Soybean Yield Response Following a Triticale Cover Crop

Creative Component By: John D. Burger
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Introduction

John D. Burger

- Native of Ottumwa, Iowa
- BSME in 1997 from U of I
- Employed 19 yrs with John Deere
  - Hay, Forage, and Construction Product Experience
  - Test, Manufacturing, and Design Engineering Experience
  - Round Baler Patents and Marketing Videos
- 4rth Generation Operator of Burger Family Farm
  - Located in Appanoose County, near Udell, Iowa Since 1921
  - Presently About 1,150 Acres of Row Crops - Corn and Soybeans
  - Stopped Deep Tillage in 1962 and Began Minimum Tillage
  - Switched to 100% No-Till in 1994
  - Outstanding Conservation Farmer Award from NRCS in 2002

Today's Agenda

Project Introduction

Materials and Methods

Results and Discussion

Summary and Conclusions

Questions

Project Introduction - What is it?

Describe from Engineer's Perspective…

- What Are the Nuts and Bolts?
- If Put Together Correctly, What do They Build?

Overview - The "Nuts and Bolts" of the Project:

- Broadcast Triticale (Triticum x Secale) into Corn Stalks in Fall '12
- Planted Soybeans *(Glycine max)* into Triticale in Spring '13
- Terminated Triticale Prior to Soybean Emergence
- Compared Soybean Yields with/without Triticale in Fall '13

Overview – The "What is Built" Part of the Project:

- 1 yr Benchmark for Future Research, Using On-Farm Data
- Demonstrates 1 Solution for Addressing Offsite Movement of Nitrate Into Groundwater, which is Built for a Crop Producer.

Project Introduction – Why do it?

Why Would a Producer Care About Offsite Movement of Nitrate?

- Wasteful and Expensive to the Producer's Bottom Line
- Damaging to the Environment
- Impacts Other Individuals, Communities, and Businesses

Examples:

- Producer's bottom line in 2012
- Hypoxia Zone at Gulf of Mexico

Example – Appanoose County Corn Producer in 2012

- Producer Sets Yield Goal for 180 bu/Acre Corn Yield, Requires 127lb/acre of Nitrogen Following Soybeans (Duffy, 2012)
  - Many Producers Responsibly Use ISU Data for Nitrogen

- Nitrogen Cost is $0.63/lb (Duffy, 2012) or $80 Per Acre

- Appanoose County 10 yr Average Corn Yield is 127 Bushels/Acre (Ag Decision Maker, 2012)

- Due to Weather Issues, Assume Actual Production is 135 bushels/acre, or 45 Bushels (25%) Less than Planned

- Assume Actual Amount of Nitrogen Used by Corn is 25% Less Than Planned, Resulting in Some Left Over at the End of the Season

- The 25% Unused Portion is Unrecoverable with the Corn/Soybean Cropping System, and Represents a $20 per Acre Loss to Bottom Line

Example – Hypoxic Zone in Gulf of Mexico

- First Documented in 1972 (Lumcom, 2012)
- Caused from Non Point Source Nutrient Loading in Mississippi River
- Second Largest Hypoxic Zone in the World
- Detrimental to Marine Life, Impacts Fishing Industry, Communities
- Scientific Assessment of Hypoxia in US Coastal Waters Done by US Government in 2010. Comment on Pg 1 of the Executive Summary:

  > "Despite the use of improved production methods in recent years, agriculture is still a leading source of nutrient pollution in many watersheds due, in part, to the high demand for nitrogen-intensive crops, principally corn." (Committee on Environment and Natural Resources, 2010)

- Corn is Identified

Project Introduction – Why do it?

Offsite Movement of Nitrate Into Groundwater:

- Results in Wasted Expense for Producer
  - $20 per Acre in 2012 Example

- Contributes to Hypoxic Zone in Gulf of Mexico
  - 2nd Largest In World
  - Study by US Government Identifies Corn Production

Important for Corn Producers to Understand this Issue

- Be Proactive in Resolving it Quickly
- Develop a Profitable and Sustainable Solution

Project Introduction – Summary

What are the Nuts and Bolts?

- Winter Triticale used as a Cover Crop Following No-Till Corn
- 2 yr Rotation is Corn CC – Soybeans

What do they Build?

- Cover Crop Functions as a Biological Recycling Process to System
  - Scavenges Excess Nitrate from the System
  - Stabilizes Into Organic Forms that do not Leach
  - Does Not Impact Yield Potential of Following Soybean Crop

What is the Purpose of this Project?

To Examine a Solution to Address Offsite Nitrogen Movement

- Uses On-Farm Data as Benchmark for Further Research
- Compares Soybean Yields with and without a Triticale Cover Crop
- Null Hypothesis: No Difference Between Mean Soybean Yields

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Materials and Methods – Cover Cropping

Using Another Plant as N Source is not a New Idea

- During 1940's, Alfalfa Meadow Often Used for 2 Yrs Prior to Corn
- Legume Fixation Resulted in Low External Inputs to System
- System Not Sustainable by Today's Standards Due to Tillage

Is it Possible to Integrate Some Benefits?

- Yes, If System is Built Correctly
- Resources Like Managing Cover Crops Profitably (SARE, 2007)
- Advice to Producers - Start Small and Learn

Materials and Methods – Previous Attempts

2011 Attempt with Tillage Radish

- Goal to Scavenge Nitrogen Into Radish Tuber
- Broadcast with End Gate Seeder in Mid September (Photo)
- Dry Conditions Delayed Germination, Experiment Failed
- Labor Intensive and Inefficient for Mainstream Production
- Seed Cost Expensive
- Success Highly Dependant on Late Summer Rainfall, which Presents an Elevated Risk to the Bottom Line

End Gate Seeder – Labor Intensive

Materials and Methods – Indy Blend

Based on Handbook, Selected Radish, Ryegrass, and Red Clover

- Radish is Scavenger
- Ryegrass is Stabilizer
- Red Clover Fixates Nitrogen
- Indy Blend was Best Match, Substituting Crimson Clover

Broadcast with Modified Sprayer in Late September

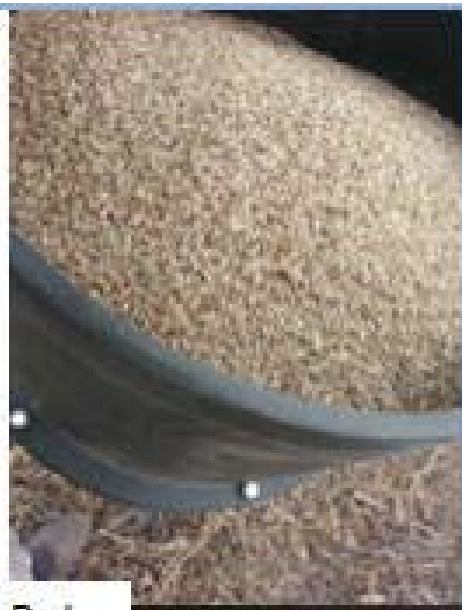
Modified Spray Rig Using Dual Electric Seeders

Calibrated Seeder Distribution Pattern Using Ice Cube Trays

Able to Seed 10 Acres Between Fills

Timely Germination, but Limited Seedling Growth Due to Dry Soil


Broadcast Seeder Installation
SPIN TECH



Fill Seeder with Indy Blend and Adjust Rate


Broadcast Seeder Calibration


Block C 10/29/12

Materials and Methods – Indy Blend Results

- RBCD - 5 Blocks with 4 Treatments
- Experiment Failed with No Early Spring Growth
- Success Highly Dependant on Late Summer Rainfall, which Presents an Elevated Risk to the Bottom Line
- Labor Intensive and Perhaps Inefficient for Mainstream Production
- Success Highly Dependant on Early Seeding Date, which Adds Cost If Aerial Seeded ($10 per Acre in 2013)
- Theoretically Still a Good Choice, May Warrant Further Research?
- Presently Cost Prohibitive and Not Robust with Current System

Materials and Methods – Triticale?

Original Purpose Not for Creative Component, but Indy Blend Failed

Create Rural Opportunity for Younger Neighbor's Livestock Business

Win/Win Scenario to Help Offset Cost of Cover Crop Seed

Favorable Nitrogen Uptake from Triticale with Current System

- 45lbs to 65lbs per Acre (Workman, 2013)

- Balances with 25% Unused Nitrogen (54 lbs per Acre) from Appanoose County Corn Producer Example
  - 180 Bushels per Acre Planned – 135 Actual = 45 Bushels
  - 45 Bushels per Acre Less x 1.2 lbs N per Bushel = 54 lbs N

Materials and Methods – Triticale, A Good Match

Favorable Cover Crop Synergies with Current Production System

- Zero Application Cost Due to Synergy with Dry Fertilizer
- Zero Integration Cost to Synergy with Current System
- Did Not Grow Too Fast In Early Spring, but was Noticeably Better than Ryegrass from the Indy Blend
- 14” Tall Triticale Did Not Impact Soybean Planter Including:
  - Speed, Furrow Opening, Depth, Singulation, or Furrow Closure
- Terminated Quickly with 40oz per Acre of Glyphosate

Favorable Cover Crop Synergies with Current Production System

- Already Using Floater Truck to Broadcast Dry Fertilizer

Favorable Cover Crop Synergies with Current Production System

- Already Using Harrow to Incorporate Dry Fertilizer and Manage Standing Residue

Link: http://youtu.be/9Xgd1gr4E9I

Triticale Block A:

Triticale was Seeded 4Oct12:

50 lbs per Acre, blended w/

50 lbs per Acre DAP

50 lbs per Acre Potash

9.6 Plants/ft^2, Est. 37% Germ

$0.39/lb or $19.50 per Acre

Typical Forage 70-90 lbs per Acre

Point of Reference (Barn)

Soybean Planting: 15May13

Link: http://youtu.be/5EwGTH30mB8

Machine: 1790 Planter
Rate: 205,000
Speed: 5.6 MPH
Depth: ¾ “
Variety: 93Y15 (Pioneer)
Triticale Height: About 14”

Terminate Triticale: 16May13

Link: http://youtu.be/b0S-uOVLJp4

Machine: 220 Melroe
Speed: 7.8 MPH
Width: 60 ft
Carrier: 10 Gal/Acre
Chemical: Glyphosate
Adjuvant: Choice
Cal: May’13
Rate: 40 oz/Acre

Triticale Burndown Block A (30May13)

Full Light Inception to Ground Surface at VC

Materials and Methods – Integrating Triticale

- Minimizes Partial Input Costs for Cover Crop (Seed, App, Terminate)

- Minimizes Probability of Negative Soybean Yield Impact
  - 50 lbs per Acre vs. Higher Rate for Forage Crop
    - Provides More Sunlight Inception to the Surface
    - Did Not Require a Preplant Burndown
    - Did Not Impact Planter Performance

  - Did Not Grow Too Fast and Escape Cash Crop System
    - Point of Risk for Other Cover Crops Like Cereal Rye
    - 14" Height Assumed as "Worst Case Scenario"

This Approach Enabled More Flexibility to the System
  - Longer Planting Window

Materials and Methods – Additional Observations

Recall the Purpose of This Project is to Examine a Potential Solution for Reducing Offsite Movement of Nitrogen.

Several Other Potential Benefits were Observed with the Triticale

- Worth Mentioning In Case the Project is Repeated
- Quantification is Beyond the Scope of This Project
- Additional Benefits Included:
  - Soil Conservation
  - Weed Suppression
  - Grazing Value

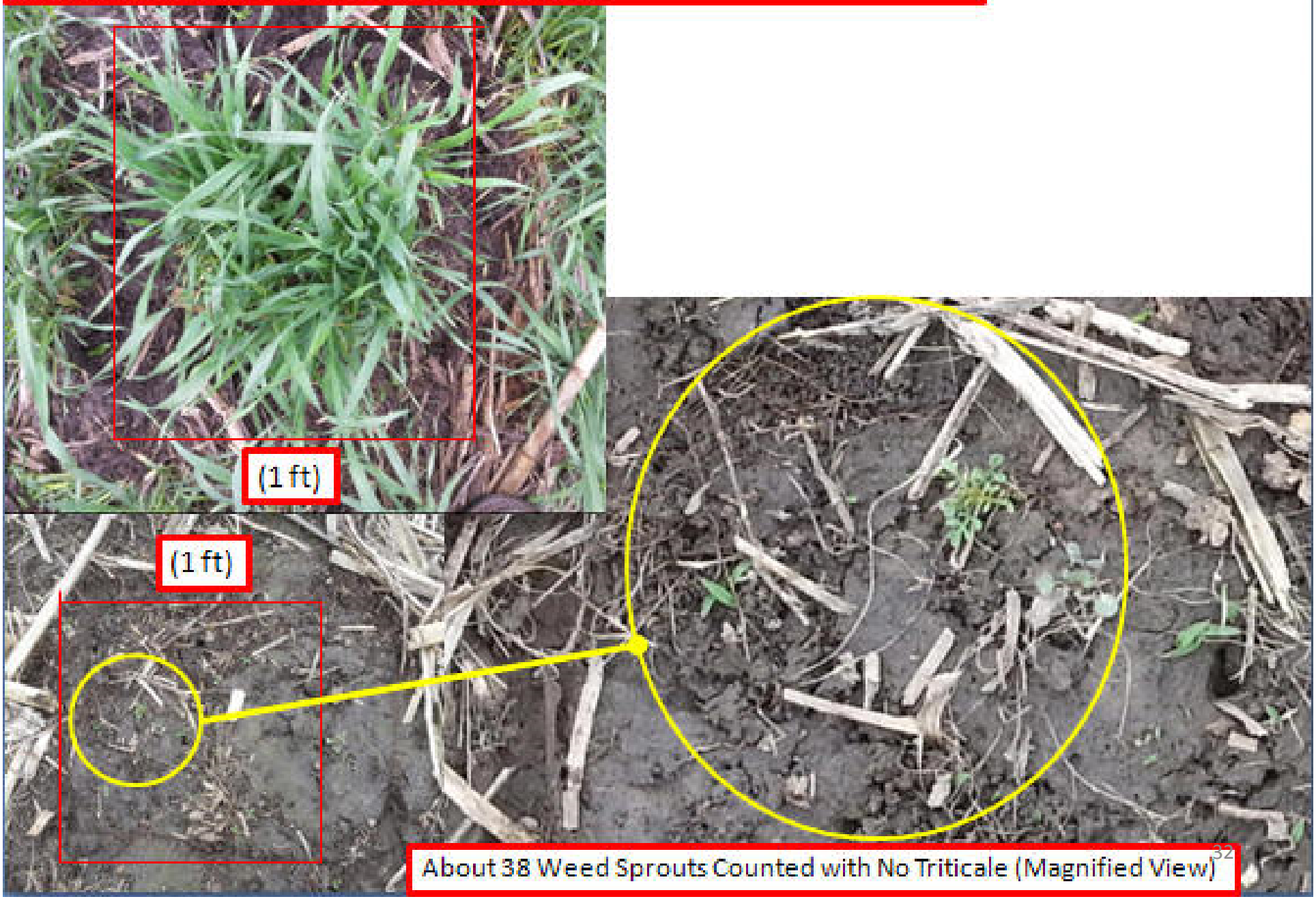
Soil Conservation Observation: About 1-2" Rill Erosion on No-Till After Approx 6" Rainfall with Cover Crop

Observation: Rill Erosion Occurrence And Depth Reduced by Approximately 1/2 With Use of Triticale Cover Crop

Erosion Control: 3″ Rill Erosion on No-Till After Approx 6″ Rainfall – No Triticale Cover Crop

Weed Control Observation: Suppression of Weed Growth From Triticale Canopy

7 Sprouts per Square Foot Observed with Triticale



About 38 Weed Sprouts Counted with No Triticale (Magnified View)


Observation: Triticale
Grazing Value (10May13)

Materials and Methods – Design of Experiment

Primary Focus to Capture Yield Data from Two 20 Acre Blocks A and B

Generalized Randomized Block Design (GRBD) was Used

Each Block Consisted of 6 Replications with Paired Treatments

Treatments Consisted Of:

- X – Soybean Yield with Triticale Cover Crop
- X_0 - Soybean Yield without Triticale Cover Crop

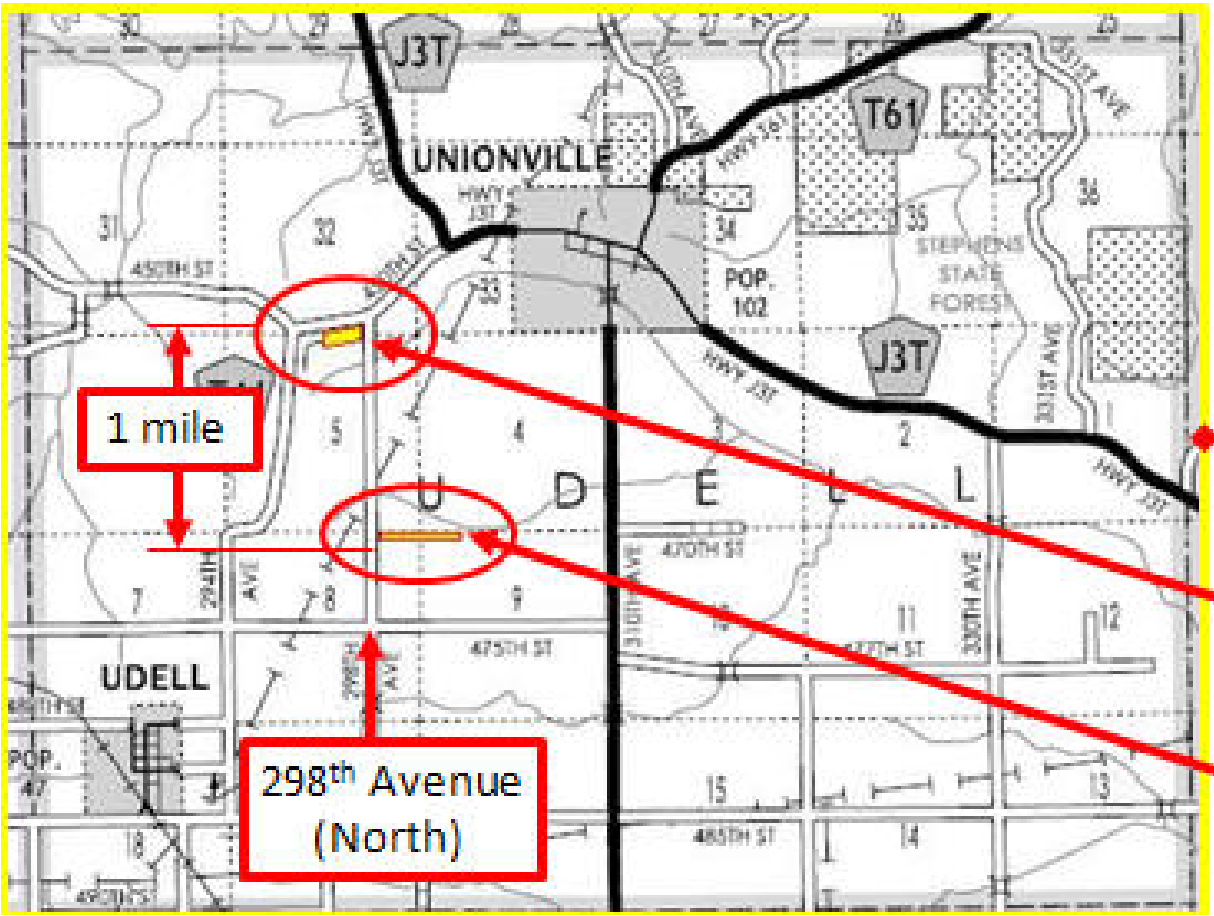
In this Manner, Treatment Effect X is Compared with the Absence of the Treatment Effect X_0

Null Hypothesis is No Significant Difference Between Means

H_0: $\mu_X = \mu_{Xo}$, α: 0.05

Chart 1: Triticale Block Locations

- Appanoose County
- Udell Township
- Sections 32 and 8



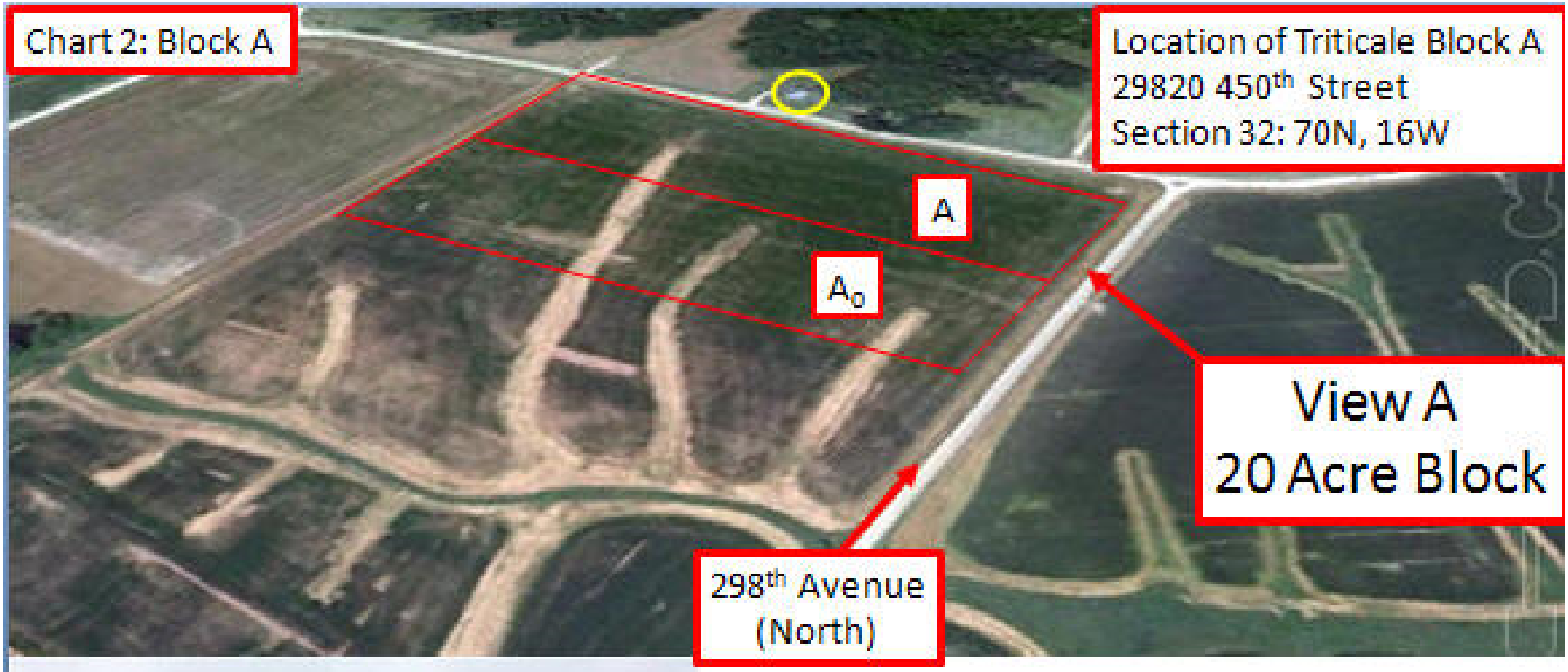
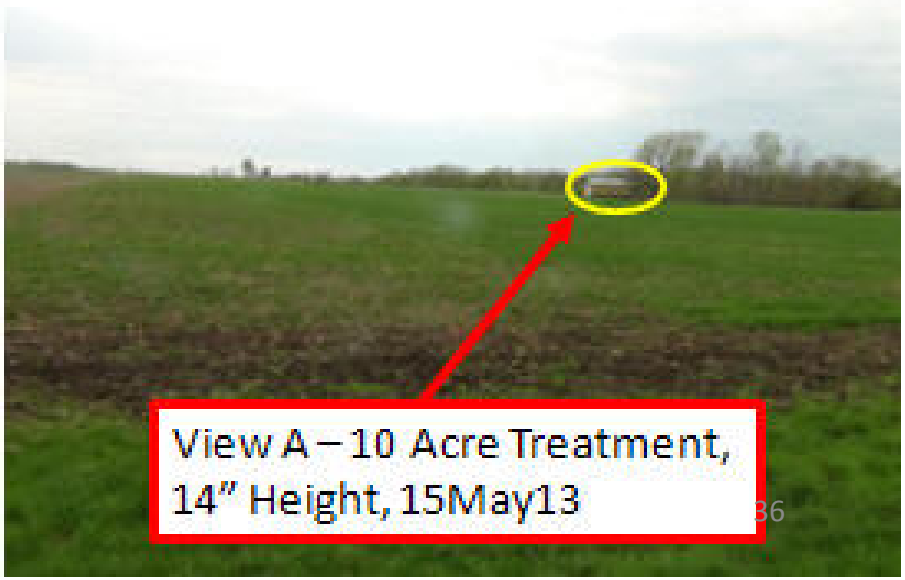


Chart 2: Block A
Location of Triticale Block A
29820 450th Street
Section 32: 70N, 16W
A
A_o
View A
20 Acre Block
298th Avenue
(North)


View A – 10 Acre Treatment,
2" Height, 29Oct12


View A – 10 Acre Treatment,
14" Height, 15May13

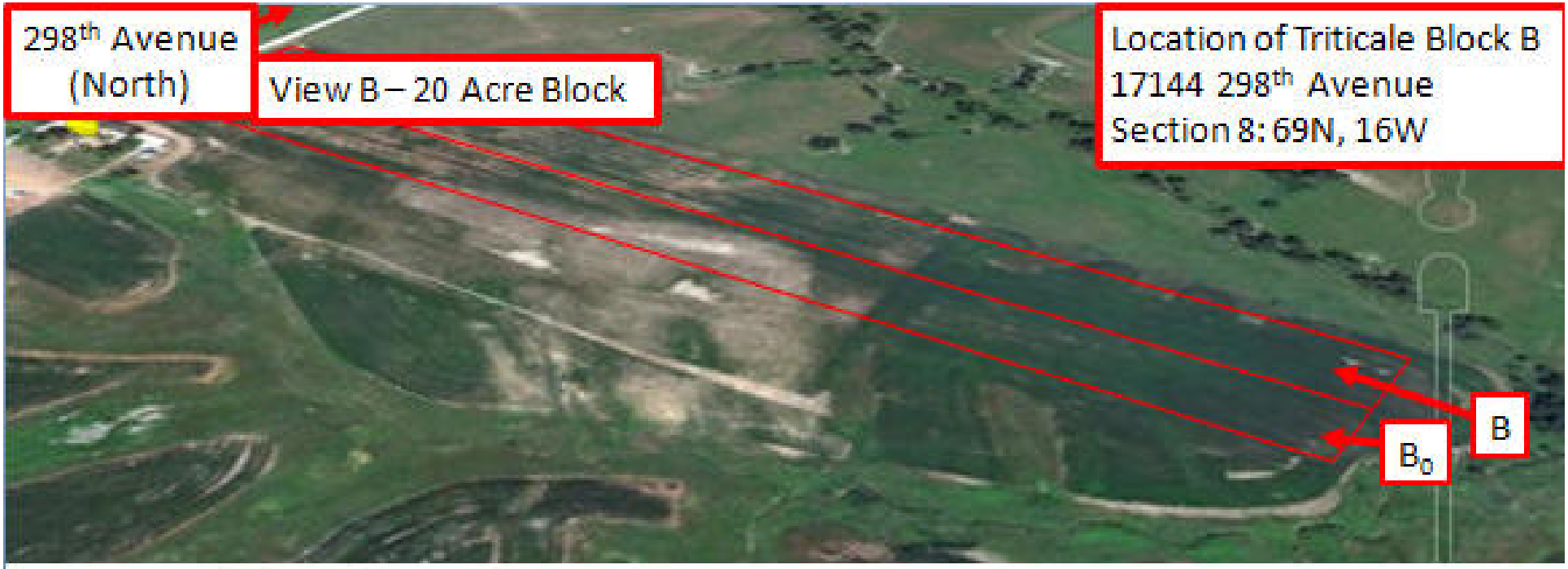


Chart 3: Block B

•*Materials and Methods – Design of Measuring System*

Size of Area Needed to be Large Enough for Production Using 12 Row (30ft Wide) Machinery for Planting and Harvesting

Area Needed to Produce Enough Yield to Facilitate a Precise Measurement Using a Field Scale (aka weigh wagon), including 1.5% Cumulative Scale Error Assumption

For This Project, ½ Acre Replication Size was Selected:

- Expected Precision of System was +/- 0.3 Bushels per Acre
- Assume 40 Bushel per Acre Yield: 40 x 0.015 = 0.6, or +/- 0.3
- Typical On-Farm Data Expected to be +/- 2.5 Bushels per Acre

Based on This Initialization, the ½ Acre Size Would Provide Adequate Fidelity for the Experiment to Achieve Its Objectives

Materials and Methods – Scale Calibration Procedure

Calibration Checked Using Two 5 Gallon Buckets Full of Water

- Person Weighed on Bathroom Scale 3 Times with and Without Holding Buckets, Average Empty Bucket Weight was 4.4 lbs.

Buckets Precisely Filled with Water Using 128oz Graduated Scale

- Density of 10 Gal Water at 70 deg F Assumed to be 83.29 lbs (EngineeringToolbox, 2013)
- Standard Weight was 87.7 lbs (83.29 + 4.4)

- The Scale was and Zero'd and the Standard was Placed on a the Frame.
  - The Scale Measurement was Recorded
  - Process was Repeated 2 More Times

- 3 Sample Average was within 1.2% of the Standard Value.
  - Scale within 1.5% and Calibration Assumed Correct

Field Scale Calibration Check
10 Gallon Water Standard was 87.7 lbs
Average of 3 Weighs was 86.6 lbs, within 1.2% of Standard
This was Within 1.5% of Cumulative Error Assumption

Materials and Methods – Growth Analysis Using Pod Counts

Growth Analysis Performed Prior to Leaf Drop

- Impending Risk for Pod Fill Due to Dry Weather in August ’13
- Some Insect Feeding
- Potential for Lodging Due to Weather (Wind)

Pod Counts Procedure for Blocks A and B:

- 7 Replications Made for Each Treatment
- 7 Samples Pulled for Each Replication
- Samples Located Next to Each Other within Randomly Selected Row
- Pods with 1-2 Beans Counted ½; Pods with 3+ Beans Counted as 1
- Total of 196 Plants (7 Samples x 7 Reps x 2 Treatments x 2 Blocks)

Soybean Pod Count Sample Taken on 8Sep13 (7 Plants Used in Sample)

Materials and Methods – Soybean Yield Harvest Prep

Rainfall Events Occurred After the Pod Count and Harvest Proceeded

Prior to Harvesting, Each ½ Acre Replication was Laid Off

Lawnmower Used to Cut Control Boundaries

- Functioned to Reduce Chance of Error from Dusty Conditions
- Precisely Limits Yield to Dimensions Measured by Wheel
- Assisted Operator to Make Square Cuts with 30ft Wide Head
- If Repeated, Lawnmower Muffler May Pose Elevated Fire Risk

Harvest Proceeded and Each Replication was Weighed Individually

Sample was Taken to Local Elevator for Grading and Moisture Test

Materials and Methods – Soybean Yield Data Acquisition

Weigh wagon parked on level surface, cal checked, scale zero'd

Prior to Harvesting, Grain Tank Unloaded

- Unload Auger Left on for 20 Seconds After Grain Flow Stopped

Each Replication Harvested in Same Direction at 2.5 MPH

- Unloaded Directly Into Weigh Wagon
- Harvester Parked in Same Location and Position During Unload
- Grain Sample Obtained at Conclusion

21October, 2013
Harvesting Block A

Block B Video Link:
http://youtu.be/8hAERZtcU30

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Results and Discussion – Treatment Effects

Treatment Mean Results Listed in Table 3

- Cover Crop (X) vs. Absence of Cover Crop (X_0)
- Pod and Yield Data
- Probabilities
- ANOVA Table At Bottom

Pod Count Highlight, Average Difference was 1 Pod (P=0.30)

Yield Highlight, Average Difference was 0.06 Bushels/Acre (P=0.92)

Yield Results Within Capability of +/- 0.3 Bu/Acre Measuring System

Results are Plausible Because:

- Triticale Did Not Impede Soybean Planter Performance
- Triticale Burned Down Quickly and Did Not Impede Sunlight Inception to the Soil Surface at VC Growth Stage

Table 3: Summary of Experimental Test Results

Test Result	Cover Crop (X)	No Cover Crop (X_0)	P-value	Conclusion
Soybean Average Yield Data (bushels / acre):	35.70	35.64	0.92531	Fail to reject null hypothesis for yields
Soybean Average Pod Count Data (pods / plant):	22	23	0.30164	Fail to reject null hypothesis for pods

Notes: P-values obtained from X vs. X_0 Columns in Anova output summaries below

Null Hypothesis: No significant difference between the treatment means X and X_0 $(\mu_X = \mu_{X_0}, \alpha > 0.05)$

ANOVA - Soybean Yield Data

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Blocks A vs. B)	57.74577	1	57.74577	26.16995	***0.00005***	4.35124
Columns (Treatment X vs. X_0)	0.01989	1	0.01989	0.00901	0.92531	4.35124
Interaction (Block x Treatment)	0.31420	1	0.31420	0.14239	0.70989	4.35124
Residual	44.13136	20	2.20657			
Total	102.21121	23				

ANOVA - Soybean Pod Count Data

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample (Block A vs. B)	44.10787	1	44.10787	4.68318	***0.04063***	4.25968
Columns (X vs. X_0)	10.49563	1	10.49563	1.11438	0.30164	4.25968
Interaction (Block x Treatment)	49.27114	1	49.27114	5.23139	***0.03130***	4.25968
Residual	226.04082	24	9.41837			
Total	329.91545	27				

Results and Discussion – Other Effects

Significant Difference Between Block Effects

- Soybean Pod Data (P=0.04063)
- Soybean Yield Data (P=0.00005)

Results are Plausible Because:

- Blocks Are Large (20 Acres) and About 1 Mile Apart
- Blocks Management History Varies

Significant Pod Count Difference with Block x Treatment Effect (P=.0313)

- This May be Due to Physiological Differences at Pod Count
  - Rain Event Delayed Block B Planting Date 4 Days
  - At Harvest, Both Blocks were Mature
  - At Leaf Drop on 8Sep13, Maturity may have Varied
- For Purposes of this Experiment, Disregard Block x Treatment Result

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Summary and Conclusions:

Key Point – The 14” Tall Triticale Represented a Worst Case Scenario for Producer who Didn’t Get the Cover Crop Terminated

Demonstrates the Triticale Population Used in this Experiment did not Pose and Elevated Risk to the Soybean Production System

Flexibility and Larger Planting Windows in the Spring may be a More Desirable Approach for a Producer than Maximizing Cover Crop Yield

The Experiment Could Not Significantly Prove that a Mean Soybean Yield or Pod Count Difference Existed Between the X and X_0 Treatment Effects

Under Present Circumstances, Resulting from 1 Growing Season and 2 Separate Blocks, the Conclusion is to Fail to Reject the Null Hypothesis

Conclusions Favorable to Advancement of Cover Cropping:

Important and Urgent Reasons Include:

- Triticale Did Scavenge Some Nitrogen In Order to Grow 14” Tall
  - Producer May Have Lost $20 per Acre Waste in 2012
  - Wasted N May have Otherwise Entered Local Watershed, Potentially Contributing to Hypoxic Zone Issue

Other Reasons Beyond Scope of This Project – Triticale May Have:

- Reduced Number of Weed Seedling Sprouts
- Reduced Offsite Soil Movement on Sloping Ground
- Enabled a Rural Development Opportunity with Neighbor
- Helped to Mitigate Climate Change by Sequestering Carbon Dioxide from Atmosphere
- Promoted Biodiversity Leading to Healthier Soils
- And Triticale Could Have Theoretically Offset Some Corn Stover Tonnage Removed for Cellulosic Ethanol

Closing and Questions:

In Closing, I believe the Triticale Used In this Experiment Does In Fact Demonstrate One Solution of How to Intensify and Agricultural System In Order to Solve Problems and Create Possibilities for the Future.

Thank you for this Opportunity to Visit with You More About It

QUESTIONS ?

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