2011 KBS LTER Agronomic Report

MICHIGAN STATE UNIVERSITY
AgBioResearch

KBS LTER
Kellogg Biological Station
Long-term Ecological Research

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Acknowledgements

Results of 2011 Agricultural Field Operations

Long-term Ecological Research Site
W. K. Kellogg Biological Station
Michigan State University

This report is designed to provide a brief summary of the field operations and agricultural data collected during 2011 on the Long-term Ecological Research Site at the W.K. Kellogg Biological Station. It is not designed to provide an in-depth analysis of the experiments and the underlying factors leading to the data. It is hoped that interested parties request the raw data tables for their own individual analyses. Statistical analyses were conducted at the 0.05 level unless indicated differently.

Acknowledgement is given to the following individuals for their contributions:

Phil Robertson
LTER Project Leader

Joe Simmons
LTER/GLBRC Agronomic Manager

Peter S. Hudy
Stacey Vanderwulp
Todd Martin
Mike Miner
Josh Paff
Jeff Wolf

Comments and questions about this report should be sent to:
Joe Simmons, Agronomic Manager, 3700 East Gull Lake Drive Hickory Corners MI, 49060

Additional thanks is given to Peter Hudy for his assistance in the preparation of this report.

Front page photo credit: J.E. Doll/KBS-MSU.

2010 Agronomic Report
Table of Contents

LTER Main Site Treatments

LTER Main Site Treatment T1—Conventionally Tilled Corn Yield Data 1
LTER Main Site Treatment T2—No-till Corn Yield Data 2
LTER Main Site Treatment T3—Reduced-input Corn Yield Data 3
LTER Main Site Treatment T4—Biologically-based (Organic) Corn Yield Data 4
LTER Main Site Treatments T1, T2, T3, and T4—Comparison of Corn Grain Yields Under Different Agronomic Practices 5
LTER Main Site Treatment T3 Micro-plot Study—Influence of weed populations and nitrogen availability on corn yield in a low-input cropping system 7
LTER Main Site Treatment T4 Micro-plot Study—Influence of weed populations and nitrogen availability on corn yield in an organic cropping system 8
LTER Main Site Treatment T5—Poplar Tree Biomass Management 9
LTER Main Site Treatment T6—Alfalfa Biomass Yield 10
LTER Main Site Treatment T7—Early Successional Community 11
LTER Main Site Treatment T8nt—Corn Yields in Traditionally Never-Tilled Fields 12

LTER Nitrogen Fertility Rate Study

LTER Nitrogen Fertility Rate Study—Dryland Corn Grain Yield Data 13
LTER Nitrogen Fertility Rate Study—Irrigated Corn Grain Yield Data 14
LTER Nitrogen Fertility Rate Study —Comparison of Dryland versus Irrigated Corn Grain Yields with Different Nitrogen Fertilization Levels 15

LTER Biodiversity Study

LTER Biodiversity Study—Experimental Design and Overview 17
LTER Biodiversity Study—Corn Treatments Grain Yield Comparison 18
LTER Biodiversity Study—Soybean Treatments Grain Yield Comparison 19
LTER Biodiversity Study—Winter Wheat Treatments Grain Yield Comparison 20

LTER Additional Studies

LTER Cellulosic Ethanol Study—Corn and Soybean Grain Yield Data 21
LTER Cellulosic Ethanol Study—Cellulosic Crops, Comparison of 2010 vs. 2011 Biomass Yield Data 22
LTER Cellulosic Ethanol Study—Comparison of the Effect of Added Nitrogen on Biomass Yields of Different Switchgrass Varieties 23
LTER Cellulosic Ethanol Study—Cellulosic Crops, Multi-Species Prairie Biomass Yield Data 24

CHART 1. Precipitation (inches) on the KBS-LTER Main Site at the W.K. Kellogg Biological Station, Michigan State University 25

GRAPH 1. Weather Data for the 2011 Growing Season. Growing Degree Days$_{Corn}$, Average Daily Temperature, and Cumulative Precipitation. KBS-LTER Main Site W.K.Kellogg Biological Station, Michigan State University. 26

LTER Main Site
Treatment T1 Conventionally Tilled
Corn Grain Yield Data

Purpose

Determine the amount of annual grain production under best management practice for tilled agriculture with a three-year crop rotation with inputs of fertilizer and/or herbicides as needed.

Rotational sequence is Corn (2011)-Soybean (2009/2012)-Winter Wheat (2010/2013).

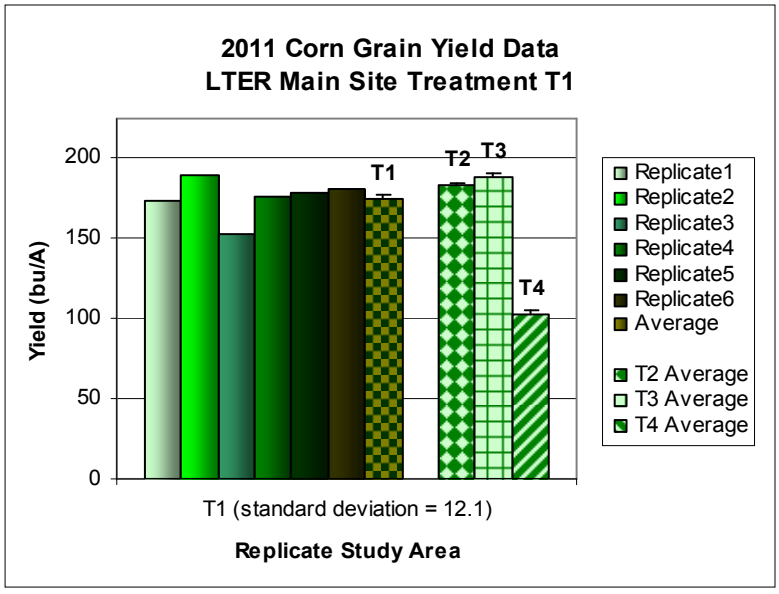
T1	Yield (bu/A)
Replicate1	174
Replicate2	189
Replicate3	153
Replicate4	176
Replicate5	179
Replicate6	181
Average	175

Crop:	**Corn**
Variety:	Dekalb DKC52-59 Hybrid
Planting date:	May 9, 2011
Irrigation:	None
Tillage:	None
Row Spacing:	30 inches
Seeding Rate:	30,800 seeds/A
Harvest date:	November 14-15, 2011
Fertilization:	**March 30, 2011** 0-0-60 39 lbs K_2O/A **May 9, 2011** 19-17-0 29 lbs N/A 26 lbs P_2O_5/A **June 15, 2011** 28-0-0 110 lbs N/A
Herbicide Preemergence:	**May 11, 2011** Lexar: 3 qts/acre
Herbicide Postemergence:	**2011: None**

Results

Compared to all LTER Main Site corn treatments in 2011, Treatment T1 had the second lowest grain yield at 175 bu/A. Both T2 (184 bu/A) and T3 (189 bu/A) had higher yields; the yield of T4 was (103 bu/A).

The yield for T1 across the replications was the most variable (standard deviation=12.1). The yields of T2, T3 and T4 were all more uniform across replicates (standard deviations: 11.7, 10.0 and 8.7 respectively).



LTER Main Site Treatment T2 No-till Corn Grain Yield Data

Crop:	**Corn**
Variety:	Dekalb DKC52-59 Hybrid
Planting date:	May 6-7, 2011
Irrigation:	None
Tillage:	None
Row Spacing:	30 inches
Seeding Rate:	29,500 seeds/A
Harvest date:	November 14-15, 2011
Fertilization:	**March 30, 2011** 0-0-60 39 lbs K_2O/A **May 6-7, 2011** 19-17-0 29 lbs N/A 26 lbs P_2O_5/A **June 13-15, 2011** 28-0-0 110 lbs N/A
Herbicide Preplant/ Preemergence:	**May 2, 2011** RoundUp 44 oz/A Ammonium Sulfate 3.4 lbs/A **May 11, 2011** Lexar: 3 qts/acre
Herbicide Postemergence:	**2011: None**

Purpose

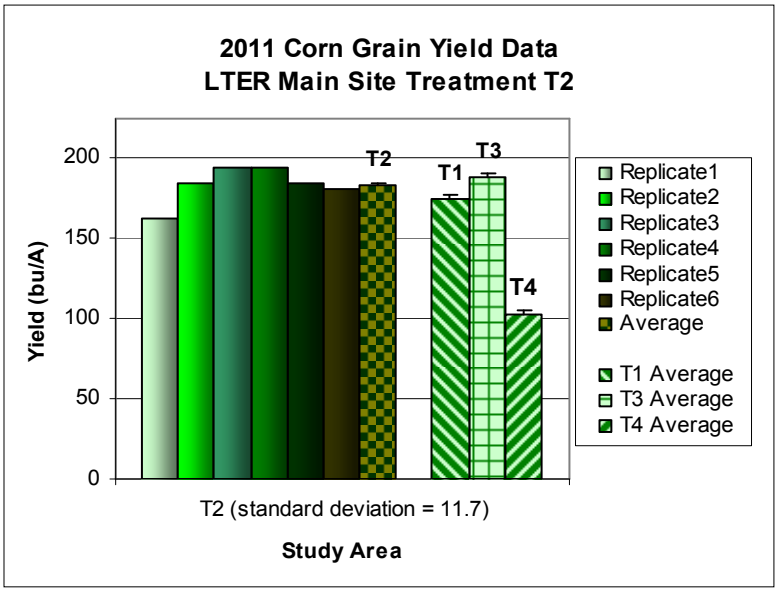
Determine the amount of annual grain production under best management practice for no-till, rotational agriculture with a three-year crop rotation with inputs of fertilizer and/or herbicides as needed.

Rotational sequence is Corn (2011)-Soybean (2009/2012)-Winter Wheat (2010/2013).

T2	Yield (bu/A)
Replicate1	162
Replicate2	185
Replicate3	194
Replicate4	194
Replicate5	185
Replicate6	181
Average	**184**

Results

In the 2011 growing season, Treatment T2 had the second highest grain yield compared to the other LTER corn treatments. Variability between replications was the second highest of all LTER treatments (standard deviation 11.7 vs. 12.1, 10.0 and 8.7 for T1, T3 and T4 respectively).



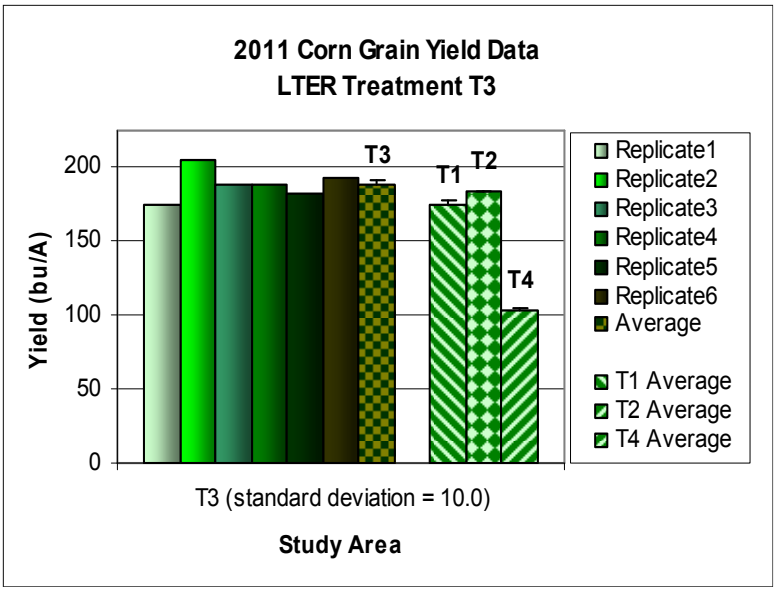
LTER Main Site
Treatment T3 Reduced-input
Corn Grain Yield Data

Purpose

Determine the amount of annual grain production under best management practice for tilled agriculture with a three-year crop rotation with reduced levels of inputs of fertilizer and/or herbicides as needed.

Rotational sequence is Corn (2011)-Soybean (2009/2012)-Winter Wheat (2010/2013).

T3	Yield (bu/A)
Replicate1	175
Replicate2	205
Replicate3	189
Replicate4	188
Replicate5	183
Replicate6	193
Average	**189**



Crop:	**Corn**
Variety:	Dekalb DKC52-59 Hybrid
Planting date:	May 24, 2011
Irrigation:	None
Tillage:	**May 10, 2011** Chisel plow **May 24, 2011** Soil finish
Row Spacing:	30 inches
Seeding Rate:	30,000 seeds/A
Harvest date:	November 15-16, 2011
Fertilization:	**March 30, 2011** 0-0-60 39 lbs K_2O/A **May 24, 2011** 19-17-0 29 lbs N/A 26 lbs P_2O_5/A
Row Cultivation	**June 2, 2011** **June 3, 2011** Rotary hoed twice to loosen soil so seedlings could emerge.
Herbicide Postemergence:	**June 17, 2011** Lexar: 3 qts/acre RoundUp 44 oz/A Ammonium Sulfate 3.4 lbs/A

Results

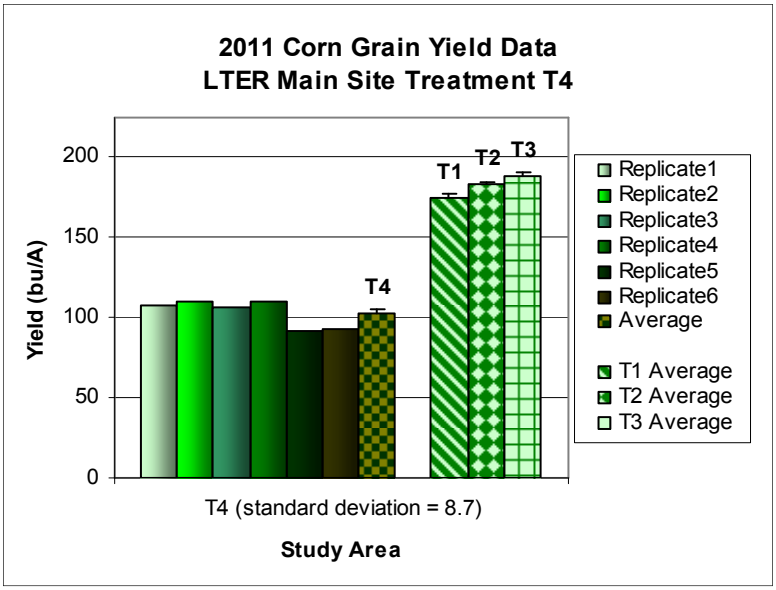
Compared to all LTER Main Site corn treatments in 2011, Treatment T3 had the highest grain yield at 189 bu/A; that yield was higher, but not significantly higher, than any other 2011 LTER corn treatment.

The only nitrogen fertilization which Treatment T3 received was 29 lbs/A at planting and the red clover cover crop which was seeded into the wheat crop which preceded the 2011 corn crop.

Treatments T1—T4 all had comparable yield variability (standard deviations =12.1, 11.7, 10.0 and 8.7 respectively for T1, T2, T3 and T4).

LTER Main Site
Treatment T4 Biologically-based (Organic)
Corn Grain Yield Data

Crop:	**Corn**
Variety:	Blue River Hybrid 22A10 (Organic hybrid)
Planting date:	June 4, 2011
Irrigation:	None
Tillage:	**May 24, 2011** Chisle plow **June 2-3, 2011** Soil finish
Row Spacing:	30 inches
Seeding Rate:	32,000 seeds/A
Harvest date:	November 16, 2011
Fertilization:	**NONE; Organic**
Herbicide:	**NONE: Organic**
Row Cultivation:	June 8, 2011 June 20, 2011 June 27, 2011 July 5, 2011



Purpose

Determine the amount of annual grain production under best management practice for no-till, rotational agriculture with a three-year crop rotation without inputs of fertilizer or herbicides, managed as if it were an organic system.

Rotational sequence is Corn (2011)-Soybean (2009/2012)-Winter Wheat (2010/2013).

T4	Yield (bu/A)
Replicate1	108
Replicate2	110
Replicate3	107
Replicate4	110
Replicate5	92
Replicate6	93
Average	**103**

Results

In the 2011 growing season, Treatment T4 had the lowest yield of any of the other LTER corn treatments with an average yield of 103.2 bu/A. Because T4 is an organic treatment, it did not receive any supplemental nitrogen except through the cover crop.

Variability between replicates was the lowest of all the LTER Main Site corn treatments.

LTER Main Site Treatments T1, T2, T3, and T4 Comparison of Corn Grain Yields Under Different Agronomic Practices

Purpose

Compare the yields of corn grown under agricultural different management practices:

T1 Conventionally tilled field with fertilizer and/or herbicides as necessary;

T2 No-tilled with the addition of fertilizer and/or herbicides as necessary;

T3 Tilled field with reduced levels of fertilizer and/or herbicides; In 2010, soft red winter wheat was grown. Red clover was established at the beginning of the growing season as a cover crop and was left to produce biomass and capture nutrients. The cover crop was tilled in at the start of the 2011 growing season.

T4 Tilled Biologically-based (Organic) with no additions of fertilizers or herbicides; In 2010, soft red winter wheat was grown. Red clover was established at the beginning of the growing season as a cover crop and was left to produce biomass and capture nutrients. The cover crop was tilled in at the start of the 2011 growing season.

Results

Yields varied by treatment in 2011 (ANOVA). The highest yielding treatment was T3 (reduced-input), followed by T2 (no-till), T1 (conventionally tilled), then by T4 (organic). The yield of T1, T2 and T3 were not significantly different from each other but were significantly higher than the yield of T4.

2011 was the first year that different corn varieties were planted in the LTER treatments within the same growing season. 2011 was the first year that GMO corn was planted on the LTER. Treatments 1-3 were planted to Dekalb DKC52-59. Treatment 4 was planted to Blue River Hybrid 22A10.

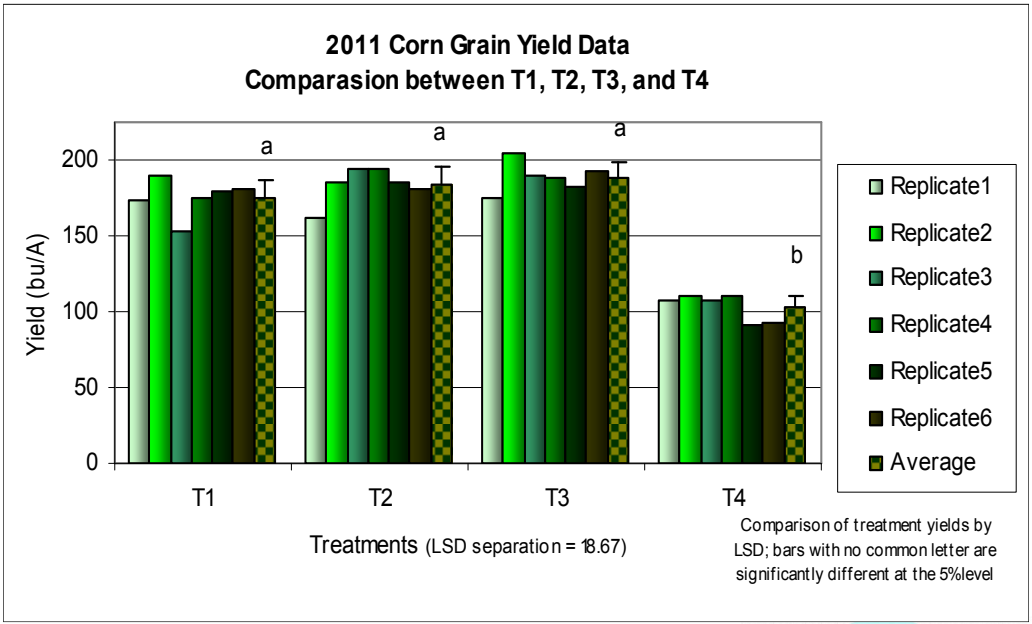
2011 LTER Corn	Treatment Grain Yield (bu/A)			
	T1	T2	T3	T4
Replicate1	174	162	175	108
Replicate2	189	185	205	110
Replicate3	153	194	189	107
Replicate4	176	194	188	110
Replicate5	179	185	183	92
Replicate6	181	181	193	93
Average	**175**	**184**	**189**	**103**
Standard Deviation	12.1	11.7	10.0	8.7

Lower yields of T4 could be due to different genetics or the later planting date (June 4) and the weather conditions at that time. The only nitrogen applied to the T4 plots was the red clover cover crop which was seeded into the 2010 winter wheat crop which preceded the 2011 corn crop.

Additionally, as demonstrated by the micro-plot data for T3 and T4 (pages 7-8), weed control and nitrogen can significantly effect corn yields.

(continuation of facing page)

Crop:	Corn (T1)	Corn (T2)	Corn (T3)	Corn (T4)
Variety:	Dekalb DKC52-59 treated seed	Dekalb DKC52-59 treated seed	Dekalb DKC52-59 treated seed	Blue River Hybrid 22A10 untreated seed
Planting date:	May 6, 2011	May 6-7, 2011	May 24, 2011	June 4, 2011
Irrigation:	None	None	None	None
Tillage:	Tilled	Untilled	Tilled	Tilled
Row Spacing:	30 inches	30 inches	30 inches	30 inches
Population (seeds/A):	30,800	29,500	30,000	32,000
Harvest date:	November 14-15	November 14-15	November 15-16	November 16
Fertilization: (28-0-0)	**May 9, 2011** 29 lbs N/A **June 15, 2011** 110 lbs N/A	**May 6-7, 2011** 29 lbs N/A **June 15, 2011** 110 lbs N/A	**May 24, 2011** 29 lbs N/A	None
Cover Crop	None	None	Medium Red Clover	Medium Red Clover
Herbicide Burndown:	None	**May 2, 2011** Roundup + AMS	None	None
Herbicide Postemergence:	**May 11, 2011** Lexar 3 qt/A	**May 11, 2011** Lexar 3 qt/A	**June 17, 2011** Lexar + RoundUp + Ammonium Sulfate	None



LTER Main Site
Treatment T3 Micro-plot Study

Influence of weed populations and nitrogen availability on
Corn yield in a reduced-input cropping system

Purpose

Determine how crop yield is influenced by weed populations and nitrogen availability. A total of 6 treatments [shown below in table] were selected to represent possible combinations of typical field practices for weed control and fertilizer levels.

Weed control treatments

- Business as usual (BAU): Micro-plots received the same field weed operation as the main plot.
- Weed Free (complete) weed control (WF): No weeds were allowed to become established; plots were hand weeded one time during the growing season.
- No Weed Control (NWC): Micro-plots were allowed to grow without any form of weed control.

Fertilizer levels

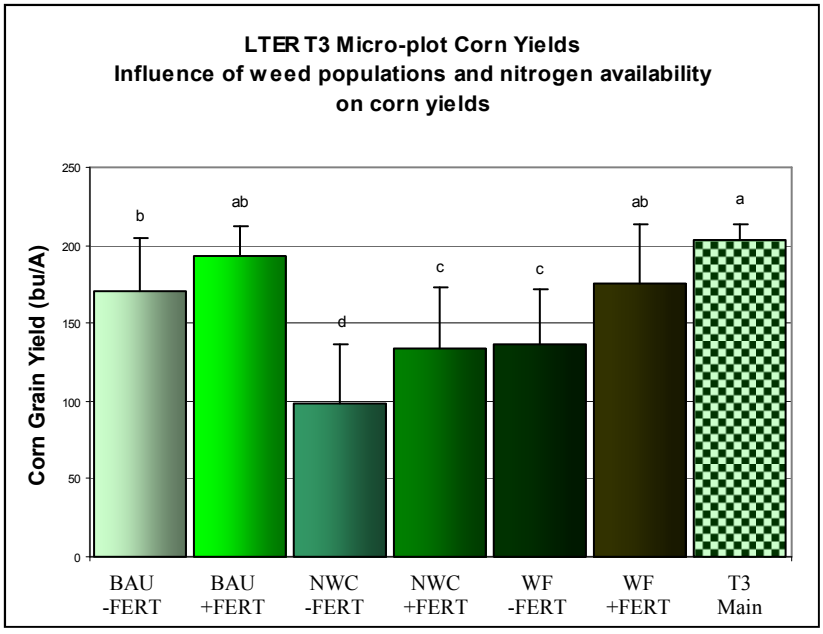
- + Fertilizer (+FERT): Fertilizer was applied at the same rate and manner as the LTER main site treatment 1 main plots.

Treatment Combinations			
	BAU	**WF**	**NWC**
+ FERT	BAU + FERT	WF + FERT	NWC + FERT
- FERT	BAU - FERT	WF - FERT	NWC - FERT

Results

Micro-plots yields were significantly different ($p<<0.001$) and differed significantly across replicates ($p<<0.01$). Micro-plot data was also more variable than main plot data (standard deviations: 34.7 vs 9.3 respectively).

Less weedy plots yielded significantly higher than weedier plots ($p<<0.01$). Plot weed control was visually rated as BAU>WF>NWC. BAU had the least weeds due to season-long, chemical control. WF only had one weeding event; by the end of the season, there was light weed pressure. NWC had dense weed growth.



Plots which received additional nitrogen also yielded significantly higher than comparable plots which did not ($p \cong 0.01$).

The best yielding micro-plot treatments yielded comparable to the T3 main plot; however, the BAU-FERT treatment yielded significantly less than the T3 main plot.

Current weed and fertilizer management practices for T3 seem to be adequate for achieving the highest possible yield.

LTER Main Site
Treatment T4 Micro-plot Study

Influence of weed populations and nitrogen availability on
Corn yield in an organic cropping system

Purpose

Determine how crop yield is influenced by weed populations and nitrogen availability. A total of 6 treatments [shown below in table] were selected to represent possible combinations of typical field practices for weed control and fertilizer levels.

Weed control treatments

- Business as usual (BAU): Micro-plots received the same field weed operation as the main plot.
- Weed Free (complete) weed control (WF): No weeds were allowed to become established; plots were hand weeded one time during the growing season.
- No Weed Control (NWC): Micro-plots were allowed to grow without any form of weed control.

Fertilizer levels

- + Fertilizer (+FERT): Fertilizer was applied at the same rate and manner as the LTER main site treatment 1 main plots.

Treatment Combinations			
	BAU	**WF**	**NWC**
+ FERT	BAU + FERT	WF + FERT	NWC + FERT
- FERT	BAU - FERT	WF - FERT	NWC - FERT

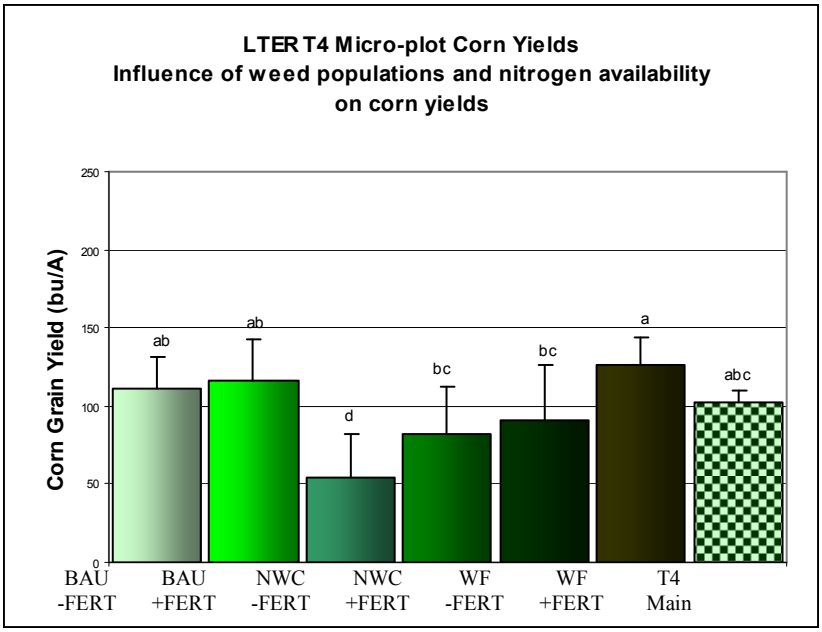
Results

Micro-plots yields were significantly different based on treatments ($p<<0.001$) but did not differ across replicates. Micro-plot data was also more variable than main plot data (standard deviations: 27.0 vs 7.6 bu/A respectively).

Plots with no weed control (NWC) yielded significantly less than other plots ($p<<0.01$). LSD separation does not support separating BAU from WF plots.

Plots which received additional nitrogen yielded significantly higher than comparable plots which did not receive additional nitrogen ($p=0.016$).

The best yielding micro-plot treatments were comparable to the T4 main plot. Based on this single year's data, the current weed and fertilizer management practices for T4 are adequate for achieving the best possible yields. it is not possible to select management practice which would lead to increased yields.



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LTER Main Site
Treatment T5
Poplar Tree Biomass Management

Purpose

Determine the amount of biomass production for cellulosic yields under a short-rotation system of trees (Poplars).

Crop:	**Poplar Trees**
Variety:	NM-6
Planting date:	May 12-13, 2009
Irrigation:	None
Tillage:	None
Row Spacing:	8' x 5'
Population:	1,089 trees/A
Harvest date:	Not harvested in 2011
Fertilization:	**June 6-22, 2011** Ammonium Nitrate 140 lbs N/A
Weed Control	**2011:** None

Results

Poplar trees in treatment T5 were harvested in 2008. Treatment T5 was replanted to trees by Midwest Forestry, Inc, Scottville, MI on May 12-13, 2009 using 10 inch poplar cuttings. Cuttings were planted so that only one or two dormant buds were left above the soil surface. The variety planted was NM-6 hybrid poplar tree: *Populus nigra* x *populus maximowiczii.*

In April 2010, missing trees were replanted with 1 year-old whips measuring 4-6' tall. All replicates were mowed two times in 2010 to control weeds between the rows: May and August.

All replicates were fertilized in 2011 with 140 lbs N/A (provided as ammonium nitrate).

In June 2011, six micro-plots were established, and fertilized, in each replicate plot as follows:

- **(N1)** 0 lb N/acre;
- **(N2)** 50 lb N/acre, single application in 2011;
- **(N3)** 100 lb N/acre, single application in 2011;
- **(N4)** 50 lb N/acre, annual application;
- **(N5)** 100 lb N/acre, annual application; and
- **(N6)** 100 lb N/acre, single application in the year prior to harvest (expected to be applied in 2015).

LTER Main Site
Treatment T6
Alfalfa Biomass Yield

Crop:	**Alfalfa**
Variety:	WL 347 LH Alfalfa
Planting date:	June 23, 2009
Irrigation:	None
Tillage:	No-Till
Row Spacing:	7.5 inches
Population:	18 lbs/A
1st Cutting	June 6, 2011
2nd Cutting	July 14, 2011
3rd Cutting	August 23, 2011
Fertilization:	**March 30-April 5, 2011** 0-0-60 @ 460 lbs K_2O/A Boron @ 0.43 lbs B/A **April 14, 2011** 0-46-0 @ 92 lbs P_2O_5/A
Herbicide Preemergencnce:	None

Purpose

Determine the biomass production of alfalfa under best management practices for the region surrounding the KBS-LTER site.

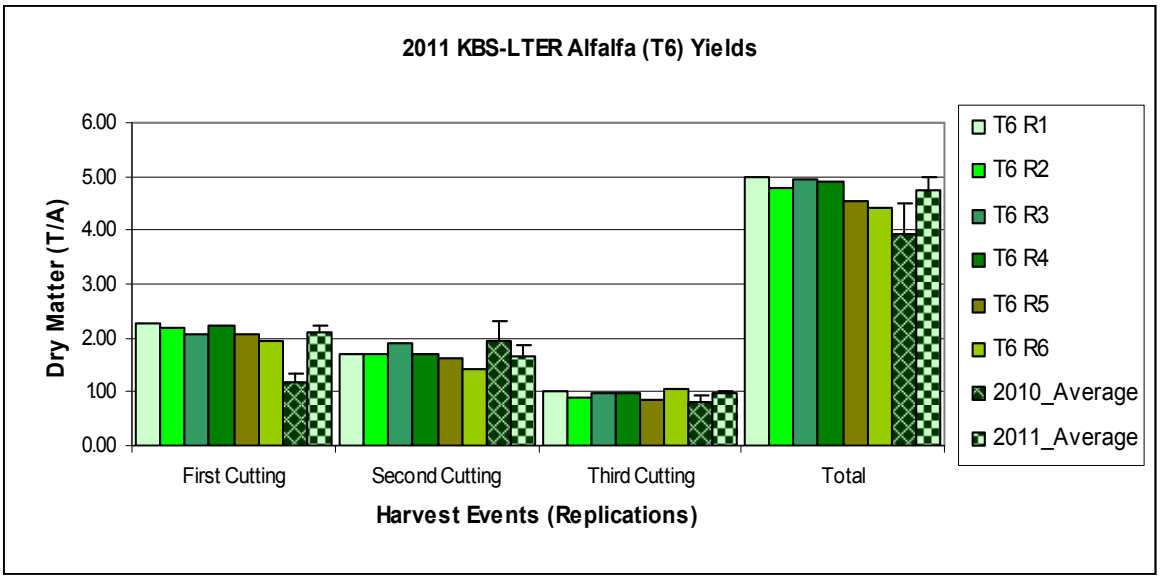
Results

Treatment T6 was planted to alfalfa in July 2009. In that year, only one cutting was taken of alfalfa (October).

In 2010, an average yield of 3.93 t/A was harvested.

In 2011, the average yield was 4.76 t/A when the three separate cuttings combined. There was a significant difference ($p<<0.001$) in biomass production based on the harvest time: the first cutting produced the most, followed by the second and third cuttings respectively.

Comparing 2010 to 2011, there was not a significant difference between the amount of biomass produced in the two years.



LTER Main Site
Treatment T7
Early Successional Community

Crop:	**Successional Community**
Variety:	Natural colonization
Planting date:	—
Irrigation:	None
Tillage:	No-Till
Burn date:	April 13, 2011
Population:	Not determined
Harvest date:	Not harvested in 2011
Fertilization:	None
Herbicide:	None

Purpose

The Early Successional Community Study is mostly observational with no agricultural measurements being taken.

Results

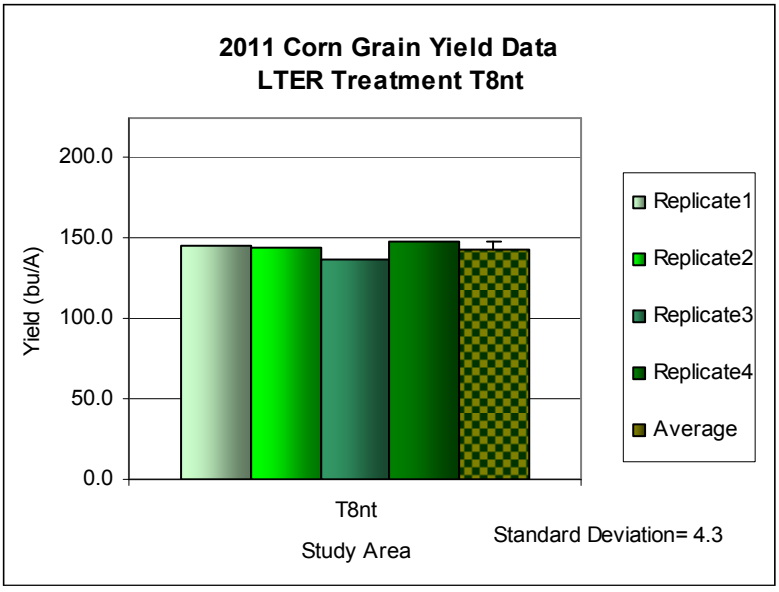
The Early-Successional Community plots are burned annually to help maintain them in a state of early succession. Plots were burned on April 13, 2011. All plots burned great with a visual rating of 97-99% of each plot burned.

Tilled micro-plots on the north end of all replicates were chisel plowed on May 9, 2011 followed by soil finishing (2 times) on May 13, 2011.

No further management was given to the plots during the year except for routine data collection and measurement.

LTER Main Site
Treatment T8nt Corn Grain Yields
in Traditionally Never-Tilled Fields

Crop:	**Corn**
Variety:	**Dekalb DKC52-59**
Planting date:	
Irrigation:	None
Tillage:	No-Till
Row Spacing:	30 inches
Population:	
Harvest date:	November 19, 2011
Fertilization:	**June 27, 2011** 105 lbs N/A
Herbicide:	**May 12, 2011 (pre)** Roundup 44oz/A Ammonium Sulfate 3.4 lbs/A **June 20, 201 (post)** Lexar 3 qt/A RoundUp Power Max 22 oz/A Ammonium Sulfate 3.4 lbsA



Purpose

Determine the amount of annual grain production under best management practice for no-till agriculture.

Treatment T8nt has traditionally never been tilled so original soil structure has been maintained.

In management practices T8nt is treated similarly to LTER Main Site Treatment T2.

Rotational sequence has been Corn (2008) - Soybean (2009) - Corn (2010) - Corn (2011).

	Yield (bu/A)
Replicate1	145
Replicate2	144
Replicate3	138
Replicate4	148
Average	143

Results

In 2011, the average yield for T8nt plots was 143 bu/A of corn with a standard deviation of 4.3 bu/A.

T8nt plots are no-till plots and smaller than the normal LTER Main Site plots (0.015 acres for T8nt versus 2.18 acres for T1-T4 plots).

LTER Nitrogen Fertility Rate Study
Comparison of Dryland versus Irrigated Corn Grain Yields

Purpose

Compare grain yields under different levels of nitrogen fertilization with non-irrigated (dryland) and irrigated corn.

Rotational sequence: Corn (2008, 2011) - Soybean (2009, 2010)-Winter Wheat (2010/2013).

Fertilizer was applied in the form of 28% N (Urea-ammonium nitrate liquid) knifed into the soil between corn rows split between at planting time and post-emergence.

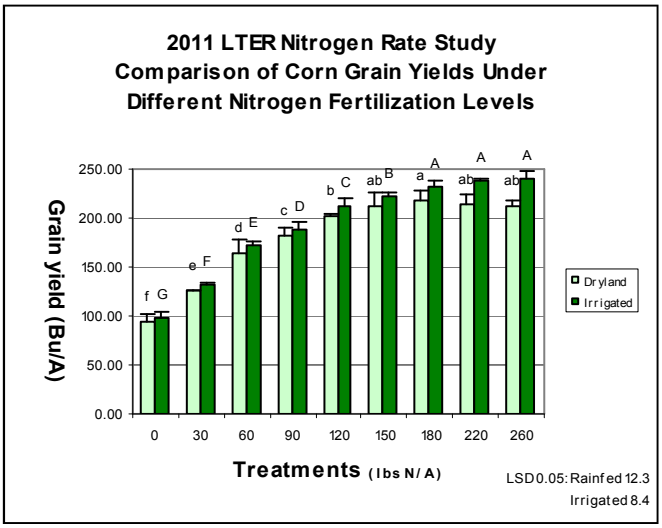
Crop:	Corn
Variety:	DKC52-59 Hybrid
Planting date:	May 10, 2011
Irrigation:	None vs. Irrigated (6 times)
Tillage:	No-Till
Row Spacing:	30 inches
Population:	29,000 seeds/A
Harvest date:	November 17, 2011
Fertilization:	**May 3, 2011** 0-0-60 @ 42 lbs K_2O/A **May 10, 2011** 19-17-0 29 lbs N/A 26 lbs P_2O_5/A
Herbicide Postemergence:	**May 3, 2011** RoundUp Power Max 44 oz/A Ammonium Sulfate 3.4 lbs/A **May 11, 2011** Lexar 3 qt/A

Fertilizer Lbs N/A	Dryland Avg Yield (bu/A)	Irrigated Avg Yield (bu/A)
0	94	97
30	125	133
60	165	171
90	183	188
120	202	211
150	212	221
180	217	233
220	214	237
260	211	240

Results

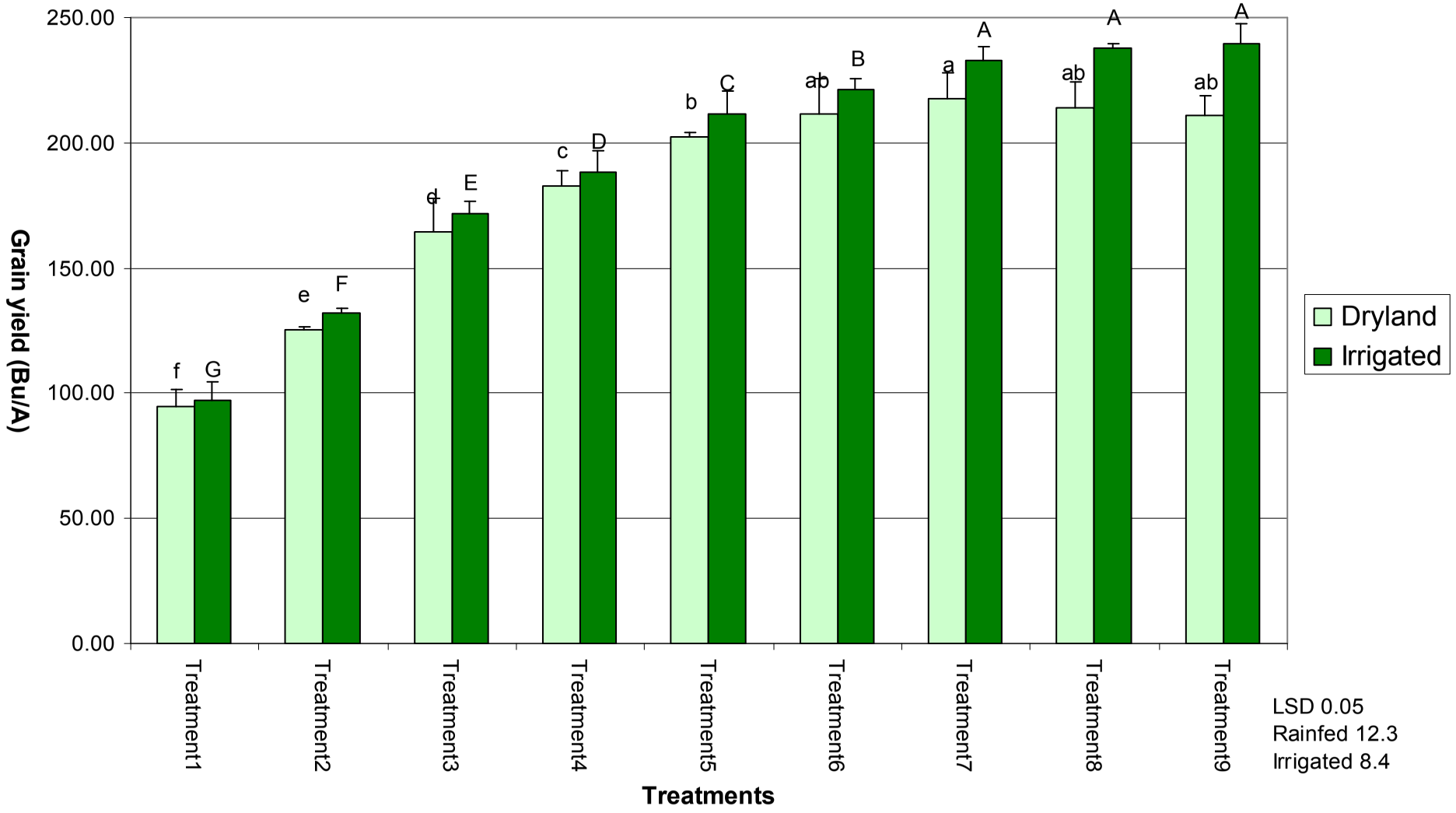
No direct comparison between the dryland and the irrigated areas are statistically valid due to the experimental design.

Analyzing dryland and irrigated separately, there was a significant nitrogen effect under both irrigation protocols. Side-by-side comparison suggests that the 180 lbs nitrogen/A might be the optimal level of fertilization .



2011 LTER Nitrogen Rate Study

Comparison of Corn Grain Yields Under Different Nitrogen Fertilization Levels



LTER Nitrogen Fertility Rate Study
Dryland Corn
Grain Yield Data

Purpose

Compare grain yields under different levels of nitrogen fertilization with non-irrigated (dryland) corn.

Rotational sequence: Corn (2008, 2011) - Soybean (2009, 2010) - Winter Wheat (2010, 2013).

Fertilizer was applied in the form of 28% N (Urea-ammonium nitrate liquid) knifed into the soil between corn rows split between at planting time and after plant emergence.

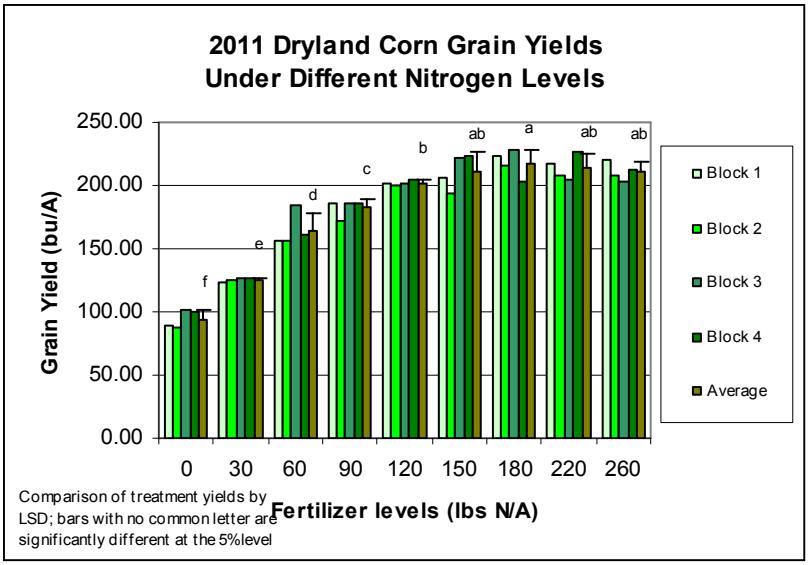
Crop:	**Corn**
Variety:	DKC52-59 Hybrid
Planting date:	May 10, 2011
Irrigation:	None
Tillage:	No-Till
Row Spacing:	30 inches
Population:	29,000 seeds/A
Harvest date:	November 17, 2011
Fertilization:	**May 3, 2011** 0-0-60 @ 42 lbs K_2O/A **May 10, 2011** 19-17-0 29 lbs N/A 26 lbs P_2O_5/A
Herbicide Postemergence:	**May 3, 2011** RoundUp Power Max 44 oz/A Ammonium Sulfate 3.4 lbs/A **May 11, 2011** Lexar 3 qt/A

Fertilizer Lbs N/A	Average Yield (bu/A)	LSD0.05 separation
0	94	f
30	125	e
60	165	d
90	183	c
120	202	b
150	212	ab
180	217	a
220	214	ab
260	211	ab

Results

In 2011, ANOVA showed that there was a significant difference between yield for treatments under different nitrogen levels.

Least significant difference analysis showed that there were significant yield differences for all treatments up to 150 lbs N/A but that the treatments from 150 to 260 lbs N/A yielded the same.



LTER Nitrogen Fertility Rate Study
Irrigated Corn
Grain Yield Data

Crop:	**Corn**
Variety:	DKC52-59 Hybrid
Planting date:	May 10, 2011
Irrigation:	June 29 0.7” July 1 1.0” July 5 0.7” July 8 1.25” July 21 1.0” July 26 1.1”
Tillage:	No-Till
Row Spacing:	30 inches
Population:	29,000 seeds/A
Harvest date:	November 17, 2011
Fertilization:	**May 3, 2011** 0-0-60 @ 42 lbs K_2O/A **May 10, 2011** 19-17-0 29 lbs N/A 26 lbs P_2O_5/A **June** Various
Herbicide Postemergence:	**May 3, 2011** RoundUp Power Max 44 oz/A Ammonium Sulfate 3.4 lbs/A **May 11, 2011** Lexar 3 qt/A

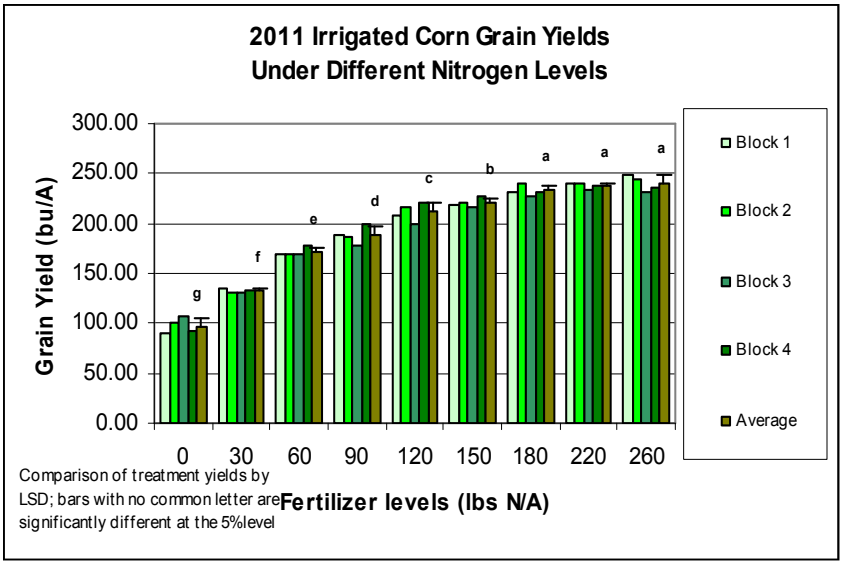
Purpose

Compare grain yields under different levels of nitrogen fertilization with irrigated corn.

Rotational sequence: Corn (2008, 2011) - Soybean (2009, 2010) - Winter Wheat (2010/2013).

Fertilizer was applied in the form of 28% N (Urea-ammonium nitrate liquid) knifed into the soil between corn rows split between at planting time and post-emergence.

Fertilizer Lbs N/A	Average Yield (bu/A)	LSD0.05 separation
0	97	g
30	132	f
60	172	e
90	188	d
20	211	c
150	221	b
180	233	a
220	237	a
260	240	a



Results

In 2011, ANOVA showed that there was a significant difference between yield for treatments under different nitrogen levels.

Least significant difference analysis showed that there were significant yield differences for all treatments up to 180 lbs N/A but that the treatments from 180 to 260 lbs N/A yielded the same.

LTER Biodiversity Study
Experimental Design and Overveiw

Summary

The Biodiversity Study represents combinations of crops, crop rotations, and farming systems which affect yield and weed population pressures.

Individual treatments are grouped by crop and are located on separate pages: Corn (p.18), Soybean (p. 19), and Wheat (p. 20).

In 2011, there were no significant differences in harvest yields between any treatments involving winter wheat. However, there were significant differences between treatments with corn and soybeans.

Biodiversity		Reference (year)	
Crop	Yield (bu/A)	Yield (bu/A)	Study
Winter Wheat	35.3	28.0	LTER $T4_{2010}$
Soybean	39.3	33.4	LTER $T4_{2009}$
Corn	74.2	104	LTER $T4_{2011}$

System	Treatment	---------- Crop Rotation ----------
A	B1	Fall Fallow
A	B2	Spring Fallow
B	B3	Wheat $_{\text{covers A \& C}}$ – Corn $_{\text{covers A \& C}}$ – Soybeans $_{\text{cover B}}$
B	B4	Corn $_{\text{covers A \& C}}$ – Soybeans $_{\text{cover B}}$ – Wheat $_{\text{covers A \& C}}$
B	B5	Soybeans $_{\text{cover B}}$ – Wheat $_{\text{covers A \& C}}$ – Corn $_{\text{covers* A \& C}}$
C	B6	Wheat $_{\text{cover A}}$ – Corn $_{\text{cover A}}$ – Soybeans
C	B7	Corn $_{\text{cover A}}$ – Soybeans – Wheat $_{\text{cover A}}$
C	B8	Soybeans – Wheat $_{\text{cover A}}$ – Corn $_{\text{cover A}}$
D	B9	Wheat – Corn – Soybeans
D	B10	Corn – Soybeans – Wheat
D	B11	Soybeans – Wheat – Corn
E	B12	Soybeans – Corn
E	B13	Corn – Soybeans
E	B14	Soybeans – Wheat
F	B15	Corn $_{\text{cover A}}$ – Corn $_{\text{cover A}}$ – Corn $_{\text{cover A}}$
F	B16	Soybeans $_{\text{cover C}}$ – Soybeans $_{\text{cover C}}$ – Soybeans $_{\text{cover C}}$
F	B17	Wheat $_{\text{cover A}}$ – Wheat $_{\text{cover A}}$ – Wheat $_{\text{cover A}}$
G	B18	Corn – Corn – Corn
G	B19	Soybeans – Soybeans – Soybeans
G	B20	Wheat – Wheat – Wheat
H	B21	Continuous Fallow

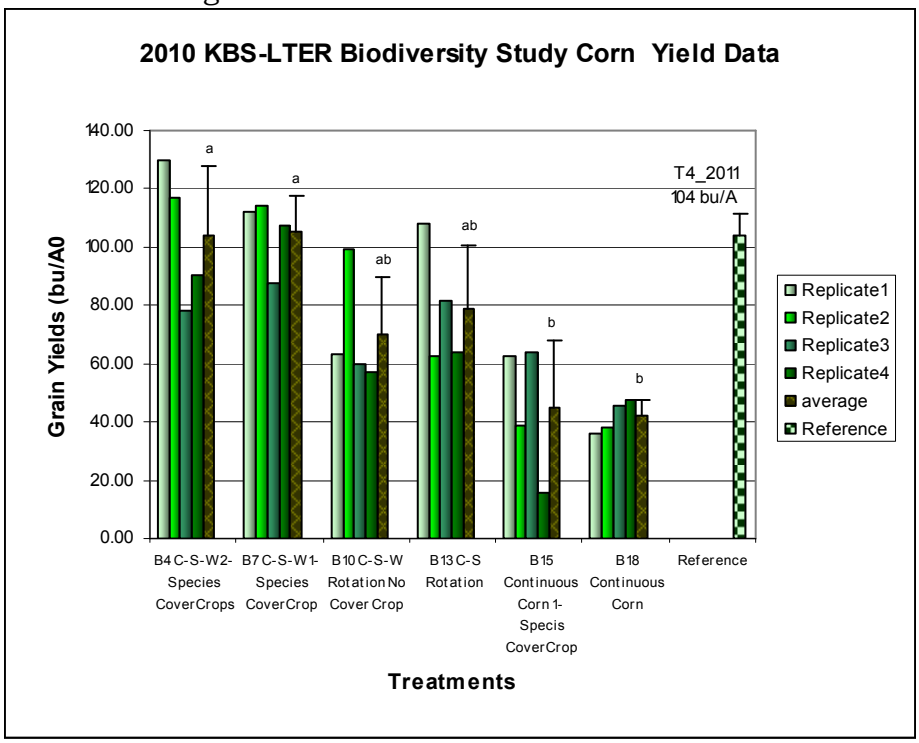
System	---------- Descriptions ----------
A	Fallow system: No crop is planted. Plots are tilled once a year.
B	One annual crop with two cover crops. Three year crop rotation.
C	One annual crop with one cover crop. Three year crop rotation.
D	One annual crop with no cover crop. Three year crop rotation.
E	One annual crop with no cover crop. Two year crop rotation.
F	One annual crop with one cover crop. Monoculture cropping system (no crop rotation).
G	One annual crop with no cover crop. Monoculture cropping system (no crop rotation).
H	Continuous fallow system: No cover, no crop growth. Plots are tilled as needed (2 - 6 times) a year to prevent plant growth from becoming established.

LTER Biodiversity Study
2011 Corn Treatments
Grain Yield Comparison

Research Objective

Incorporating biological diversity into weed management. Determine the impact of crop rotation and cover crops on weed communities in row crops. In 2011, treatments B4, B7, B10, B13, B15 and B18 were planted to corn. The variety used was Blue River Hybrids 22A10 Organic Corn.

Cropping System	Average Yield (bu/A)
B/C	104.5
D/E	74.4
F/G	43.5



Results

In 2011, there was a significant difference between yields of LTER Biodiversity Study corn treatment ($p<<0.001$).

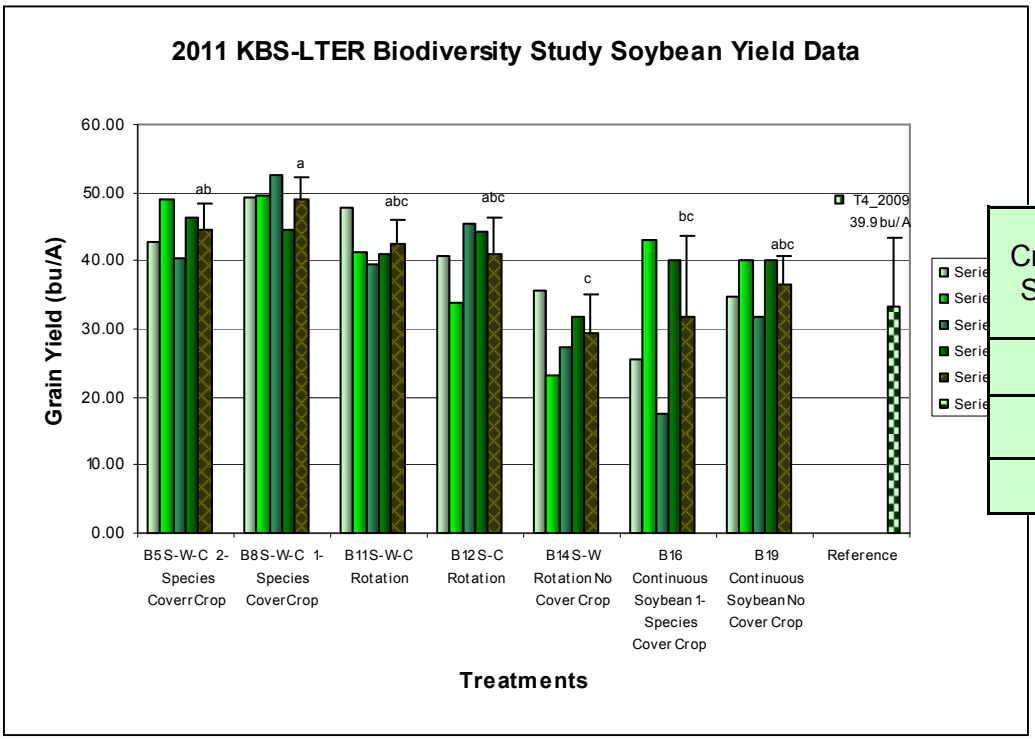
- Overall, biodiversity corn treatments averaged 74.2 bu/A
- Rotational corn treatments with cover crops (B4, B7) averaged 104.5 bu/A and yielded significantly higher than continuous corn treatments. The rotational corn average yield was comparable to the 2011 main site T4 corn yield.
- Rotational corn treatments without cover crops (B10, B13) averaged 74.4 bu/A and could not be separated from any of the other treatments.
- Continuous corn treatments (with or without cover crops, B15, B18) averaged 43.5 bu/A and yielded lower than rotational corn with cover crops.

Both the Biodiversity Study and main site T4 are managed as organic treatments which means no addition of herbicides or fertilizer. As a comparison, the 2011 LTER treatment T4 (the last year the LTER Main Site was in corn) average yield was 104 bu/A.

LTER Biodiversity Study
2011 Soybean Treatments
Grain Yield Comparison

Research Objective

Incorporating biological diversity into weed management. Determine the impact of crop rotation and cover crops on weed communities in row crops. In 2011, treatments B5, B8, B11, B12, B14, B16 and B19 were planted to soybeans. The variety used was Blue River Hybrids 2A12 Soybeans (Organic Soybeans).



Cropping System	Average Yield (bu/A)
B/C	46.9
D/E	37.7
F/G	34.2

Results

In 2011, there were significant differences between the yields of the Biodiversity Study soybean treatments ($p<<0.1$). In general, rotational soybeans with one or two cover crops in the rotation yielded more that all other treatments without cover crops.

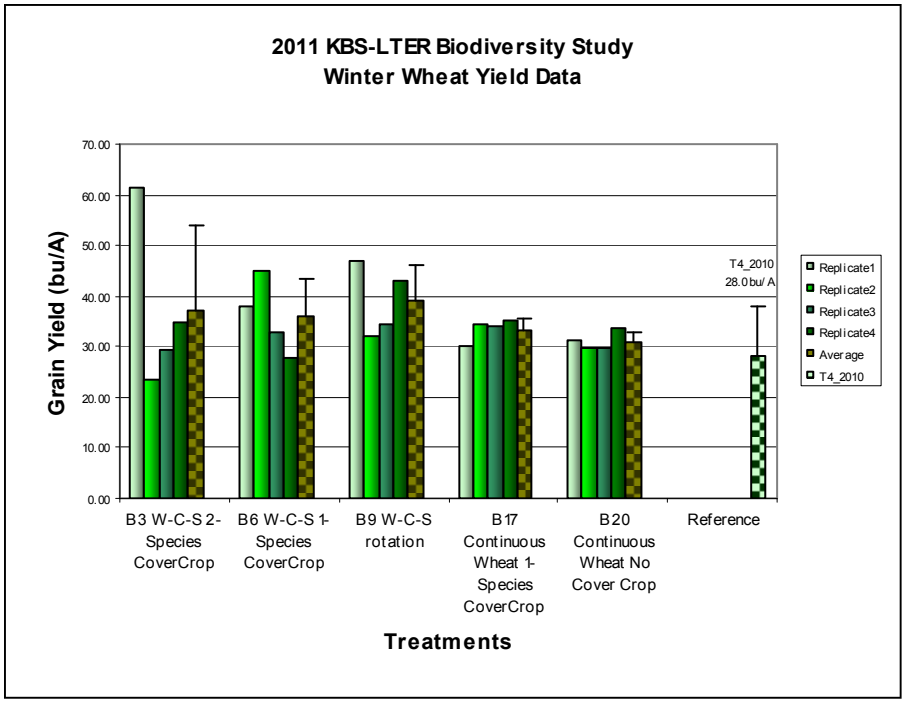
Both the Biodiversity Study and main site T4 are managed as organic treatments which means no addition of herbicides or fertilizer. As a comparison, the 2009 LTER treatment T4 (the last year the LTER Main Site was in soybean) average yield was 33.4 bu/A. The 2011 Biodiversity soybean treatments averaged 39.3 bu/A.

LTER Biodiversity Study
2011 Winter Wheat Treatments
Grain Yield Comparison

Research Objective

Incorporating biological diversity into weed management. Determine the impact of crop rotation and cover crops on weed communities in row crops. For 2011, treatments B3, B6, B9, B17 and B20 were planted to winter wheat on October 13, 2010. The variety used was Pioneer 25R47 Soft Red Winter Wheat (treated seed).

Cropping System	Average Yield (bu/A)
B/C	36.6
D/E	39.1
F/G	32.2



Results

In 2011, there were no significant differences between the yields of any of the Biodiversity Study winter wheat treatments. Biodiversity winter wheat treatments averaged 35.3 bu/A.

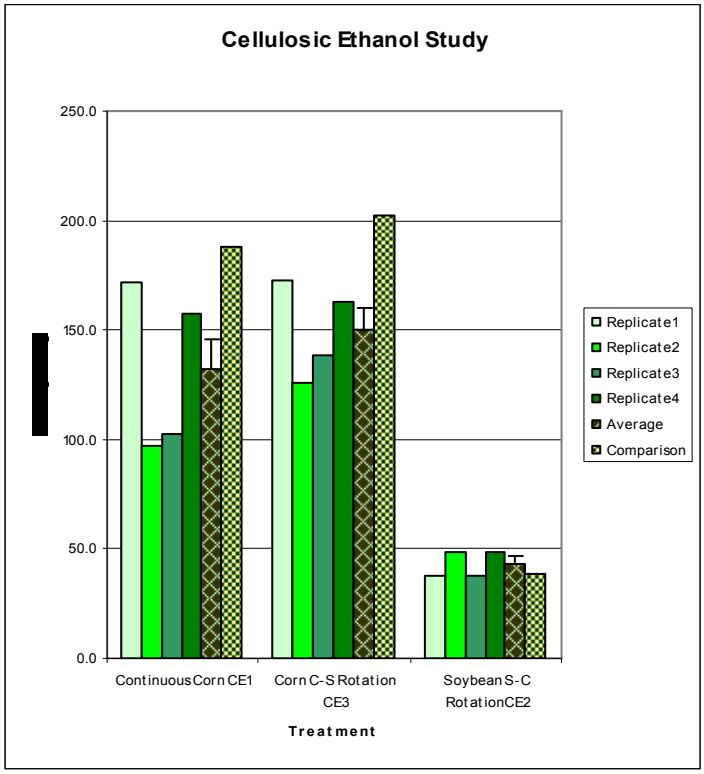
Both the Biodiversity Study and T4 are managed as organic treatments which means no addition of herbicides or fertilizer. As a comparison, the 2010 LTER treatment T4 average yield was 28.0 bu/A.

LTER Cellulosic Ethanol Study (CE)
Corn and Soybean Treatments
Grain Yield Data

Purpose

Determine the amount of annual grain production that can be used for biofuel production.

The varieties used were Dekalb DKC52-59 Corn and Pioneer 92Y30 Soybean; both are RoundUp Ready varieties. These varieties are also used in different studies in the LTER and the Great Lakes Bioenergy Research Center (GLBRC) which allows other treatments to serve as yield references.



Results

In 2011, the Cellulosic Ethanol Study (CE) corn treatments' yields were lower, and the CE soybean yields were comparable to, reference treatments from other studies.

Continuous Corn treatment CE1 was referenced to the GLBRC G1 Continuous Corn treatment.

Treatment CE3 Rotational Corn (two year rotation Corn/Soybean) was referenced to the GLBRC G2 Rotational Corn treatment (three year rotation of Corn/Soybean/Canola).

CE Study			Reference	
Crop	Treatment	Yield (bu/A)	Yield (bu/A)	Study
Corn	CE1	132.1	188.0	GLBRC $G1_{2011}$
Soybean	CE2	43.11	38.9	GLBRC $G3_{2011}$
Corn	CE3	149.9	202.0	GLBRC $G2_{2011}$

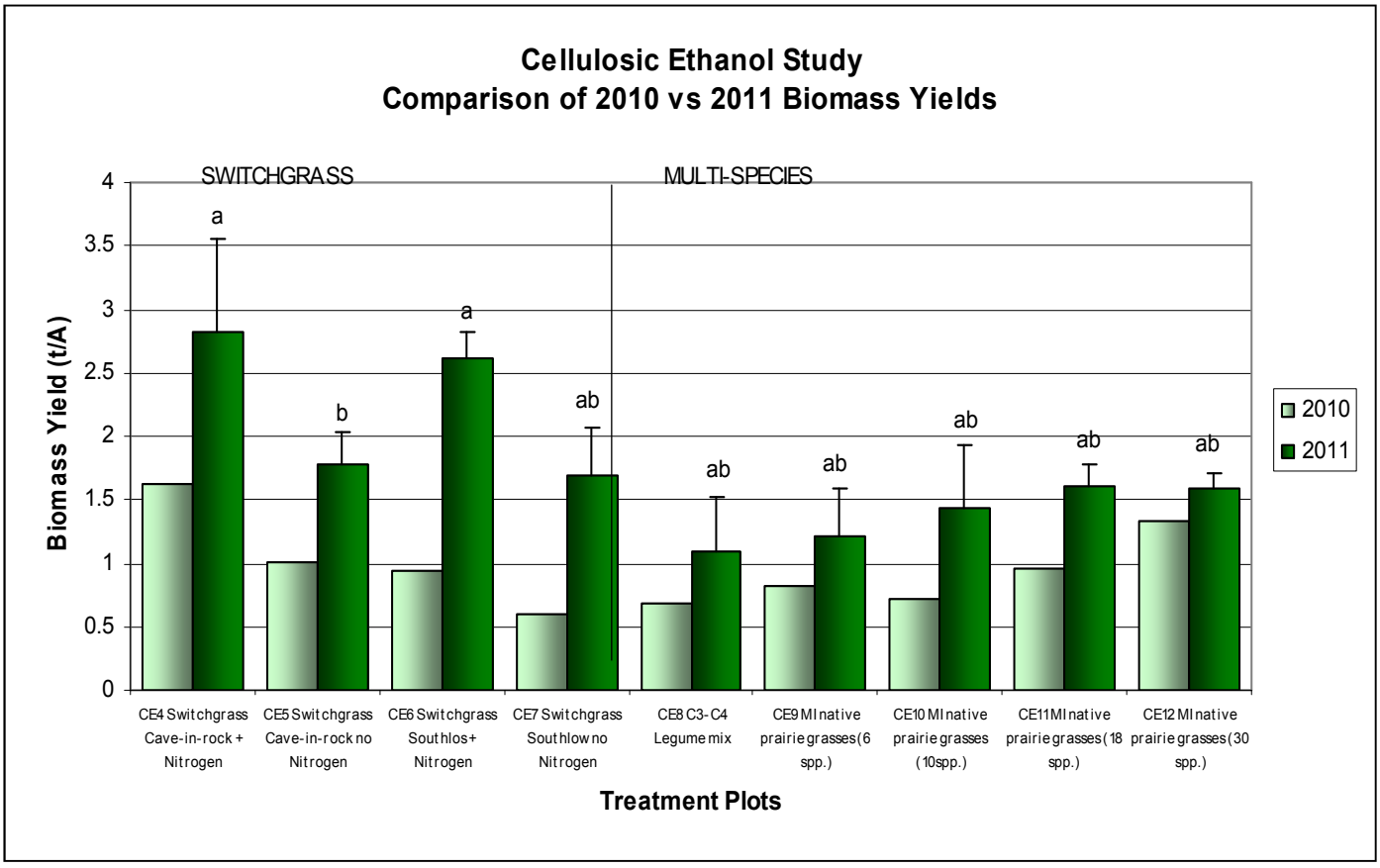
Treatment CE2 Rotational Soybean (two year rotation of Soybean/Corn) was referenced to the GLBRC Main Site G3 2011 Rotational Soybean treatment (three year rotation of Soybean/Canola/Corn)

Statistical analysis of the corn treatments, CE1 and CE3, showed that there were no significant differences between the two.

LTER Cellulosic Ethanol Study (CE)
Cellulosic Crops
Comparison of 2010 vs. 2011 Biomass Yield Data

Purpose

Determine the amount of cellulosic biomass production from forage plots that are under different fertilization regimes and/or different species compositions.



Results

All cellulosic crops plots produced significantly more biomass in 2011 than in 2010 ($p<<0.01$). There was also a significant interaction between yield and years.

Biomass data from the Cellulosic Ethanol (CE) Study can be broadly compared based on additional fertilizer (treatments C4 vs C5 and C6 vs C7) or based on the increased species complexity of the plots (treatments C8-C12).

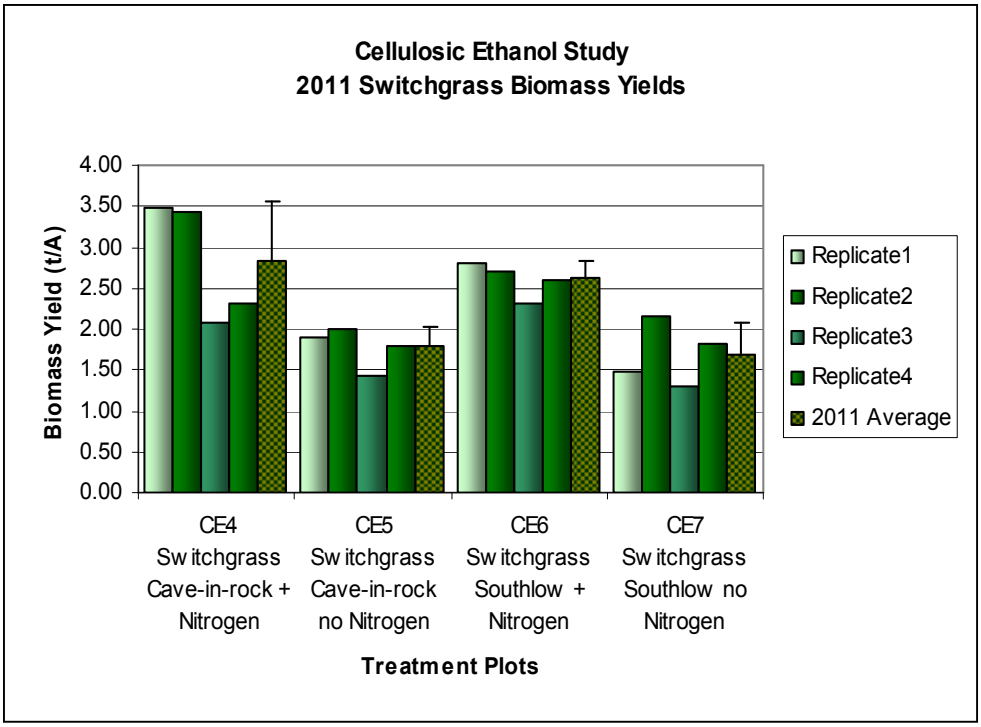
Comparing C4-C6 (all Switchgrass treatments with and without additional nitrogen), analysis indicates that in 2011, additional nitrogen lead to a higher biomass yield ($p>0.01$).

Data additionally suggest that increased species complexity leads to an increased yield, although the differences are not significant when analyzed at $p=0.05$. Observing data from 2010, we can see a similar trend although it was not significant in that year either.

LTER Cellulosic Ethanol Study (CE)
Comparison of the Effect of Added Nitrogen on Biomass Yields of Different Switchgrass Varieties

Purpose

Determine the amount of cellulosic biomass production from Switchgrass plots that are under different fertilization regimes. Two different Switchgrass varieties were used: Cave-in-rock and Southlow



Results

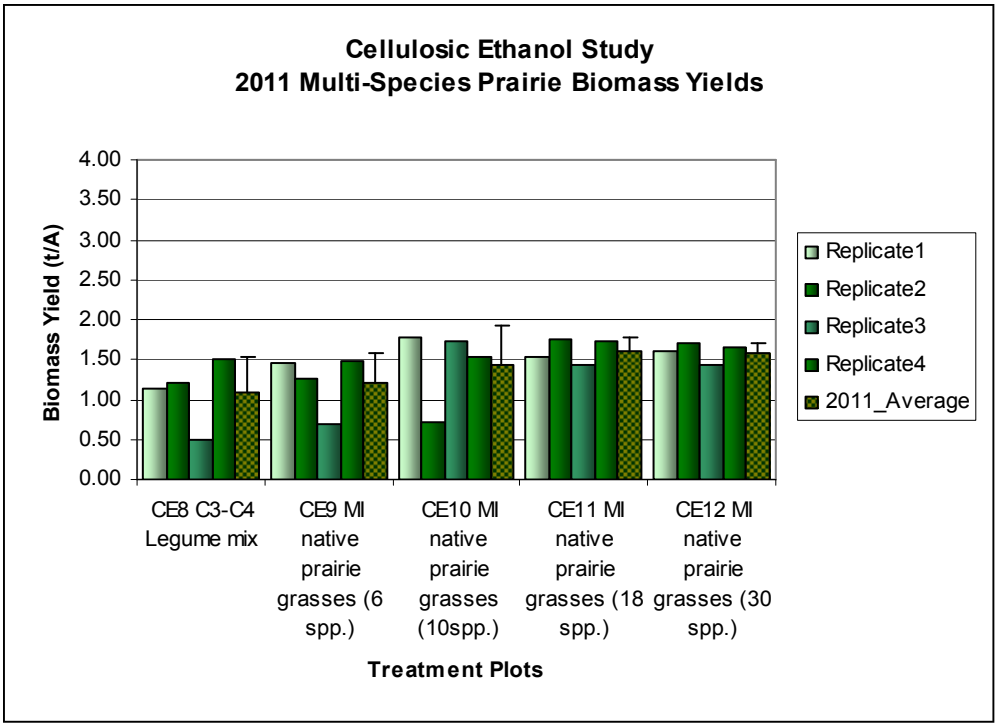
Biomass data from the Cellulosic Ethanol (CE) Study can be broadly compared based on additional fertilizer (treatments C4 vs C5 and C6 vs C7) or based on the increased species complexity of the plots (treatments C8-C12).

Comparing C4-C6 (all Switchgrass treatments with and without additional nitrogen), analysis indicates that in 2011, additional nitrogen lead to a higher biomass yield ($p>0.01$).

LTER Cellulosic Ethanol Study (CE)
Cellulosic Crops
Multi-Species Prairie Biomass Yield Data

Purpose

Determine the amount of cellulosic biomass production from forage plots that have different species compositions and number of species.



Results

Biomass data from the Cellulosic Ethanol (CE) Study can be broadly compared based on the increased species complexity of the plots (treatments C8-C12).

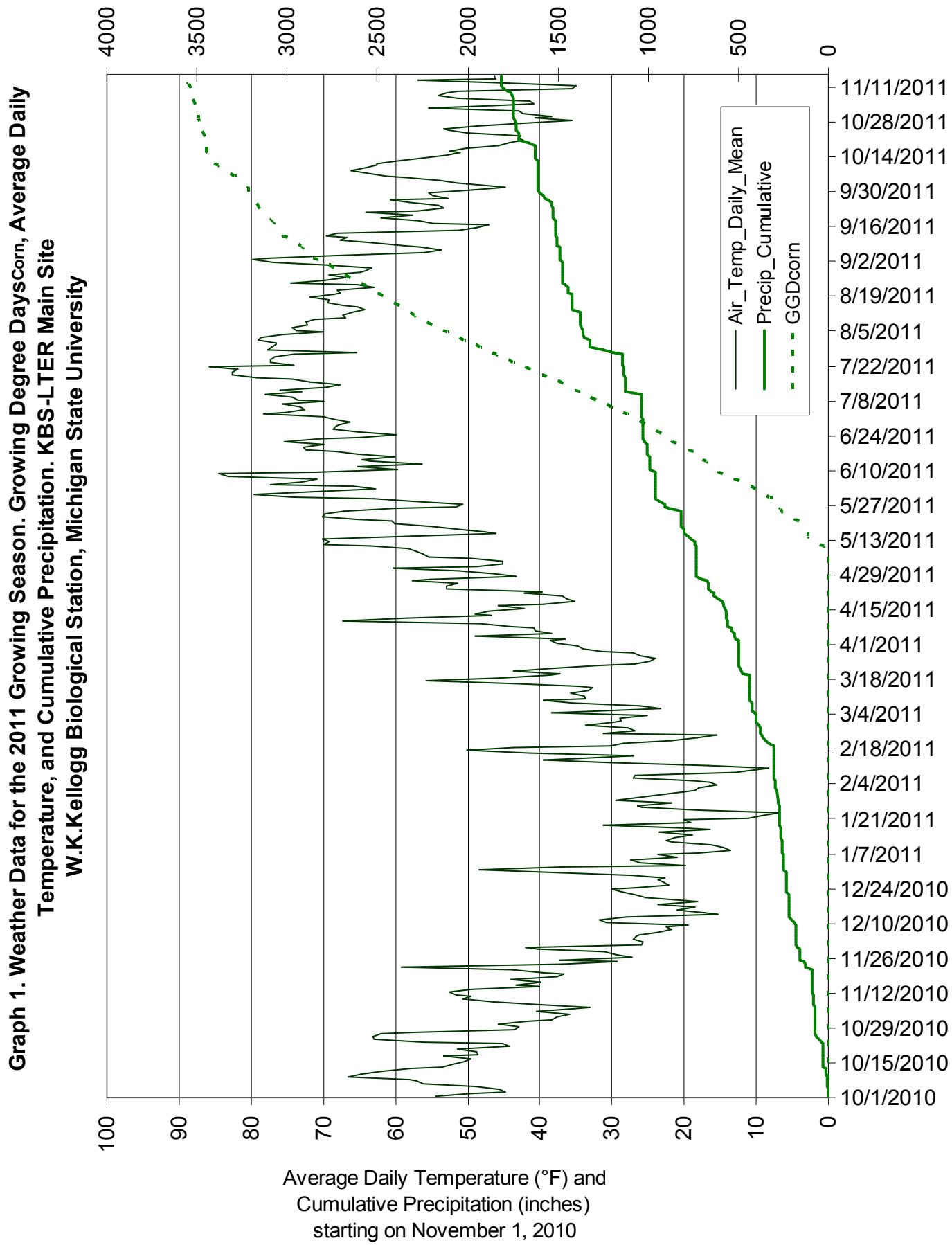
Comparing C8-C12, analysis suggests that in 2011, additional species complexity led to a higher biomass yield, although the differences are not significant when analyzed at p=0.05.

Chart 1. Precipitation (inches) on the KBS-LTER Main Site at the W.K. Kellogg Biological Station, Michigan State University.

Precipitation data is reported beginning 10/1/10 through 11/30/11 to reflect growing condition for winter wheat and winter canola.

Day	October	November	December	January	February	March	April	May	June	July	August	September	October	November
1	0.03	0.01	0.06		0.23					0.05	0.01			
2		0.03			0.20						0.62	0.30		
3	0.01	0.01	0.01				0.37				0.29	0.01		
4	0.03	0.02				0.32	0.15					0.03		
5	0.04					0.26								
6	0.04	0.02		0.10	0.10		0.35	0.02			0.07			
7	0.02	0.02		0.06							0.21			0.04
8	0.05	0.04	0.04	0.03		0.01	0.55				0.04	0.28		0.37
9	0.05	0.04	0.01			0.38					0.05			0.29
10	0.04	0.03	0.12			0.04			0.86			0.12		0.62
11	0.04	0.03	0.40	0.10	0.02		0.25	0.17		2.32				0.31
12	0.02	0.04	0.35	0.01	0.02							0.07		
13	0.31	0.07	0.01	0.03				0.52			1.15		0.40	
14			0.02	0.02		0.01		0.42			0.01	0.11	0.05	0.06
15	0.08			0.09		0.02	0.05	0.52	0.06		0.01		0.07	
16	0.02	0.01	0.03			0.05	0.25		0.22		0.01			0.06
17		0.06												
18				0.09			0.18	0.38		0.21			0.01	
19							0.65	0.04				0.27	0.82	
20	0.05				0.87	0.98	0.43				0.46		1.40	
21	0.01			0.03	0.40	0.04			0.46					0.87
22	0.01	0.87	0.40	0.02	0.30	0.27	0.51	0.01	0.26	0.13	0.01			
23	0.10			0.06	0.19	0.25	0.27		0.01	0.02	0.40			0.24
24	0.34	0.24		0.06	0.11						0.41	0.18	0.43	0.48
25	0.38	0.48			0.03		0.08	1.68		0.01			0.02	
26	0.14				0.07		0.25	0.64				0.67		
27				0.05	0.18		0.63			1.33		0.41		0.02
28	0.06	0.02			0.26		0.77	0.72		1.36		0.11	0.07	0.07
29		0.07					0.01	0.49		1.92		0.51	0.18	0.43
30		0.43										0.19	0.06	
31	0.02		0.32								0.04		0.03	
Monthly Totals 2010/2011	1.9	2.5	1.8	0.7	3.0	2.6	5.7	5.6	1.9	7.3	3.8	3.3	3.5	3.9
Monthly Average Rainfall	3.2	2.6	2.2	1.9	1.6	2.3	3.2	3.4	4.0	2.8	4.1	3.9	3.2	2.6

Average rainfall based on the average of 31 complete years between 1931 and 1995 from the
National Climatic Data Center Cooperative Station at Gull Lake Biological Station, Kalamazoo County, Michigan


Growing Degree Days (min 50°F, max 86°F) from first planting on May 9 2011 through last harvest on November 15, 2011
Graph 1. Weather Data for the 2011 Growing Season. Growing Degree DaysCorn, Average Daily Temperature, and Cumulative Precipitation. KBS-LTER Main Site W.K.Kellogg Biological Station, Michigan State University
4000
3500
3000
2500
2000
1500
1000
500
0
11/11/2011
10/28/2011
10/14/2011
9/30/2011
9/16/2011
9/2/2011
8/19/2011
8/5/2011
7/22/2011
7/8/2011
6/24/2011
6/10/2011
5/27/2011
5/13/2011
4/29/2011
4/15/2011
4/1/2011
3/18/2011
3/4/2011
2/18/2011
2/4/2011
1/21/2011
1/7/2011
12/24/2010
12/10/2010
11/26/2010
11/12/2010
10/29/2010
10/15/2010
10/1/2010
Air_Temp_Daily_Mean
Precip_Cumulative
GGDcorn
100
90
80
70
60
50
40
30
20
10
0
Average Daily Temperature (°F) and Cumulative Precipitation (inches) starting on November 1, 2010

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