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Decision Support for Economic and Environmental Impact of Tractor Guidance on Small Crop and Livestock Farms

By Karen Lindsay, Michael Popp, Amanda Ashworth and Phillip Owens

Southern Agricultural Economics Association Annual Meeting,
Jacksonville, FL, Feb 4-6

Introduction and Objectives

- ▶ Tractor guidance (TG) is to:
 - ▶ Improve yield
 - ▶ Reduce input use
 - ▶ Extend workdays
- ▶ Using existing literature and a growing body of field observations, a decision support software was developed to:
 - ▶ assess economic feasibility of TG investment (incl. min. acreage required)
 - ▶ automate sensitivity analysis using farm-specific operating conditions
 - ▶ calculate breakeven yield, input cost savings and equipment efficiency gains
 - ▶ quantify environmental impact



Tractor Guidance Analysis DSS



[Title](#)
[Machinery](#)
[Output Comparison](#)
[Crop 1](#)
[Crop 2](#)
[Crop 3](#)
[PRINT](#)



Operation Parameters and Expenses for Circle 'C' Farms



Enter Operation Name:

Circle 'C' Farms

Load Defaults

Estimated Profitability of Guidance Equipment: **\$8,653**

Modify Green Cells Below – Do NOT use Copy and Paste

Operation Parameters					
Field Crop Planted	Acres	Exp. Yield units/acre	unit	Expected Price (\$/unit)	\$/acre
Corn	250	210	bu	\$3.50	\$735
Soybean	250	60	bu	\$10.00	\$600

Total Acres Planted 500

Field Characteristics by Crop	
Slope (%)	Irregularity
0-1%	low
0-1%	low

Operating Expenses				
Fuel	\$/gal	Labor	\$/hour	
Diesel	\$1.75	Operator Labor	\$13.14	\$13.14
Interest Rates (percent)		Hired Labor	\$9.06	\$9.06
Operating Interest	4.75%	Custom Applications \$/acre		
Discount Factor	6.00%	Ground Fertilizer	\$7.00	\$7.00
		Air Herbicide	\$7.00	\$7.00
		Ground Herbicide	\$7.00	\$7.00
		Ground Insecticide	\$7.00	\$7.00
		Ground Seeding	\$7.00	\$7.00
		Air Seeding	\$7.00	\$7.00



Example Field Characteristics



Low irregularity
Low slope



Medium irregularity
High slope



High irregularity
Medium slope

Tractor Guidance Analysis DSS

Choose from Corn, Cotton, Soybean, Sorghum, Peanuts, Rice, Wheat and Establishing Pasture or Hay



Machinery Output Comparison Crop 1 Crop 2 Crop 3 PRINT

Operation Parameters and Expenses for Circle 'C' Farms

Load Defaults

Estimated Profitability of Guidance Equipment: **\$8,653**

Modify Green Cells Below – Do NOT use Copy and Paste

Operation Parameters							Field Characteristics by Crop		Operating Expenses				
Field Crop Planted	Acres	Exp. Yield units/acre	unit	Expected Price (\$/unit)	\$/acre	Slope (%)	Irregularity	Fuel	\$/gal	Interest Rates	(percent)	Hour	\$/hour
Corn	250	210	bu	\$3.50	\$735	0-1%	low	Diesel	\$1.75	Operating Interest	4.75%	Discount Factor	\$13.14
Soybean	250	60	bu	\$10.00	\$600	0-1%	low	Ground Fertilizer	\$7.00	Air Herbicide	\$7.00	Ground Herbicide	\$7.00
								Ground Insecticide	\$7.00	Ground Seeding	\$7.00	Air Seeding	\$7.00

Choose field characteristics.



Set acreage, price yield and other input costs or remain with defaults.

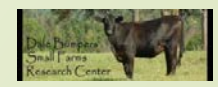
Example Field Characteristics



Medium irregularity
High slope



High irregularity
Medium slope



Tractor Guidance Analysis DSS

Navigate the program

Monitor profitability of TG



Title Machinery Output Comparison Crop 1 Crop 2 Crop 3 PRINT

Operation Parameters and Expenses for Circle 'C' Farms



Enter Operation Name:

Circle 'C' Farms

Load Defaults

Estimated Profitability of Guidance Equipment: \$8,653

Modify Green Cells Below – Do NOT use Copy and Paste

Built-in Tutorial

Operation Parameters							Field Characteristics by Crop		Operating Expenses						
Field Crop Planted	Acres	Exp. Yield units/acre	unit	Expected Price (\$/unit)	\$/acre		Slope (%)	Irregularity	Fuel	\$/gal		Labor	\$/hour		
			Default		Default					Default			Default		
Corn	250	210	210	bu	\$3.50	\$3.50	\$735	0-1%	low	Diesel	\$1.75	\$1.75	Operator Labor	\$13.14	\$13.14
Soybean	250	60	60	bu	\$10.00	\$10.00	\$600	0-1%	low	Interest Rates (percent)		Hired Labor	\$9.06	\$9.06	
										Operating Interest	4.75%	4.75%	Custom Applications \$/acre		
										Discount Factor	6.00%	6.00%	Ground Fertilizer	\$7.00	\$7.00
													Air Herbicide	\$7.00	\$7.00
													Ground Herbicide	\$7.00	\$7.00
													Ground Insecticide	\$7.00	\$7.00
													Ground Seeding	\$7.00	\$7.00
													Air Seeding	\$7.00	\$7.00

Total Acres Planted 500



Example Field Characteristics



Low irregularity
Low slope



Medium irregularity
High slope



High irregularity
Medium slope

Machinery Selection



Title Inputs Output Comparison Crop 1 Crop 2 PRINT

Machinery Selection for Circle 'C' Farms



Click green buttons to select technology and machine options

Tractor Guidance

Tractor Guidance Technology	Corn		Soybean	
	Annual Use by Crop	Annual Use for Specified Field Operations	Annual Use by Crop	Annual Use for Specified Field Operations
Sub-meter Receiver 1	46.8	46.8	46.8	93.6

Estimated Profitability of Guidance Equipment: \$8,653

Tractors

Tractor Name	Tractor Size	Specified Use Hours	Annual Use by Crop with Guidance	Annual Use for Specified Field Operations with Guidance	Weighted Avg. Operating Cost \$/hr	Tractor Capital Recovery \$/hr
Tractor 1	MFWD 190	72.84	36.4	36.4	\$23.73	\$153.20
Tractor 2 Used	MFWD 150	600.00	10.4	10.4	\$15.23	\$6.61

Row Planters

Implement— Size — Tractor Guidance	Tractor Selection	Benchmark Estimated Annual Use	Annual Use by Crop with Guidance	Annual Use Hours with Guidance	Fuel Cost \$/hr	Repair & Maintenance \$/hr	Capital Recovery \$/hr	Total Cost \$/hr	Acres per hour	Total Cost \$/acre
Row Planter 1 — 8R-30 — Sub-meter Receiver 1	Tractor 1	57.69	28.4	28.4	\$8.75	\$43.47	\$211.38	\$281.27	8.8	\$31.96

Grain Drills

Not in use

Sprayers

Over-the-Top Sprayer 1 — 120 ft — Sub-meter Receiver 1	Tractor 1	16.27	8.0	8.0	\$14.63	\$45.05	\$440.72	\$518.07	62.4	\$8.30
Not in use										

Fertilizer Spreader

Fertilizer Spreader — 40 ft — Sub-meter Receiver 1	Tractor 2 Used	21.05	10.4	10.4	\$11.55	\$11.07	\$41.56	\$81.85	24.1	\$3.40
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Manure Spreader

Not in use

Machinery Selection

Focus is on Tractors, Tractor Guidance, Planting, Chemical and Fertilizer applications



Click green buttons to select technology and machine options



Tractors

Row Planters

Grain Drills

Sprayers

Fertilizer Spreader

Manure Spreader

Tractor Guidance

Comparison

Crop 1

Crop 2

PRINT

Machinery Selection for Circle 'C' Farms

Corn Soybean



Tractor Guidance Technology	Annual Use by Crop	Annual Use for Specified Field Operations
Sub-meter Receiver 1	46.8	93.6

Estimated Profitability of Guidance Equipment: **\$8,653**

Tractor Name	Tractor Size	Specified Use Hours	Annual Use by Crop with Guidance	Annual Use for Specified Field Operations with Guidance
Tractor 1	MFWD 190	72.84	36.4	72.84
Tractor 2 Used	MFWD 150	600.00	10.4	20.75

Weighted Avg. Operating Cost \$/hr	Tractor Capital Recovery \$/hr
\$23.73	\$153.20
\$15.23	\$6.61

Track cost/acre and per hour incl. ownership charges

Implement— Size — Tractor Guidance	Tractor Selection	Benchmark Estimated Annual Use	Annual Use by Crop with Guidance	Annual Use Hours with Guidance	Fuel Cost \$/hr	Repair & Maintenance \$/hr	Capital Recovery \$/hr	Total Cost \$/hr	Acres per hour	Total Cost \$/acre
Row Planter 1 — 8R-30 — Sub-meter Receiver 1	Tractor 1	57.69	28.4	56.8	\$8.75	\$43.47	\$211.38	\$281.27	8.8	\$31.96
Grain Drills	Not in use									
Over-the-Top Sprayer 1 — 120 ft — Sub-meter Receiver 1	Tractor 1	16.27	8.0	16.0	\$14.63	\$45.05	\$440.72	\$518.07	62.4	\$8.30
Sprayers	Not in use									
Fertilizer Spreader — 40 ft — Sub-meter Receiver 1	Tractor 2 Used	21.05	10.4	20.7	\$11.55	\$11.07	\$41.56	\$81.85	24.1	\$3.40
Manure Spreader	Not in use									

Example: Tractors

Click green buttons to select technology and machine options

Tractors

Tractor

PRINT

Tractor

Specify Quantity: Save Cancel

Tractor 1

Specify Tractor Size Reset to Saved

Assign Tractor Name

Use Suggested Retail Price and Salvage Value

Purchase Price

Hours at Purchase

Expected Hours at Salvage

Expected Salvage Value

Specify Annual Use Hours

Standard

Acre-Based

User-Specified hours/year

Tractor 2 Used

Specify Tractor Size Reset to Saved

Assign Tractor Name

Use Suggested Retail Price and Salvage Value

Purchase Price

Hours at Purchase

Expected Hours at Salvage

Expected Salvage Value

Specify Annual Use Hours

Standard

Acre-Based

User-Specified hours/year

Guidance **\$8,653**

Cost /hr	Acres per hour	Total Cost \$/acre
1.27	8.8	\$31.96
8.07	62.4	\$8.30
1.85	24.1	\$3.40



Example: Implements & Efficiency Parameters

Click green buttons to select technology and machine options

Tractor Guidance

Tractors

Row Planters

Grain Drills

Sprayers

Fertilizer Spreader

Manure Spreader

Row Planter

Specify Quantity: 1

Row Planter 1 Specifications

Specify Row Planter: 8R-30 feet Reset to Saved

Standard Implement Values

\$41,000.00 Purchase Price

0 Hours at Purchase

900 Expected Hours at Salvage

\$19,630.01 Expected Salvage Value

Assign Tractor: Tractor 1

Standard Fuel Use 5 gallons/hour

Select Associated Tractor Guidance System: Sub-meter Receiver 1

Specify Efficiency Improvements:

Standard Field Capacity Increase 0 percent

Standard Input Use Decrease 2.35 percent

Standard Yield Increase 0 percent

Save
Cancel

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Guidance **\$8,405**

Total Cost \$/hr	Acres per hour	Total Cost \$/acre
278.91	8.7	\$32.18
516.25	62.4	\$8.27
\$81.85	24.1	\$3.40

Modify ownership parameters, fuel use and associated tractor, guidance technology and efficiency gains

Partial Budget - Corn




Corn Production Practices for Circle 'C' Farms

Modify Green Cells Below – Do NOT use Copy and Paste


										Benchmark without Tractor Guidance	Adjusted for Tractor Guidance		
<div style="border: 1px solid green; padding: 5px; width: fit-content;"> <p style="color: red; font-weight: bold;">Modify budget specifications using the green cells provided</p> <p style="color: red; font-size: 2em;">↓</p> </div> <div style="margin-top: 10px;"> <input type="button" value="Load Defaults"/> <input checked="" type="checkbox"/> View Defaults </div>										Partial Returns (\$/acre):	\$389.11	Adjusted for Tractor Guidance	\$408.34
										Yield (units/acre):	210	Adjusted for Tractor Guidance	212
										Adjusted for Tractor Guidance			
Operation/ Operating Input	Timing	Unit	Performance Rate (acres/hour)	Cost/Unit (\$/acre)	Default Cost/Unit (\$/acre)	Quantity of Trips/Inputs	Default Quantity of Trips/Inputs	Total Cost (\$/acre)	Performance Rate (acres/hour)	Cost/Unit (\$/acre)	Quantity of Trips/Inputs	Total Cost (\$/acre)	
Burndown Weed Control Spring													
Over-the-Top Sprayer 1			61.45	\$8.40	\$8.40	1	1	\$8.40	62.40	\$8.27	1	\$8.27	
Glyphosate		pt		\$4.75	\$4.75	2.0	2.0	\$9.50		\$4.75	1.56	\$7.40	
Field Preparation Spring													
Fertilizer Spreader			23.76	\$3.45	\$3.45	1	1	\$3.45	24.10	\$3.40	1	\$3.40	
Nitrogen 100%		lb		\$0.33	\$0.33	223.0	223.0	\$73.59		\$0.33	218.00	\$71.94	
Phosphate (P2O5) 100%		lb		\$0.41	\$0.41	60.0	60.0	\$24.60		\$0.41	58.66	\$24.05	
Potash (K2O) 100%		lb		\$0.20	\$0.24	120.0	90.0	\$24.00		\$0.20	117.31	\$23.46	
Sulfur 100%		lb		\$0.36	\$0.36	24.0	24.0	\$8.64		\$0.36	23.46	\$8.45	
Zinc Sulfate 100%		lb		\$1.48	\$1.48	10.0	10.0	\$14.80		\$1.48	9.78	\$14.47	
Planting													
Row Planter 1			8.67	\$32.18	\$32.18	1	1	\$32.18	8.67	\$32.18	1	\$32.18	
Seed		acre		\$115.00	\$115.00	1.0	1.0	\$115.00		\$115.00	0.98	\$112.30	
Over-the-Top Sprayer 1			61.45	\$8.40	\$8.40	1	1	\$8.40	62.40	\$8.27	1	\$8.27	
Prevathon		oz		\$1.16	\$1.16	14.0	14.0	\$16.24		\$1.16	10.91	\$12.65	
Benchmark Operating Interest:								\$7.09	Adjusted Operating Interest:		\$6.81		
Benchmark Total Specified Expenses (\$/acre):								\$345.89	Adjusted Total Specified Expenses (\$/acre):		\$333.66		

Output Analysis



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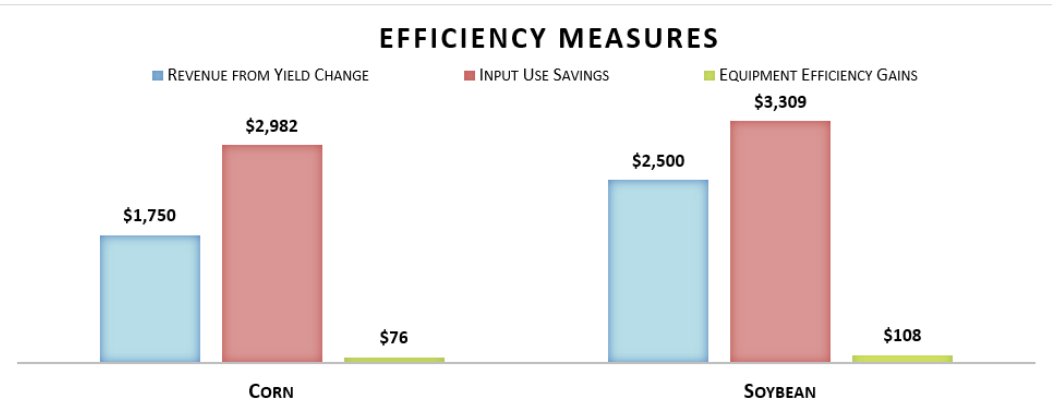
Title **Inputs** **Machinery** **PRINT**

Stop & Save

Output Comparison for Circle 'C' Farms

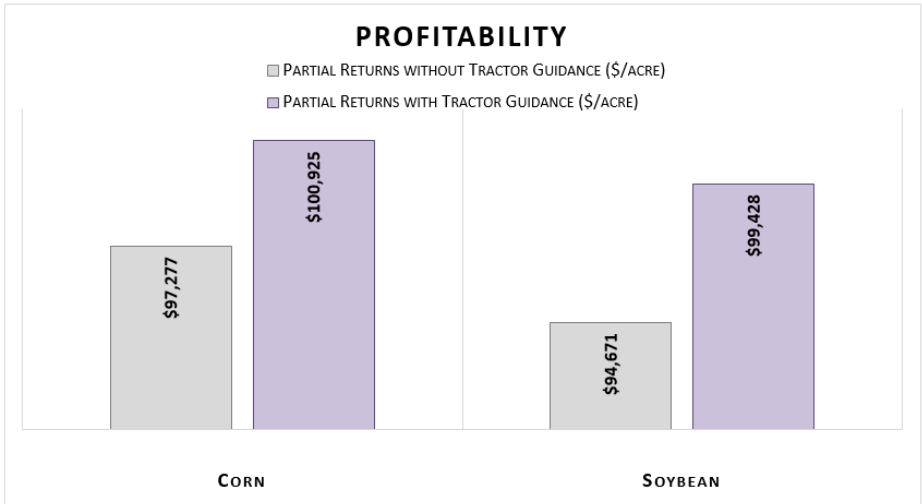
	Crop 1	Crop 2	Total
	Corn	Soybean	Total
Acres Planted	250	250	500
Partial Returns without Tractor Guidance (\$/acre)	\$97,277	\$94,671	\$191,947
Partial Returns with Tractor Guidance (\$/acre)	\$100,925	\$99,428	\$200,353
Annual Use Hours for Sub-meter Receiver 1	47	47	94
Annual Allocated Cost of Sub-meter Receiver 1	\$1,159	\$1,159	\$2,319
Total Annual Allocated Cost of Tractor Guidance (\$/year)	\$1,159	\$1,159	\$2,319
Breakeven Yield Change	0.6%	0.8%	
Breakeven Equipment Efficiency Gains	8.8%	7.6%	
Breakeven Input Savings	1.6%	2.9%	
Calculate Breakeven Acreage	51.4	51.4	103

EFFICIENCY MEASURES



Crop	Revenue from Yield Change	Input Use Savings	Equipment Efficiency Gains
CORN	\$1,750	\$2,982	\$76
SOYBEAN	\$2,500	\$3,309	\$108

PROFITABILITY



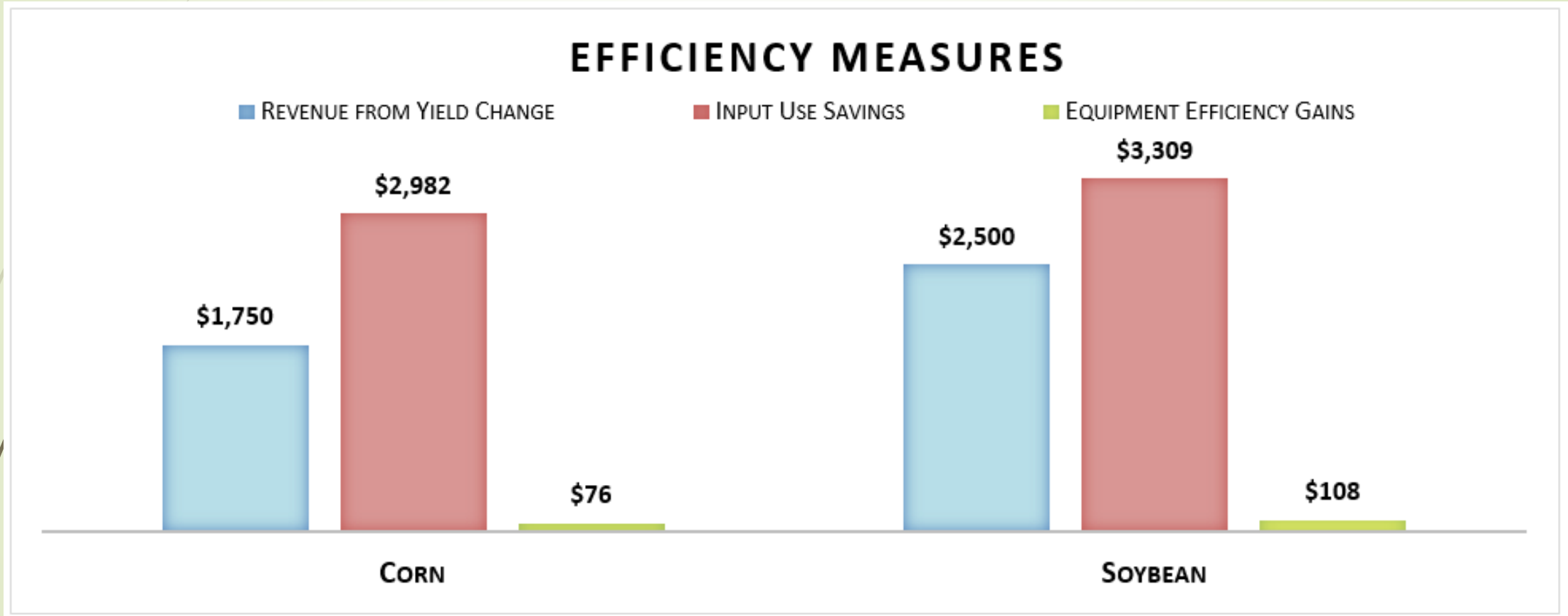
Crop	Partial Returns without Tractor Guidance (\$/acre)	Partial Returns with Tractor Guidance (\$/acre)
CORN	\$97,277	\$100,925
SOYBEAN	\$94,671	\$99,428

Estimated Profitability of Guidance Equipment: \$8,405

Output Analysis

	Corn	Soybean	Total
Acres Planted	250	250	500
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Output Analysis



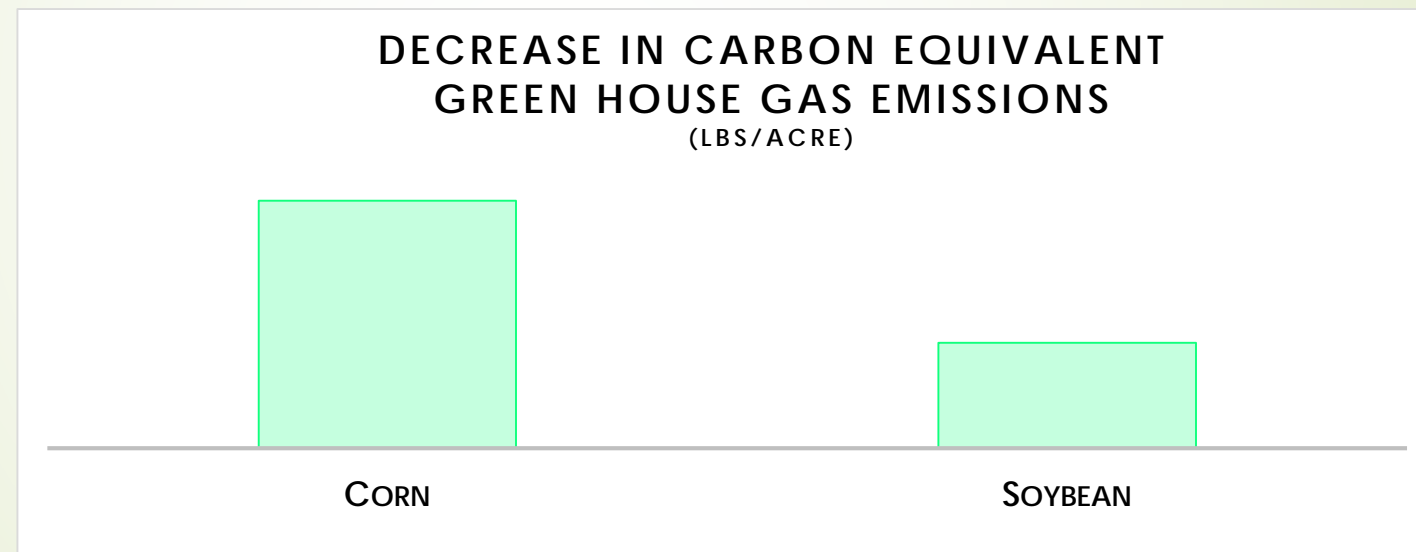
Output Analysis

	Corn	Soybean	
Yield Change across All Field Passes (units/acre)	2 bu	1 bu	
(% increase)	1.0%	1.7%	
Input Use Change (\$/acre)	-\$11.93	-\$13.23	
Total Input Use	\$293.46	\$160.49	
(% decrease)	4.1%	8.2%	
Seed Cost Change (\$/acre)	-\$2.70	-\$1.85	
Chemical & Fertilizer Cost Change (\$/acre)	-\$8.95	-\$11.08	
Operating Interest (\$/acre)	-\$0.28	-\$0.31	
Equipment Efficiency Change (\$/acre)	\$0.30	\$0.43	
Labor, Fuel, R&M and Capital Recovery (\$/acre)	\$52.43	\$60.83	
(% decrease)	-0.6%	-0.7%	
Labor Cost Change (\$/acre)	-\$0.02	-\$0.02	
Fuel Cost Change (\$/acre)	-\$0.01	-\$0.02	
R&M Cost Change (\$/acre)	-\$0.03	-\$0.04	
Capital Recovery Cost Change (\$/acre)	-\$0.24	-\$0.35	
Revenue from Yield Change	\$1,750	\$2,500	\$4,250
Input Use Savings	\$2,982	\$3,309	\$6,290
Seed Cost Savings	\$676	\$462	\$1,137
Chemical & Fertilizer Savings	\$2,236	\$2,770	\$5,006
Operating Interest Savings	\$70	\$77	\$147
Equipment Efficiency Change	\$76	\$108	\$184
Labor Cost Savings	\$5	\$6	\$11
Fuel Cost Savings	\$4	\$4	\$8
R&M Cost Savings	\$7	\$10	\$17
Capital Recovery Cost	\$60	\$87	\$148

Output Analysis

	Corn	Soybean
--	------	---------

Decrease in GHG Emissions (lbs/acre)	17.78	7.56
from Fuel Use (lbs/acre)	0.07	0.07
from Fertilizer Application (lbs/acre)	13.69	0.4
from Herbicide Application (lbs/acre)	2.97	5.81
from Other Chemical Applications (lbs/acre)	1.05	1.28
Total Decrease in Carbon Emissions (tons)		3.16



Conclusions

- ▶ These results show that economic and environmental impacts depend on:
 - ▶ Farm size
 - ▶ Equipment use
 - ▶ Crops grown and crop inputs selected
- ▶ Impacts are difficult to quantify
- ▶ Informing users of estimated impacts of TG use, adoption of this technology is expected to increase

Breakeven Output

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Stop & Save

Output Comparison for Circle 'C' Farms

	Crop 1	Crop 2	Total
	Corn	Soybean	Total
Acres Planted	51	51	103
Partial Returns without Tractor Guidance (\$/acre)	\$12,520	\$10,569	\$23,089
Partial Returns with Tractor Guidance (\$/acre)	\$12,397	\$10,695	\$23,091
Annual Use Hours for Sub-meter Receiver 1	10	10	19
Annual Allocated Cost of Sub-meter Receiver 1	\$1,159	\$1,159	\$2,319
Total Annual Allocated Cost of Tractor Guidance (\$/year)	\$1,159	\$1,159	\$2,319
Breakeven Yield Change	3.1%	3.8%	
Breakeven Equipment Efficiency Gains	11.4%	9.6%	
Breakeven Input Savings	7.7%	14.1%	
Calculate Breakeven Acreage	51.4	51.4	103

Estimated Profitability of Guidance Equipment: \$2

