directed to poorly conceived tillage comparison studies would have been devoted instead to optimizing the no-till system, many of the constraints to adoption would no longer exist. The best time to start this approach was 20 years ago. The next best time is now.

 Competition for crop residues. Most small-holder farmers manage mixed crop/livestock systems and rely on crop residues for animal feed and often fuel. CA systems need to incorporate components that provide for animal feed while at the same time enabling adequate soil surface residue cover. There is room to turn this constraint into an advantage through linking CA and intensive livestock production.

This is a major issue where crop residues are used for fuel or building material. There is particular worry about some of the trends in “developed” countries as well. Cellulosic ethanol (or other use of crop residue for fuel) is one area that could be worrisome. This is particularly true because many of the proponents of using crop aftermath for fuel production have dismissed concerns about OM loss by saying that Conservation Tillage (big tent) perhaps along with continuous corn will minimize this concern as compared to present practices. That is not the issue. Present tillage based systems are not acceptable. Replacing them with systems that are similar in terms of C (and other nutrient) cycling is also not acceptable. The standard needs to be compared to native systems or at least compared to where we need to be for long-term viability. Or where we need to be in terms of providing necessary environmental services (water quality, wildlife habitat, soil erosion, etc.) There are ways to produce bioenergy while at the same time improving the soils AND performing environmental services. One example would be long rotations that utilize both perennial crop sequences and annual cropping sequences.

Integrating livestock should not be an issue in PROPERLY MANAGED systems. The problems at present in livestock systems are either that the soil and the animal are separated or the animals are not controlled while on the soil. This means the issue is not with the animals, it is with the people who manage the animals. Plant material flow through livestock leads to very little loss of nutrient from the landscape IF transport by erosion processes is prevented. There most likely is a positive interaction between the microbes associated with saliva and the animals gut and those needed to have proper nutrient and residue cycling in the soil. Taking the plant material to a feedlot for consumption there is extremely energy intensive and leads to excessive loss of nutrients and breaks the interaction of micro-organisms. In addition, livestock provide a means of obtaining benefit from the land during periods when it would not be possible to grow a crop for grain. In conventional systems the land is left idle and bare during these periods. Growing a cover crop or a crop for forage adds profit potential while enhancing crop diversity and microbial biomass. The bottom line is that livestock are most likely of significant benefit to the system if they are managed properly. Wildlife are part of the native system. Livestock (wild or tame) probably need to be part of a good no-till system as well.

 Social issues. Communal grazing rights often apply in rural communities making it difficult for farmers to decide unilaterally that they will keep residues on their fields. Changes in communal and local policies may be required to allow for residue retention. Fire protection may also be necessary.

This is a major constraint in many countries. In the US we have less of an issue with someone grazing our residue than they do in many countries where by tradition anything left in the field is considered “community property”. In the US we have lots of people wanting to buy and remove the residue. Sometimes this is the landlord. It will take a major education effort to change this. It will take farmer to farmer action to demonstrate the value of leaving residues on the soil. Just as importantly, there needs to be work on developing alternatives that can replace the residue. If the residue is traditionally used for animal feed, perhaps cover-crops that can be grazed are an option. If they are used for fuel, it might be possible to work on micro-hydro, micro-wind, or solar systems that can replace some of these energy needs. This is not an issue just for the developing world; it pertains to areas where there is substantial push for crop aftermath to be used in biofuel production.

 Weed control. The principal function of tillage is weed control and so, when tillage stops, weed control becomes a major factor. In many cases controlling the weeds present at seeding time has been achieved with herbicides, especially the wide-spectrum “glyphosate”. However, for farmers who do not have access to herbicides or the equipment to apply them, or want to engage in organic farming, manual weed control can be difficult and very time-consuming in the first years of practicing a CA system. After a few years of good weed control and use of cover crops, weed populations decline and become more manageable.

Even the authors of this list have fallen into the trap of the “mindset of the plow”. Tillage does not control weeds. If it were so good at weed control, there should be no more weed problems. Plant pests (weeds, diseases, and insects) are simply species that have taken advantage of opportunities provided by the farming system they plague. There are several papers in the literature (Anderson, R. and Beck, D.L. 2007 Impact of Rotation Design on Weed Community Density in Central South Dakota. Weed Technology) that support the position of tillage actually making weed pressure worse. Native systems seldom have “weeds” or insect issues unless a major disturbance has occurred. Tillage is a major disturbance (catastrophic event) in a native ecosystem. The plants we now consider crops were actually weeds at one time. These plants appeared where a disturbance occurred. Some of them were selected and seeded with artificial disturbance (tillage) created by a stick.

□ **Sufficient fertility amendments.** The success of CA depends on adequate residue cover. In very infertile and degraded soils sufficient fertility amendments must be applied to increase production not only of the economic portion of the crop but also of the residues/cover crops.

This is an extremely important aspect especially the part about full residue cover. Almost all of the "no-till' in the US has issues with this. There is plenty of fertilizer use in the US, but there is a shortage of residue because of poor rotations, residue removal, and high-disturbance (not true no-till) techniques.

Besides seeking to maximize residue cover it will become more important to minimize the translocation of nutrients from one location to another. This includes translocation that occurs on the landscape due to erosion (tillage or other) or to transportation from the landscape when grain or residues are removed. Integrating livestock into no-till systems is one method of more closely mimicking the way that nutrients cycle in natural systems. Some nutrient will move from the landscape when crops and livestock are marketed. This will require importing nutrients to replace those exported.

Just as importantly, it is imperative that nutrient be cycled properly to keep them from having negative impacts elsewhere (water quality degradation).

□ **Input market linkages.** Poor linkages may limit farmer access to fertilizer and other inputs for well managed crops.

If techniques are used that minimize nutrient transfer then this becomes less of an issue. This is actually going to be easier for subsistence farmers than for those that are grain only producers. Nitrogen is the primary fertilizer nutrient that leaves the farm with grain. Mother Nature transports N back to the field in the atmosphere. This N can be made available to plants by using legumes or associative and free-living microbial N fixers. The latter do much better in no-till systems. There is also the possibility that atmospheric N can be fixed on the local level using electrolysis or other innovative means. Other nutrients like P, K, S, etc. need to be replaced if they are transported from the landscape. As mentioned earlier, preventing movement from the landscape is the major objective. With proper no-till systems, it is probable that nutrient sources that have not been extensively processed could be used more efficiently.

Other inputs besides fertilizer (seed, herbicide, fungicide, etc.) can be limiting as well. In the US the inputs that are lacking are those that have lower costs or less technology. Is it possible to buy a non-RR corn hybrid with good genetics? How about corn or soybean seed without a full package of seed treatments? Can alternative crops seed like pea, oats, etc. or cover-crop seed be sourced easily? This is a primary constraint in enabling producers to have more diverse systems.

 Knowledge intensity. True Conservation Agriculture is a knowledge intensive system and farmers, extension agents and researchers need to obtain, share and integrate new knowledge into their practices. Small-holder farmers are often poorly linked to knowledge and information systems, and even extension personnel in many developing countries may have little access to new information.

Farmers everywhere prefer to learn from other farmers. If efforts to create universal use of no-till are to be successful, it will need to be done via a grass roots farmer to farmer movement. Researchers can play a role in providing needed information to the lead farmers. Similarly, extension personnel will be important to facilitate the farmer to farmer interaction and make sure the late majority does not get left behind. It is important to look at several models like AAPRESID and the CREA movement in Argentina or the Dakota Lakes Research Farm Corp. in South Dakota for clues as to why they were so successful. The land grant university system in the US was wildly successful in the past but it is now being dismantled in favor of a system controlled by USDA and the NSF or by large private-industry concerns.

 Land tenure. Farmers that do not have secure access to land may be reticent to invest the time and effort in conserving and improving the land when this may not provide them with longer term benefits.

This is an issue even on land that is owned. By this I mean there is a constant conflict between the desire to maximize short-term profits and the realization that this action may jeopardize the long-term productivity and health of the operation. Part of this is due to the lack of knowledge on the long-term impacts of different management schemes. Similar to the conflict between long-term and short-term priorities that exists with producers the same is true with research priorities. There is almost no long-term research comparing different true no-till systems. There are a few medium-term studies comparing a specific (usually not well designed) no-till program with a conventional tillage program traditionally used in the area. One trend that has begun to surface is landowners wanting assurances from their renters in regards to conservation and maintenance of soil productivity. This is one area that needs much more development on the policy and education level.

 Equipment. Small-scale equipment for seeding crops without tillage is not readily available in many areas. Suitable equipment needs to be introduced, tested and adapted, and local manufacture stimulated where possible.

Equipment designed specifically for no-till is almost non-existent. There are "no-till" drills and planters sold in most countries but they are in reality a modification of machines designed to plant in tilled systems. Consequently they often have issues with residue clearance or operating in moist conditions. Maybe what needs to happen is to rethink the seeding operation. Natural systems are seeded successfully without the use of a machine. Perhaps things like clay seed balls have potential to work in both develop and developing countries..

 Excess soil water. CA captures and conserves more water in the soil. As such it is not well adapted to soil types with poor drainage as it may exacerbate problems of waterlogging. However, permanent raised beds which ensure that part of the root system is in aerobic conditions offer a possible solution.

There are issues with excessive soil moisture in many ecosystem-soil-landscape position combinations. The first issue is to identify what happens in these instances when they are in a native system. If it was a wetland under native conditions, it will be almost impossible to utilize it for traditional grain farming without resorting to “engineering approaches”. Engineering approaches tend to cause greater collateral damage and have more unintended consequences than biological approaches. This is because engineering approaches are attempting to modify the ecosystem so it will support what humans want to do instead of trying to design a system that matches the native condition. The most common application has been the use of drainage tile. Raised beds and drainage ditches move water through the watershed too quickly. Maybe the solution to this problem needs to be addressed at the watershed level rather than the field level where there is a preponderance of mechanized farming.

Perhaps these areas are best suited for use in an alternative fashion. The grain and graze or grass and grain systems we are beginning to study at Dakota Lakes may have significant potential. These combine annual and perennial species into a complex (over time) system that produces both biomass and grain.

 Time. The principles of conservation agriculture need to be adapted to local biophysical conditions and farmer circumstances. This takes time. Massive short-term uptake of this philosophy (the brain transplant) is difficult – a problem for politicians looking for short-term impact.

It took less than 10 years to transform the majority of land in some areas of the Great Plains and prairies from intensive tillage based systems to acceptable but not mature no-till systems. There were several agronomic, economic, climatologic, and policy circumstances that combined to aid the process in this region but it does indicate that the process can go much faster that it normally does. It is important to look at local conditions in each area and make sure that impediments to adoption of no-till are removed or modified. Examples that were impediments in central South Dakota at the beginning included Farm Program Regulations on crop bases, crop insurance regulations, market constraints on rotational crops, and others. This required action on many levels. Farmers are best at identifying the constraints.

 Policies. Often the policies and procedures of governments and international institutions tend to favour short-term approaches to stimulating agricultural output and keeping consumer prices low, rather than encouraging sustainable land management and the creation of conditions in which farmers are rewarded with adequate livelihood prospects, including compensation for ecosystem services.

If I am a grain farmer and decide to use a perennial crop sequence in my rotation to build the soil, add diversity and compete with weeds, I will be penalized financially because of what this does to my FSA payments and crop histories. On the other hand, putting land into the CRP program will garner a payment. Would it not make more sense to remove the disincentives to using a more diverse rotation? The Freedom to Farm portion of the Farm Bill was a key piece of legislation that allowed farmers in the Prairie States to diversify their rotations without incurring a penalty in the protections offered by the Farm Bill.

One of the largest impediments in the US at this time is the regulations associated with crop insurance. No banker will allow a producer to try a new crop rotation or a new crop that does not maximize the revenue protections offered by that subsidized program. Maybe subsidies to the system should be removed so that private industry sets the “rules” and rates. If this were done, more diverse rotations would provide LESS risk of loss than rotations that lack diversity. The risky rotations now used by many farmers are only possible because crop insurance steps in when the all too common problems occur.

Farmers with prairie pothole type landscapes struggle in adopting no-till because of the wet areas in the field. These areas are too small to be separated and too small to be entered into CRP programs. Surely there are ways of adjusting regulations that would change these types of areas to perform environmental services without incurring short-term economic loss to the farmer. All that needs to be done is to take a look at ALL of the factors that impact a farmer’s decision to use specific practices, and then to adjust these so that they do not discourage use of environmentally friendly techniques. I do not think we need to overtly encourage no-till with monetary incentives because it will win if there is a level playing field. REGULATIONS need to be written to obtain a specific landscape goal not to encourage a particular practice.

The biggest policy change that needs to occur is to focus the effort on attitudes and knowledge not at structures. It is incomprehensible that money is still being used in the US to build terraces. Politicians love to have “impacts” to talk about. Structures are easy to document. The number of terraces, stock dams, shelterbelts, etc. that were subsidized provide an easy means of documenting an agency has accomplished something. Similarly the number of acres enrolled in CRP or CSP provides a number to PROVE impacts. It is much more difficult to take the approach of changing attitudes and approaches that was outlined in these comments. But the latter is much more permanent. When the subsidy goes away so does the CRP (or Land Band in the old days) When the regulators stop watching, most terraces, shelter belts, and stock dams do not last very long.

Questions and answers on no-till

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Managing Wheat Residue

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Importance of wheat residue in the field

Advances in cropland productivity throughout the High Plains region have come through improvements in precipitation use efficiency (PUE) and precipitation storage efficiency (PSE). Precipitation use efficiency has been improved by replacing a summer fallow period with a summer crop, typically corn, grain sorghum, proso millet, or sunflower, thus creating a wheat-summer annual-fallow rotation. The addition of a summer annual improves PUE by utilizing water for transpiration that would have been lost to evaporation during the fallow period of the traditional wheat-fallow rotation. Precipitation storage efficiency has been improved through reducing tillage intensity and increasing surface residues.

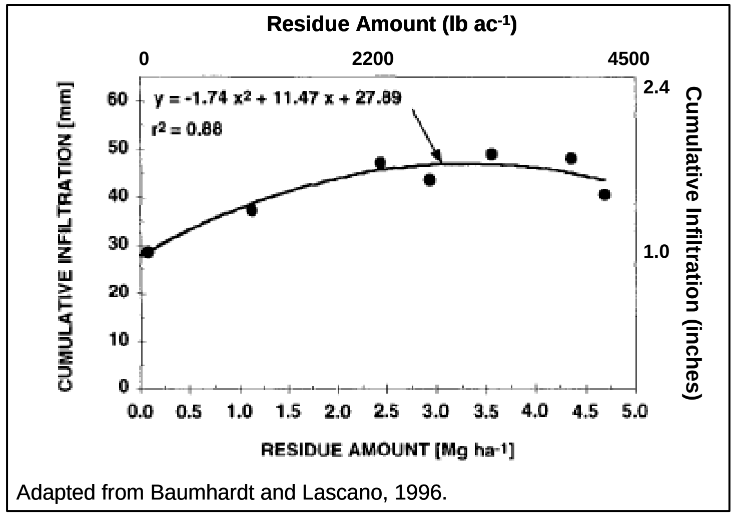

Figure 1 - Infiltration as affected by wheat residue level at Lubbock, TX.

A critical component to the success of a summer annual in this rotation is the quantity and longevity of residue produced by the proceeding wheat crop. It has been shown that residue improves infiltration, reduces evaporation, reduces weed growth, and when standing retains snow. Increasing surface residue levels has been shown to improve infiltration rates as shown in Figure 1. Baumhardt and Lascano (1996) applied 2.6 in hr^{-1} over a one hour time period. Infiltration was lowest for bare soil, 1.13 in., and increased with residue up to a plateau of 1.73 in. Increasing levels of residue has improved precipitation storage efficiency at locations representing the entire Great Plains (Figure 2), particularly when preceding a summer-annual crop such as grain sorghum (Bushland, TX data in Figure 2).

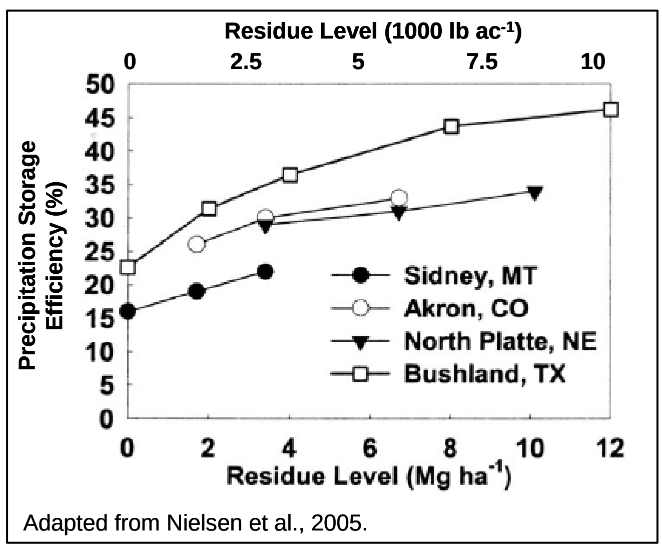

Figure 2 – Precipitation storage efficiency as affected by wheat residue level at various Great Plains locations.

Removal of wheat residue from the field has both direct and indirect economic consequences that must be considered. The most direct relates to the removal of plant nutrients that typically would have been cycled back into the soil. Removal of straw from a field yielding 50 bu. ac^{-1} also removes 35 lb. of N, 10 lb of P_2O_5, 35 lb of K_2O, and 10 lb of S on a per acre basis. Indirect consequences involve decreased precipitation storage efficiency, decreased infiltration, and increased evaporation which leads to lower row-crop yields the following year.

Good Management Starts at Harvest

In order to utilize the previously mentioned benefits, residue management at harvest should focus on two key objectives: leaving stubble standing at the maximum height possible and evenly distributing the residue that must pass through the combine.

Stubble Height

Cutting wheat as high as possible with a grain platform or the use of a stripper header offers many benefits from both machinery management and agronomic perspectives. Increasing cutting height reduces the MOG (material other than grain) that must pass through the gathering, separation, and cleaning systems of a combine. Reducing MOG increases the clean grain capacity of the combine, improves separation efficiency, decreases specific fuel consumption, reduces straw-walker loss in conventional machines, and desensitizes the combine's response to varying crop conditions (Hill and Frehlich., 1985). Use of a stripper header has been shown to increase field capacity by 15 – 49% (Haag et al., 2004). This is achieved by essentially eliminating the straw portion of MOG entering the combine. A common perception among producers using straight cut platforms is that too many heads are missed when wheat is cut tall. Data from eastern Colorado (McMaster et al., 2000) shows that the heights of winter-wheat heads are normally distributed around their mean with a typical standard deviation of +/- 2.6 in. This information can be translated into Figure 3. A common height for TAM 111 in the western Kansas variety trials is around 32 inches. Assuming a standard deviation of 2.6 in, 99.5% of the heads are above 22 in. (Figure 3). This translates into less than a 0.5% grain loss as lower heads typically yield significantly less than those closer to the mean height.

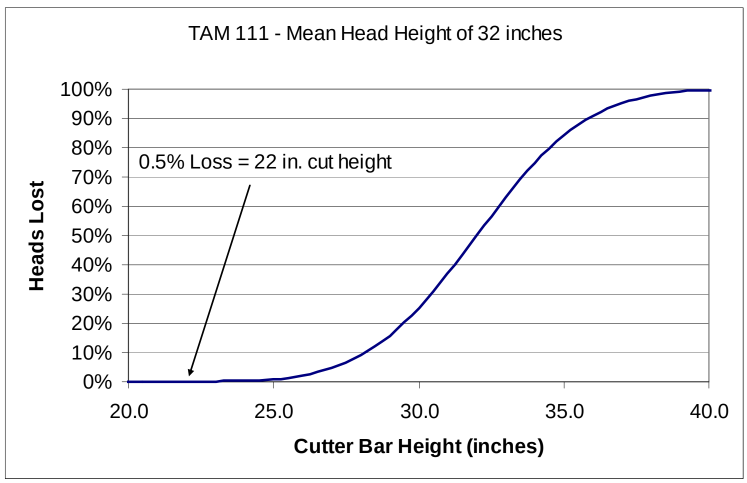

Figure 3 - Distribution of head heights for TAM 111

Residue Distribution

It's important to evenly distribute the crop residues leaving the combine regardless of which header design is used. This has become increasingly challenging as header widths continue to increase. Even distribution of the residue is essential for a variety of reasons. Improvements in evaporation suppression, increased infiltration, and improved weed control as a result of residue can be considered a typical diminishing returns situation. The largest gains happen as the first pounds of residue are applied to a bare soil condition and then diminish with each additional pound of residue until not further benefit can be seen. Poor residue distribution results in areas near the edges of the combine pass in a near bare soil condition while the area directly behind the combine may have more residue than is beneficial, and in some cases detrimental to successful no-till planting. In addition, the nutrients located within the chaff and straw are unevenly redistributed creating additional spatial variability of nutrients within the field. Cutting wheat shorter than necessary compounds these problems as residue becomes even more concentrated in a band directly behind the combine (Figure 4).

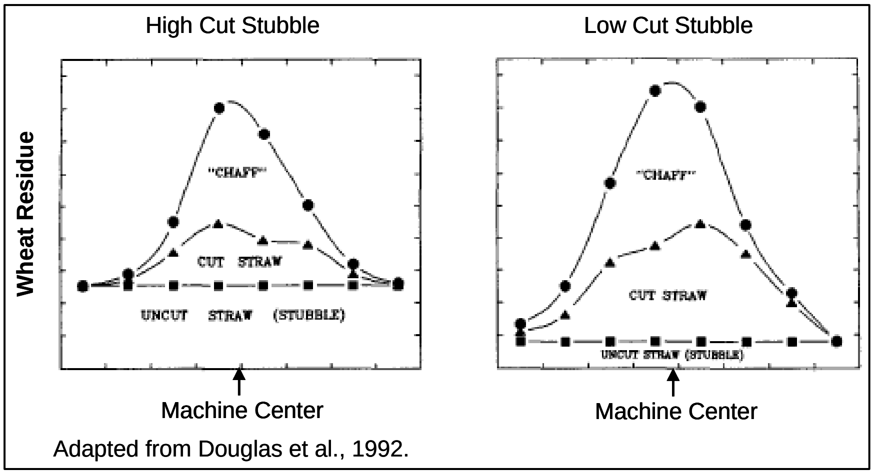

Figure 4 - Residue distribution behind a high cut and low cut wheat stubble.

Current Research on Wheat Residue Management

Effect of Stubble Height on Post-Wheat Harvest Evaporation

Plots in Decatur Co., KS, and Red Willow Co., NE were equipped with soil moisture monitoring equipment in 2005 and 2006 to evaluate the impact of stubble height on evaporation. Intervals where no precipitation occurred were used to calculate evaporation. The short cut stubble always had the highest amount of water loss followed by the tall cut and stripped stubble (Table 1).

Table 1 – Evaporation (inches) from the top inch of soil during precipitation-free periods following wheat harvest in 2005 (Decatur Co., KS) and 2006 (Red Willow Co., NE).

	2005 - Decatur County, Kansas				
Days of Year	229-236	238-248	249-283	284-292	Total
Potential ET (inches)	1.74	3.34	9.10	1.41	15.59
4 in. cut	0.12	0.26	0.31	0.10	0.79
12 in. cut	0.04	0.15	0.25	0.04	0.49
28 in. stripped	0.05	0.12	0.25	0.04	0.46

	2006 - Red Willow County, Nebraska						
Days of Year	220-224	225-230	231-237	239-244	244-250	252-262	Total
Potential ET (inches)	1.63	1.36	1.67	1.22	1.47	2.43	9.79
4 in. cut	0.17	0.12	0.14	0.15	0.17	0.08	0.84
12 in. cut	0.06	0.09	0.08	0.08	0.09	0.11	0.52
28 in. stripped	0.09	0.07	0.07	0.08	0.09	0.08	0.48

Effect of Stubble Height on Snow Catch

Improvements in snow capture for stored soil water at planting could increase and/or stabilize crop yields, and may provide opportunities for further system intensification. Standing residue improves snow catch by increasing surface roughness and drag, thus increasing the wind velocity needed to move snow, and by also reducing wind speeds immediately above the residue. Snow depth observations in Red Willow Co., NE (2006, 2009) and Greeley Co., KS (2009) have been made in various stubble heights including unaltered stripper harvest (stubble approximately 28 in.), cut height of 10-14 in., and cut height of 4-8 in. Measured snow depths and equivalent precipitation were significantly different among stubble heights (Table 2).

Table 2 – Effect of stubble height on snow catch and equivalent precipitation at three site years in the west-central Great Plains.

	Precipitation Value of Snow		
Stubble Height	Lebanon - TCT†	Lebanon - FAH	Tribune - SWREC
	---------------------------- inches ----------------------------		
Stripped	(2.27)a‡	(0.45)a	(1.94)a
Tall Cut	(1.28)b	(0.33)b	(1.58)b
Short Cut	(0.68)c	(0.31)b	(1.09)c

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

Effect of Stubble Height on Subsequent Crop Yields

Studies have been conducted since 2004 at SWREC-Tribune evaluating the impact of stubble height on subsequent corn yields. When averaged over years the stubble heights have resulted in corn grain yields of 75.8, 72.7, and 62.4 bu. ac^{-1} for the stripped, high cut (cutter bar at 2/3 height), and low cut (cutter bar at 1/3 height) treatments (Figure 5).

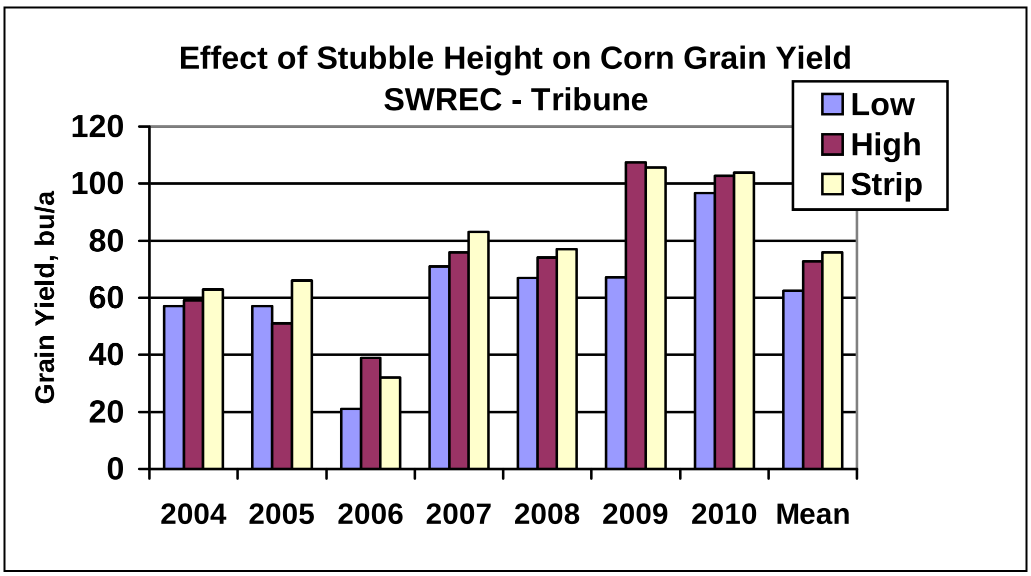

Figure 5 - Corn grain yields as affected by stubble height. SWREC-Tribune 2004-2010.

Research conducted in Decatur Co., KS (2006), Red Willow Co., NE (2007, 2009), and Rawlins Co., KS (2007) on the impact of stubble height on grain yields of a short season and long season hybrid planted across a range of populations. The impact of stubble height and the accompanying increase in plant available water is best shown by the response of the long-season hybrid in Decatur Co., 2006 (Figure 6). Both the stripped and tall cut stubble treatment yielded higher than the short cut stubble at all populations and exhibited a positive response to increasing plant population. The short cut stubble treatment resulted in a yield reduction of 16.2 bu. ac^{-1} at the lowest population. This reduction grew larger as grain yields from the short cut stubble treatment declined further with increasing plant population. The short season hybrid at the Decatur 2006 location averaged 58, 56, and 33 bu. ac^{-1} for the stripped, tall cut, and short cut stubble treatments. The long season hybrid responded to stubble height at the Rawlins Co., KS location in 2007 with yields of 116 and 96 bu. ac^{-1} for the stripped and high cut stubble treatments respectively.

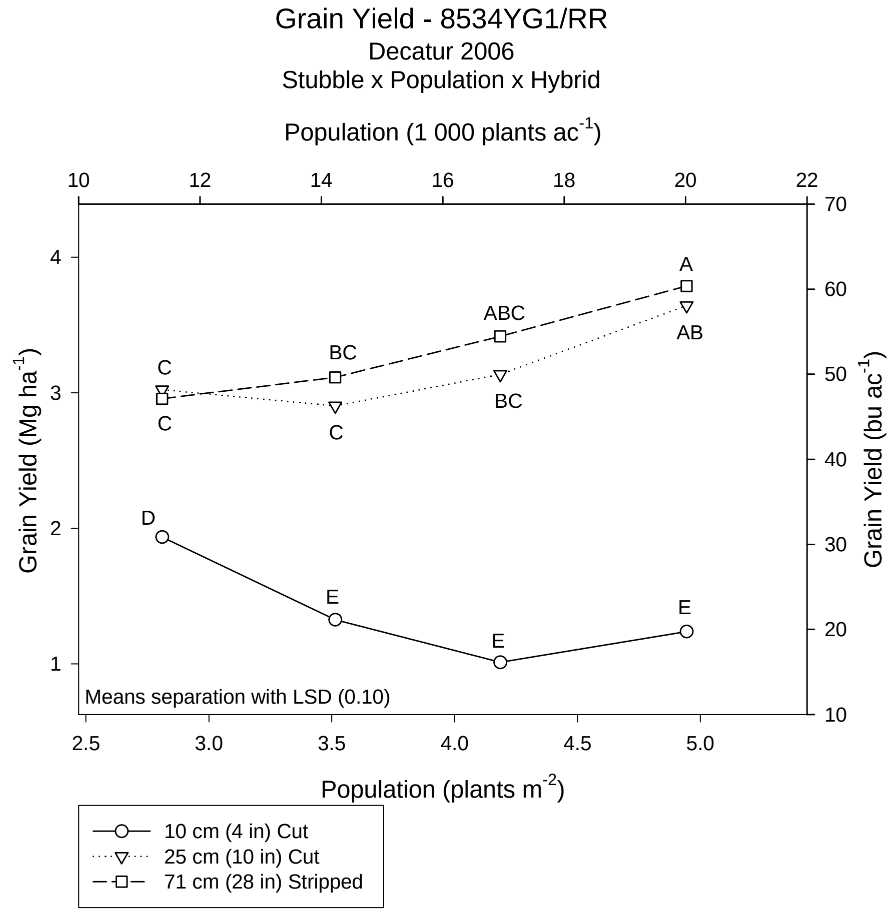

Figure 6 – Grain yield response of 8534YG1/RR to stubble height and population - Decatur 2006.

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Strategies for Selecting Wheat Varieties

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Jim Shroyer, Kansas State University, Agronomy

Introduction

Selecting wheat varieties is among the most important decisions a wheat farmer will make during an annual production cycle. As we might expect, there are a number of resources that provide valuable information regarding potential strengths and weaknesses of the different varieties. This information is particularly important when new vulnerabilities in a popular variety or group of varieties is exposed. For example, stripe rust reemerged as a serious threat to wheat production in Kansas during the 2010 growing season. Stripe rust was problematic in 2010 because the population of the fungus that causes disease developed the ability to overcome the genetic resistance of many popular varieties. This new vulnerability to stripe rust has many farmers wondering if they should drop previously successful varieties in hopes of reducing their risk to stripe rust. This response seems reasonable but may have negative impacts of the genetic diversity of wheat varieties within the region. New strategies are needed to help farmers evaluate wheat varieties that will help them avoid the most common production problems and maintain genetic diversity.

Selecting Varieties with Resistance to Multiple Diseases

Each year multiple diseases impact the productivity of wheat varieties in Kansas. The reaction of many wheat varieties to these diseases is evaluated annually and the information distributed via extension publications and seed companies. We have been testing a summary statistic that combines multiple disease reactions into a single variable and facilitates comparison of the wheat varieties. The experimental wheat disease resistance index weights each disease based on their potential to cause serious yield loss and how frequently they occur within different regions of the state. Wheat varieties with a low disease resistance index values have higher levels of resistance to the most important disease problems. Comparison of the disease resistance index to the yield of wheat varieties in 2009 and 2010 K-State Wheat Variety Performance Tests indicates that varieties with resistance to multiple diseases generally yield more than those with susceptibility to the same diseases (Figure 1). The relationship is most pronounced in central and eastern Kansas where diseases are more common. The disease resistance index can also be used to identify which wheat varieties are most likely to provide a profitable yield response to fungicide application.

Selecting Varieties from Different Genetic Backgrounds

Maintaining diversity in the wheat varieties that are grown on a farming operation may also reduce the risk that any one factor (freeze, drought, disease) will negatively impact the entire farm. In this analysis we are grouping some the most common wheat varieties in Kansas based on pedigree information that is available in the reference book "Wheat Varieties for Kansas and the Great Plains, 2011". These results suggest that most wheat varieties could be grouped into three general pedigree categories: 1) Jagger, 2) Pioneer, and 3) TAM (Figure 2). A fourth group can be added to represent varieties that do not fall into the previous categories.

Figure 1. Relationship of wheat yield to a disease resistance index

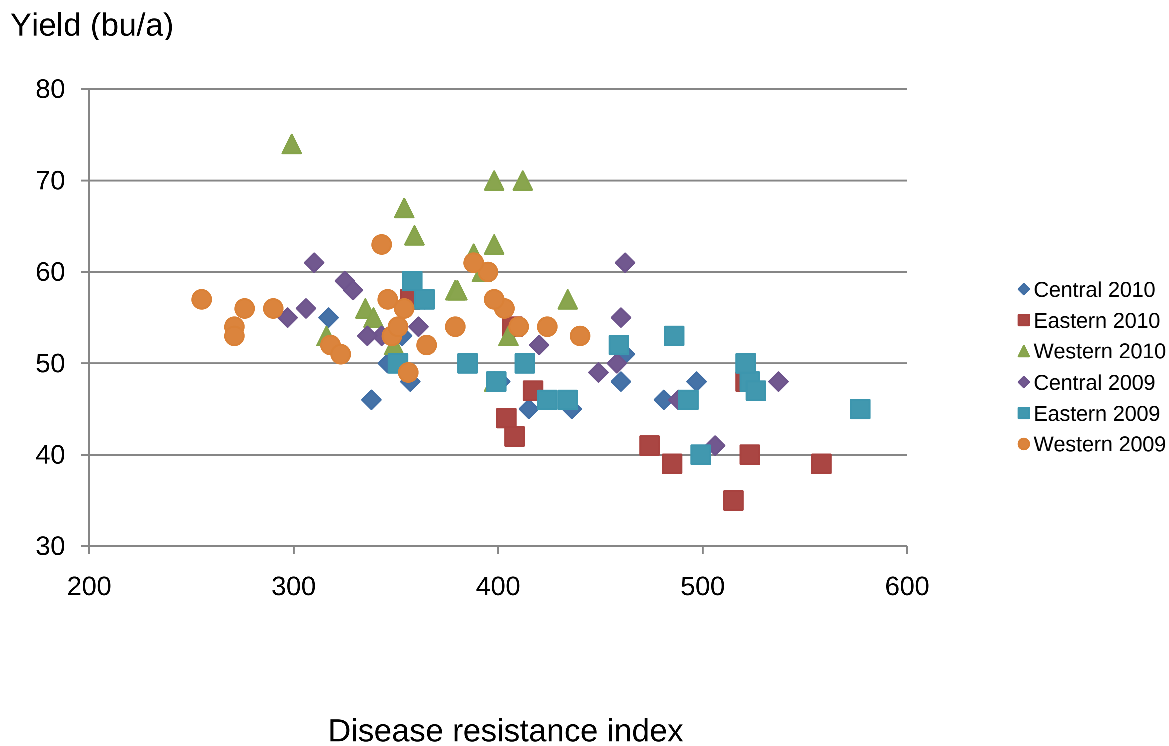

Figure 2. Grouping of wheat varieties based on evaluation of breeding pedigree

Jagger Art Danby Fuller Hitch PostRock Santa Fe Smoky Hill	**Pioneer** Armour Everest Endurance Duster
TAM 107 TAM 111 TAM 112 T81 T158	**Other** Hatcher Bill Brown Aspen Winterhawk

The Dakota Lakes Project Overview

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We normally like to think we work on developing "Profitable No-till Systems Designed for Producers in the North American Great Plains and Prairies" instead of using a term like "Conservation Farming on the North American Great Plains and Prairies". On the surface there does not appear to be a great deal of difference between these. The geographic region of interest is the same. Both imply that farming practices are the focus. However one uses the words "Conservation Farming". This refers to soil and water conservation. In reality, this needs to be done in order for agriculture to be a renewable industry rather than (as it predominately is now) an extractive industry such as mining, petroleum, etc. Conserving soil and water resources should be a primary goal for every producer. However, the present economic system does not directly reward a farmer for conserving the soil and water with which he works. In fact with numerous "conservation farming" techniques the opposite occurs. The producer is often faced with the decision whether to conserve the resource or maximize profit. If he doesn't do the latter, someone else will be farming his land in the future; mining the soil that he conserved. For this reason, conservation **cannot be the only goal**. Maximizing short-term profitability also cannot be the only goal if a producer hopes to remain (or have his family remain) on the land he farms.

The Dakota Lakes Research Farm has both a research and a production enterprise. The production enterprise must produce sufficient profits to fund a majority of the operational expenses of the research enterprise. For this reason, the first priority of the production enterprise is to be profitable.

This dual enterprise structure was established in 1983 in an attempt to provide an independent source of funding that was less prone to influence by special interests and politics. This required substantial change in what was then a conventional tillage based research operation. Substantial expansion in the amount of land managed was required to provide a sufficient base to operate both a production and a research enterprise. If conventional farming practices were to be used on both the production and research enterprises a large investment in machinery and manpower would be required. This did not appear to be a prudent course. Consequently, it was decided that the production enterprise would be designed to utilize the manpower available and require only minimal investment in new machinery. The plan was to accomplish this through the use of diverse crop rotations. Weak-link analysis indicated that moisture would be a limiting factor for many of the potential rotational crops. Consequently, a key component of this plan was adoption of moisture conserving practices to allow growing of high water use crops in a region where their production was marginal with conventional tillage.

A holistic or systems approach was taken. This meant that component and technique choices were based on evaluation of how that choice would impact other components in the system. It was evident that (in 1983) there was not an adequate amount of knowledge available on the type of farming system needed for this situation. This meant that many of the component choices required to build the system could not be based directly on research data or producer's experience as is commonly done in agriculture. Consequently, many choices were based on fundamental agronomic principles using natural cycles and native vegetation as a guide. Research projects were initiated concurrently to better define components and techniques for areas where knowledge was lacking.

The present operation at the Dakota Lakes Research Farm is substantially different than what was begun in 1983. Only part of this difference is due to technological changes that have occurred in the last 17 years. A majority of the difference stems from developing a better understanding of what happens when crops are grown in a manner which places heavy emphasis on developing a healthy and biologically active soil ecology and uses cultural practices (rotation, sanitation, competition) as the primary methods of pest control.

An example of this philosophy sees weed problems as a symptom that the farming system does not contain sufficient diversity (the weed is Mother Nature's way of trying to add diversity). With conventional thinking attempts would be made to control this weed with herbicides or tillage. The systems approach adds a crop to provide the diversity that was lacking. With this philosophy, attempts are made at preventing problems by addressing the cause rather than merely treating the symptoms as they appear.

Many of the farmer practitioners of this technique refer to accepting this approach as having a "brain transplant" since it requires developing new skills and a different attitude. Most important among these is the need to realize that to be sustainable and profitable on a long-term basis the farming system must be designed such that natural cycles and principles become an ally rather than an enemy. Inputs such as fertilizers or pesticides then become methods to augment or initiate natural cycles rather than being tools designed to stop processes that are natural.

Tillage selection is a primary example of this different approach. In natural systems, **tillage is a catastrophic event** (associated with glaciers, erosion, volcanoes, etc.) that occurs only rarely. Both macro and micro fauna are profoundly impacted. Soil dwelling specie are disrupted to an even greater degree than those that can migrate to more suitable habitat. With frequent and repeated tillage, the soil ecology becomes predominated by species that require tillage in order for residue and nutrient cycling to occur. Since tillage generally occurs prior to plant growth being initiated, nutrients have been placed in a mobile form before they are needed, making them vulnerable to loss. If tillage is not performed, lack of aeration (caused by the poor soil structure that results from repeated tillage) causes nutrient cycling and crop growth problems. In undisturbed natural systems, nutrients and residues are cycled by a complex web of macro (grazing animals, earthworms, mites, spring tails, etc.) and micro (fungi, VAM, bacteria) fauna. In this system, residues are maintained to protect the soil until new plant growth occurs. Canopy conditions created by this new growth allow residue decomposition rates to accelerate.

This residue decomposition releases nutrients for use by the subsequent crop when they are needed. If this system were not properly balanced, the prairies of North America would either be desserts or hay stacks. In farming systems designed to mimic undisturbed natural systems, fertilizers are utilized to replace nutrients exported from the system and are applied in a manner to provide an early competitive advantage to the crop that is to be harvested.

This complex web does not reappear quickly when a soil that has been tilled for a number of years is managed without tillage. The soil structure and organic matter lost during the tillage period does not reappear quickly either. For this reason, initiating low-disturbance techniques requires careful planning in regard to how the transition can be made without sacrificing short-term profitability. Many of the struggles and failures associated with producers adopting low disturbance methods traces to inadequately addressing this issue.

Similar analysis can be performed in relation to the impact tillage choice will have on weed pressure, insects, diseases, etc. Nutrient and residue cycling was chosen to provide an example of the thought processes involved.

The Dakota Lakes Research Farm did not initially choose to use reduced tillage techniques because of the soil and water conservation benefits; or due to the fact that soil health and nutrient cycling would be improved; or for wildlife benefits; or for carbon sequestration potential; or any of the other benefits brought to light in the last 10 to 15 years. The decision was made on the basis of the potentially improved profitability that the moisture conservation and workload spreading characteristics provided. The ultra-low disturbance, diverse crop rotations system that has evolved also owes much to the desire to maximize the utilization efficiency of manpower and machinery resources. It has also resulted in lower pesticide use and higher yield levels than anticipated. It is believed that much of this is due to a better understanding of the use of natural cycles. It is also quite possible that soil health and soil ecology play a much greater role than has been realized in the past.

It is almost certain that no producer will utilize exactly the same system components used at the Dakota Lakes Research Farm. Their physical (soil, climate, etc.) and fiscal (machinery, capital, manpower) resources differ from ours. Their choice of components should reflect these differences. The fact that the basic laws of nature function the same independent of these differences does indicate that the “SYSTEMS” approach successfully used at the Dakota Lakes Research Farm (and more importantly by producers in other parts of the world) may provide insight in potential approaches to be used in developing improved farming systems.

Customizing the “SYSTEM”

The Dakota Lakes Research Farm enterprise presents a good example of how basic principles are used to create systems suited to differing physical resources. At the present time, the operation manages slightly over 1,200 acres of land. Some of this land is classed as a short-grass prairie due to the fact that it has shallow, clay, soils that limit available water holding capacity. Some of the land is short-grass prairie because of sandy soils that limit available water holding capacity. Some land is classed as mixed-grass prairie because the soils have good water holding characteristics. Some of the land is irrigated. This removes water availability as a primary constraint. Some land is close to the headquarters. Other land is as much as 40 miles away and requires moving machinery through the city and across the Missouri River Bridge in order to reach it. Some of this land has over 10 years of no-till history; some has just been acquired. Some has a history of over 50 years of wheat-fallow management with tillage; some has never been tilled (it was brought into production from native sod without tillage). Some land is owned; some land is rented. Differences in addition to these exist as well. It would be unwise to attempt to manage each of these situations with the same components. They are, however, all managed using the same approach to create a system designed to optimize the contribution that property makes to the operation. This approach is based on the application of fundamental agronomic and biological principles. **These principles do not change**.

One of these basic principles is that water utilization intensity must be **proper**. In other words the water use must match the water available. If the system is not sufficiently intense problems such as water logging, saline seep formation, nutrient loss, traffic ability problems, etc. are common. If the system is too intense, poor yields due to water stress or stand establishment problems are likely. Under irrigated conditions at Dakota Lakes the intensity of water use is limited only by the amount of growing season and heat received in the summer and by the availability of capital, manpower, and equipment to pump water from the Missouri River when it is needed. The choice to limit intensity under irrigation therefore is based on fiscal (manpower, equipment costs, energy) resources. On the dryland portion of the operation, intensity of water use is controlled by physical resources (soil type, rainfall, climate, etc.). In both cases, improper intensity results in management problems and less than optimum profitability. No-till management allows (requires) more water use by the crop (transpiration) since less water will be wasted by the direct and indirect impacts of tillage (evaporation and runoff).

Another basic principle is that diversity must be **adequate (appropriate)**. As mentioned before, lack of diversity provides an opportunity for weed and disease organisms to build to harmful levels. The cost of controlling these opportunistic specie and the capability to do so needs to be evaluated in each situation as it compares to what can be accomplished by using more diverse crop rotations. Under irrigated conditions at the Dakota Lakes Research Farm, corn (field and popcorn) and beans (edible and soybean) are the crops capable of returning the most increase in yields from the fixed costs associated with the irrigation development. If all acres were devoted only to these crops much of this increase would be offset by increased variable costs (pesticides), reduced efficiency in use of fixed machinery resources, and reduced yields. In addition, energy costs would rise on both a per acre and per unit of production basis. Some of this is caused by lower yields but most is due to a reduction in electricity price if the supplier is allowed to control (turn off) the irrigation pumps during periods of peak electrical demand. By devoting part of the acreage to rotational crops which do not share the same peak water use characteristics as corn and beans this can be done without limiting the ability to supply all crops with their full water needs. Consequently, on the irrigated portion of the operation, adding diversity has more impact in reducing variable costs than on reducing fixed costs although both are benefited. Conversely, on the dryland portion of the operation adding diversity provides the most benefit to reducing fixed costs (land, family labor, and machinery) per unit of production (not necessarily per acre). Variable costs are also reduced dramatically (especially pesticide inputs) once the system is in place and working properly. This may not be true during transition periods. Seed and fertilizer costs change very little on a per unit of production basis.

The bottom line of this approach is to view each farming operation as unique. The goal is to optimize the utilization of the resources (land, labor, capital, and machinery) available to that operation in a profitable and environmentally compatible manner. This requires devising a unique system for each operation, owner, parcel of land (and even portions of a piece of property), etc. rather than attempting to devise a farming recipe that fits all fields of all producers in all situations.

Common Characteristics

This is not meant to imply that there are no common characteristics amongst the most successful no-till systems being used at Dakota Lakes and by real producers throughout the plains and prairies. Foremost among these is the inclusion of three or four crop types (cool-season grass, cool-season broadleaf, warm-season grass, and warm-season broadleaf) in the rotations used. Where cool-season crops are traditionally grown, addition of the warm-season grass component provides more benefit (adds more diversity) that adding a warm-season broadleaf because of the commonality of some diseases (such as white mold) and herbicide programs among warm and cool-season broadleaf crops. Rotations that are not consistent in terms of either **interval or sequence** provide the best protection against species shifts and biotype resistance. In other words rotations such as wheat-canola or wheat-canola-wheat-pea are consistent in both interval and sequence. Wheat always occurs in alternate years and always follows a cool-season broadleaf. Rotations such as s.wheat-w.wheat-pea-corn-millet-sunflower are not consistent in either interval or sequence. Rotations should have crop type to crop type intervals of a minimum of two years somewhere in the rotation. Extended perennial phases (grass seed, alfalfa) minimize agronomic problems associated with the low diversity rotations in the annual cropping portion of the rotation. This approach is useful in some situations but does not normally lead to optimization of machinery and labor resources. Perennial sequences are an excellent way to “jump start” the system. Another trend that is obvious especially in the Dakotas, Kansas, Nebraska, and Colorado is a move to the use of lower disturbance techniques as rotations improve. This trend is stymied at times by limited choices in seeders that have the capability to properly place fertilizer while accurately seeding with low-disturbance. Dormant seeding of spring cereals (especially wheat) has become a predominant practice for many producers. This technique shifts workload from the busiest time of the year to a less busy time. When this is properly done, benefits for many operations far outweigh the risks. Dormant seeding of canola is not as well proven and consequently is not as widely employed.

Producers in higher rainfall areas and those with irrigation are beginning to utilize cover crops as a means of adding diversity and intensity to their systems.

Wrapping it up

Soil and water conservation are a consequence or side benefit of utilizing properly designed no-till systems. Sustainable profitability must be the primary goal in order to assure that conservation continues long-term. The best systems attempt to mimic native vegetation in terms of intensity (water use) and employ as much diversity as needed to optimize the system. Each resource (land, machinery, labor, etc.) is managed to optimize its contribution to the operation without overtaxing its capability. More in depth information on these subjects can be found at the dakotalakes.com web site and related pages. Of specific interest would be “No-Till Guidelines for the Arid and Semi-arid Prairies”.

An Emphasis on Rotations

Determining what to grow as rotational crop(s) and how they will be sequenced can be a complex process. There are however some general guidelines that can be extremely helpful in beginning the process. Consider this to be Beck's **TOP 10 LIST**. The order they appear does not denote their importance.

1. Reduced and no-till systems favor the inclusion of alternative crops. Tilled systems may not.
2. A two season interval between growing a given crop or crop type is preferred. Some broadleaf crops require more time.
3. Chemical fallow is not as effective at breaking weed, disease, and insect cycles as are black fallow, green fallow, or production of a properly chosen crop.
4. Rotations should be sequenced to make it easy to prevent volunteer plants of the previous crop from becoming a weed problem.
5. Producers with livestock enterprises find it less difficult to introduce diversity into rotations.
    a. Use of forage or flexible forage/grain crops and green fallow enhance the ability to tailor rotational intensity.
6. Crops destined for direct human food use pose the highest risk and offer the highest potential returns.
7. The desire to increase diversity and intensity needs to be balanced with profitability.
8. Soil moisture storage is affected by surface residue amounts, inter-crop period, snow catch ability of stubble, rooting depth characteristics, soil characteristics, precipitation patterns, and other factors.
9. Seedbed conditions at the desired seeding time can be controlled through use of crops with differing characteristics in regard to residue color, level, distribution, and architecture.
10. Rotations that are not consistent in either crop sequence or crop interval guard against pest species shifts and minimize the probability of developing resistant, tolerant, or adapted pest species

Classification of Rotation Types

It is sometimes easier to discuss concepts if they are placed into categories of some sort. We have developed the following scheme with this in mind. This classification is totally arbitrary and is meant to serve only as a tool to help understand rotation planning.

SIMPLE ROTATIONS: Rotations with only one crop of each crop type used in a set sequence. This is the most common type.

EXAMPLES: Winter Wheat-Corn-Fallow; Wheat-Canola;
S. Wheat-W. Wheat-Corn-Sunflower; Corn-Soybean; Winter Wheat-Corn-Pea

ADVANTAGES: Simple-limited number of crops to manage and market.

DISADVANTAGES: Limited number of crop sequence/interval combinations. All corn is sequenced behind wheat or all winter wheat goes into spring wheat.stubble.
In other words this style is consistent in both sequence and interval. Conditions for each crop are the same an all of the acreage.

SIMPLE ROTATIONS WITH PERENNIAL SEQUENCES: Simple rotations that are diversified by adding a sequence of numerous years of a perennial crop.

EXAMPLES: C-Sb-C-Sb-C-Sb-Alf-Alf-Alf-Alf and many others.

ADVANTAGES: Simple. Limited number of annual crops to manage and market. The perennial crop is an excellent place to spread manure. Perennial crops probably can produce more soil structure than annual crops. This is especially true when grass or grass mixtures are the perennial crop**.** Biomass crops and use of grazing systems have potential.

DISADVANTAGES: It is difficult to manage a sufficient percentage of the farming enterprise as a perennial crop without grazing. Harvesting 40% of the farmland as forage is tough. Using less than 40% perennial crop minimizes its impact)
Marketing perennial crop is an issue.

For instance: If the producer could only harvest 400 acres of alfalfa in a timely manner with the machinery and labor resources available, he would be limited to having 300 acres of each corn and soybeans in the above rotation. If he expanded his corn and soybean acreage more than this, the rotational benefit of the alfalfa sequence would be negated on the extra acreage. If he had 400 acres of alfalfa and 1000 acres each of each corn and soybeans (leaving the alfalfa for 4 years), alfalfa would be placed on any given field only one time in a 24-year period. He would in essence have 6 years of corn-soybean in a perennial sequence rotation and 14 years or corn soybeans in a simple rotation. Perennial sequence rotations have substantial benefit when used on fields close to the farmstead or feedlot. A producer could allocate 1,000 acres in proximity to where the forage would be used to a perennial sequence rotation. His remaining acreage could be managed in a more diverse rotation that did not involve perennials. Another option for obtaining a larger percentage of annual crop acres is to combine a more diverse type of rotation and a perennial sequence.

COMPOUND ROTATIONS: Combination of two or more simple rotations in sequence to create a longer more diverse system.

EXAMPLE**:** S. Wheat-W. Wheat-Corn-Soybean-Corn-Soybean.
This results from a combination of the Corn-Soybean and S. Wheat-W. Wheat- Corn-Soybean rotations.

ADVANTAGES: There are still a limited number of crops to manage and market. This approach creates more than one sequence for some crop types. There is diversity in both sequence and crop environment for corn and wheat (not soybeans). Diversity exists in interval for all crops.

DISADVANTAGES: There is a limited ability to spread workload since 1/3 of the acreage is in corn and 1/3 in soybeans.

COMPLEX ROTATIONS: Rotations where crops within the same crop type vary.

EXAMPLE: Barley-W.Wheat-Corn-Sunflower-Sorghum-Soybean or Barley-Canola-Wheat-Pea. This is similar to the example cited for compound rotations. Barley has been substituted for one of the wheat crops; sorghum for one corn; and sunflowers for one soybean.

ADVANTAGE: This type of approach is capable of creating a wide array of crop type x sequence combinations. If the crops are chosen wisely there is substantial ability to spread workload. This approach is effective at combating species-specific pest problems such as cyst nematode in soybeans, blackleg in canola, or corn rootworm in corn. Pests such as white mold that have multiple hosts respond similarly to the way they behave in compound rotations.

DISADVANTAGE: The larger number of crops requires substantial crop management and marketing skill.

STACKED ROTATIONS: One of the less well-known approaches is one we call stacked rotations. This includes rotations where crops or crops within the same crop type are grown in succession (normally twice) followed by a long break.

EXAMPLE: Wheat-Wheat-Corn-Corn-Sb-Sb; Barley-Wheat-Pea-Canola

Stacked Rotation Concepts: This should not be an unfamiliar concept because it is the way that plants sequence in nature. A species predominates a space for a period of time and is succeeded by another species. Eventually (after many such successions) the original species will again occupy the space. The time frame for these “rotations” is much longer than the one usually considered in annual crop production but the principles are the same. Humans tend to operate in a different time frame than other species. Days, hours, and years have a totally different meaning to a bacteria or fungi than they do to a tree. Some species have very fast growth curves, once they are given the opportunity, while others take a long time to build population. Each species has a "survival strategy" designed to increase the chances that it will continue to exist. Humans learned to build shelters, grow food, etc. because we were not the best adapted species at enduring the elements and hunting or gathering. Many annual weeds produce huge numbers of seeds increasing the probability that at least one will survive. Other weeds have seeds that contain a range in dormancy allowing them to fit into environments where all years are not good years. Many disease organisms produce resting bodies that require favorable conditions to exist before they attempt to grow.

The universal survival strategy for all species is genetic diversity. This allows some of them to survive in conditions that eliminate the rest of the population. Some of the offspring of these survivors have this same survival advantage. Consequently individuals with this trait will increase as long as the conditions that favor them continue. They may not have an advantage if conditions change. The main reason agriculture faces issues with resistant weed and insect biotypes is that cropping programs create conditions that favored specific individuals amongst the population and keep these conditions in place long enough, frequent enough, and/or predictably enough to allow that biotype to become the predominate population.

The concept behind stacked rotations (as with some of the other types of rotations as well) is to keep both crop sequence and crop interval diverse. Part of the strategy recognizes the fact that rotations containing only one crop sequence or one interval will eventually select for a species (or a biotype within a species) that suits the particular conditions. In the case of a species biotype, the population will continue to grow and purify as long as the specific conditions remain the same.

It is probably best to provide a few examples. In the Corn Belt and in irrigated areas on the plains in the US, it was at one time common for many growers to produce corn on the same land every year. When this was done, an insect known and the corn rootworm beetle (there are different species with similar habits) would feed on the corn silks and lay eggs at the base of the corn plant. Most of these eggs would hatch the next spring. If corn or other suitable hosts were present, the larvae would feed on the corn roots and cause significant losses. This required use of insecticides on land devoted to continuous corn production. When corn was seeded following soybeans this insect was initially not a problem. Interestingly enough, following a long history of corn-soybean rotation in parts of the Corn Belt corn rootworm beetles have devised two known survival strategies. In western areas an extended diapause biotype has become common and in cases predominate. The majority of the eggs laid by this biotype do not hatch the next spring (when soybeans are seeded) waiting instead for corn to predictably return the second year. In reality, eggs laid by some individuals always had a higher proportion with this tendency. They now predominate the population because the persistent and widespread use of the corn-soybean was consistent in the **interval** between successive corn crops.

This gave this biotype competitive advantage. The second example comes from more eastern areas. This adaptation involves the gravid females migrating to soybean fields to lay their eggs. When these hatch the next spring corn will most likely be there. In this case the biotype was given an advantage because the corn soybean rotation is consistent in **sequence.** A similar adaptation would probably occur if all corn in an area was seeded following wheat.

In the stacked Wheat-Wheat-Corn-Corn-Soybean-Soybean example the sequence for corn and the interval between corn crops is unpredictable in the time frame of an insect. (It looks very predictable to humans). Just as importantly, some of the population with normal habits (feeding on corn, laying eggs in corn, eggs hatching the next spring) has been kept alive due to the corn-corn stack. This will dilute the population of those with aberrant behavior.

The examples given dealt with insects. Examples can just as easily be found using weeds or diseases. The important point to remember is that these shifts in characteristics do not always occur quickly. Species with only one generation per year, may take a decade or two for a biotype with suitable survival strategy to develop into predominance. During this period the producer becomes convinced that he has developed the ultimate crop rotation, found the perfect chemical, etc. for his operation (it has worked for 7 years in a row). Then almost without warning the system fails. Everyone with resistant weed biotypes has witnessed this phenomenon.

The second part of the stacked concept is to have a long break (crop to crop interval) in the rotation. From a diversity standpoint it is better to have a mixture of intervals. To provide maximum protection against pest with short cycles, one of the intervals must be sufficiently long to allow populations of certain diseases or weeds to drop to low levels. Careful study of growth and decay curves demonstrates that "first year" crops on a given piece of land experience few crop specific pest problems. If the crop is planted a second time in succession on this "virgin" site, it does as well or maybe even better. It is only during the third year (or more) that problems begin to appear. These problems often grow very quickly once they establish. The reason this happens is that growth and decay curves for biological systems follow geometric patterns. (Examples: 2, 4, 8, 16, 13, 64 or 1, 10, 100, 1000). Since decay works the same as growth in reverse, a short break is not sufficient to decrease some problems sufficiently. This is especially true if they have survival mechanisms like seed dormancy. The power behind a perennial sequence is the long break. The theory behind stacked rotations is to provide a long break somewhere in the system.

In the "old days" it was common to have a perennial sequence followed by several years of the same crop. When the homesteaders came, that is why they were initially so successful (and the fact that they had a huge no-till history preceding them). In Argentina, it is still common to rotate 7 years of pasture with 7 years of cropping. On rented land this may be 7 years (or less if disease strikes) of continuous soybeans.

Plants develop associated positive biology just as they develop associated negative biology. These associated species can sometimes benefit crops when they are planted in the same field in subsequent years. The most commonly cited example includes VAM; the mycorrhyzal fungi that help crops like corn and sunflowers obtain moisture and nutrients from the soil. It is thought that these organisms might be the reason for corn on corn and sunflower on corn sequences performing better than expected. Another example is the N-fixing rhyzobia bacteria associated with legume crops. Soybeans grown following soybeans are capable of fixing more N because higher rhyzobia populations exist in the soil. The soil is also lower in mineral nitrogen sources since the previous years legume crop scavenged these prior to beginning the fixation process. Part of the theory of stacked rotations involves taking advantage of these positive associations before negative associations can build to harmful levels. There probably are positive associations involving predatory insects as well, but this has not been thoroughly studied.

Still another concept in stacked rotations involves allowing the use of more diverse herbicide programs, specifically those utilizing long-residual compounds. Relatively high rates of atrazine can be used in the first year corn (or sorghum or millet) of a stack since another tolerant crop will follow. This provides the time necessary for the herbicide to degrade before sensitive crops are grown. Similarly, products like Command or Scepter can be used in first year soybeans in areas where these products could not be used in other rotations. A typical herbicide program at Dakota Lakes for a S.Wheat-W.Wheat (double crop forage sorghum-Corn-Corn-Soybean-Soybean rotation (starting following the second crop soybean harvest). Year one Spring Wheat, no burndown followed by Bronate (Buctril M). Year two: winter wheat would have a burndown between spring wheat harvest and winter wheat seeding. No herbicide is normally required in the winter wheat. Two pounds of atrazine would be applied either to the double crop forage sorghum or after it is harvested in the fall. This is dependent on the weeds present. The first year corn usually does not need a burndown but normally receives an early post-emergence application of dicamba. Second year corn receives a traditional program. A GMO like Liberty-Link or Clearfield could be used. We do not use Roundup-ready in this slot at Dakota Lakes. First year soybeans receive a long residual program like Scepter plus Command. Second year soybeans are Roundup Ready. With this program, we have used ALS chemistry once in 6 years, triazines once in 6 years, Roundup Ready once in 6 years (and perhaps a burndown between wheat crops also but this could be paraquat). It is obvious that weeds (viewed from their perspective of time) will find it difficult to develop resistance or tolerance to any of the modes of action employed.

It would be possible to fill several more pages with stacked rotation concepts. I believe most readers will be able to develop these themselves once they begin to think about it. We will conclude with a final example. Recently, I saw an agronomist give what he thought was a negative example of a producer's rotational planning. He stated that the gentleman would seed a particular field to wheat every year until jointed goatgrass pressure became sufficient to preclude wheat. He would then seed it continuously to sorghum until shattercane overwhelmed him. At that point he would seed sunflowers in successive years until white mold became a major problem. At that point he began again with the wheat program. My response was that the producer was at least responding to the natural cycles in his field. It might be better if he anticipated these occurring so that the switch could be made in advance. However, he probably was doing a better job than someone who blindly planted a corn-soybean, wheat-canola-wheat-pea, or wheat-corn-soybean rotation and was surprised when he had to keep changing technology to deal with “new” problems.

ADVANTAGES: Stacked rotations attempt to keep pest populations diverse (confused) through diversity in the sequences and intervals used. Diversity is gained while keeping the number of crops smaller. They allow a mix of long and short residual herbicide programs. This approach can reduce costs and minimizes the chance of tolerance, resistance, and biotype changes.

DISADVANTAGES: Not well tested.   Some crop sequences may not be ideal. Less crops means less workload spreading.

ROTATIONS UTILIZING BOTH STACKED AND NORMAL SEQUENCES:

This approach is a hybrid between stacked rotations and the other types. The idea is to use stacks for the species where it provides the most advantage while avoiding it for other species.   This may be the most powerful rotation type. The key with this and other rotation planning to understand how natural cycles work and uses sequences and intervals to create the type of environments that favor the crops while preventing problems.

Examples include Canola-W.Wheat-Soybean-Corn-Corn and S.Wheat-W.Wheat-Pea-Corn-Millet-Sunflower.

Advantages: Depending on the rotation, either a large or smaller number of crops can be used. It provides many of the advantages of the stacked rotations but can be designed to avoid some potential problems. The spring cereal to winter cereal stack is especially powerful in areas where winter hardiness is an issue.

Disadvantages: There are few disadvantages if the rotations are well designed.

The power of this approach can be demonstrated best by using the examples given. The SW-WW-Pea-Corn-Millet-Sunflower rotation is designed for cool and dry areas. The two cereals in a row follow a 4-year break for cereal. This builds deep soil moisture and surface residue. Winter hardiness of the WW is less of a concern than with other sequences. Peas and other large-seeded, cool-season, legumes perform well in heavy residues. They turn this cool environment to their advantage and transform it into a warm environment for the subsequent corn crop. Peas make this transformation without using the deep moisture needed for the corn. Atrazine can be safely used in the corn year because millet (or corn or forage sorghum) tolerates atrazine. Millet is a low intensity crop that again allows excess moisture to recharge the subsoil. Sunflower is now seeded into a nice environment that has deep moisture most years. Any volunteer millet can be easily controlled. Broadleaf weeds should have been controlled easily in the corn and millet crops. The warm and dry environment left by the sunflowers allows early seeding of the spring cereal crop. Cereal herbicides with longer residual can be used in the spring cereal going to winter wheat than if a broadleaf were to be used the next year. If a producer feels it would be too risky to try to grow spring wheat after sunflower, he can use a less intense broadleaf (flax for instance) or include a green fallow year following the sunflowers.

It is hoped that the above discussion has been helpful. It is meant to be an overview of some rotations strategies that will allow producers and those working with them to better understand the “art” of rotation planning.

The following are some statements concerning rotations:

I have no better chance of designing the best rotation for you than I have of choosing the best spouse for you. There are things in life that you have to do on your own. I can point out some factors you should consider when choosing a rotation.

There is no “BEST” rotation. No one can design a rotation that will work every year under every circumstance. It is a probability game. There are bad rotations that work well for a while. There are good rotations that fail at times due to weather or other uncontrollable factors. Poor gamblers make money at times; good gamblers lose money at times.

Rotations can be designed that work well in dry years but they fail to take advantage of good years. Or even worse, they fail badly in good to wetter than normal years.

Producers with more risk tolerance (financially and psychologically) will be more comfortable with riskier rotations. Properly designed “risky” rotations can make more money in the long run but can result in substantial losses over the short-term.

The best approach to spreading risks is to use more than one rotation (preferably sequentially to make an even longer complex rotation).

Rotations used may differ depending on the soils involved. In other words, some of your land may require a different rotational approach than other land you farm. Some of the reasons for this include inherent soil characteristics, past history, weed spectrum, distance from the farmstead, landlord, etc.

Most farmers are good at designing rotations once they start trying.

The rotations used may have to change as market, soil, climate, and enterprise, conditions change. That is to be expected. When designing a rotation, be thinking of ways you could change it.

Don’t be afraid to ask for advice, but accept no recipes from others. DO YOUR OWN COOKING.

with the **High Plains Sunflower Committee**

Enhancing sunflower production through education, research, and promotion

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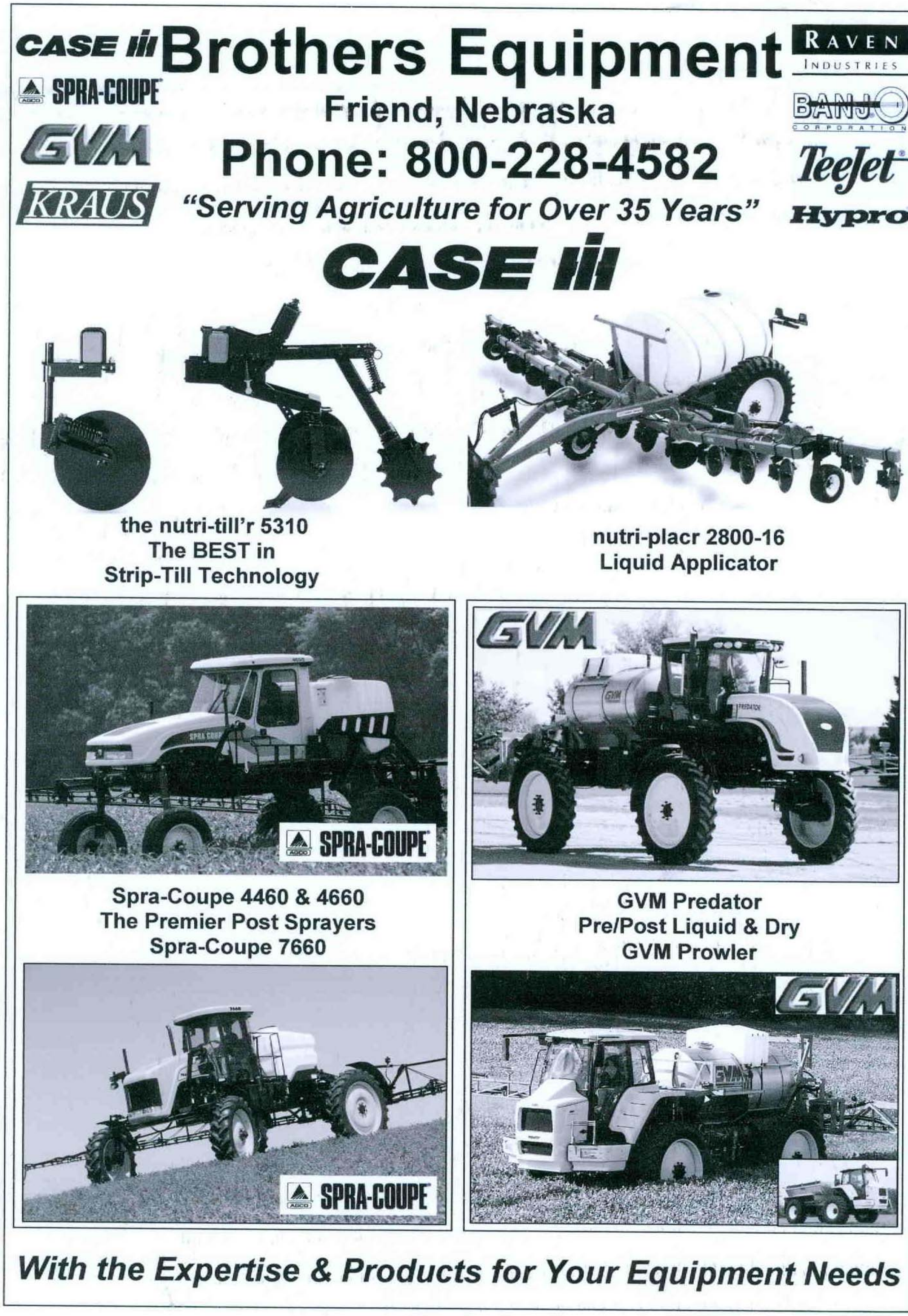
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