Table 1. Timeline of field operations for the research station trials and on farm trials

Cover crops were fall-planted rye for the 2013 KBS trial, spring-planted oats for the KBS trials in 2011 and 2012 and the on farm trials in 2012, and fall-planted wheat for the 2013 Zilke trial. Deep soil cores were not collected at the on-farm sites.

	Research station trials			On-farm trials		
Operation	2011	2012	2013	2012 Zilke	2012 Van Houtte	2013 Zilke
Cover crop planting	4-13	4-18	9-10-12	4-13	4-11	9-1-12
Cover crop termination	6-9	6-6	5-9	5-30	6-1	*
Tillage and fertilization	6-17	6-19	6-4	6-7	6-8	6-7
Planting, PRE herbicide application	6-17	6-19	6-4	6-7	6-8	6-21
N sidedress application	7-25	7-23	7-11	7-5	7-5	7-30
Harvest	8-31	8-29	8-26	8-31	8-28	9-13
Deep core collection	9-12	9-11	8-29	NA	NA	NA
Rye planting	10-12	9-20	8-30	NA	NA	NA

* Wheat cover crop plowed under in CT plots and in the IR zone in ST. Surviving wheat in the BR zone in ST terminated with glyphosate after sweet corn planting; glyphosate was tank-mixed with the PRE herbicides applied at this time.

Table 2. Summary of nitrogen applications.

Urea was used as the N source for all pre-till and at-planting applications. Either urea (2011 and 2012) or 28% UAN (2013) was used as the side-dress N source.

N application	CT	ST
	----------kg N/ha----------	
Broadcast pre-till (IR and BR zones)	45	0
Deep-banded pre-till (IR zone only, 15 cm deep)	0	45
Banded with seed or transplant (IR zone only, 5 cm deep for sweet corn)	45	45
Side-dress (IR zone only)	45	45
Total N applied	135	135
Estimated N in IR zone	105	135
Estimated % N in IR zone	78%	100%

Table 3. Monthly summary of average air temperature and precipitation (with supplemental irrigation in parentheses) at Kellogg Biological Station, 2011-2013.

Average temperature and average monthly rainfall from 2004-2013 are also presented.

	Average air temperature (ºC)				Total precipitation and irrigation (mm)			
Month	2011	2012	2013	2004-2013	2011	2012	2013	2004-2013
May	15.1	17.2	16.7	15.3	142	30	118	103
June	20.2	21.0	19.4	20.3	47	23 (13)	108	91
July	24.1	25.3	21.7	22.3	187 (13)	45 (25)	82 (6)	89
August	20.7	20.7	20.1	20.8	96	70 (19)	117	97
September	15.6	16.5	16.7	17.0	82	58	19	87
Average	19.2	20.1	18.9	19.1				
Total					556	227	446	470
Total with irrigation					568	284	452	

Table 4. Potentially leachable nitrate, or deep soil nitrate (20-100 cm), at the Kellogg Biological Station in the fall (F) and spring (S) following sweet corn in 2011, 2012, and 2013.

Averages are shown, with standard errors in parentheses. One-way ANOVA p values are also presented; ANOVA model analyzed tillage treatment effects separately by season (spring or fall) and year. Within a column, means with the same letter are not significantly different at α=0.10. The fraction of nitrate measured in these cores as a percent of total N applied (135 kg N/ha) is also presented.

	F 2011	S 2012	F 2012	S 2013	F 2013
	Nitrate in deep soil samples (20-100 cm), kg NO_3^--N /ha				
ST same	26.7 a (2.27)	1.42 (1.02)	25.7 b (3.10)	0.629 b (0.52)	6.95 (2.79)
ST offset	15.8 b (3.48)	0.93 (0.57)	40.5 ab (8.57)	0.291 b (0.29)	7.75 (3.60)
FWT	33.1 a (12.9)	2.76 (1.10)	51.5 a (7.79)	6.26 a (4.97)	8.59 (3.05)
ANOVA tillage	0.01	0.30	0.06	0.03	0.54
	Deep soil nitrate as % of N applied				
ST same	19.8		19.0		5.1
ST offset	11.7		30.0		5.7
FWT	24.5		38.1		6.4

Table 5. Area corrected soil nitrate values for 0-100 cm in the fall (F) and spring (S) following sweet corn harvest in 2011, 2012, and 2013.

Averages are shown, with standard errors in parentheses. Values have been area-corrected by using a weighted average of surface samples according to the relative area occupied by each zone (BR area = 2*IR area). One-way ANOVA p values are also presented; ANOVA model analyzed tillage treatment effects separately by season (spring or fall) and year. Within a column, means with the same letter are not significantly different at α=0.10.

	F 2011	S 2012	F 2012	S 2013	F 2013
	Area-corrected NO_3^- (0-100 cm), kg NO_3^--N /ha				
ST same	51.0 (5.52)	3.51 (1.0)	86.1 b (12.0)	2.43 (1.0)	15.9 a (3.89)
ST offset	30.5 (7.39)	3.53 (0.9)	103.8 b (15.0)	1.46 (0.7)	12.7 ab (4.67)
FWT	67.9 (19.2)	5.00 (1.2)	147.8 a (24.4)	2.83 (1.0)	11.0 b (3.72)
ANOVA tillage	0.19	0.56	0.08	0.36	0.05

Table 6. Total cost estimates ($/acre) including ownership (fixed) and operating (variable) costs for different tillage equipment.

Costs determined using machdata.xlsm (Lazarus 2014). Please refer to the methods for the numerous assumptions used in this analysis.

	age	list price/ value[1]	tractor size[2]	implement cost			tractor cost			Total costs
				Owner.[3]	Oper.[4]	sum	Owner.	Oper.	sum	
Type[5]	years	-----$----	--HP--	----------$/acre----------						
CP	8	$8,505	130	$3.20	$5.70	$8.90	$2.00	$0.60	$2.60	$11.50
FC	8	$9,922	105	$3.70	$5.30	$9.00	$1.30	$0.40	$1.70	$10.70
STH	0	$42,175	200	$13.80	$7.40	$21.20	$3.40	$1.00	$4.40	$25.60
STM	0	$22,347	200	$6.70	$6.90	$13.60	$3.40	$1.00	$4.40	$18.00
STL	8	$13,500	200	$5.70	$7.20	$12.90	$3.40	$1.00	$4.40	$17.30

[1] List price is given for new equipment, while estimated remaining value given for used equipment. Purchase price is assumed to be 90% of the list price. For medium and low cost ST options, $2000 is added here to purchase fertilizer tank/hopper, tubes, metering system, and clamps to add fertilizer banding capability.

[2] An 8 year old tractor was assumed for all tillage equipment. HP determined from Lazarus (2014) for CP and FC and from dealer recommendations for ST options.

[3] Denotes ownership costs, including depreciation, interest, and insurance

[4] Denotes operation costs, including fuel, lube, repairs and maintenance, and labor. Fuel, lube, and labor costs are included with the implement operating costs.

[5] CP=chisel plow; FC=field cultivator; STH=high cost strip till; STM=medium cost ST; STL=low cost ST

Table 7. Partial budget components for changing tillage type from full-width tillage to strip tillage.

With this change in tillage, cultivation and one fertilization pass are also eliminated; these are shown in "reduced costs". Tillage costs for three different strip tillage cost options are presented in "additional costs". No change in revenue is anticipated based on research findings.

	STH[1]	STM	STL		STH	STM	STL
Additional revenue	----------$/acre----------			**Additional costs**	----------$/acre----------		
none	0	0	0	Strip till, 1x	$25.60	$18.00	$17.30
SUBTOTAL	0	0	0	**SUBTOTAL**	$25.60	$18.00	$17.30
Reduced cost				**Reduced revenue**			
Chisel plow, 1x	-$11.40	-$11.40	-$11.40	None	0	0	0
Field cultivator, 2x	-$21.20	-$21.20	-$21.20				
Cultivation	-$12.80	-$12.80	-$12.80				
Fertilization pass	-$6.00	-$6.00	-$6.00				
SUBTOTAL	-$51.40	-$51.40	-$51.40	**SUBTOTAL**	$25.60	$18.00	$17.30
NET change in tillage-associated cost[2]	-$25.80	-$33.40	-$34.10				
total production cost[3]	$1,554.80	$1,547.20	$1,546.50				
% change in total production cost[4]	-1.63	-2.11	-2.16				

[1] STH=high cost, STM=medium cost, STL=low cost strip till options

[2] equals reduced costs + additional revenue + additional costs + reduced revenue

[3] equals total production cost with FWT ($1580.60) + change in tillage-associated costs

[4] change in tillage costs as a percent of the total production costs

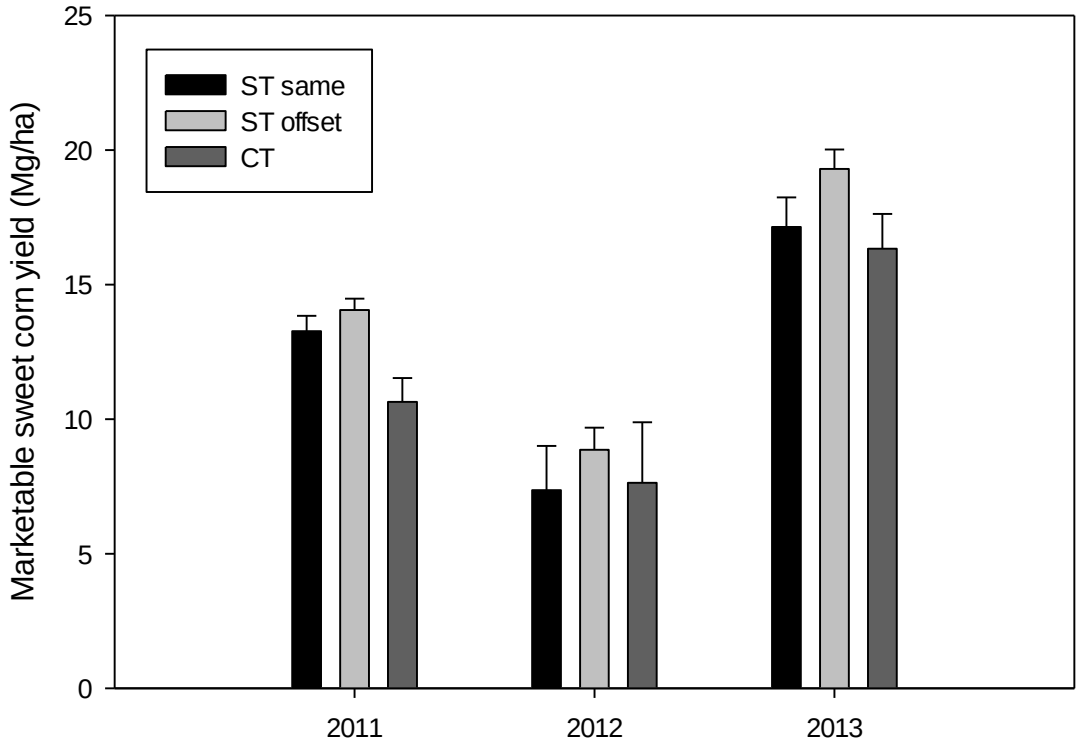

Figure 1. Average marketable sweet corn yield in 2011-2013 at the Kellogg Biological Station

Bars represent plus one SE. Two-way ANOVA indicated significant year effect($p<0.0001$) and tillage effect ($p=0.036$), but no interaction ($p=0.722$). Single df contrasts indicated that ST offset yielded more than CT ($p=0.010$), but that ST same was similar to ST offset ($p=0.112$) and CT ($p=0.258$). Single df contrasts also indicated that yield in each year was significantly different than the other years.

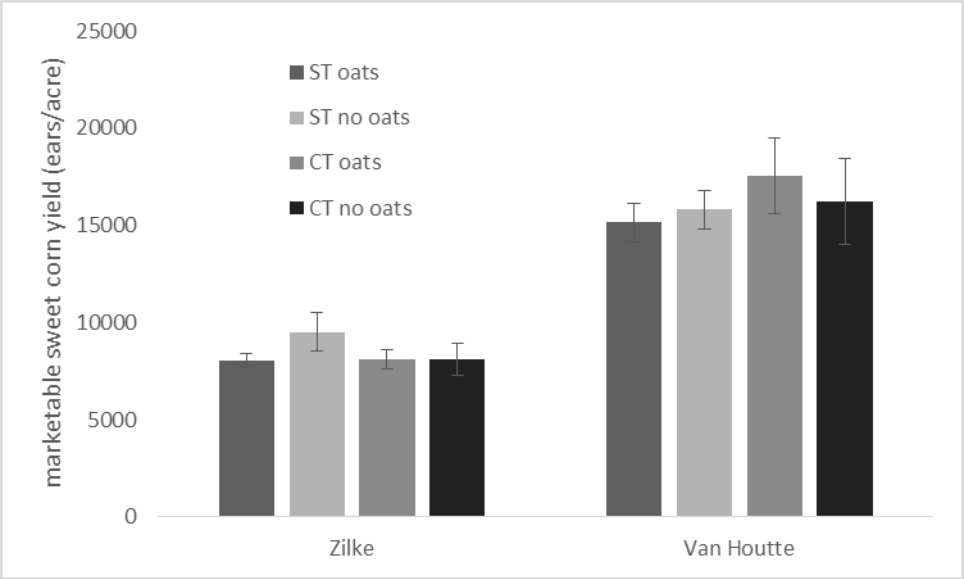

Figure 2. Average marketable sweet corn yield in 2012-2013 at the farmer cooperator sites.

At each site, yield, as measured by the number of marketable ears produced, was similar between all treatments.

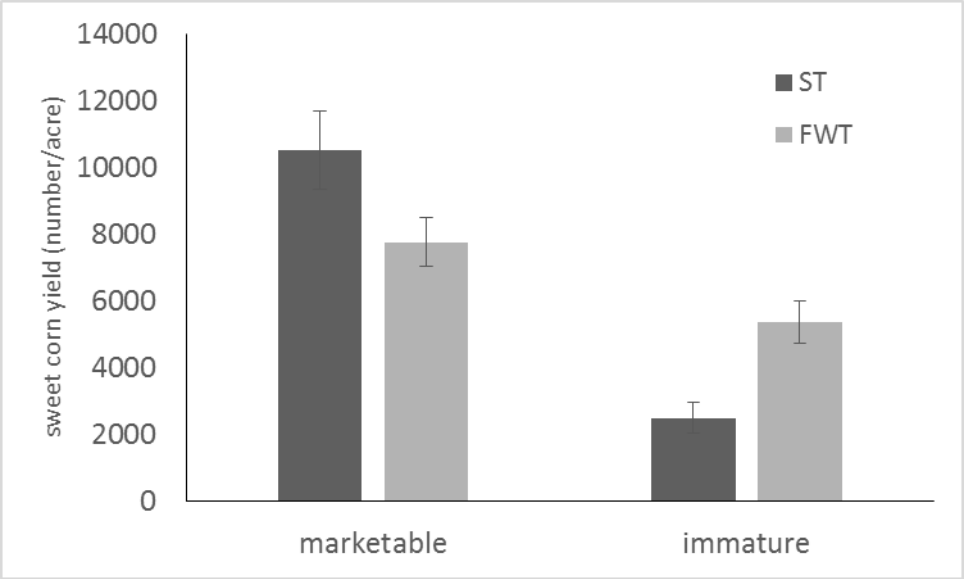

Figure 3. Sweet corn yield at the Zilke farm in 2013

There were marginally more marketable ears in ST than in FWT (p=0.104), though more immature ears in FWT than in ST (p=0.002). When added together, the number of ears was similar in both tillage treatments.

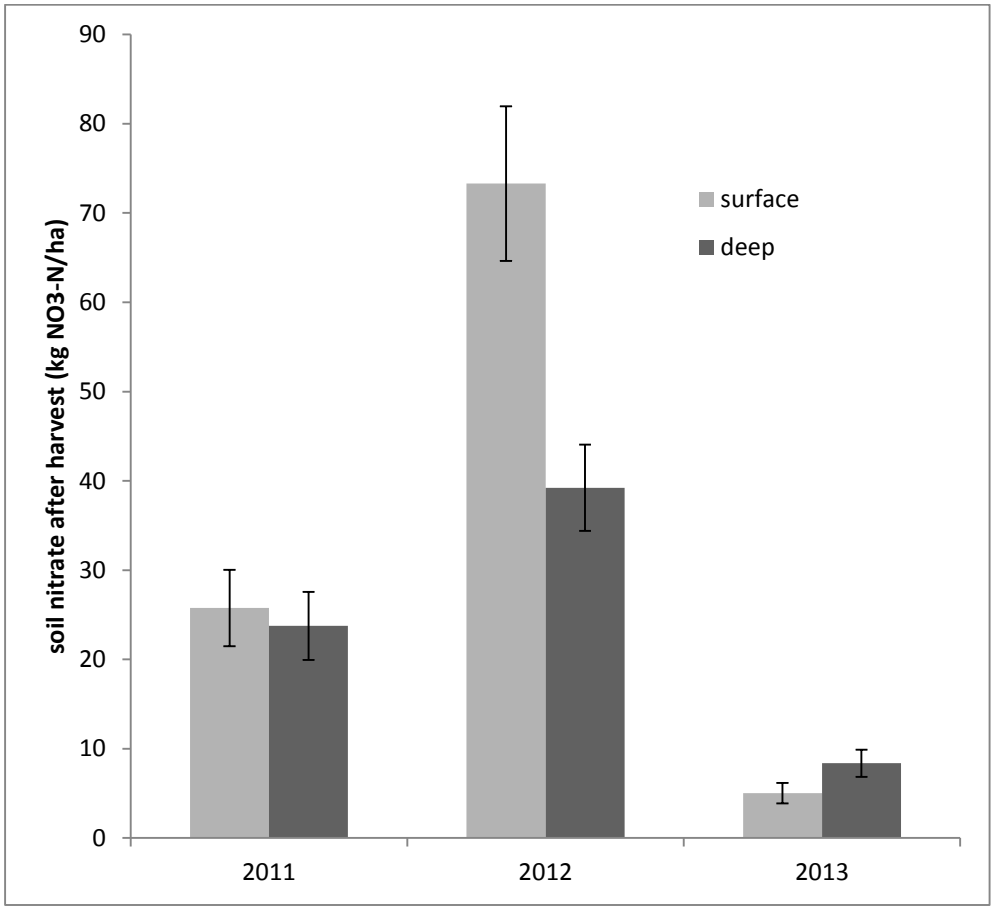

Figure 4 Surface (area corrected) and deep soil nitrate following sweet corn harvest in 2011, 2012, and 2013.

Error bars represent plus one SE. While ANOVA indicated treatment differences within the deep section (see Table 4), averages are reported here to facilitate comparison across years and with the surface sections.

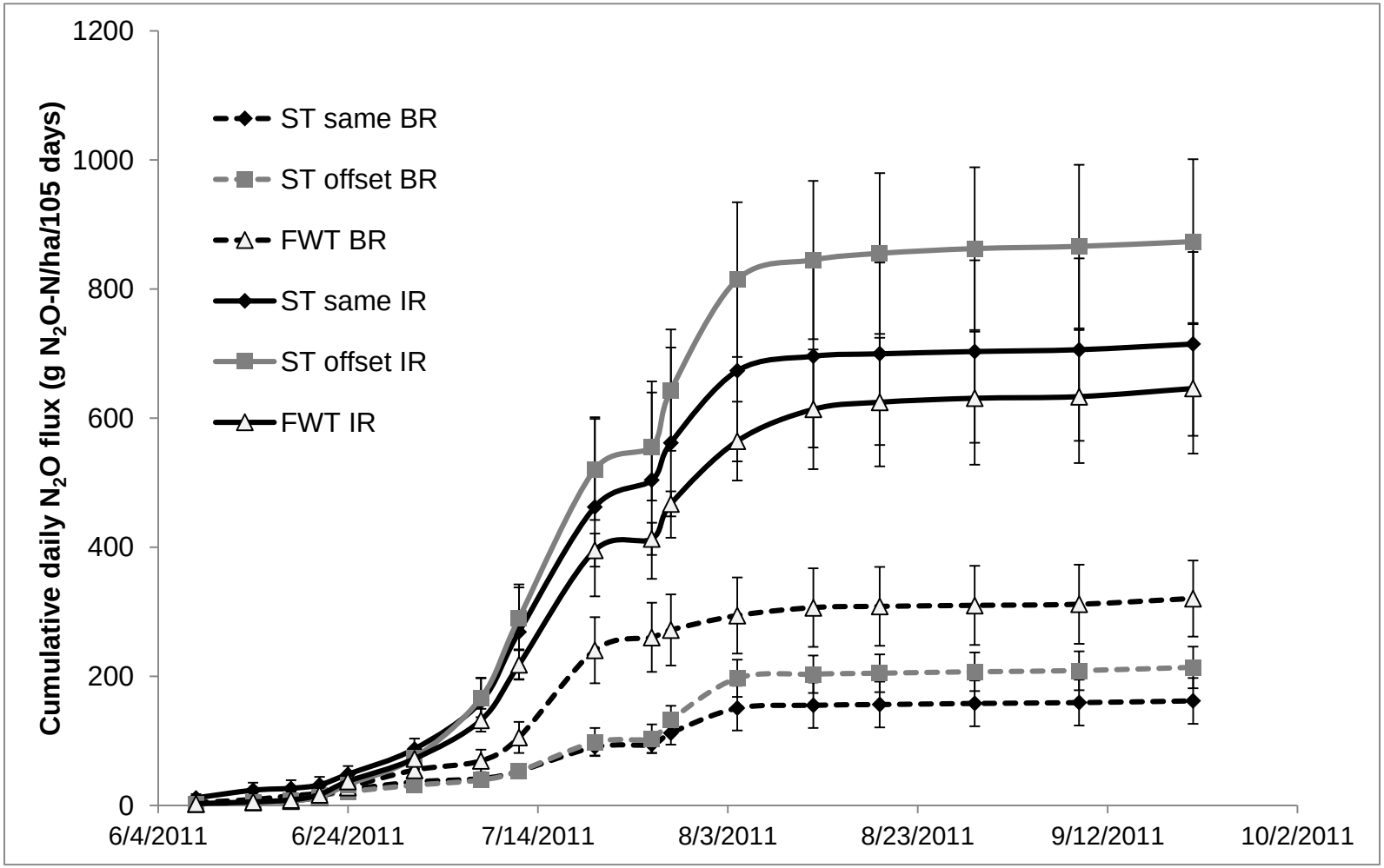

Figure 5. Cumulative season-long nitrous oxide flux in 2011.

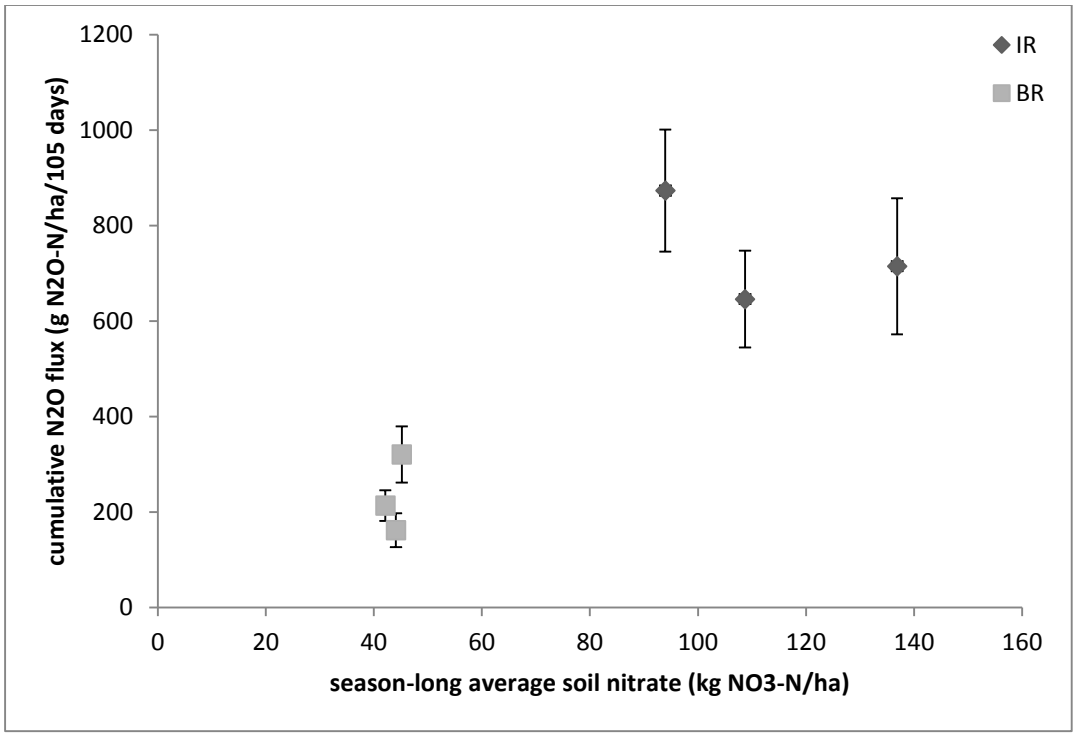

Figure 6. Average season-long cumulative N_2O flux vs. average season-long soil nitrate in sweet corn in 2011.