Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Best Practices on the Prairies: Adaptations for a changing climate…

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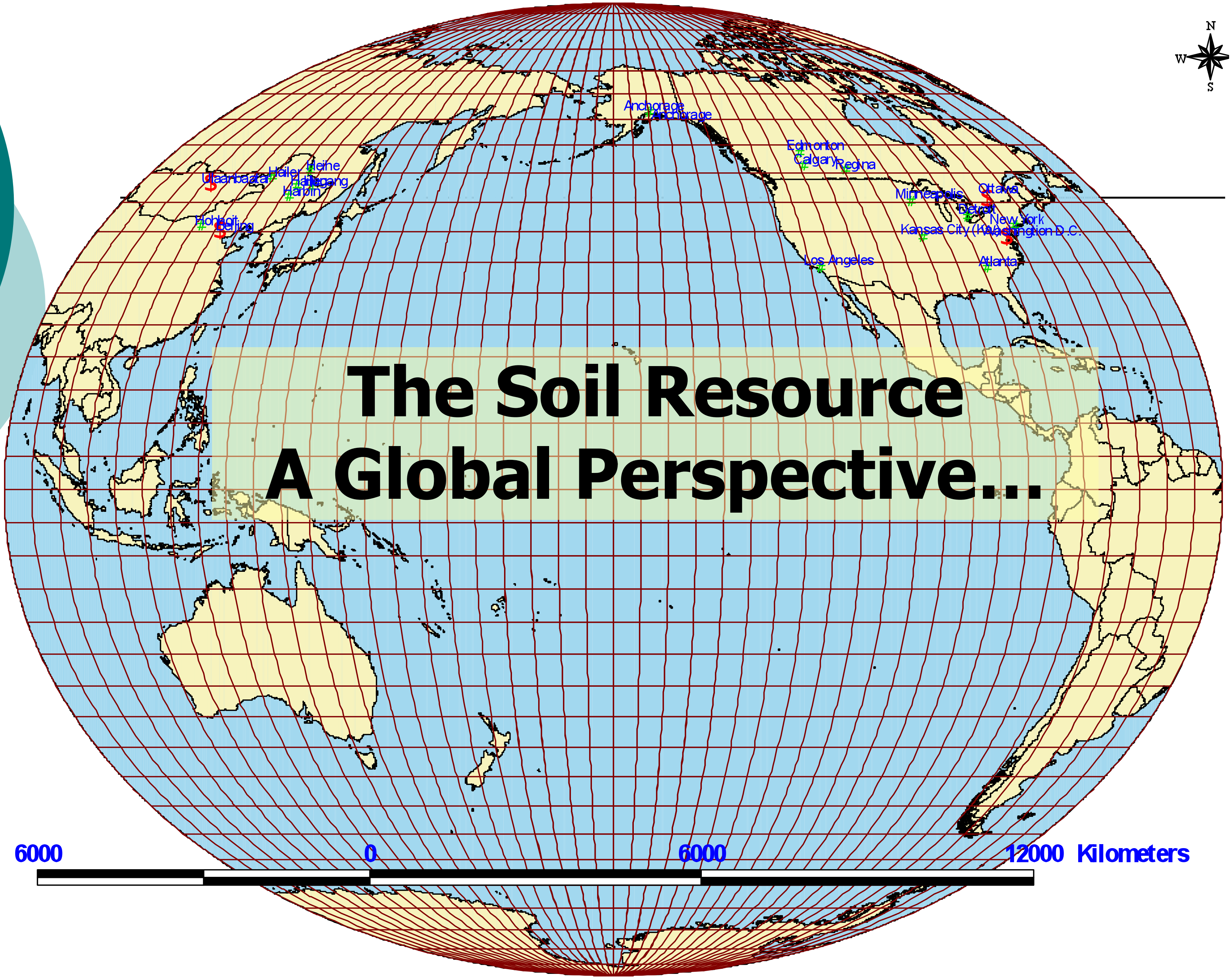
Canada

Outline of Presentation

- **Overview of the Global Soil Resource.**
- **Brief Climate Change Scenarios for the Canadian Prairies.**
- **Best Practices on the Prairies for Adaptation to Climate Change**
- **Going into the future 10 and 20 years from now. How do we proceed?**

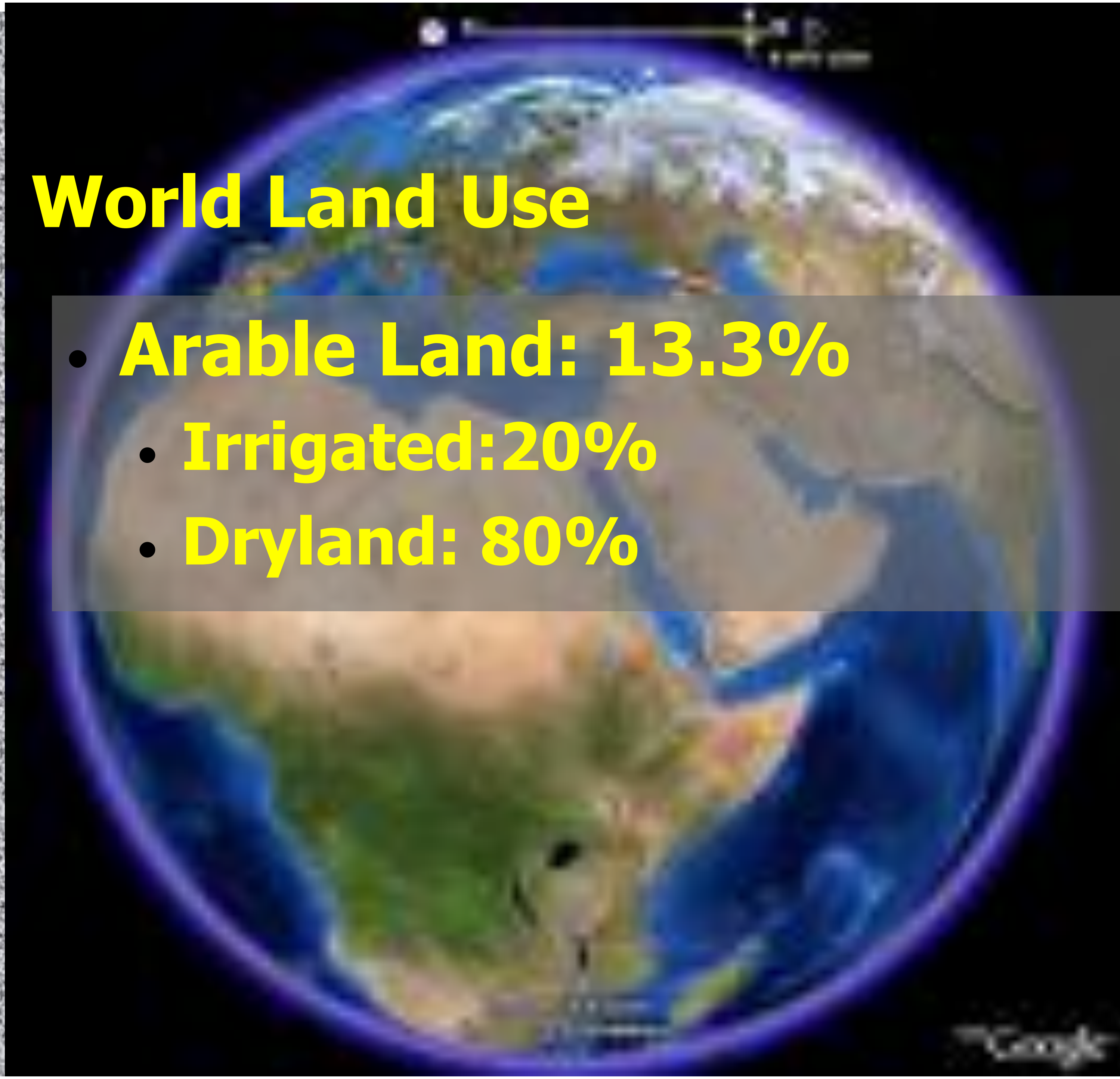
The Soil Resource
A Global Perspective…



Global Surface Area (km^2)

- **World 510.1 M**
- **Land 148.9 M (29%)**
- **Water 361.1 M (71%)**

World Land Use



- **Arable Land: 13.3%**
  - **Irrigated:20%**
  - **Dryland: 80%**


World Fresh Water Use
• Agriculture: 70%
• Industry: 20%
• Domestic: 10%

Global Arable Land Area (acres)

- **Arable Land: 3.339 B**

[Note: B=billion]

World FactBook 2009

Global Arable Land Area (per capita)

- **0.49 acres per person**
- **0.20 ha per person**

World FactBook 2009

Area of Selected Continents

Continent	Arable Land (% Global)	Percent of Global Population	Arable land area per capita (ac)
Asia	31.94	56.7	0.28
N. America	17.09	6.7	1.28
Africa	14.16	14.2	0.50
Europe	11.31	8.8	0.64
Eurasia	10.72	3.2	1.68
S. America	7.88	5.8	0.68
Australia	3.47	0.3	5.51
Middle East	2.40	3.0	0.40

Area of Selected Continents and Countries

Continent	Arable Land (% Global)	Percent of Global Population	Arable land area per capita (ac)
Asia	31.94	56.7	0.28
India	10.7	17.1	0.31
China	10.3	19.8	0.26

Area of Selected Continents and Countries

Continent	Arable Land (% Global)	Percent of Global Population	Arable land area per capita (ac)
Asia	31.94	56.7	0.28
India	10.7	17.1	0.31
China	10.3	19.8	0.26
North America	17.1	6.7	1.3
USA	12.2	4.5	1.3
Canada	3.1	0.5	3.1
Mexico	1.8	1.6	0.55

Continent	% of Global Arable Land	% of Global Population
Asia	31.9	56.7
North America	17.1	6.7
Africa	14.2	14.2
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
South America	7.9	5.8
Australia	3.5	0.3
Middle East	2.4	3.0
Central America/ Carribean	0.9	1.2
Oceania	0.2	0.2

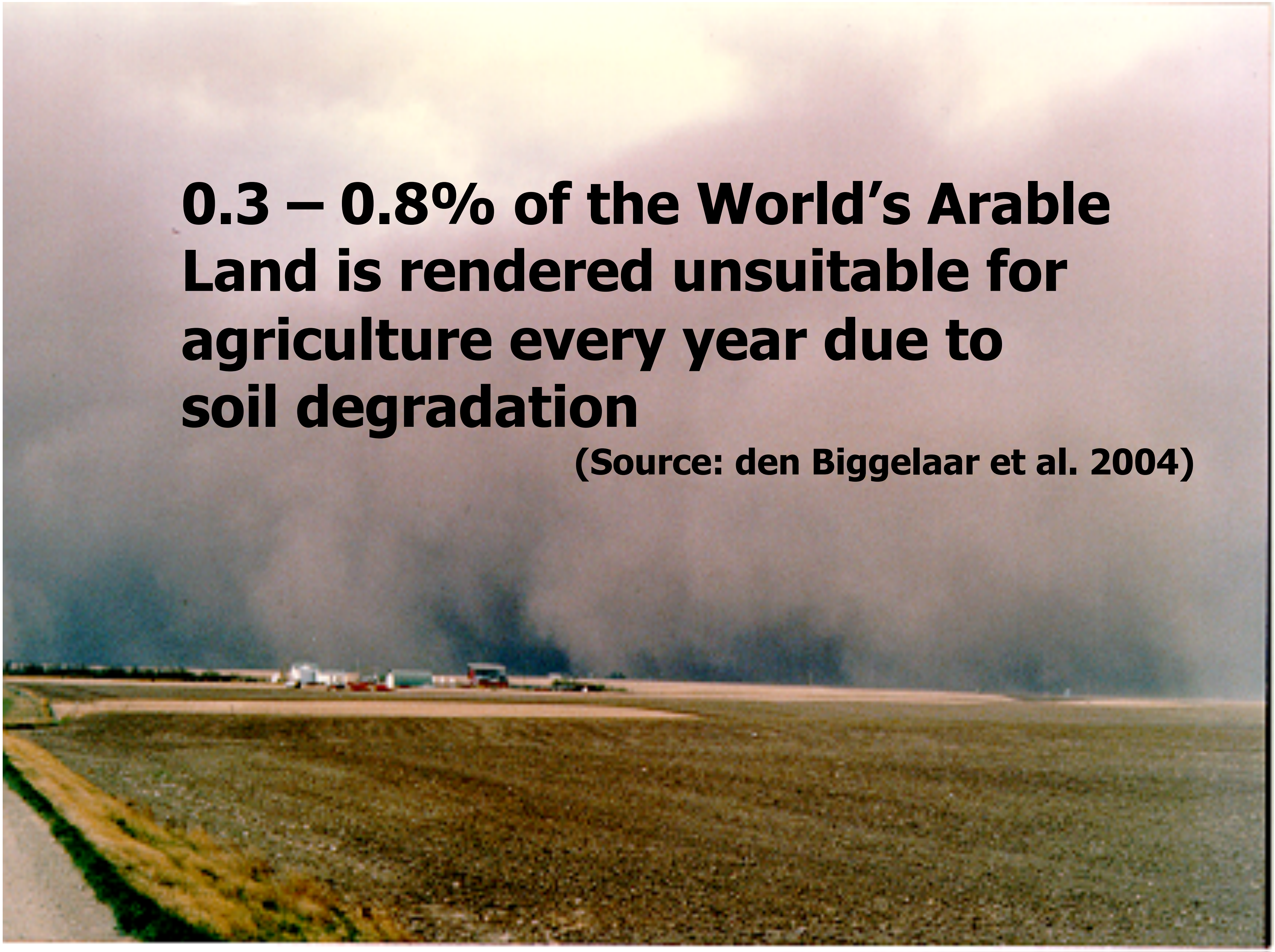
41% of Arable Land **71% of Pop'n**

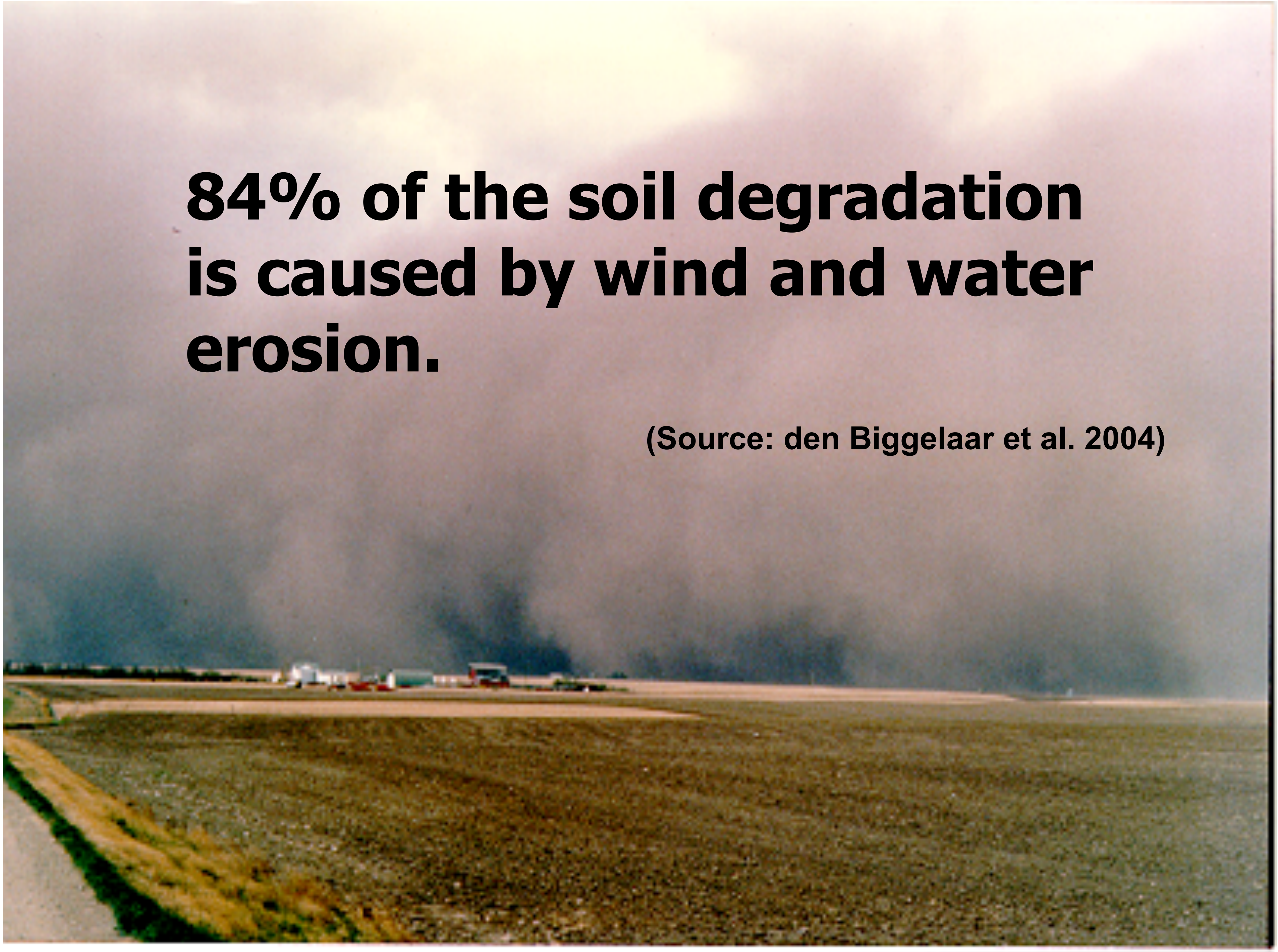
Overall Conclusion about the Global Arable Land Resource

- Arable land is a scarce resource


How well do we manage
our soil resource?


~68% of the world's arable land is affected by some form of soil degradation.
(Source: Lal 2007)


0.3 – 0.8% of the World's Arable Land is rendered unsuitable for agriculture every year due to soil degradation
(Source: den Biggelaar et al. 2004)


84% of the soil degradation is caused by wind and water erosion.
(Source: den Biggelaar et al. 2004)


Since 1950, 15%
of the earth's land area
has been affected by human activity.
(Source: den Biggelaar et al. 2004)

Status of Prairie Soils

- **Prairies soils have lost more than 40% of their original soil organic nitrogen.** **(Source: Soil at Risk…1984)**
- **Urban areas consume 3.5 M acres of land in Canada, equivalent to 1/3 the amount of cultivated land in Manitoba and growing.**

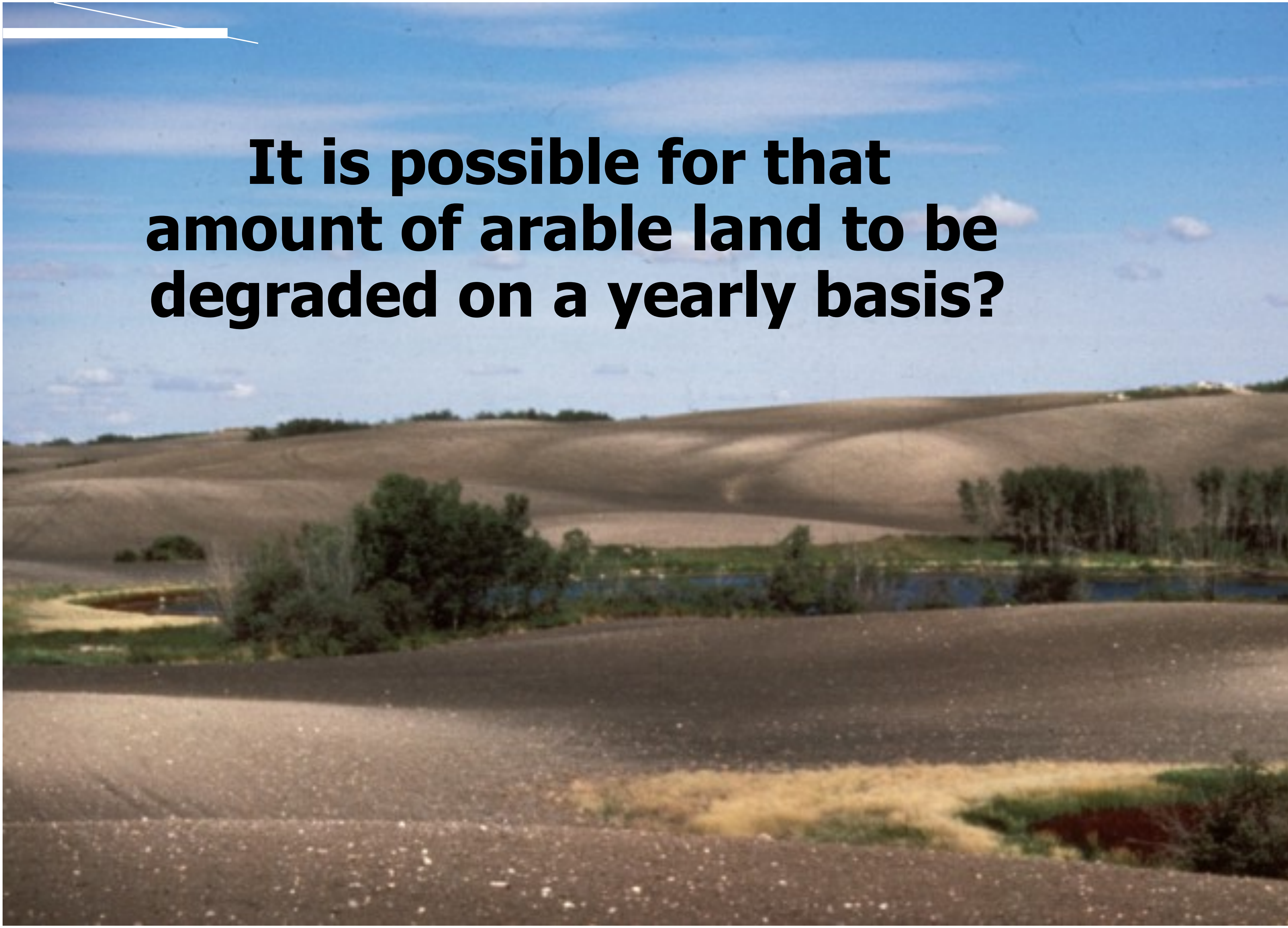
How important is land for food production?

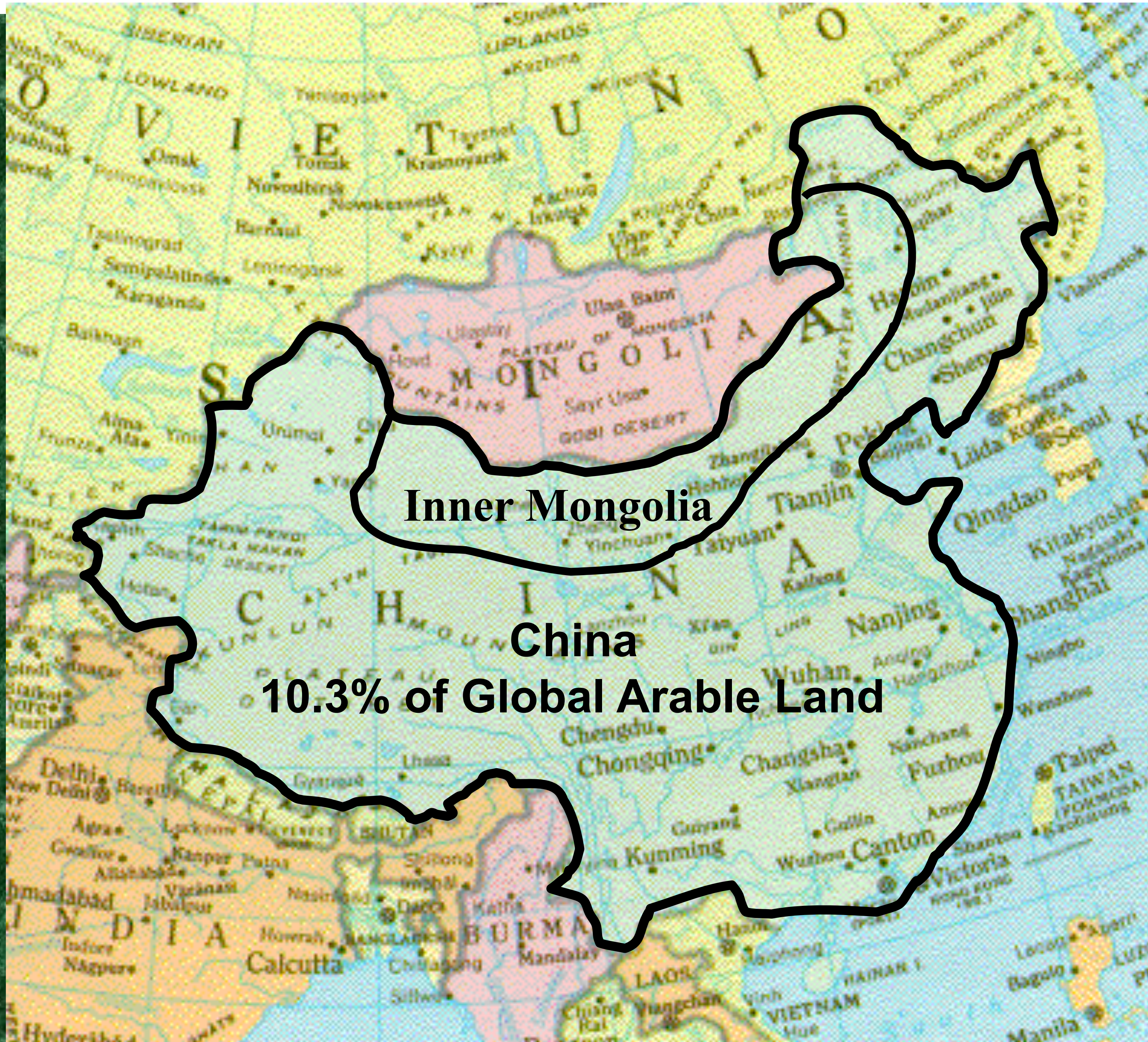

Estimate #1
99% of food consumed by humans world wide comes from the land…
[Pimental and Pimental 2000]


Estimate #2
Global Food Consumption
91% land
9% water
[Smil 2000]

How much is 0.3-0.8% of the global arable land on a relative scale?

- 0.3 % is equivalent to 10.0 M acres
- 0.8 % is equivalent to 26.7 M acres
- Manitoba has 10.3 M cultivated acres
- This represents ~1.0 – 2.6 x the cultivated acres in Manitoba

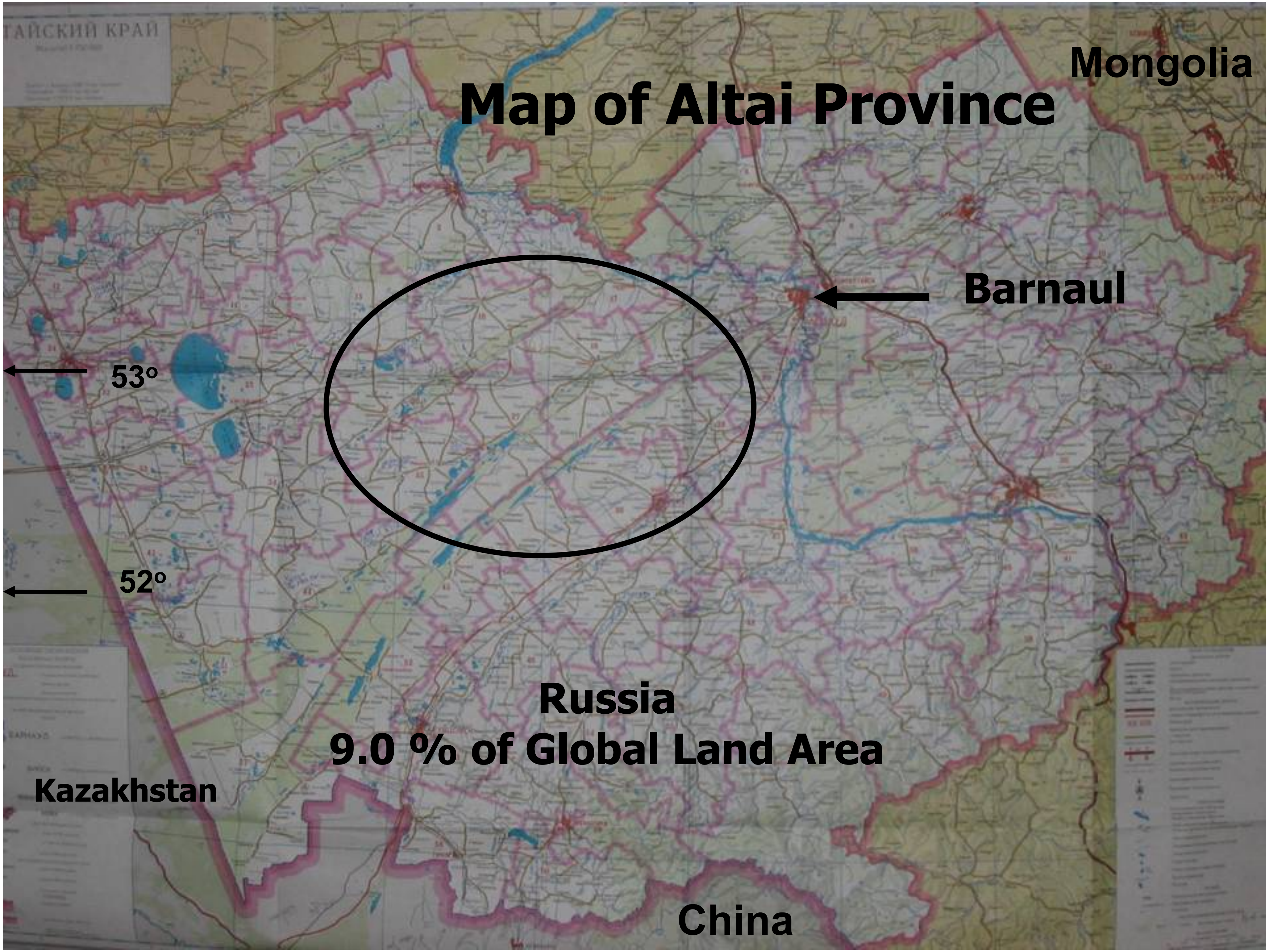

It is possible for that
amount of arable land to be
degraded on a yearly basis?


Inner Mongolia
China
10.3% of Global Arable Land
MONGOLIA
Ulan Bator
GOBI DESERT
Omsk
Novosibirsk
Urumqi
Lhasa
Tianjin
Taiyuan
Nanjing
Wuhan
Chengdu
Chongqing
Changsha
Kunming
Canton
Shanghai
Qingdao
Changchun
Harbin
Taipei
TAIWAN
Seoul
Delhi
New Delhi
Calcutta
BURMA
Mandalay
VIETNAM
Manila


April 2003…

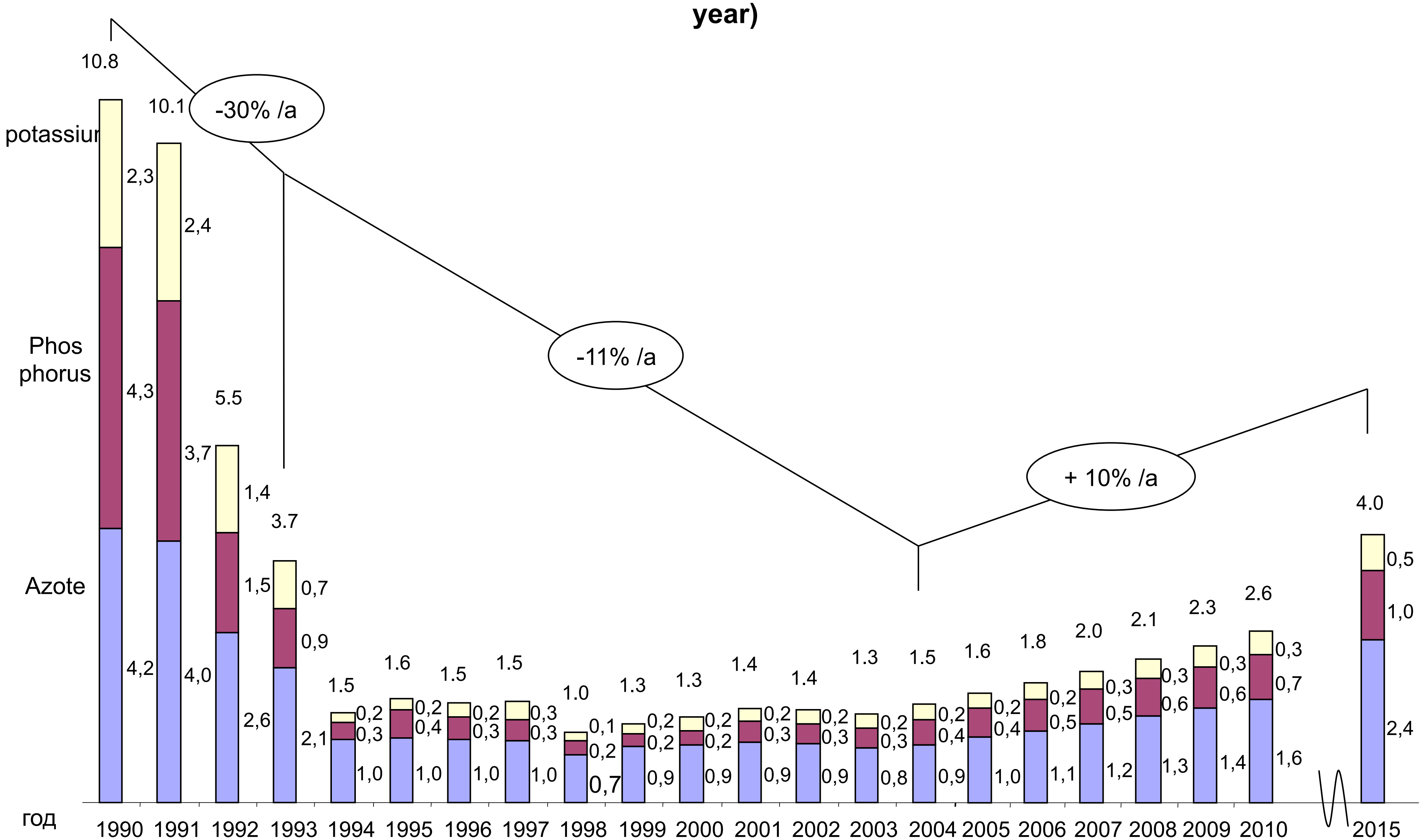

The No-till Dilemma
How can you have no-till with no crop residues?

Another Example
Siberia, Russia


Map of Altai Province
Mongolia
Barnaul
53°
52°
Russia
9.0 % of Global Land Area
Kazakhstan
China

Expected Increase of the mineral fertilizer market in the Russian federation to 2015

Sales Dynamics of mineral fertilizer for the period 1990-2004 and the expected sales to 2015 (in Mio. t./ year)



Источник: МСХ, прогноз ЗАО «МХК «ЕвроХим»


DISCOVER XS

Conclusion
Global Perspective on Soil Resources

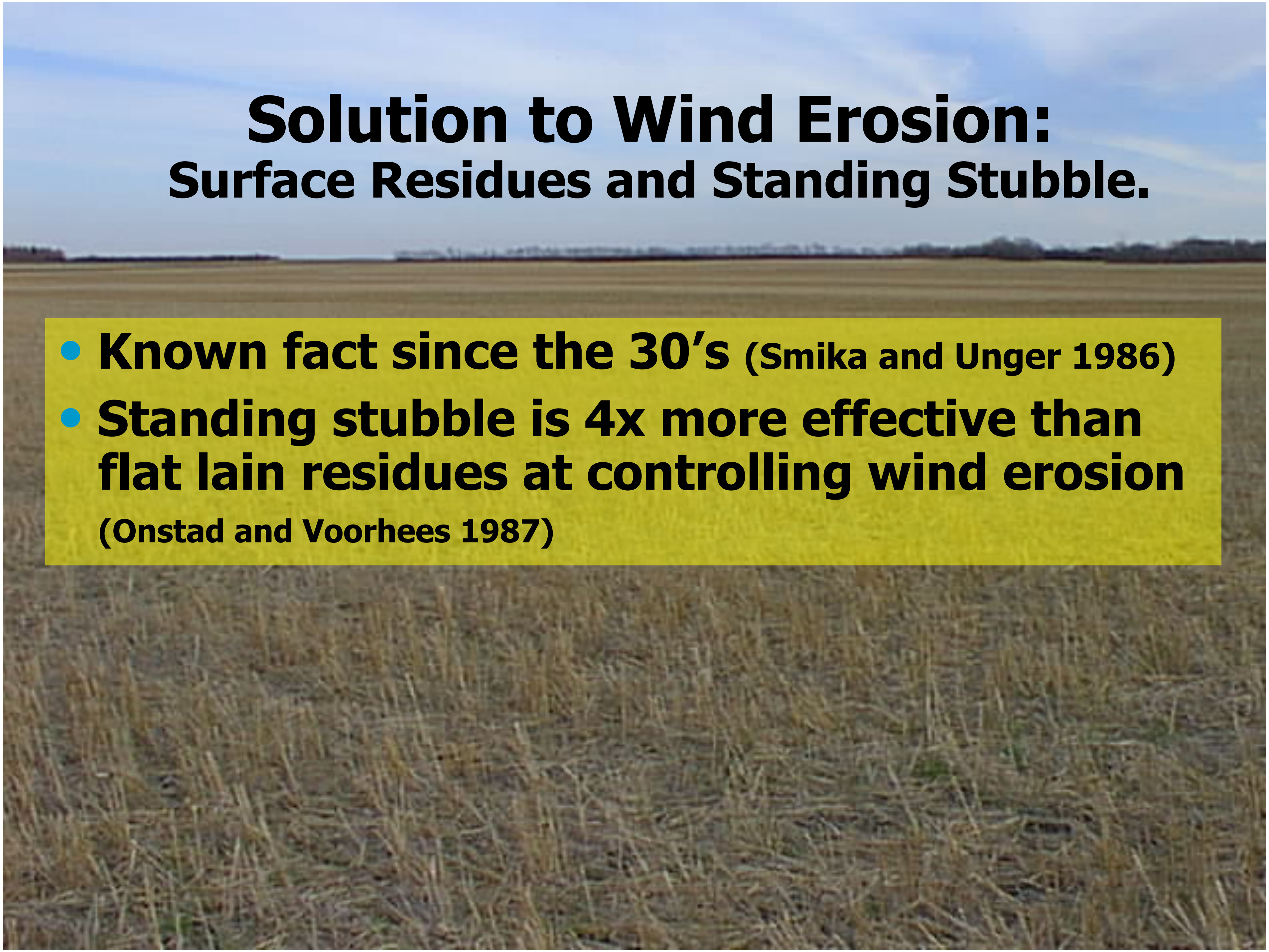
- **We must protect our soil resource at all cost.**
- **World security rests on a secure food supply.**
- **A secure food supply rests on proper management of our soil resource.**
- **Adaptation to climate change starts with focusing on the protection of the soil resource.**


“History makes it clear that sustaining an industrialized civilization will rely as much on soil conservation and stewardship of the land as on technical innovation.”
(*Montgomery 2007 in “Dirt: The erosion of civilization.”*)


If 84% of soil degradation is caused by wind and water erosion, then what is the SOLUTION?

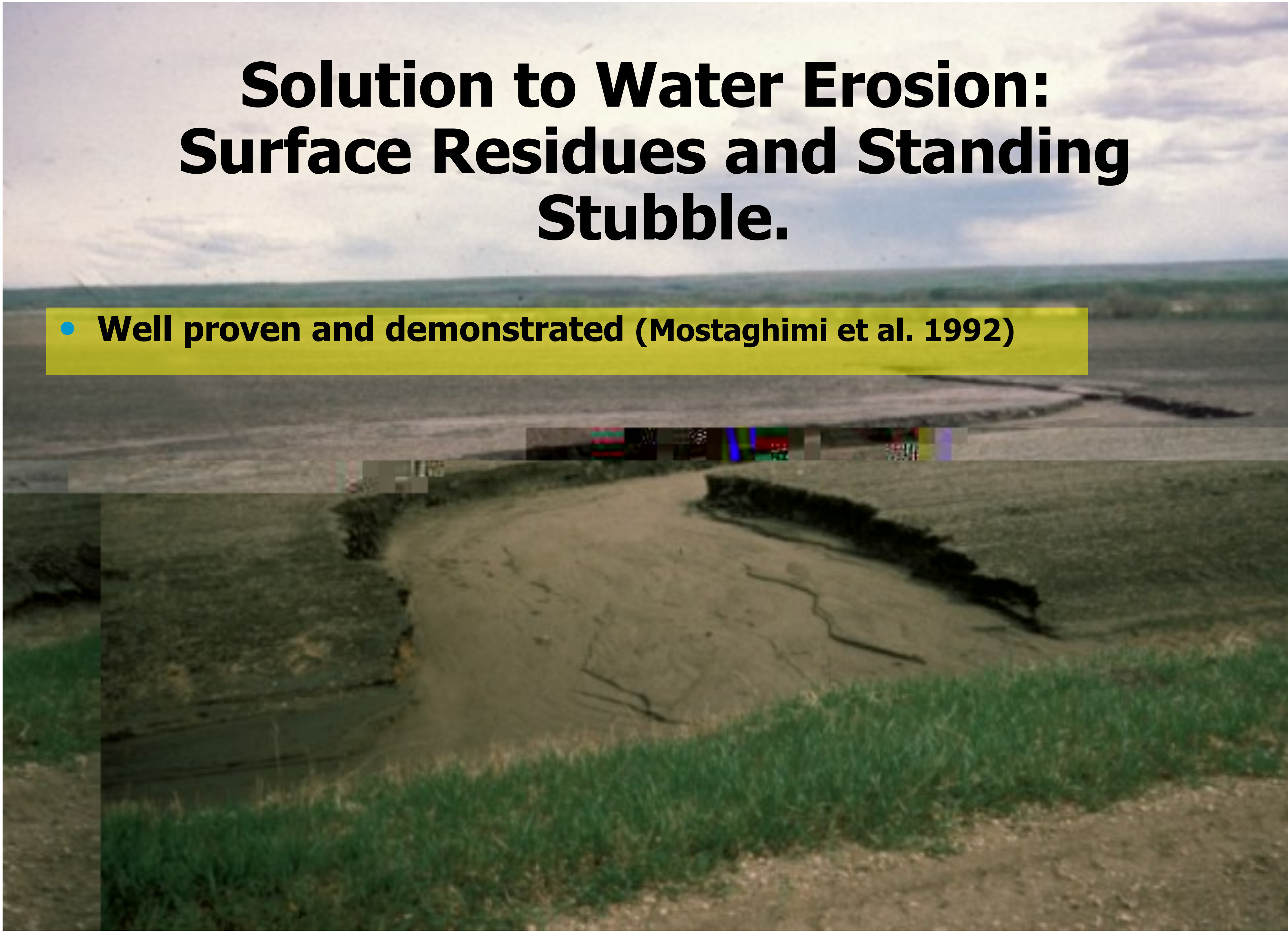
Solution to Wind Erosion:
Surface Residues and Standing Stubble.

- **Known fact since the 30's** (Smika and Unger 1986)
- **Standing stubble is 4x more effective than flat lain residues at controlling wind erosion** (Onstad and Voorhees 1987)



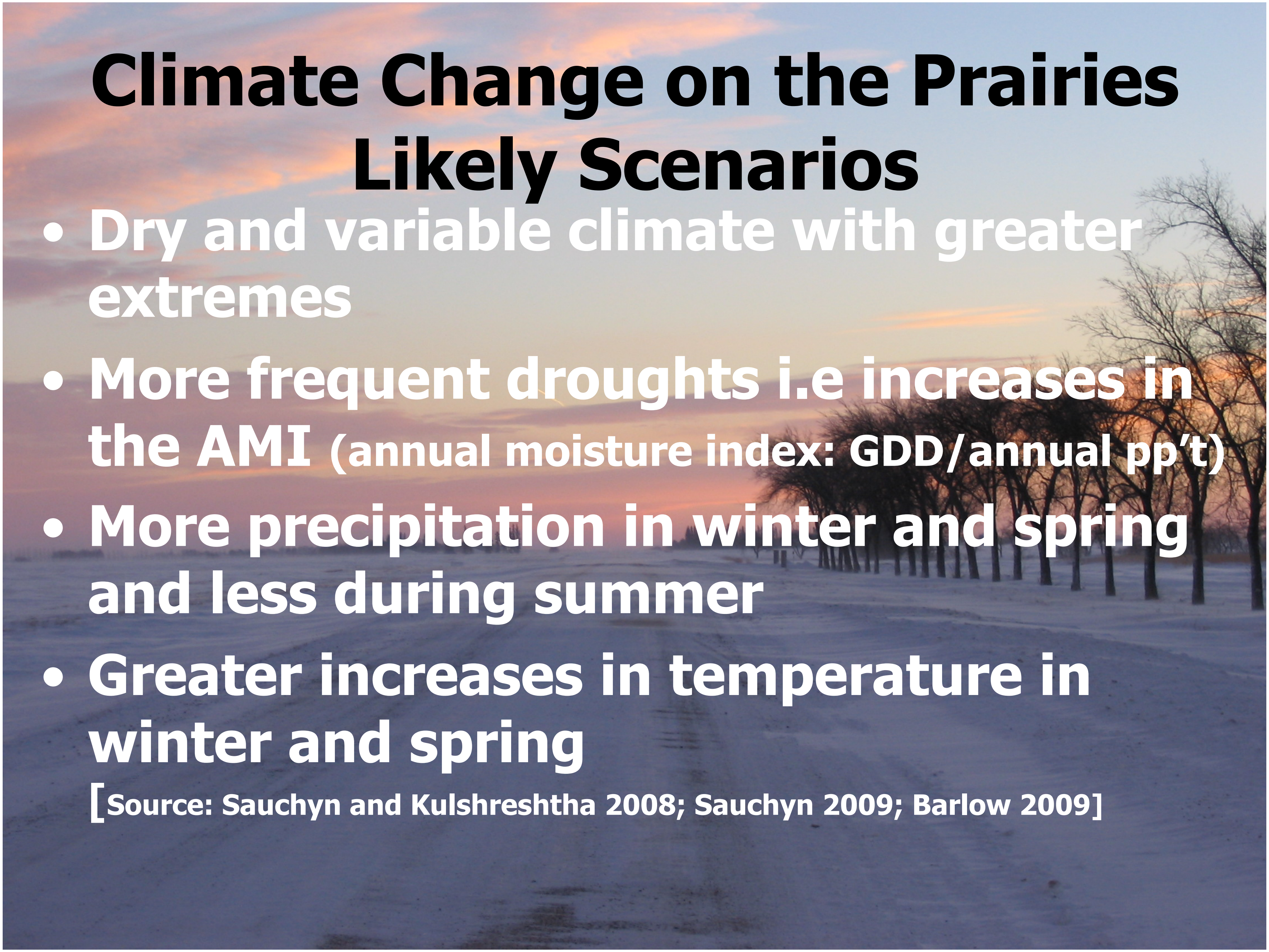
Solution to Water Erosion: Surface Residues and Standing Stubble.

- **Well proven and demonstrated (Mostaghimi et al. 1992)**



World View on Conservation Agriculture (CA)

- **FAO has endorsed conservation agriculture as the key step to meeting the long-term global demand for food and feed.**
- **CA is defined as a farming system that does away with regular plowing and tillage and promotes permanent soil cover and diversified crop rotations to ensure optimal soil health and productivity.** **(Dr Shivaji Pandey, FAO February 2009)**
- **The concept of no-till is now mainstream and has infiltrated the policy area in many countries however we have a long way to go.**


Climate Change on the Prairies
Likely Scenarios
• Dry and variable climate with greater extremes
• More frequent droughts i.e increases in the AMI (annual moisture index: GDD/annual pp't)
• More precipitation in winter and spring and less during summer
• Greater increases in temperature in winter and spring
[Source: Sauchyn and Kulshreshtha 2008; Sauchyn 2009; Barlow 2009]

Implications of Climate Change for Crop Production on the Prairies

- Type of climate variability i.e. year to year variability
- Intra-year variability across the prairies
- Uncertainty and increased economic risks with crop production

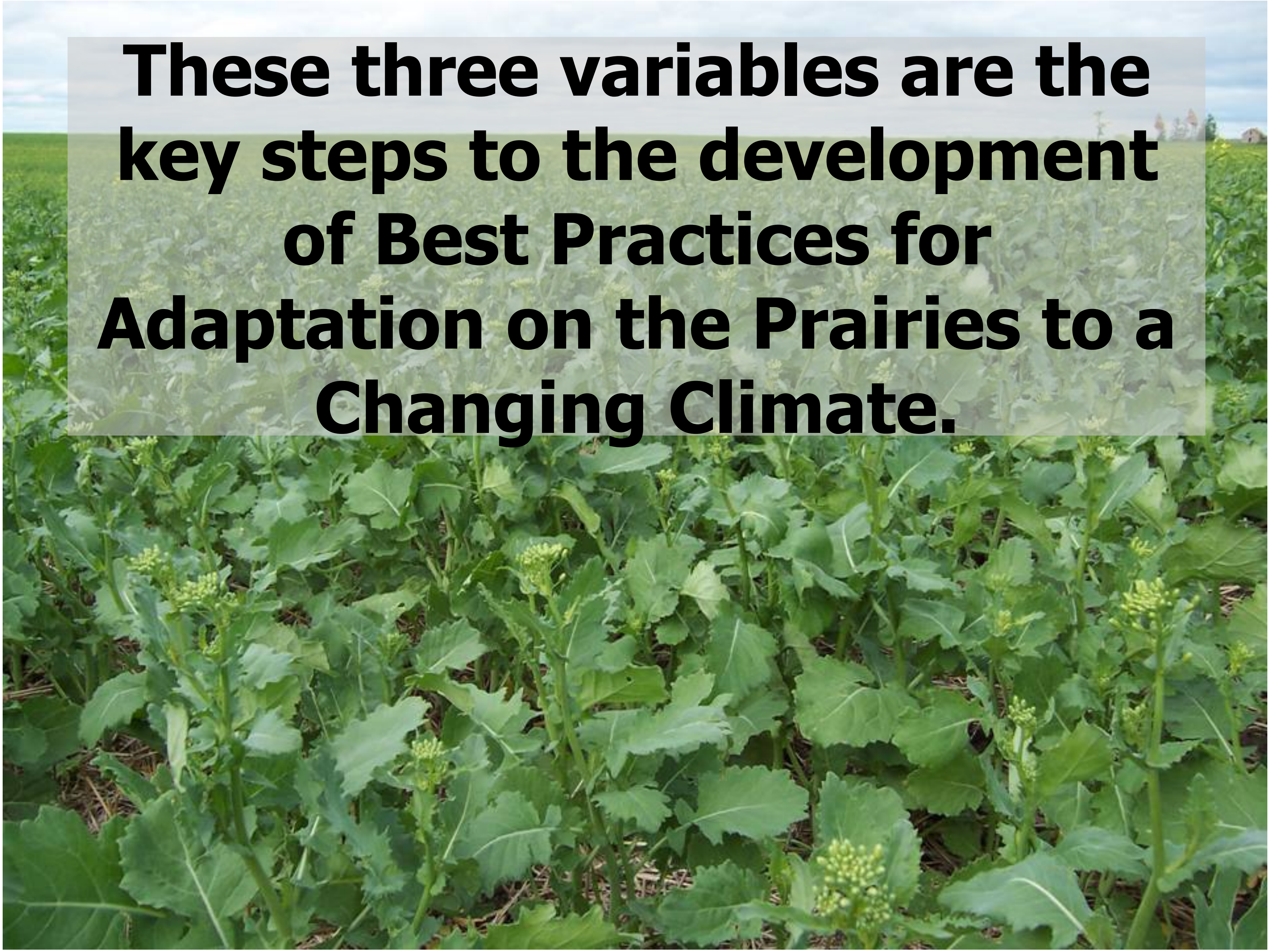
How do we proceed with appropriate Adaptive Strategies for Crop Production?


How do we proceed with
appropriate Adaptive Strategies
for Crop Production?
"Focus diligently on the most important
variables and everything else shall follow".
Avner Mandelman, Globe and Mail Febr 27,2010


What do I see as the most
important variables?

What do I see as the most important variables?

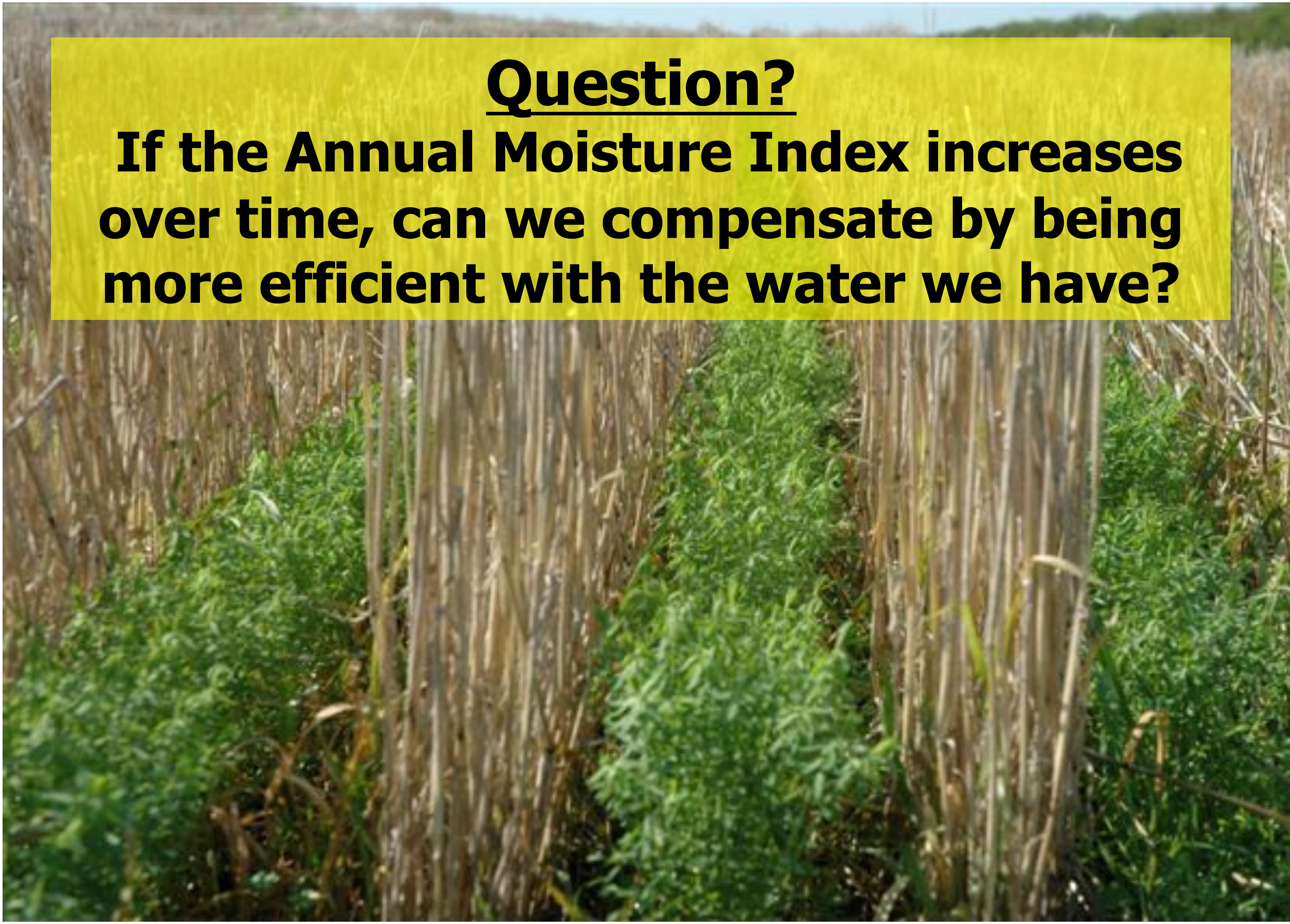
- **Soil, Water and Nitrogen**


These three variables are the key steps to the development of Best Practices for Adaptation on the Prairies to a Changing Climate.


Is there hope for the development of Adaptive Strategies to Climate Change?

Best Practices for a Changing Climate

- <u>**Practice #1:**</u> **Need to protect soils from wind and water erosion using Conservation Agriculture Practices**


Question?
If the Annual Moisture Index increases over time, can we compensate by being more efficient with the water we have?


What is possible?

Innovative
Stubble Management
Practices

30 cm

15cm

Stubble Effects: Spring wheat

Treatments	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Cultivated	309		
Short	314		
Tall	309		
Significance	ns		

Cutforth et al. 1997. Can. J. Plant Sci. 77:359-366

Stubble Effects: Spring wheat

Treatments	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Cultivated	309	2255b (100)	
Short	314	2418ab (107)	
Tall	309	2560a (114)	
Significance	ns	*	

Cutforth et al. 1997. Can. J. Plant Sci. 77:359-366

Stubble Effects: Spring wheat

Treatments	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Cultivated	309	2255b (100)	7.5b (100)
Short	314	2418ab (107)	7.9ab (105)
Tall	309	2560a (114)	8.4a (112)
Significance	ns	*	*

Cutforth et al. 1997. Can. J. Plant Sci. 77:359-366

Stubble Effects: Field Pea, Lentil, Chickpea

Treatment	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Cultivated	246		
Short	242		
Tall	240		
Significance	ns		

Cutforth et al. 2002. Can. J. Plant Sci. 82:681-686

Stubble Effects: Field Pea, Lentil, Chickpea

Treatment	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Cultivated	246	1782 (100)	
Short	242	1858 (104)	
Tall	240	2008 (113)	
Significance	ns	*	

Cutforth and McConkey…

Stubble Effects: Field Pea, Lentil, Chickpea

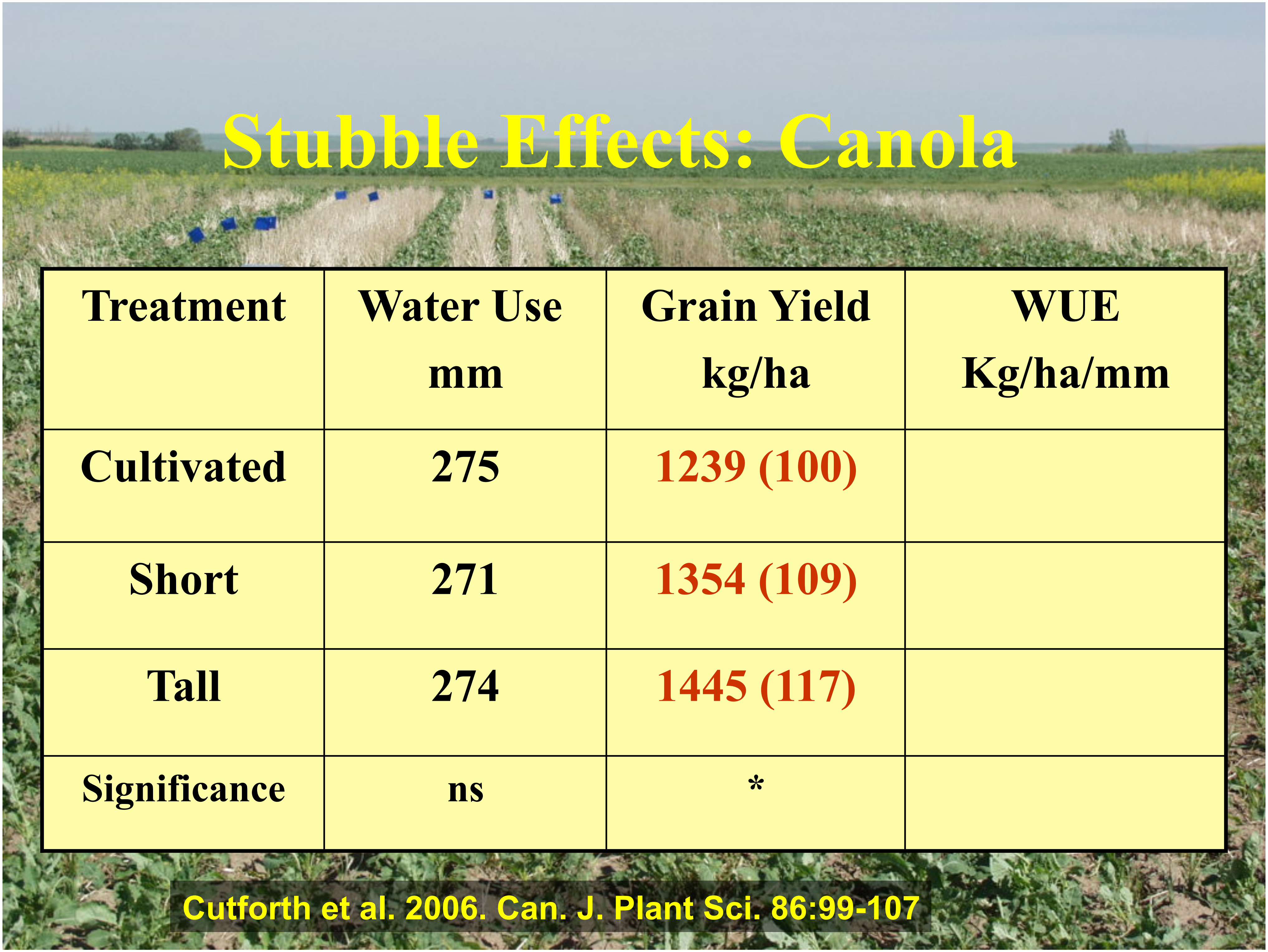
Treatment	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Cultivated	246	1782 (100)	7.49 (100)
Short	242	1858 (104)	8.06 (108)
Tall	240	2008 (113)	8.70 (116)
Significance	ns	*	*

Cutforth and McConkey…

Stubble Effects: Canola

Treatment	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Cultivated	275		
Short	271		
Tall	274		
Significance	ns		

Cutforth et al. 2006. Can. J. Plant Sci. 86:99-107



Stubble Effects: Canola

Treatment	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Cultivated	275	1239 (100)	
Short	271	1354 (109)	
Tall	274	1445 (117)	
Significance	ns	*	

Cutforth et al. 2006. Can. J. Plant Sci. 86:99-107

Stubble Effects: Canola

Treatment	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Cultivated	275	1239 (100)	4.51 (100)
Short	271	1354 (109)	4.85 (108)
Tall	274	1445 (117)	5.03 (112)
Significance	ns	*	*

Cutforth et al. 2006. Can. J. Plant Sci. 86:99-107

Stubble Effects: Canola

Treatment	Water Use mm	Grain Yield kg/ha	WUE Kg/ha/mm
Tall	274	1445 (117)	5.0 (112)
Tall + extra fertilizer	286	1680 (135)	5.8 (129)

Cutforth et al. 2006. Can. J. Plant Sci. 86:99-107


Where do we go from here?

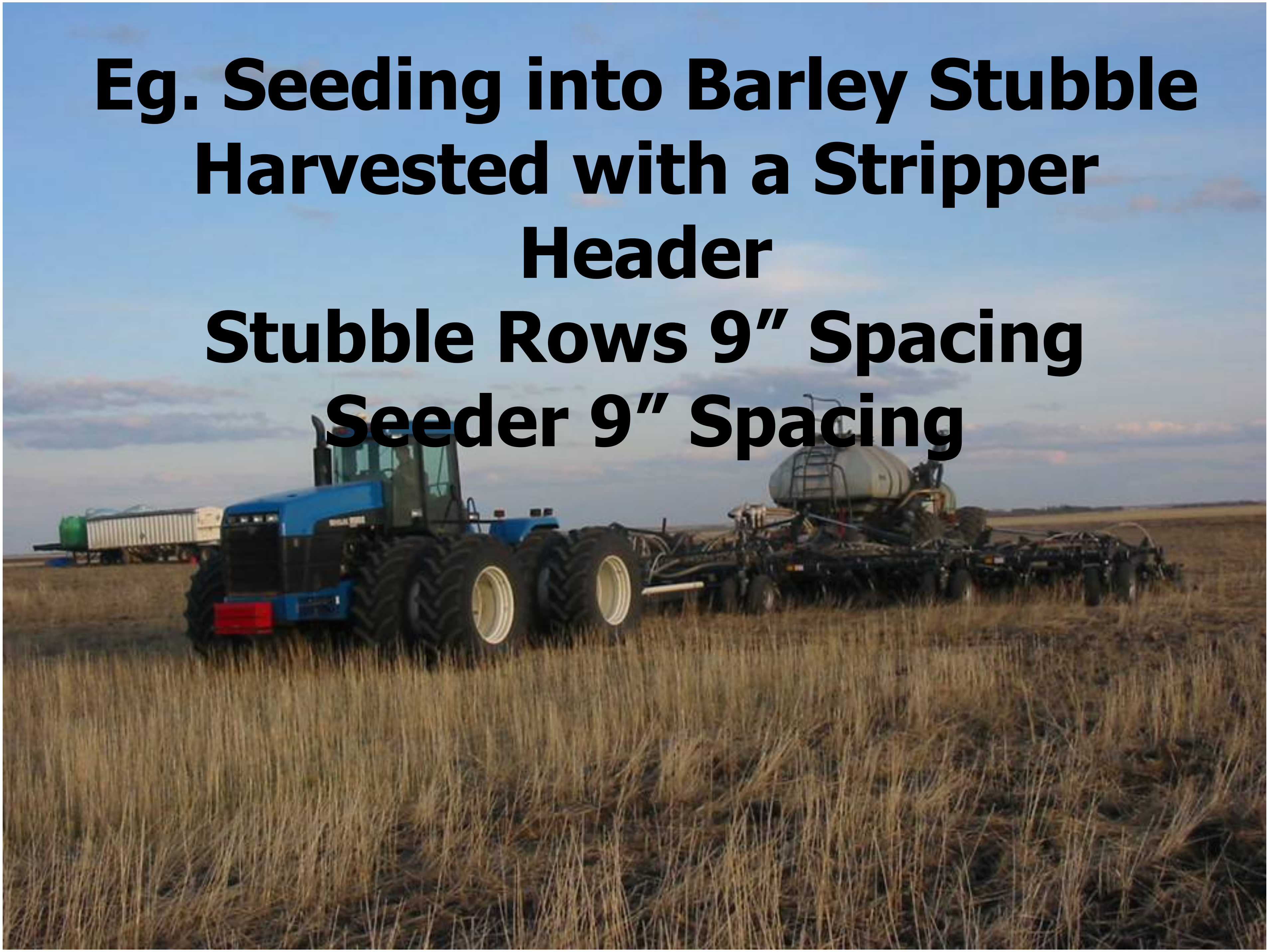
We now know that tall stubble will enhance water use efficiency.

Opens up Greater Opportunities for different harvest management techniques
eg, Stripper Headers

Proper incorporation of stripper header in a cropping systems is dependent on being able to seed between the rows.


Added benefit of Stripper Headers:
Reduction in fuel consumption
i.e 40-50% reduction.

How difficult is it to seed between the rows?


Eg. Seeding into Barley Stubble
Harvested with a Stripper
Header
Stubble Rows 9” Spacing
Seeder 9” Spacing

This is what happens when you leave the inter-row area


Seeding between the rows successfully


Almost there!!!

What is needed for implementation?

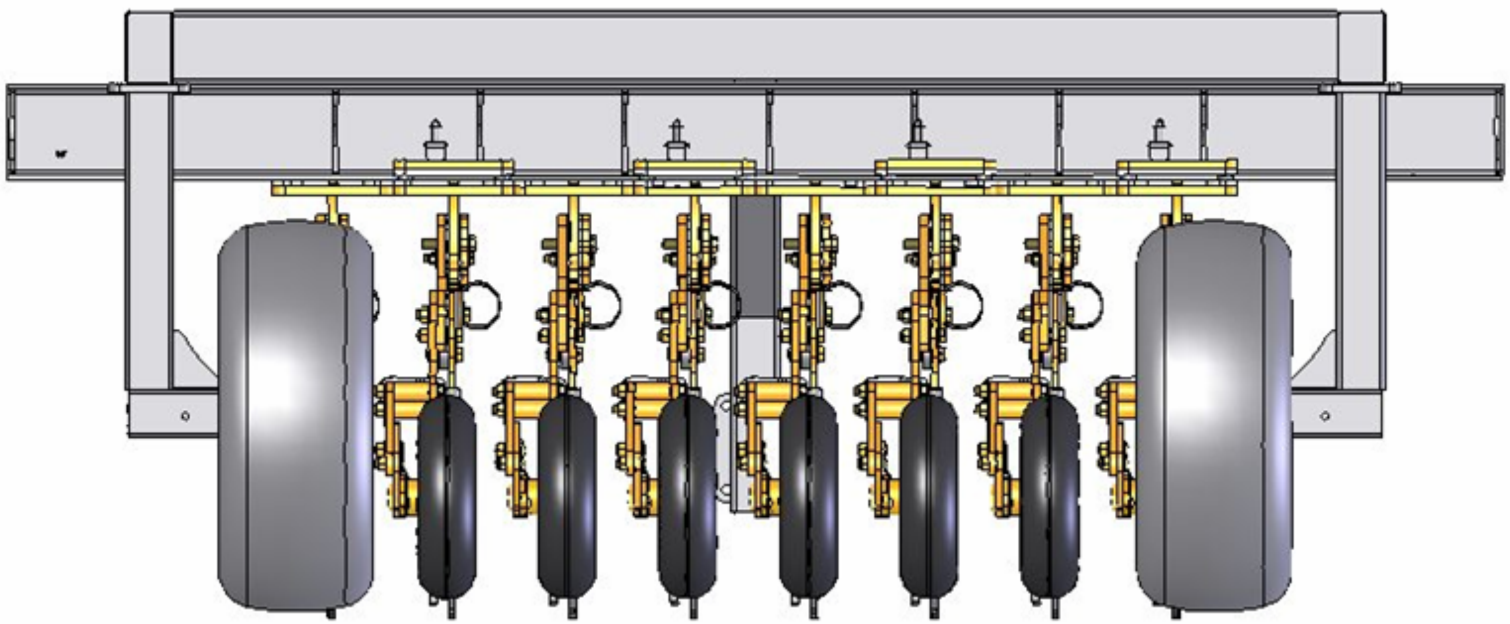
We need some engineering and agronomic solutions to allow for ease of seeding between the rows.


Part of the solution is widening the distance between crop rows for greater ease of seeding.

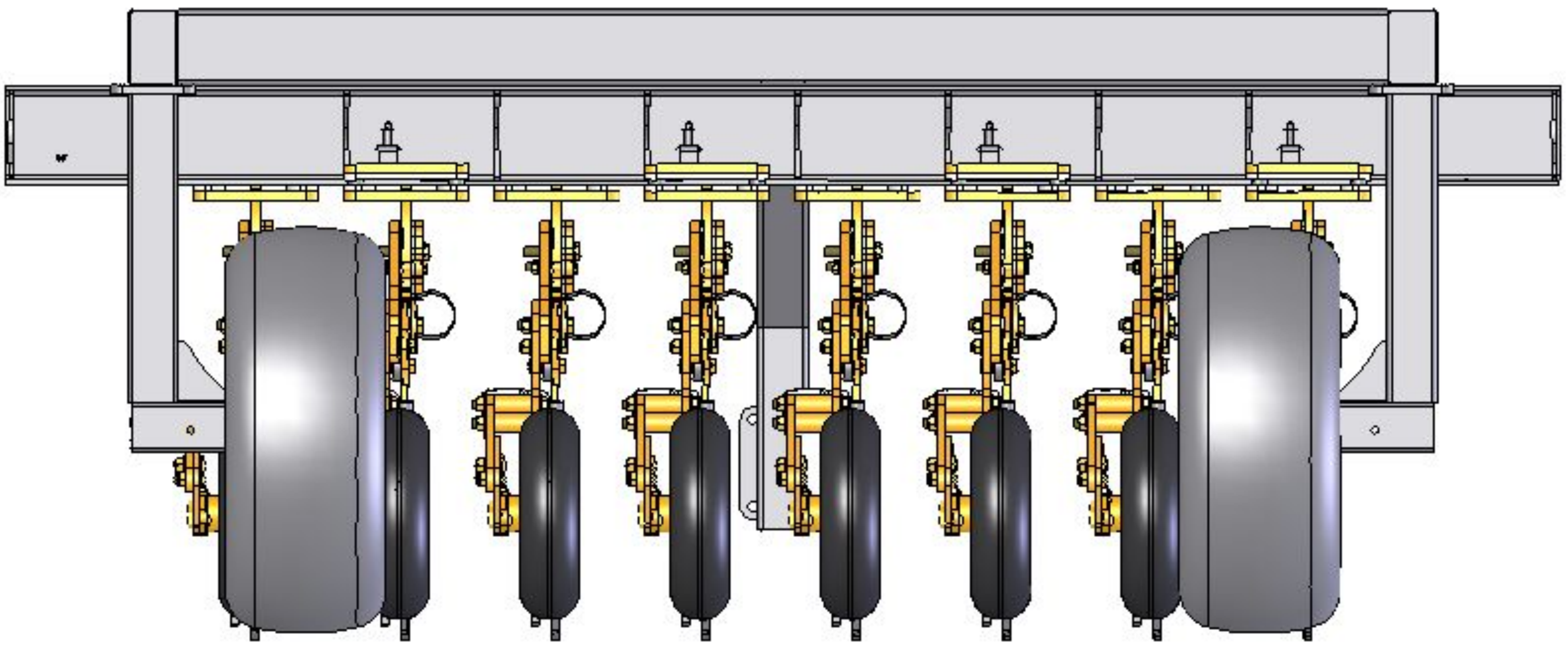
New Study
Row Spacing and Fertilizer Nitrogen in Oat - 2009


SEEDMASTER

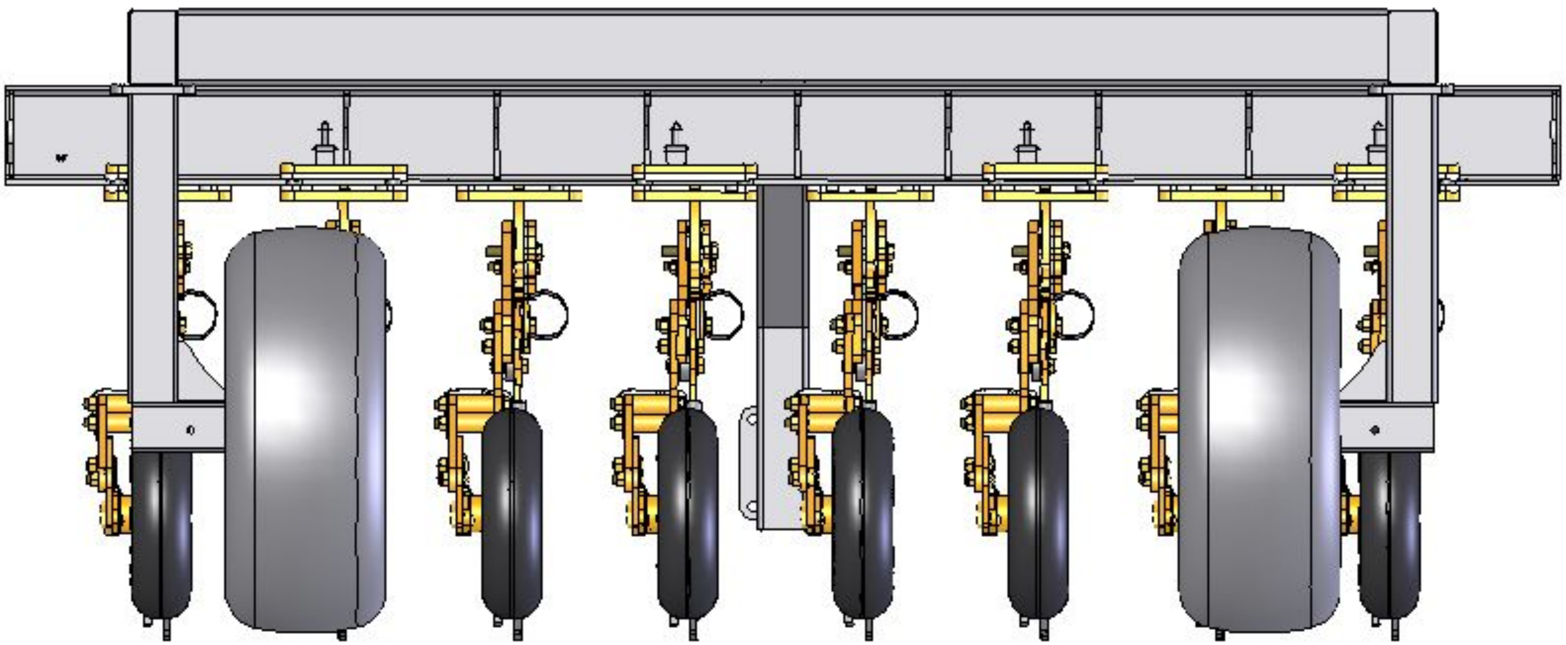
10 " (25.4 cm) spacing



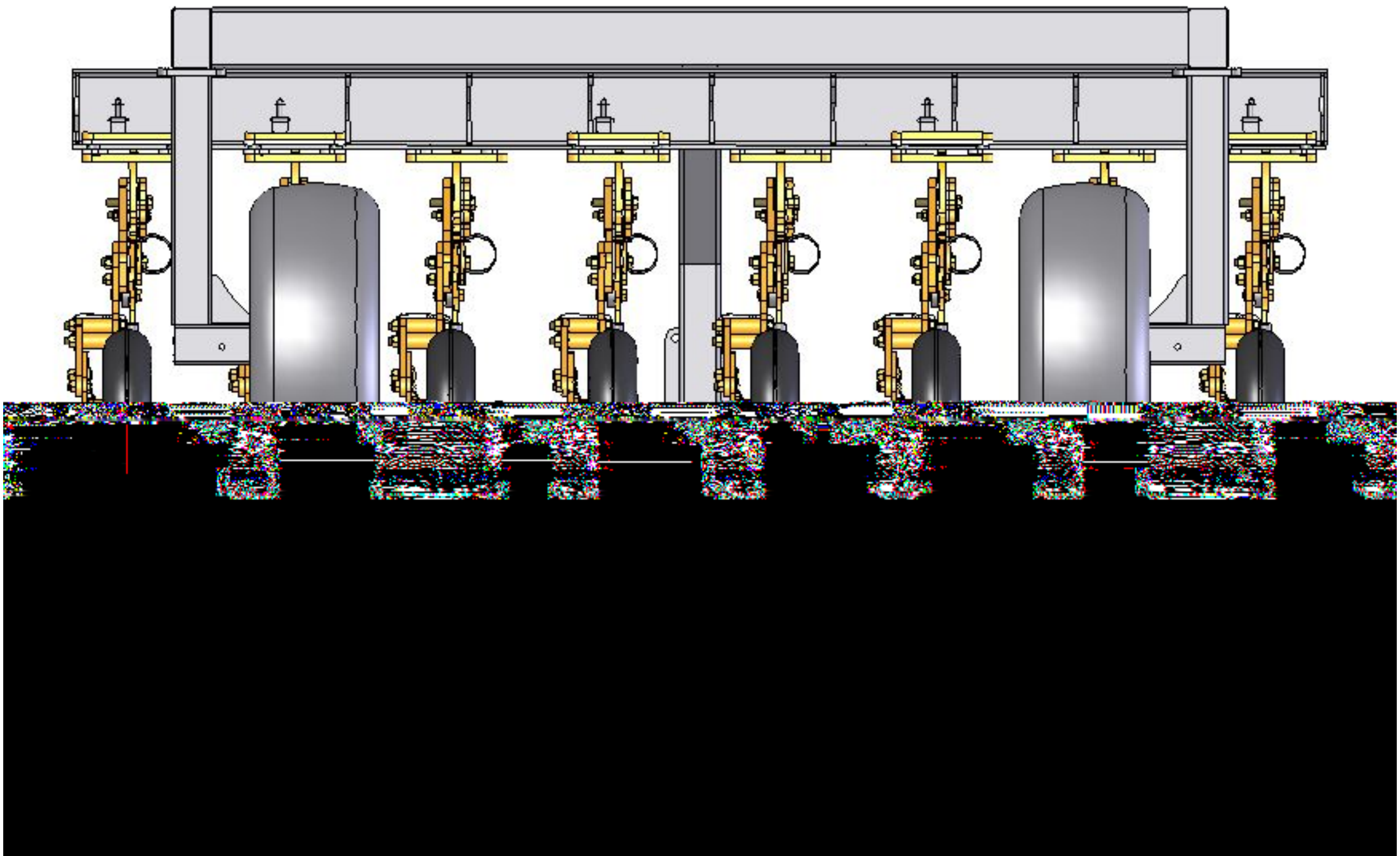
12” (30.5 cm) spacing



14” (35.6 cm) Spacing



16” (40.6 cm) Spacing



Treatments

- **Row Spacing 10”, 12”, 14” 16”**
- **Nitrogen Rates –20, 40, 60, 80 and 120 kg N/ha**
- **Urea is the N source**
- **Also added 143 kg/ha of 14-20-10-10**

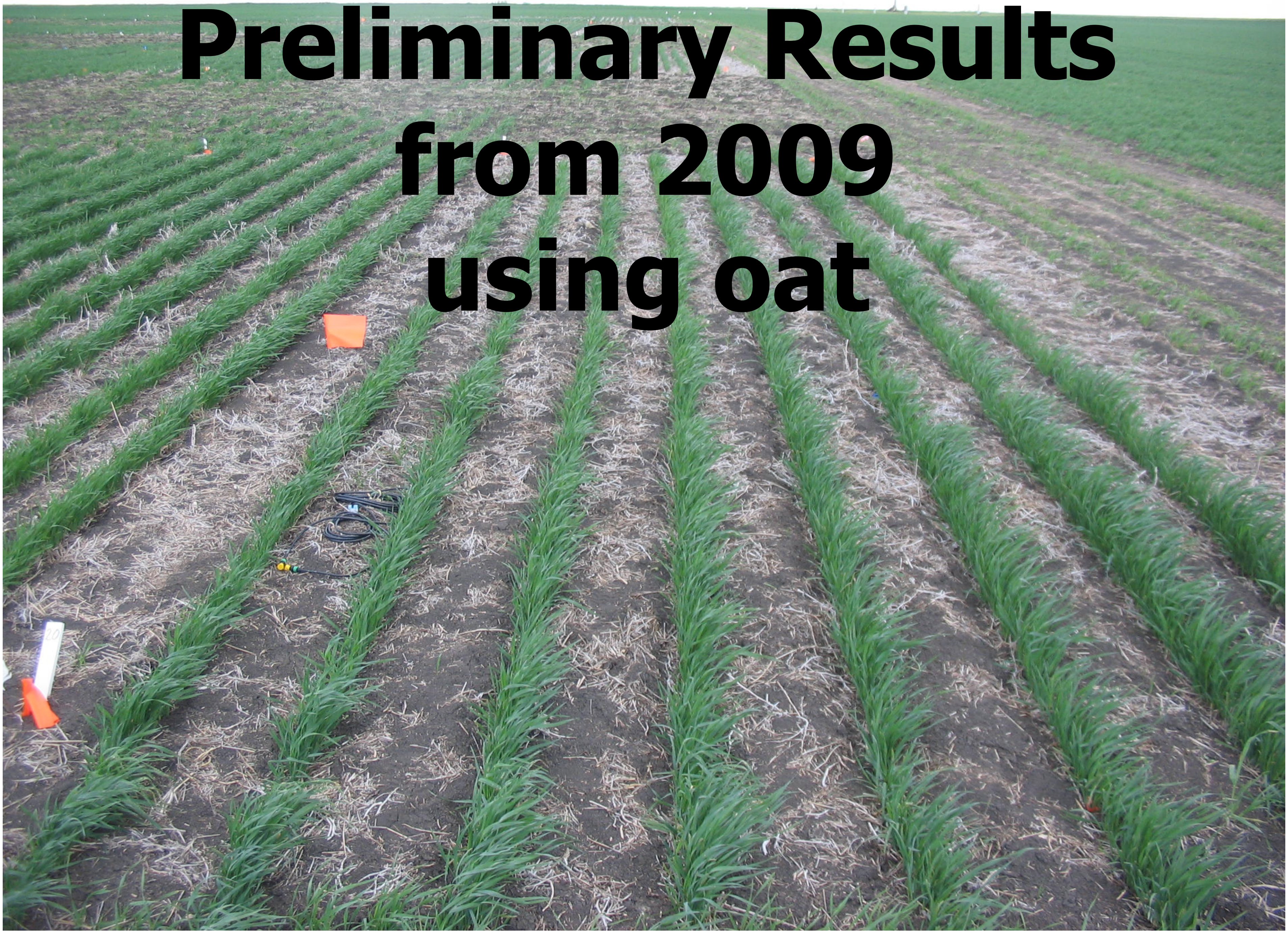

Oat 2009
10” Spacing
72 lbs N/acre
10”
80 kg N /ha
(71 lbs N/acre)

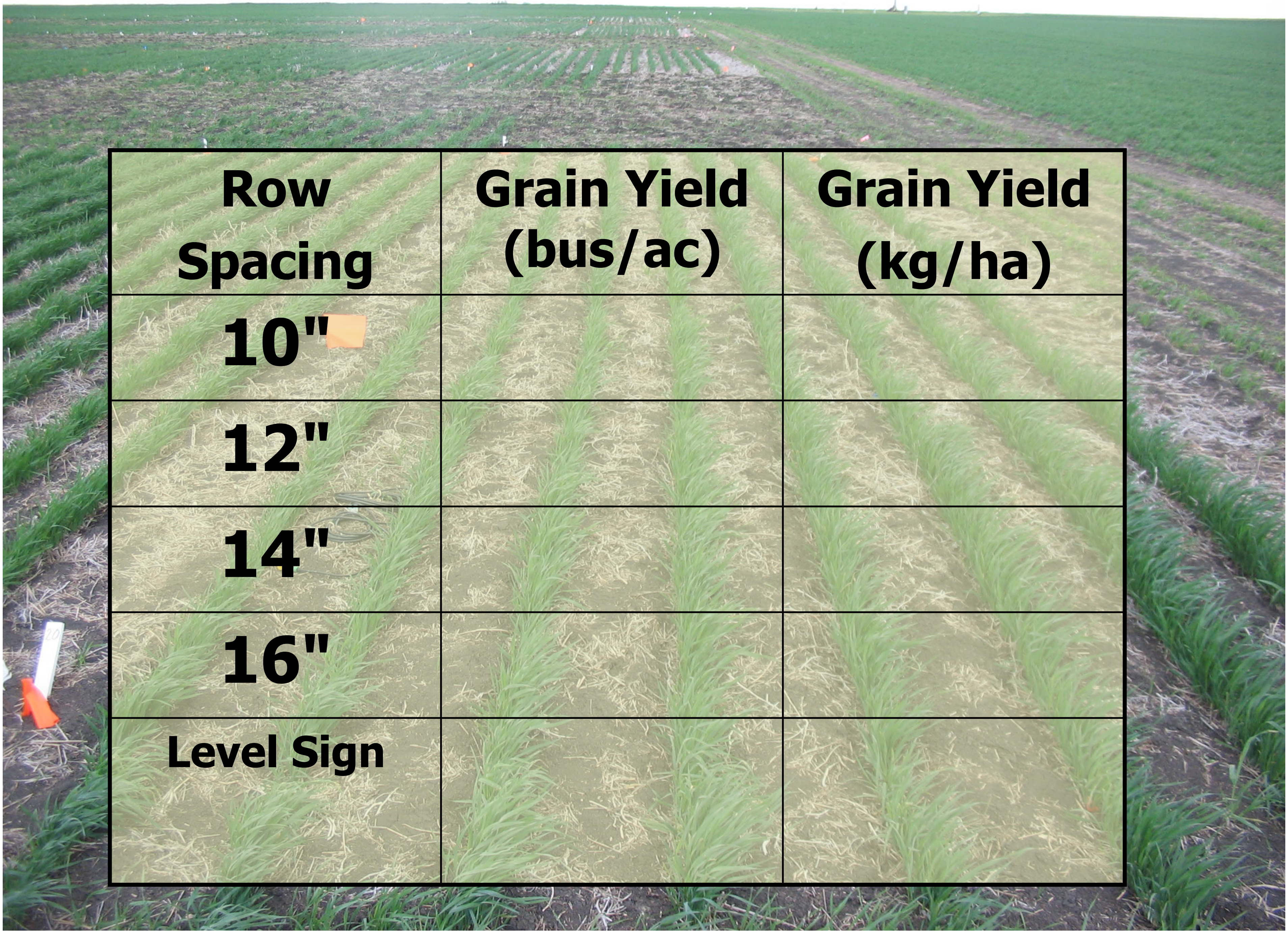
Oat 2009
12” Spacing
72 lbs N/acre

Oat 2009
14” Spacing
72 lbs N/acre

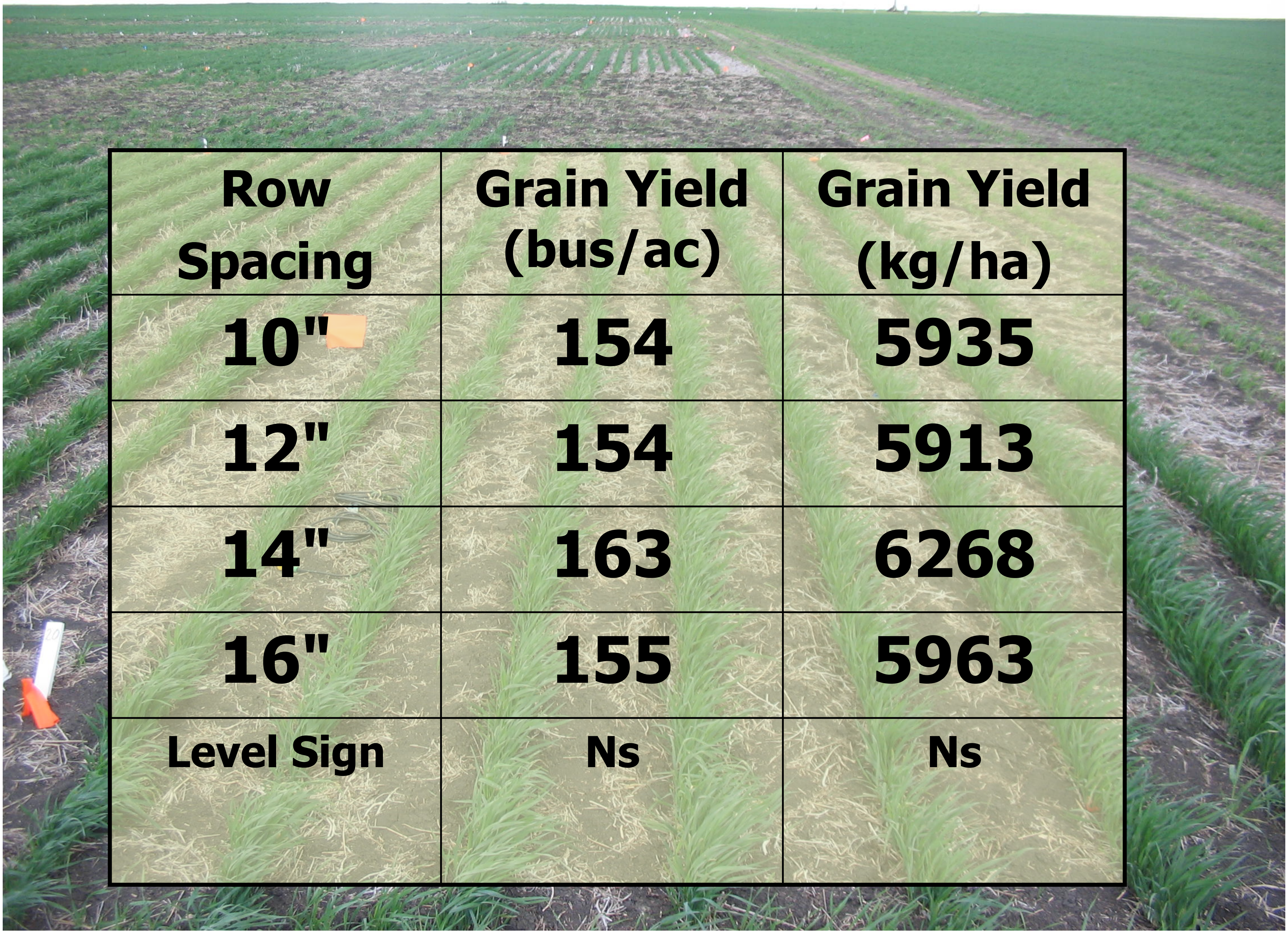
Oat 2009
16” Spacing
72 lbs N/acre

Preliminary Results from 2009 using oat

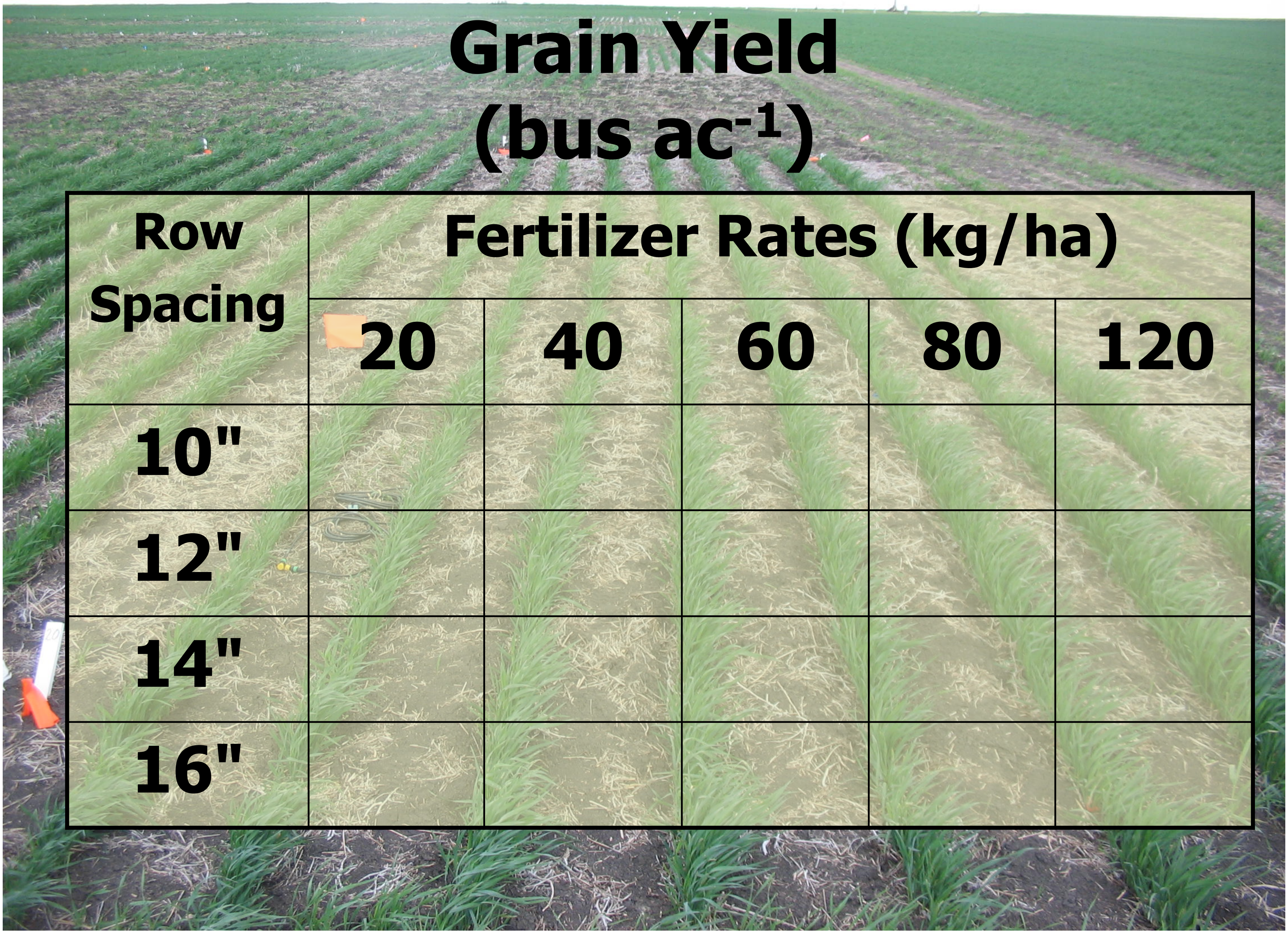




Row Spacing	Grain Yield (bus/ac)	Grain Yield (kg/ha)
10"		
12"		
14"		
16"		
Level Sign		



Row Spacing	Grain Yield (bus/ac)	Grain Yield (kg/ha)
10"	154	5935
12"	154	5913
14"	163	6268
16"	155	5963
Level Sign	Ns	Ns

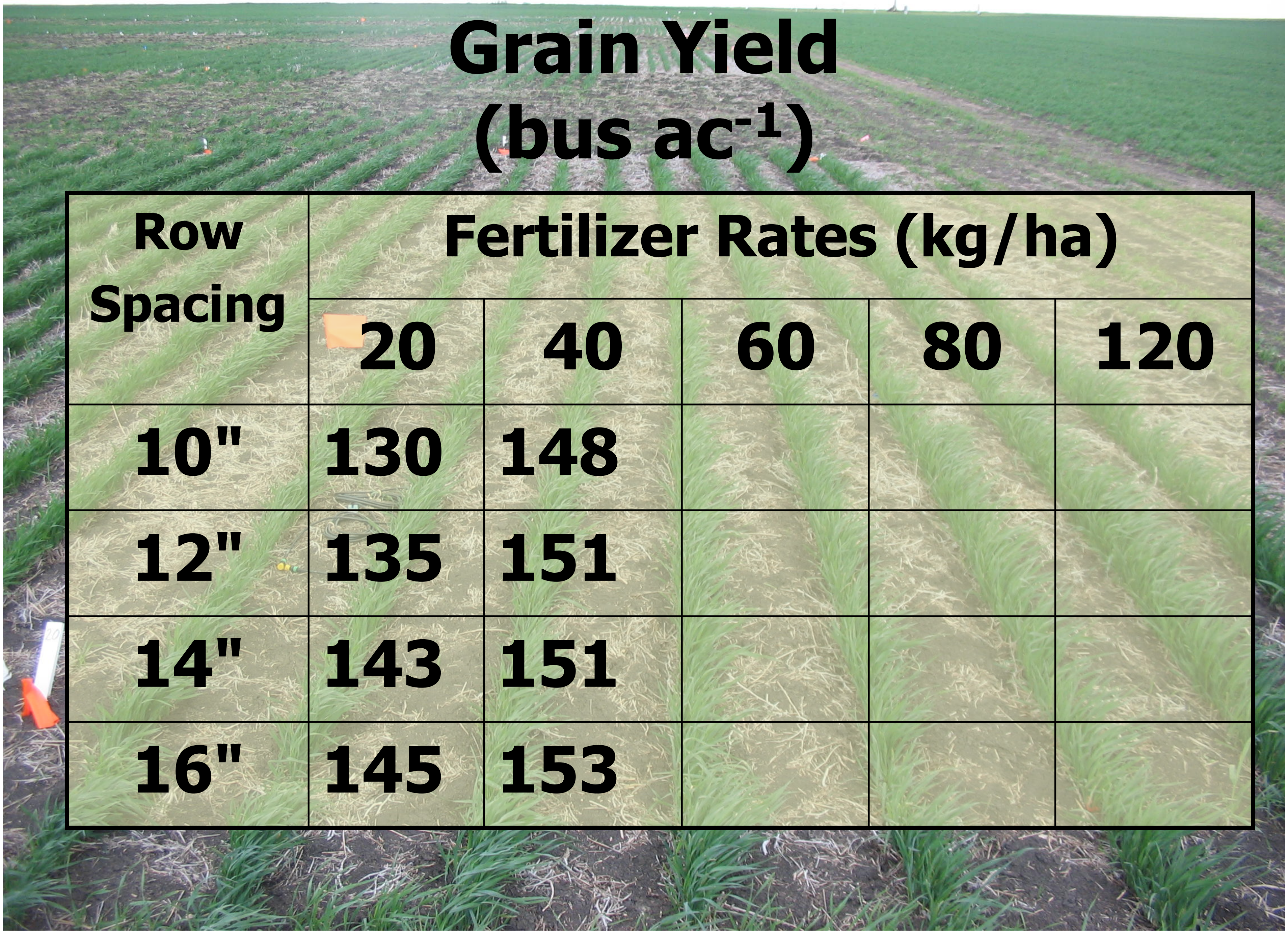


Grain Yield
(bus ac^{-1})

Row Spacing	Fertilizer Rates (kg/ha)				
	20	40	60	80	120
10"					
12"					
14"					
16"					

Grain Yield
(bus ac^{-1})

Row Spacing	Fertilizer Rates (kg/ha)				
	20	40	60	80	120
10"	130				
12"	135				
14"	143				
16"	145				



Grain Yield
(bus ac^{-1})

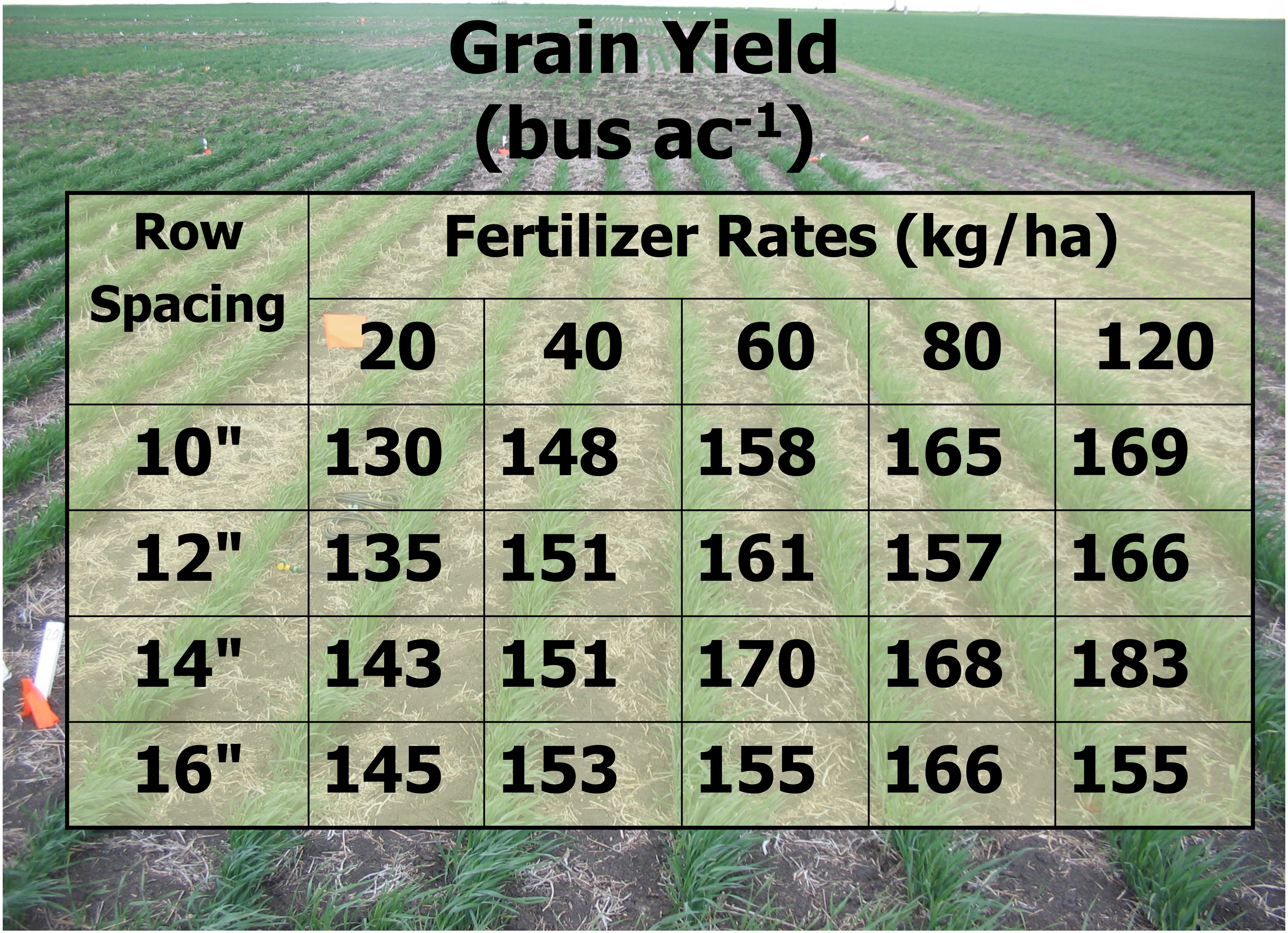
Row Spacing	Fertilizer Rates (kg/ha)				
	20	40	60	80	120
10"	130	148			
12"	135	151			
14"	143	151			
16"	145	153			

Grain Yield
(bus ac^{-1})

Row Spacing	Fertilizer Rates (kg/ha)				
	20	40	60	80	120
10"	130	148	158		
12"	135	151	161		
14"	143	151	170		
16"	145	153	155		

Grain Yield
(bus ac^{-1})

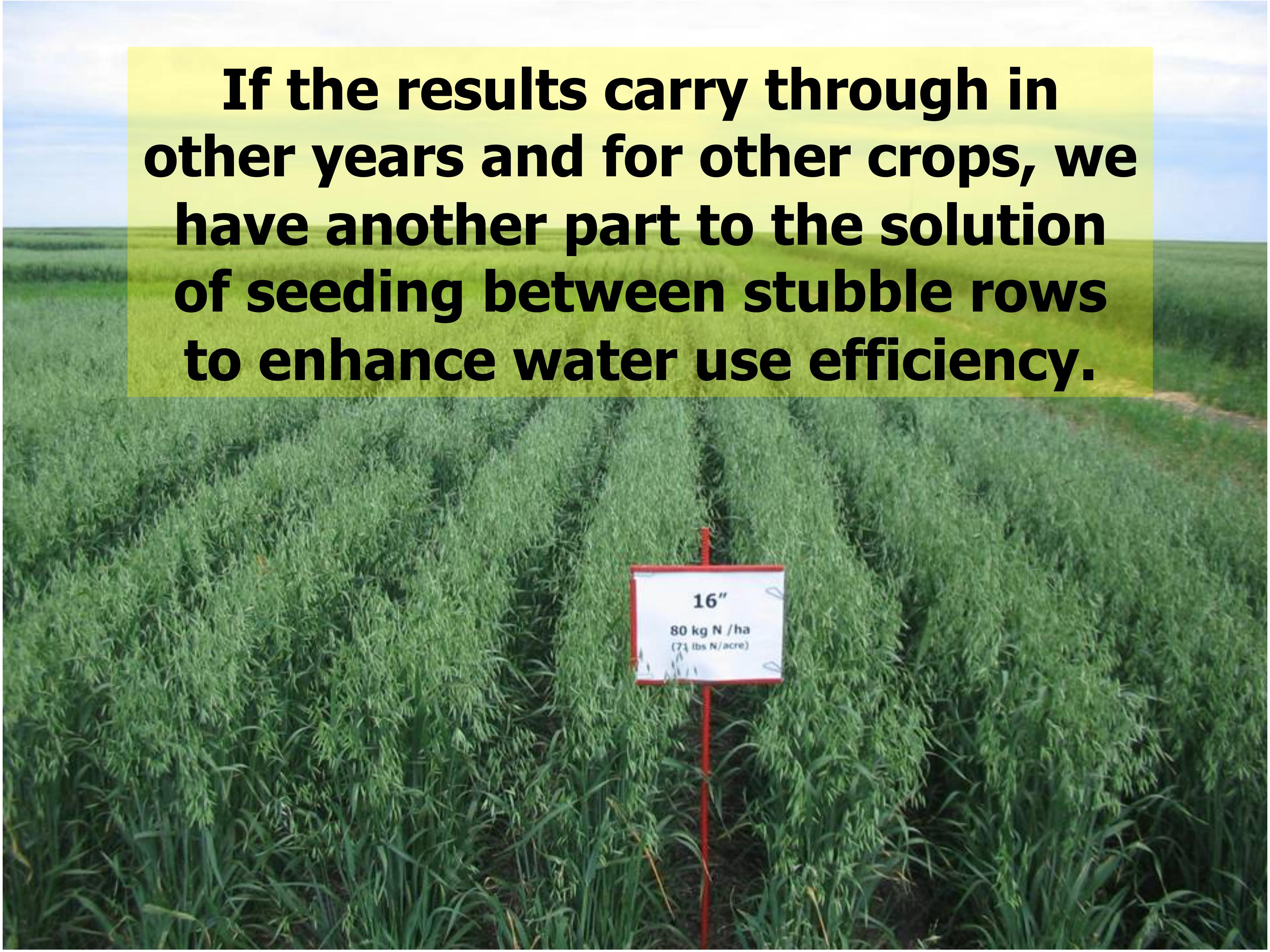
Row Spacing	Fertilizer Rates (kg/ha)				
	20	40	60	80	120
10"	130	148	158	165	
12"	135	151	161	157	
14"	143	151	170	168	
16"	145	153	155	166	



Grain Yield
(bus ac^{-1})

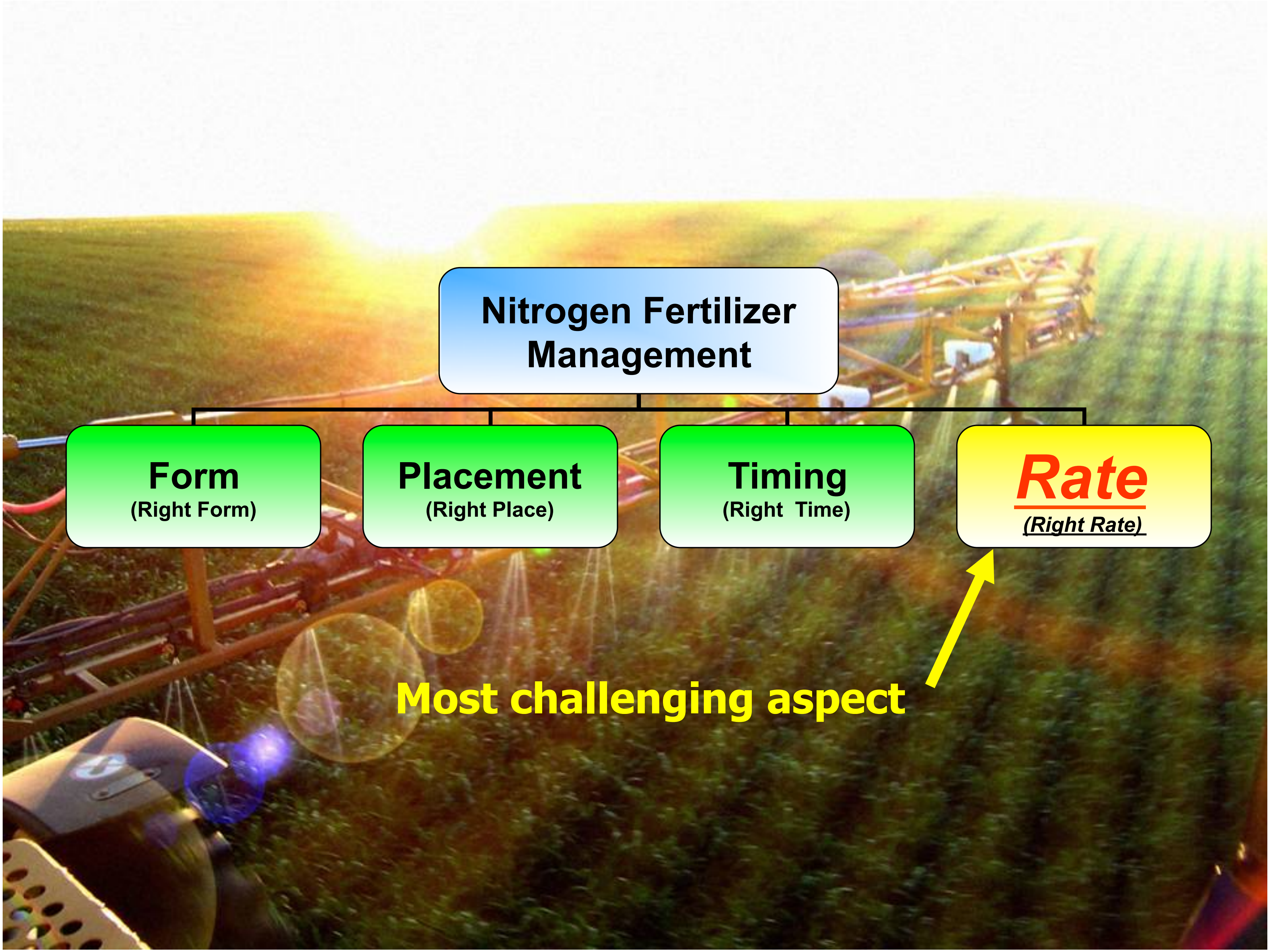
Row Spacing	Fertilizer Rates (kg/ha)				
	20	40	60	80	120
10"	130	148	158	165	169
12"	135	151	161	157	166
14"	143	151	170	168	183
16"	145	153	155	166	155

If the results carry through in other years and for other crops, we have another part to the solution of seeding between stubble rows to enhance water use efficiency.




PRACTICE #2 Enhanced
Stubble Management Practices

What about Nitrogen Management?



Nitrogen Fertilizer Management
Form
(Right Form)
Placement
(Right Place)
Timing
(Right Time)
Rate
(Right Rate)
Most challenging aspect

Extra Nitrogen (EN) vs Recommended Rate (FP)

Results	Grain Yield % of time
EN=FP	
EN>FP	

Extra Nitrogen (EN) vs Recommended Rate (FP)

Results	Grain Yield % of time
EN=FP	78
EN>FP	22

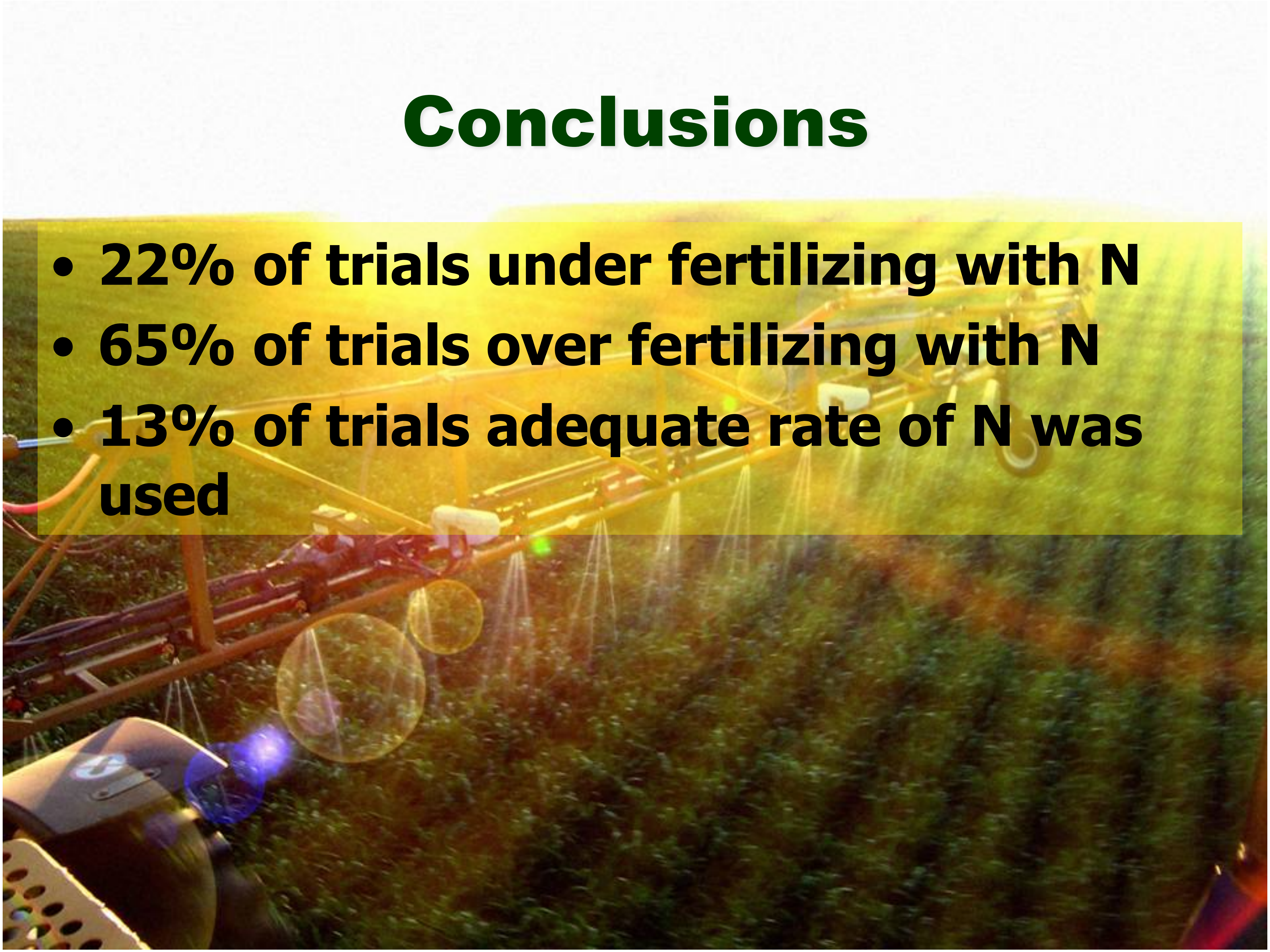
Recommended (FP) vs 66%FP (RR)

Results	Grain Yield
FP=RR	
FP>RR	

Recommended (FP) vs 66%FP

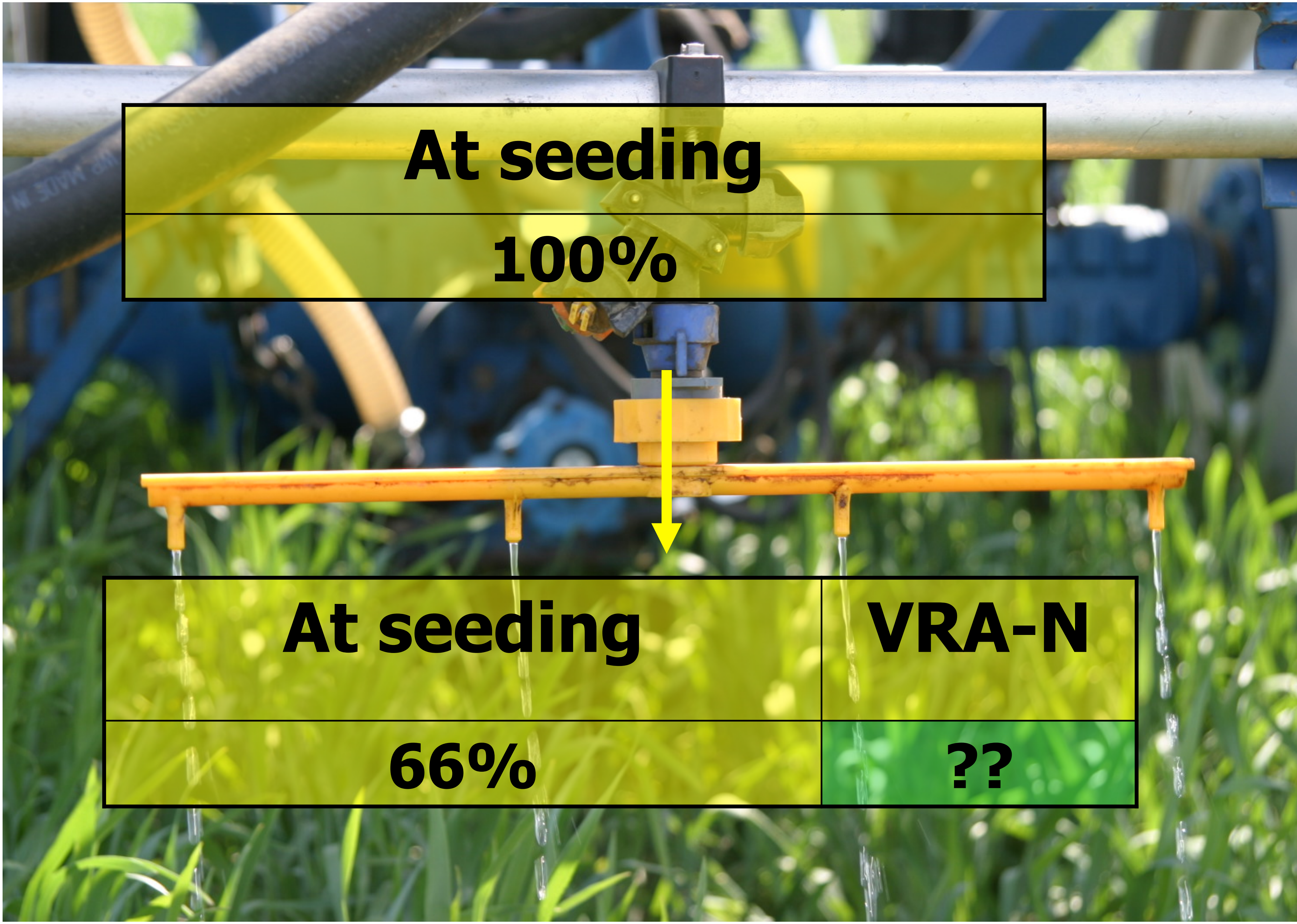
Results	Grain Yield
FP=66%FP	65%
FP>66%RR	35%

Conclusions



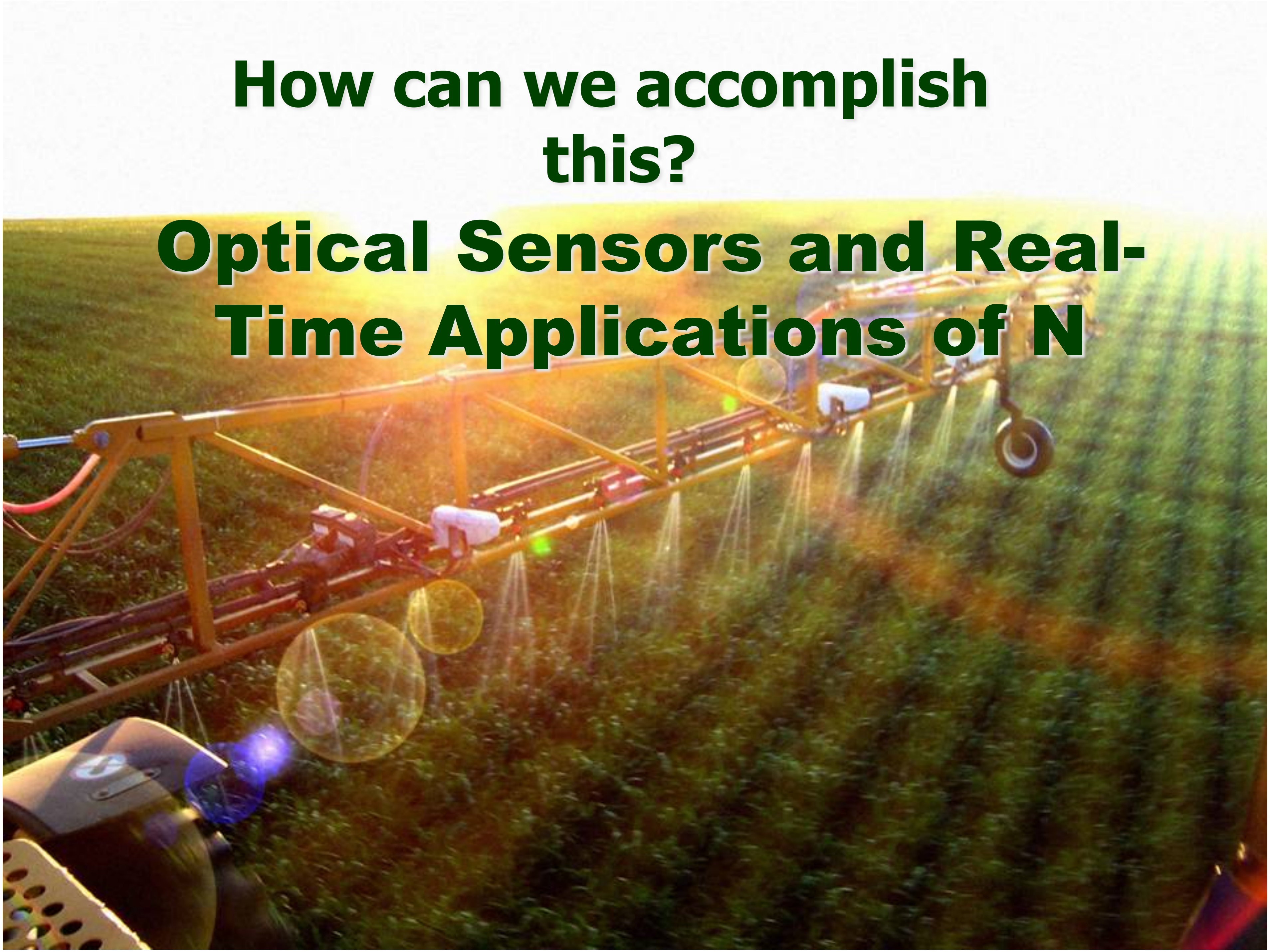
- 22% of trials under fertilizing with N
- 65% of trials over fertilizing with N
- 13% of trials adequate rate of N was used

The next step…

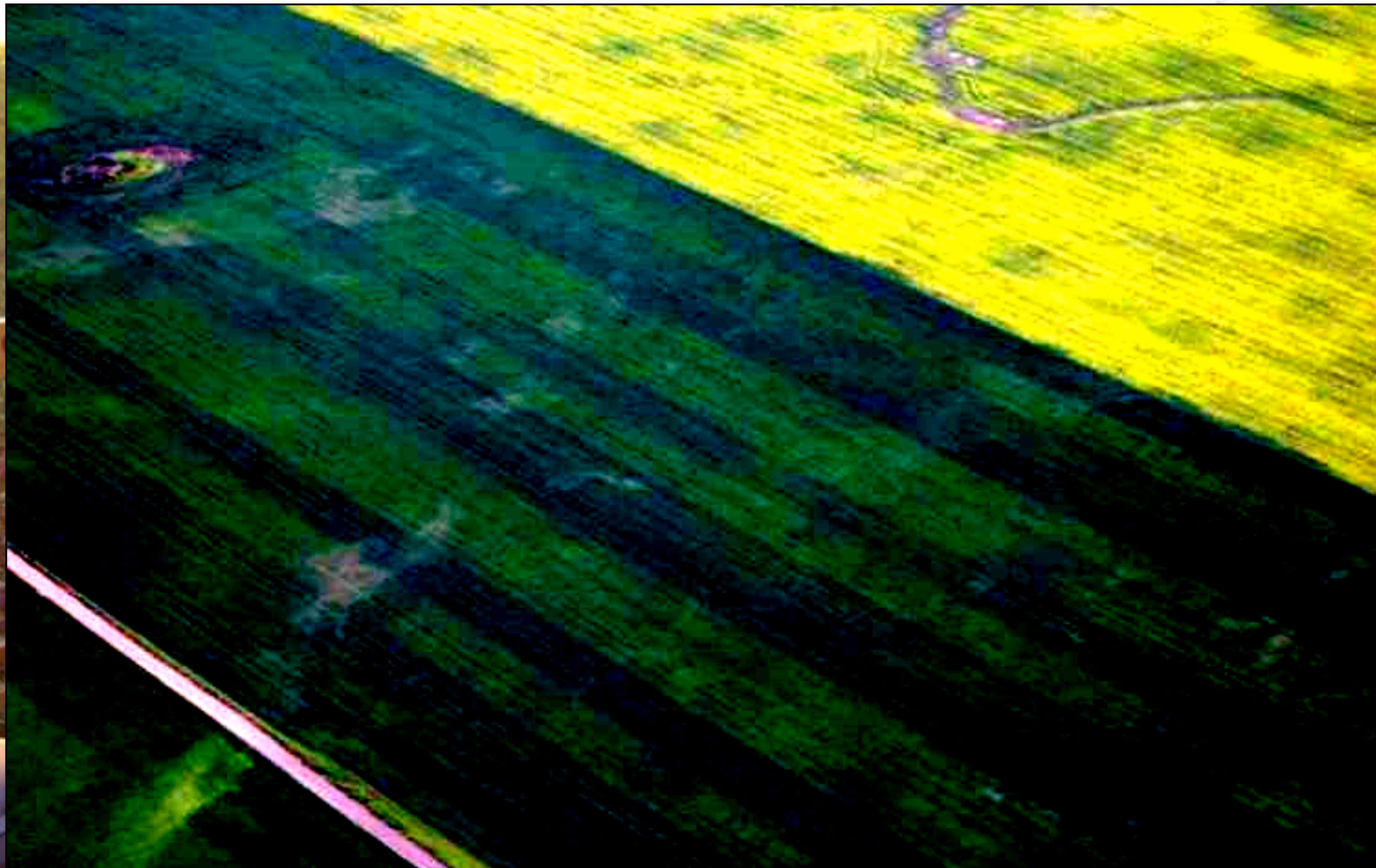

At seeding
100%
At seeding
VRA-N
66%
??

How can we accomplish this?

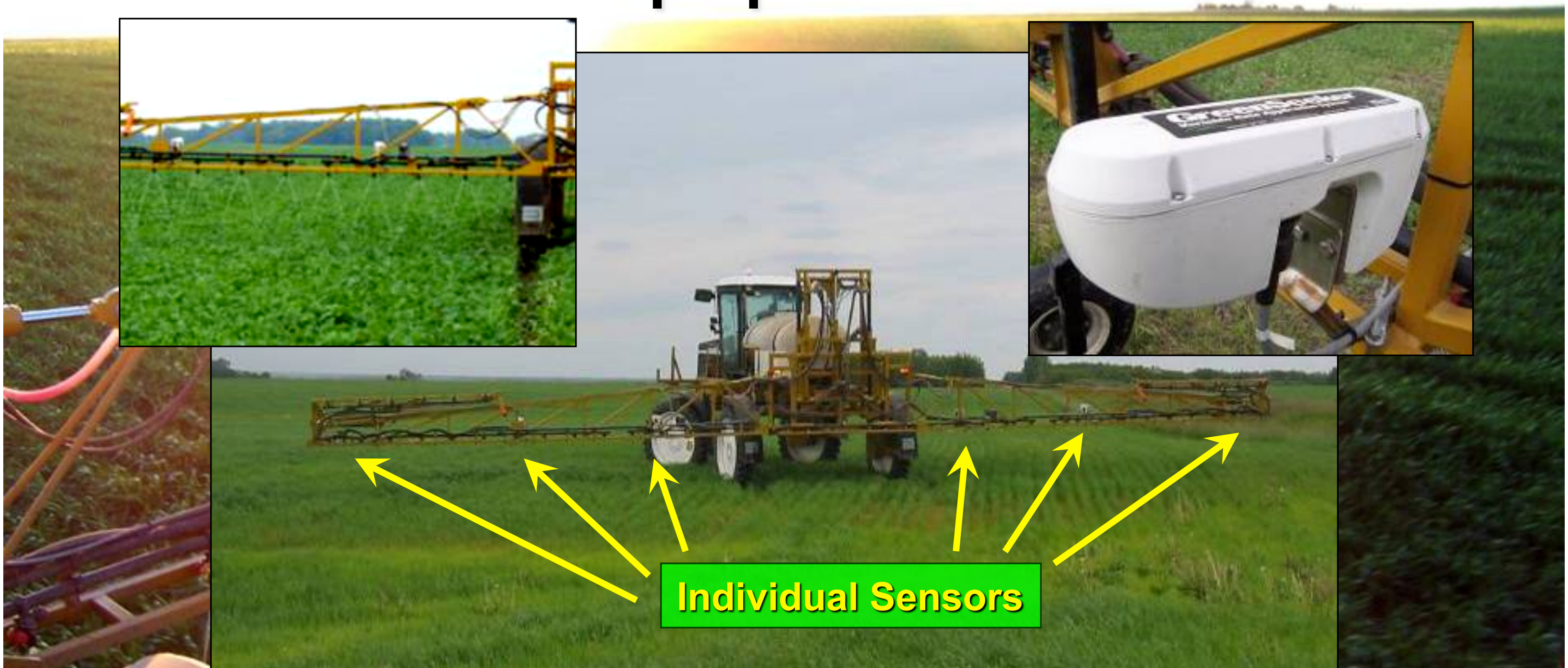
Optical Sensors and Real-Time Applications of N



Trials with Optical Sensor at a Field Scale



Commercial Application Equipment



- In the RT220™ VRA system, post-emergent N rates are based on the mean NDVI of 6 boom-mounted sensors

On-Farm Trials – Treatments

Treatment	N applied (% recommended) Seeding	Post-emergent
Farmer Practice	100%	0%
VRA w/ Optical Sensor	66%	VRA?
N-Rich	150%	0%

On-Farm Trials – Treatments

Treatment	N applied (% recommended) Seeding	Post-emergent
Farmer Practice	100%	0%
VRA w/ Optical Sensor	66%	VRA

Summary – Canola

- 9 canola field trials in total
- N applied w/OS 6% < than FP(+14 to -18%)
- Grain Yield: FP=OS 7 of 9 years
- Grain Yield: FP<OS 2 of 9 years

Canola

Treatment	Locations / Years				
	BA05	NH05	VS05	BA06	KS06
	Total N Applied (lb/ac)				
Farmer Practice	**75**	**90**	**109**	**75**	**70**
VRA/GreenSeeker	**69**	**81**	**85**	**68**	**80**
	Grain Yield (bus/ac)				
Farmer Practice					
VRA/GreenSeeker					

Canola

Treatment	Locations / Years				
	BA05	NH05	VS05	BA06	KS06
	Total N Applied (lb/ac)				
Farmer Practice	**75**	**90**	**109**	**75**	**70**
VRA/GreenSeeker	**69**	**81**	**85**	**68**	**80**
	Grain Yield (bus/ac)				
Farmer Practice	**38b**	**56a**	**30c**	**36ab**	**35b**
VRA/GreenSeeker	**42a**	**54a**	**33b**	**33b**	**34b**

Canola

Treatment	Locations / Years			
	RE06	RP06	VJ06	KS07
	Total N Applied (lb/ac)			
Farmer Practice	**75**	**127**	**90**	**67**
VRA/GreenSeeker	**77**	**108**	**95**	**57**
	Grain Yield (bus/ac)			
Farmer Practice				
VRA/GreenSeeker				

Canola

Treatment	Locations / Years			
	RE06	RP06	VJ06	KS07
	Total N Applied (lb/ac)			
Farmer Practice	75	127	90	67
VRA/GreenSeeker	77	108	95	57
	Grain Yield (bus/ac)			
Farmer Practice	50a	37a	41a	34b
VRA/GreenSeeker	50a	37a	42a	36ab

Optical Sensors and Real-Time Application in a Changing Climate

- **Accounts for temporal variability**
- **Accounts for spatial variability**
- **Represents a good N management risk tool**
- **This is one example of how to address variable climatic conditions with respect to risk management for nitrogen**

PRACTICE #3: Best Approaches to Nitrogen Management:

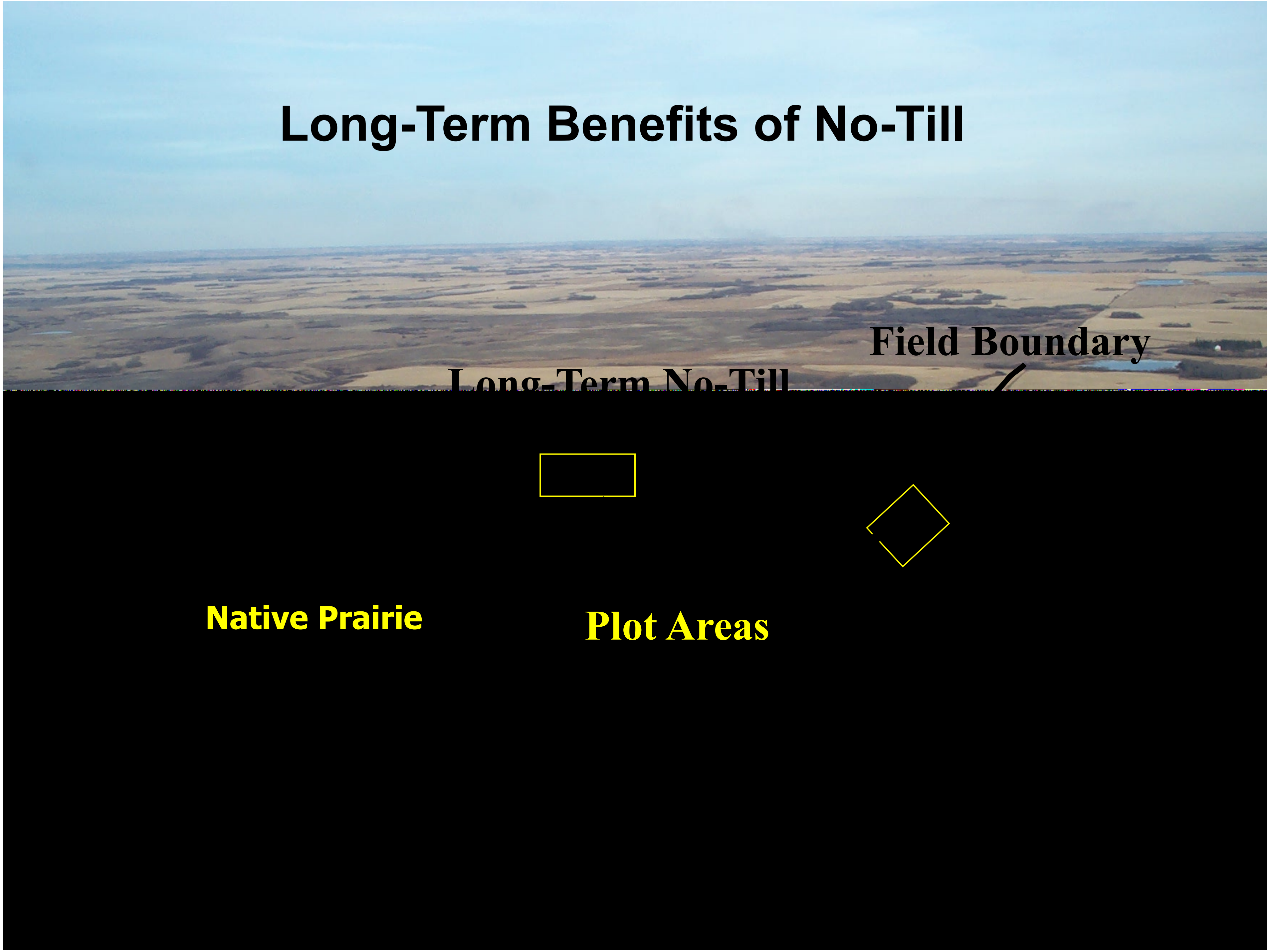
Right Form, Right Place, Right Time, Right Rate


How do we build “resiliency”
into our production systems
to address climate change?


"Resiliency" is possible if you have healthy soils.


How do we manage for
“healthy & resilient” soils?

Long-Term Benefits of No-Till



Soil Organic Matter in 2003

% (0-15 cm)

	Native	Long-term	Short-term
Organic C t/ha			
Organic N kg/ha			

Soil Organic Matter in 2003

% (0-15 cm)

	Native	Long-term	Short-term
Organic C t/ha	5.1	3.9	2.9
Organic N kg/ha			

Soil Organic Matter in 2003

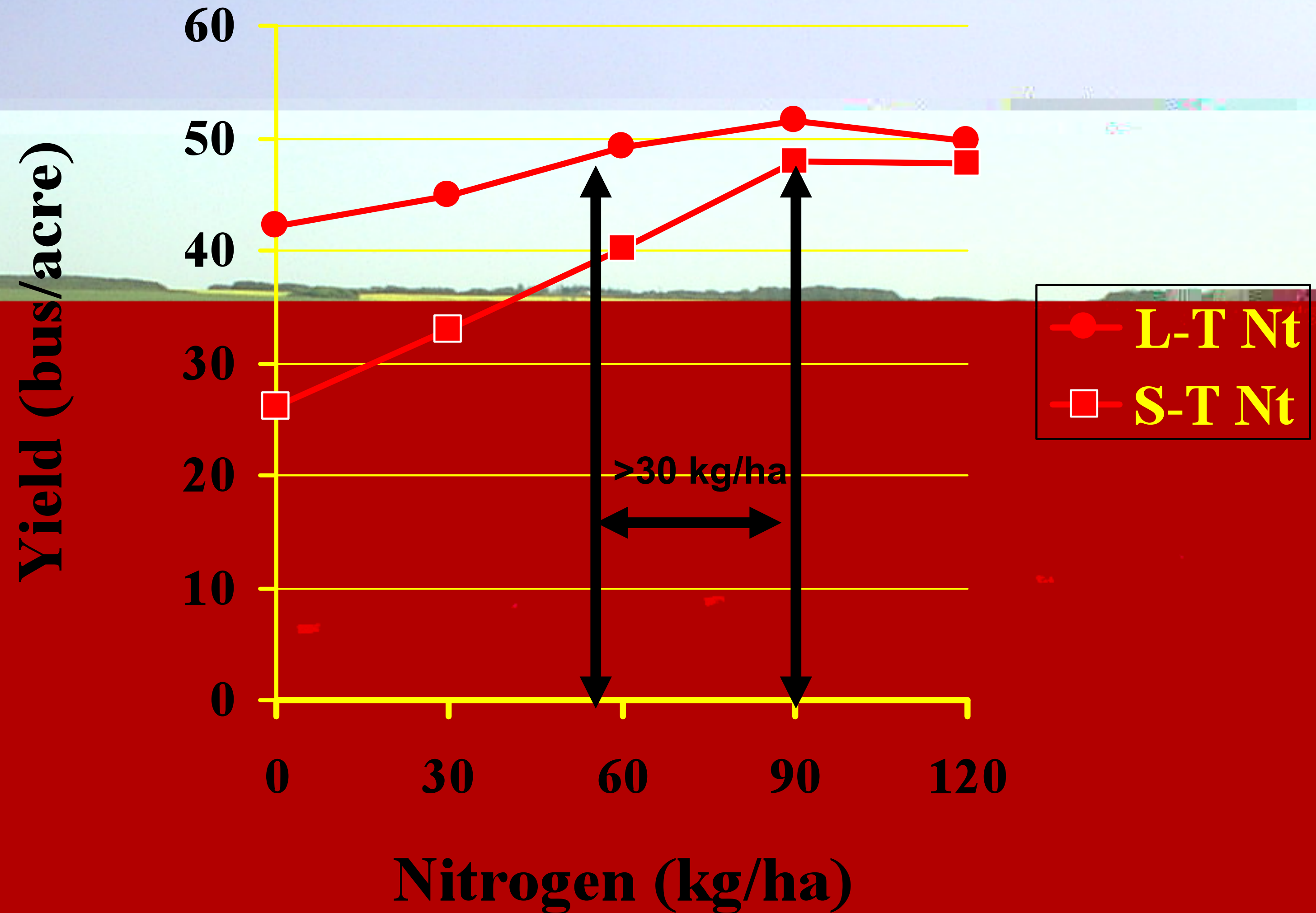
% (0-15 cm)

	Native	Long-term	Short-term
Organic C t/ha	5.1	3.9	2.9
Organic N kg/ha	5140	4610	3700

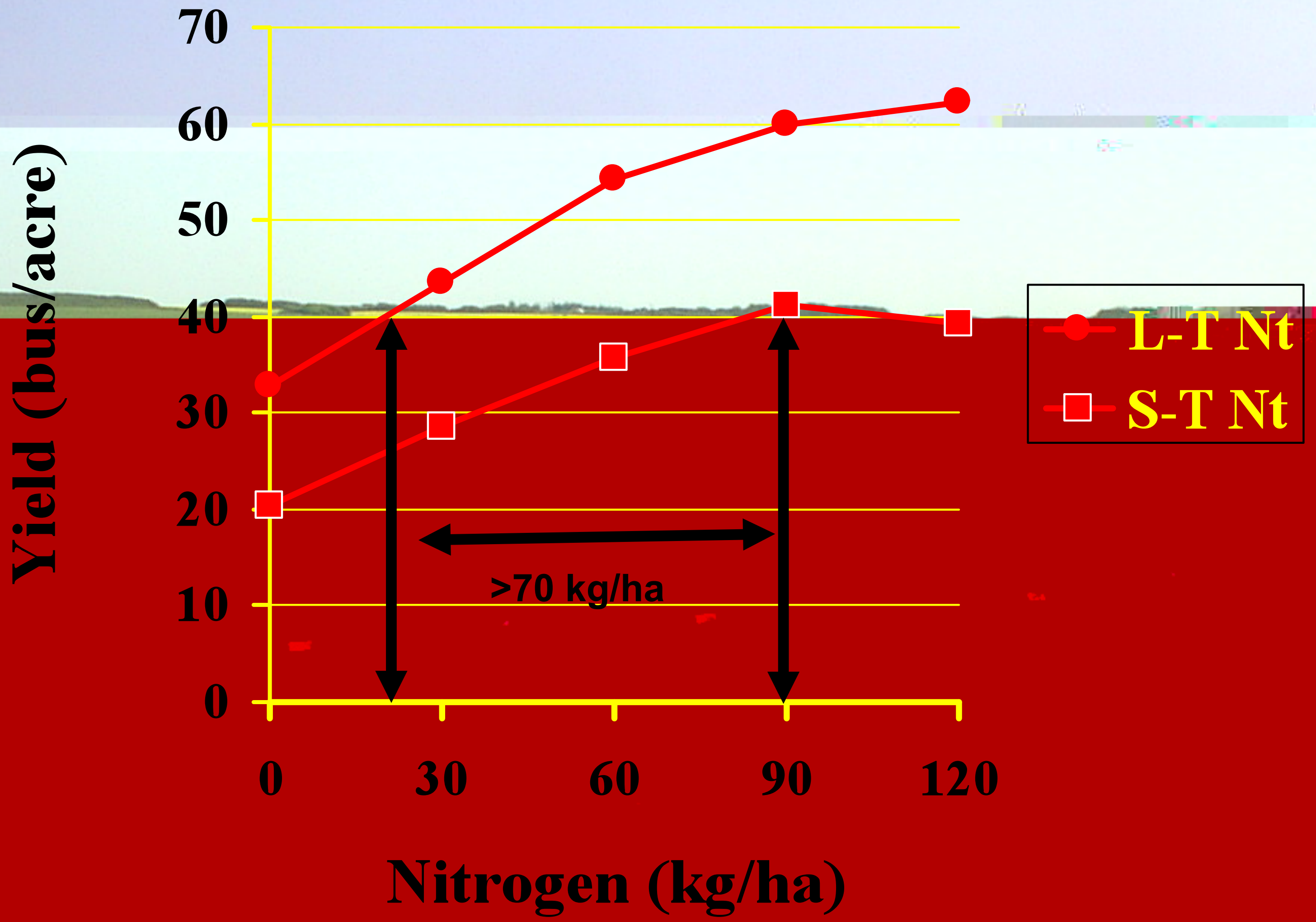
Study Description

N Rate (kg/ha)	Seed-Placed P (1 rate)	Side-Banded P (1 rate)
0	√	√
30	√	√
60	√	√
90	√	√
120	√	√

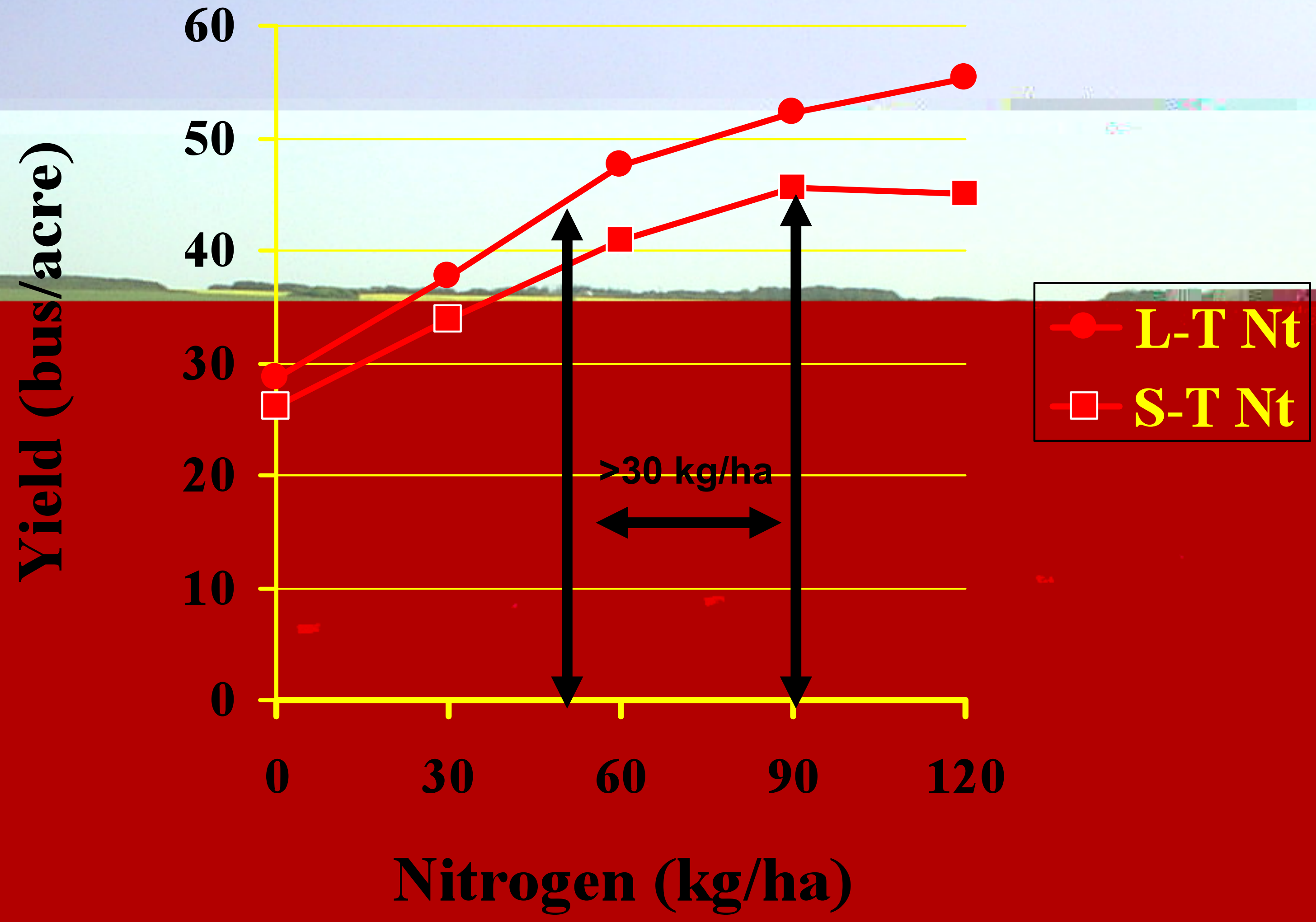
Spring Wheat (2002) – Grain Yield



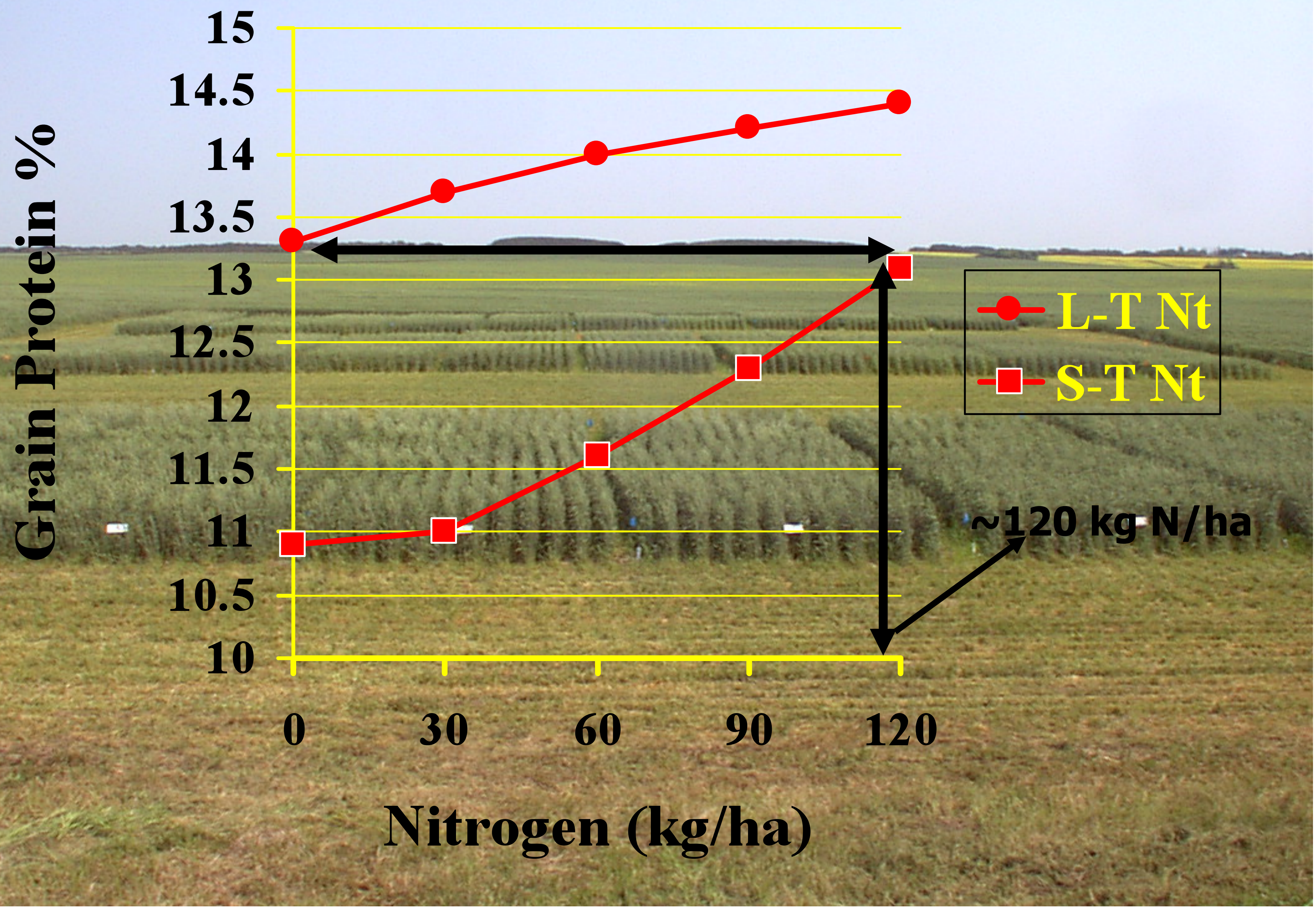
Spring Wheat (2006) – Grain Yield



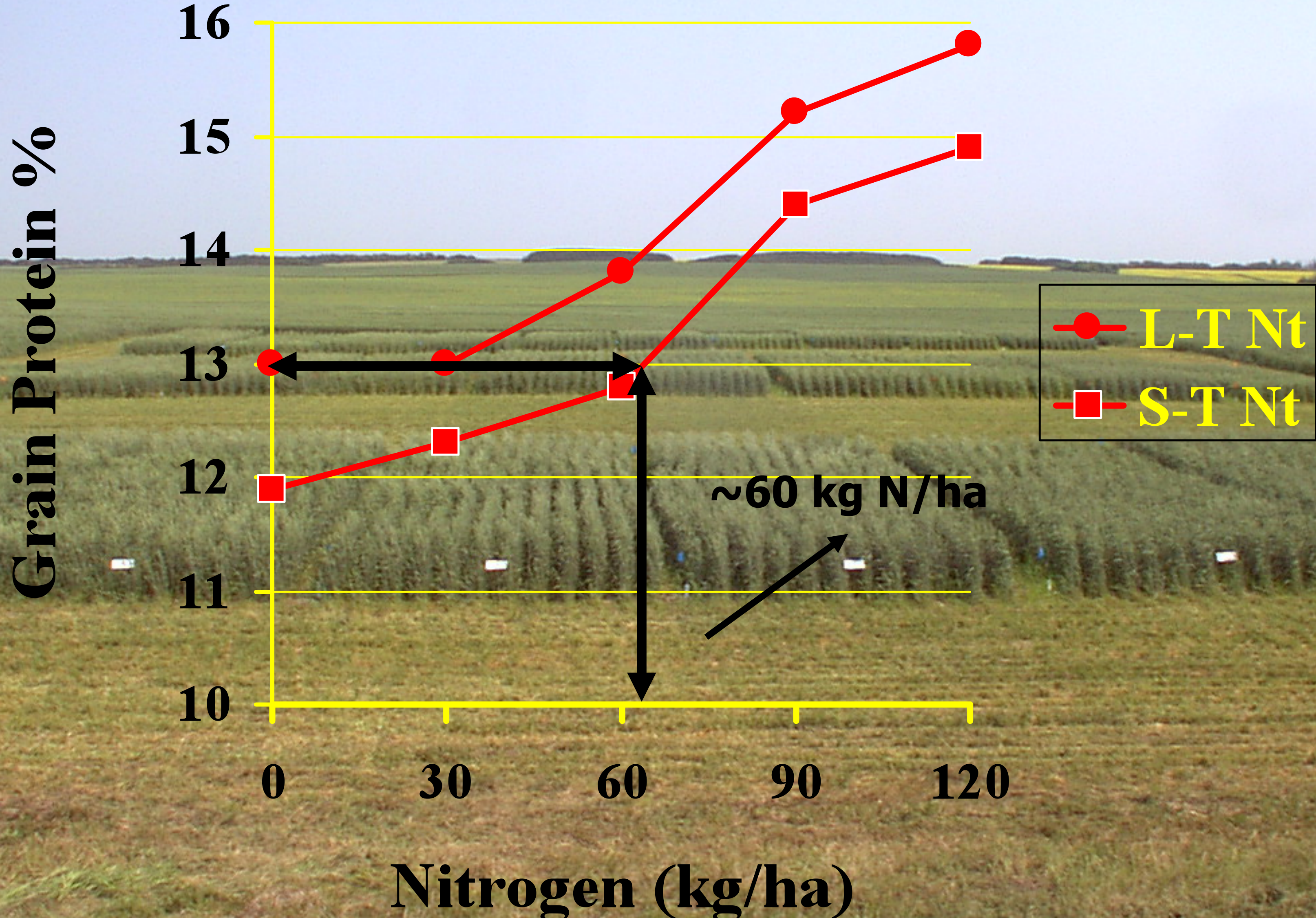
Spring Wheat (2008) – Grain Yield



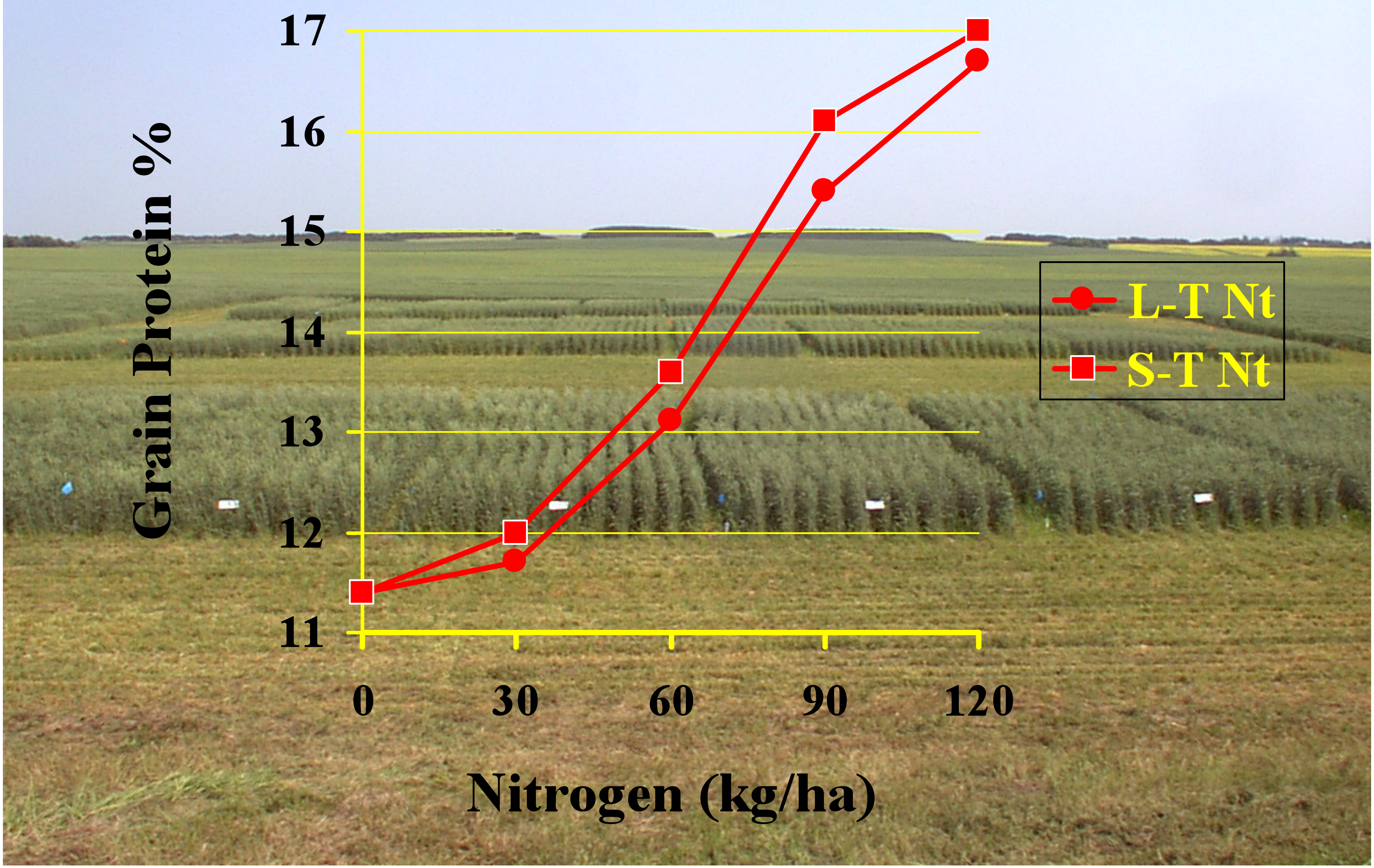
Spring Wheat (2002) – Grain Protein



Spring Wheat (2006) – Grain Protein



Spring Wheat (2008) – Grain Protein



Nitrogen Balance – Long-term vs Short-Term No-till after 8 years

N Rate (kg/ha)	Total N applied (8 years) (kg/ha)		Total N removed with grain (kg/ha)		Nitrogen Balance (kg/ha) (applied N – N in grain)	
	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term
0						
30						
60						
90						
120						

Nitrogen Balance – Long-term vs Short-Term No-till

N Rate (kg/ha)	Total N applied (8 years) (kg/ha)		Total N removed with grain (kg/ha)		Nitrogen Balance (kg/ha) (applied N – N in grain)	
	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term
0	0	0				
30	240	240				
60	480	480				
90	720	720				
120	960	960				

Nitrogen Balance – Long-term vs Short-Term No-till

N Rate (kg/ha)	Total N applied (5 years) (kg/ha)		Total N removed with grain (kg/ha)		Nitrogen Balance (kg/ha) (applied N – N in grain)	
	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term
0	0	0	270	181		
30	240	240	342	244		
60	480	480	465	349		
90	720	720	756	491		
120	960	960	634	550		

Nitrogen Balance – Long-term vs Short-Term No-till

N Rate (kg/ha)	Total N applied (8 years) (kg/ha)		Total N removed with grain (kg/ha) (8 years)		Nitrogen Balance (kg/ha) (applied N – N in grain) After 8 Years	
	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term
0	0	0	270	181	-270	-181
30	240	240	342	244	-102	-4
60	480	480	465	349	15	131
90	720	720	756	491	144	229
120	960	960	634	550	327	410

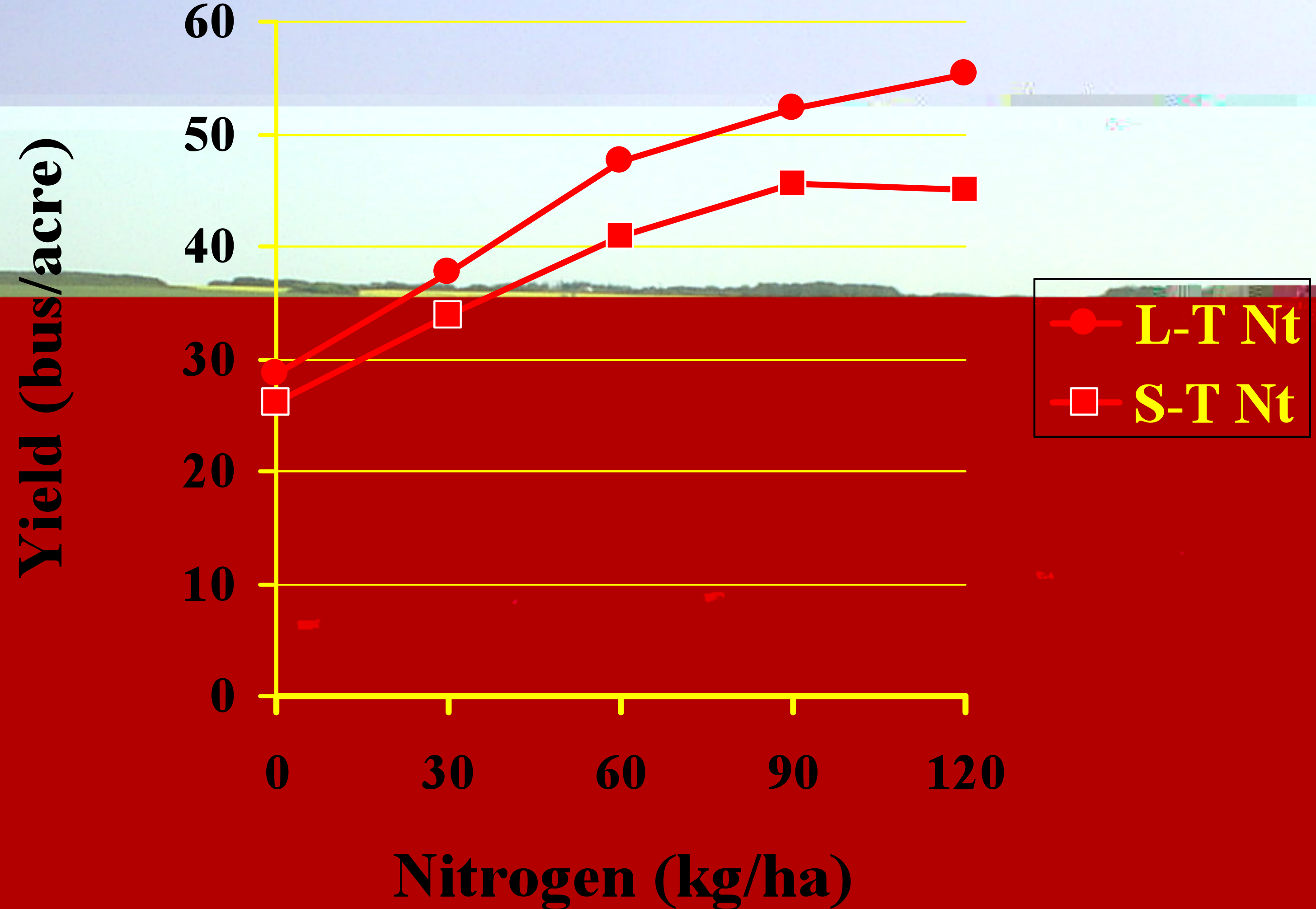
Residual NO3-N levels after 8 years

	NO3-N (kg/ha)	
N Rate (kg/ha	Long-Term	Short-Term
0		
60		
60		
90		
120		

Residual NO3-N levels after 8 years

	NO3-N (kg/ha)	
N Rate (kg/ha	Long-Term	Short-Term
0	8	7
60	9	11
60	11	11
90	6	11
120	21	28

Note: Spring Wheat (2008) – Grain Yield



Conclusions from Study

- Soils don’t degrade in one year and so we should not expect rapid improvements with crop inputs like N fertilizers after one year.
- No-till combined with proper fertility will result in significant improvements in soil productivity over time.
- Nitrogen fertilizers or other organic N amendments are a requirement to improve degraded soils.
- The time required will depend on the level of soil degradation.
- Conservation Agriculture will build resiliency in the soil systems over time.

PRACTICE #4: Continuous cropping combined with no-till and proper fertility management will ensure that soil resource is protected and improved over time.

What about Pest Management?

- Effects of weather > crop rotations > tillage systems when it comes to permanent shifts in weed populations.
- Populations shifts are slow allowing for time to adapt.
- Same principle applies to plant diseases.
- A more variable climate in the future may work in our favor by reducing directional shifts.

Climate Change on the Prairies…Best case scenarios Recap…

- Dry and variable climate with greater extremes
- More precipitation in winter and spring and less during summer
- Greater increases in temperature in winter and spring

[Source: Sauchyn and Kulshreshtha 2008; Sauchyn 2009; Barlow 2009]

What do we need to do in the next 10 years?

- Maintain on-going awareness on the state of the global soil resource.
- Continued global focus on the adoption of Conservation Agriculture.
- Refine Stubble Management Systems for water conservation
- Refine our approaches to N Management (temporal and spatial variability)
- Address the issue of weed resistance to herbicides.
- Initiate research into ways to reduce pesticide loading in the environment to extend the life of these technologies.
- More research on winter crops due to warmer winters and more spring and winter precipitation.

What do we need to do in the next 10 years cont'd?

- Remote sensing applications for measuring soil moisture across landscapes
- Focus on maintaining diversified cropping systems
- Merits of Controlled Traffic
- Development of real-time Decision Support Systems for Pest Management with intricate regional monitoring systems
- Recycle human and animal wastes eg. struvite
- Maintain focus on Energy efficiency and carbon footprint

What do we need to do in the next 20 years?

- **Better climate predictive models to help farmers manage risk**
- **Development of more *in-situ* sensors combined with robotic applications to do field monitoring**
- **Non-renewable energy conservation and lower carbon footprint from crop production**
- **Continued evolution of cropping systems and crop diversification**

How do we move in the near future?

- **Need to sustain interest by funding agencies over longer time frames**
- **Need to find strong individuals that can champion and create continued awareness about soil, food production, energy etc.**
- **Need to communicate soil and crop production sciences more effectively to the general public**

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Issue 1 - Agriculture and Its Impact on the Environment can be accessed for free. However, you will need to create a user account

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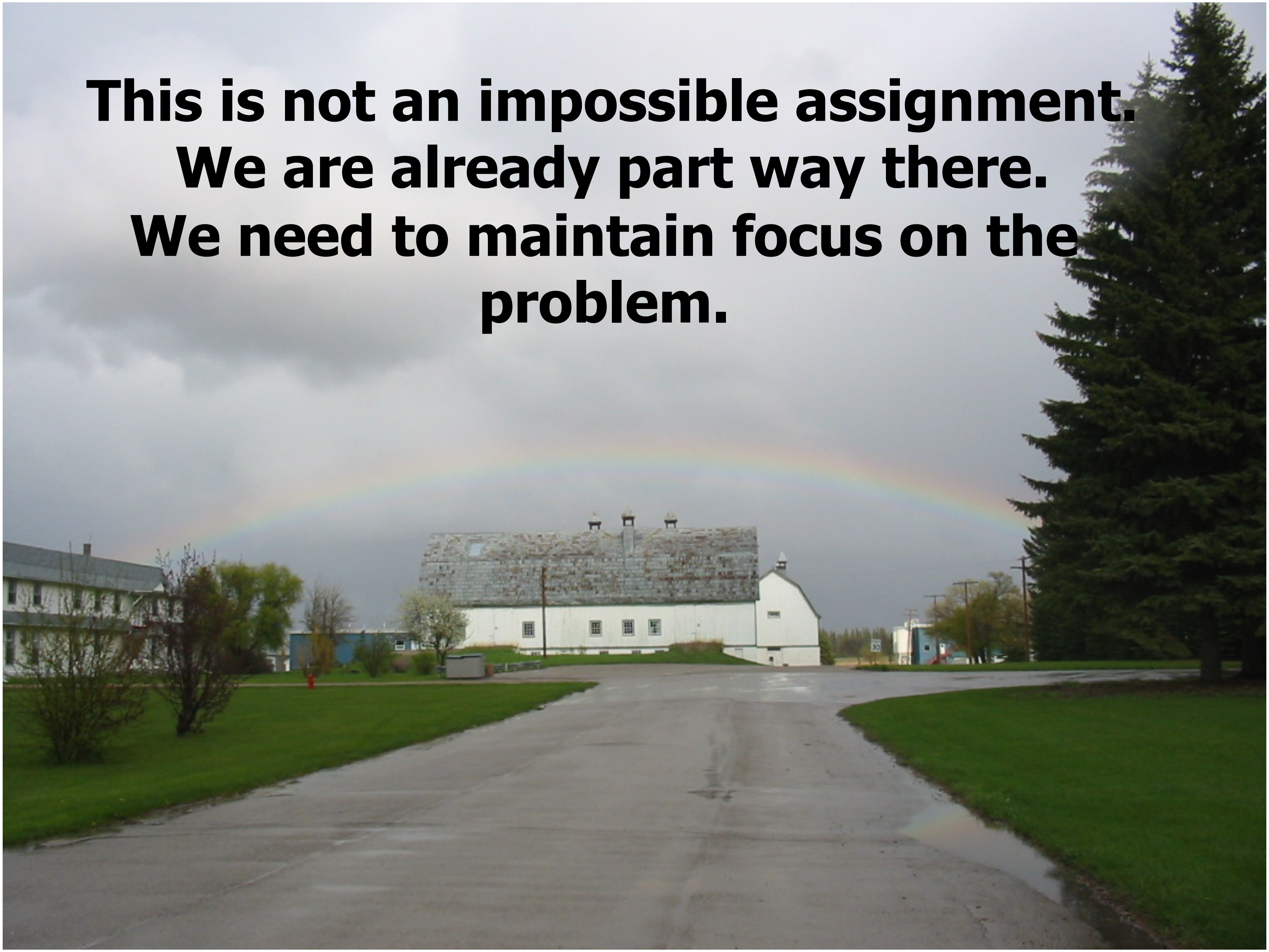
How do we move into the near future cont'd?

- Need more international forums with major stakeholders like this one for the exchange of ideas
- Need to get the funding agencies on board
- Need producers to be more effective at articulating their farm-gate needs with respect to technology and risk management


This is not an impossible assignment.
We are already part way there.
We need to maintain focus on the problem.


Thank-you

Brain Teaser!!!


Why do elks have long horns?