



Determining the economically optimal level of control on sprayers and planters

**Paper in draft form -- C.M. Smith & K.C. Dhuyvetter, 2015*

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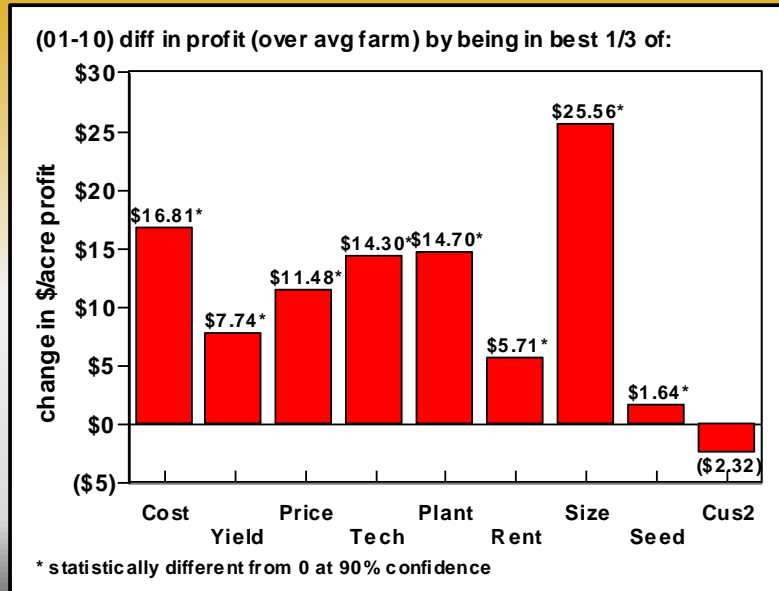
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Introduction

- Precision agriculture means different things to different people
- Can't make blanket statements that it "pays" or "doesn't pay"
- 28% of dealerships Disagree or Strongly Disagree with: "Demonstrating the value of PA to growers is a challenge." (Erickson, Widmar, Holland 2013)
- Much of differences between high- and low-profit farms can be traced to (KFMA data from 2001-2010):
 - Machinery costs
 - Farm size
 - Technology adoption

Factors impacting profitability differences (KFMA data)...



Introduction

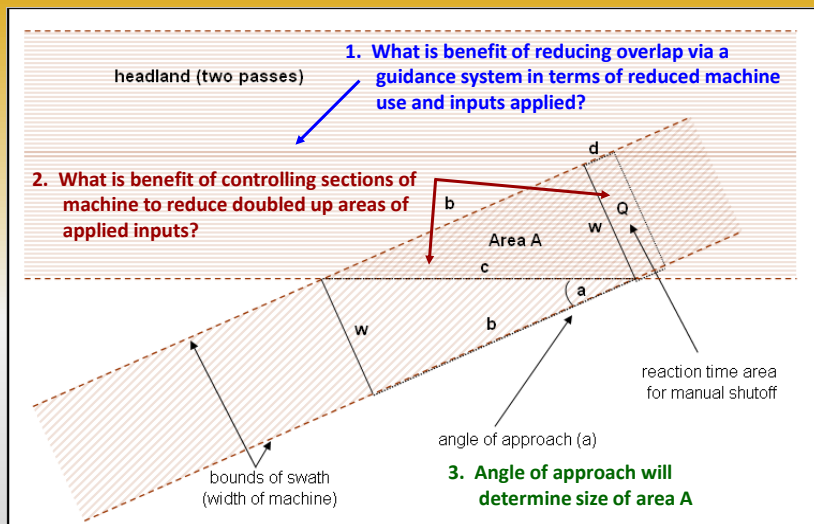
- One aspect of precision agriculture is related to machinery technology
 - Guidance systems
 - Section controllers
- Issues
 - Machinery overlap
 - Field headlands
 - Large (wide) machinery
- Observation – Most sprayers have auto-boom section control. Fewer planters have auto-row control. Why?
- What is the “optimal” level of auto-control for sprayers and planters across the Great Plains?



Guidance & Section Control Economics

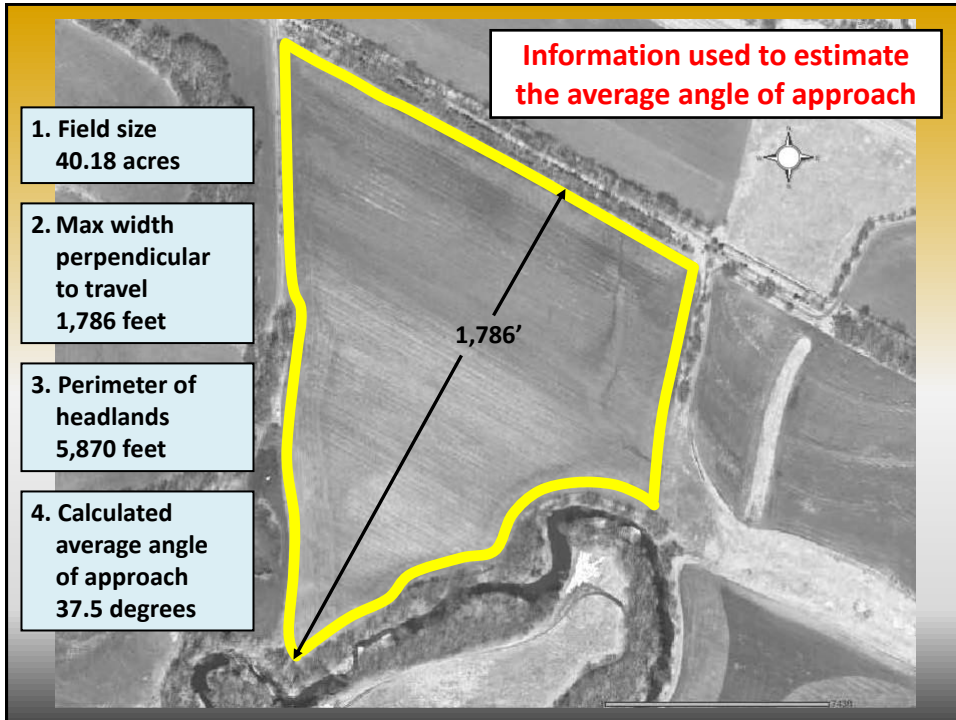
- All situations are quite site- and machine-specific
 - Hard to make general rules of thumb across operations
 - Requires individual-situation analysis
 - So, along with the PrecisionAg Institute we developed a decision tool to aid in such decisions
 - **Guidance & Section Control Profit Calculator**
 - Web Dashboard
 - Excel spreadsheet
 - Others available at www.AgManager.info

Overlap and headlands geometry



Areas A and Q and turnaround counterparts will have a) doubling-up of inputs and b) possible yield losses due to this doubling-up. After the turnaround there will be overlap along b, also accounted for.

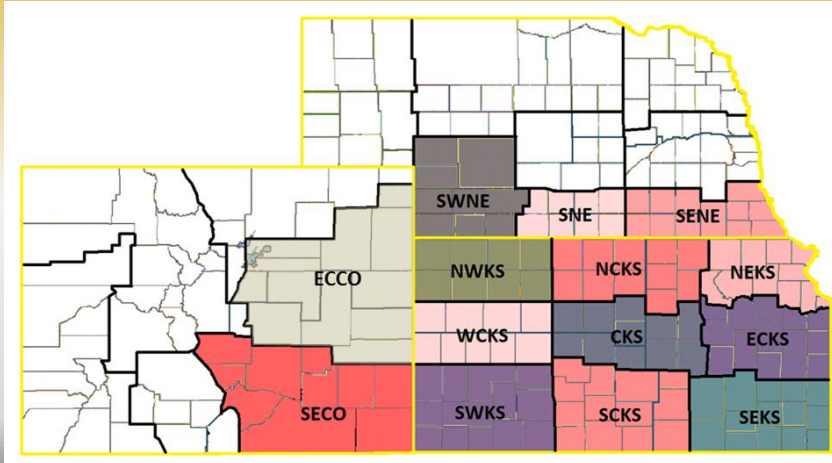




Methods

- Collected measurements on 1,445 fields in 16 CRDs, and used the Guidance and Section Control (GSC) profit calculator available on AgManager.info
- The GSC calculator uses the measurements shown in the previous figure to calculate the average angle of approach of the planter entering the headlands
- The angle of approach drives much of the economics of auto-guidance systems and section/individual controllers

Data



Summary stats of field data

Crop reporting district	Number of Fields	Total Acres	Simple Avg. field Size (ac)	Acre-Weighted Avg. field Size (ac)	Max Width (ft)	Running Headlands Distance (ft)	Average Angle (degrees)
NWKS	347	29,579	85	134	1,951	7,380	31.9
WCKS	109	15,314	140	395	2,041	7,962	30.9
SWKS	187	21,413	115	191	2,162	8,080	32.4
NCKS	228	15,270	67	127	1,785	7,158	29.9
CKS	153	8,788	57	108	1,468	6,261	28.0
SCKS	96	8,282	86	129	1,950	6,964	34.0
NEKS	37	1,259	34	83	1,059	5,026	24.9
ECKS	50	1,311	26	41	936	4,456	24.8
SEKS	10	489	49	68	1,298	5,607	27.6

Should I invest in individual nozzle control for sprayers?

- In many cases:
 - “Major” gains will be achieved when going from whole boom to section control
 - Less “major” gains will be achieved when going from section to individual nozzle control
- More important to look at the marginal effects – additional benefits compared to additional costs of going from section control to individual nozzle control

Benefits of section and individual nozzle control

- Northwest KS example field is 134.4 acres
- Chemicals applied to the following areas:
 - Auto-boom with 1 section → 143.2 acres
 - Auto-boom with 5 sections → 136.2 acres
 - Auto-boom with 60 “sections” → 134.6 acres
- Thus, less inputs are wasted.

Base Assumptions for Sprayer Analysis

Precision guidance		Differential GPS	
Width of machine		90 feet	
Cost of machine operation		\$6.00 / acre	
Average cost of input (fertilizer, herbicide, etc.)		\$15.00 / acre	
Total use annually		10,000 acres	
Interest rate		8.0%	
Amortization period		5 years	
	<u>Manual control</u>	<u>Section control</u>	<u>Individual nozzle control</u>
Sprayer control	Entire boom controlled manually	5 equal-width sections controlled automatically	60 nozzles controlled automatically
Reaction distance in headlands	15 feet	0 feet	0 feet
Investment for controllers	\$0	\$10,000	\$25,000

The need for a Marginal Analysis

- Given our base assumptions:
 - ROI of going from 1 section to 5 sections = **94.7%**
 - ROI of going from 1 section to 60 “sections” = **36.7%**
- Both ROI’s are excellent, it’s not exactly clear if a choice to upgrade to individual nozzle control from section control is a profitable choice
- Need to analyze “on the margin”

If we assume no additional crop yield improvement (NWKS)...

Marginal ROI (sprayer with 60 sections versus sprayer with 5 sections)

		Additional investment, \$/machine					
		\$5,000	\$10,000	\$15,000	\$20,000	\$25,000	\$30,000
Acres covered annually	5,000	-3.7%	-22.0%	-30.3%	-35.5%	-39.1%	-41.9%
	10,000	23.1%	-3.7%	-15.1%	-22.0%	-26.8%	-30.3%
	15,000	45.3%	10.6%	-3.7%	-12.0%	-17.7%	-22.0%
	20,000	65.7%	23.1%	6.1%	-3.7%	-10.3%	-15.1%
	25,000	85.2%	34.5%	14.9%	3.8%	-3.7%	-9.1%
	30,000	104.1%	45.3%	23.1%	10.6%	2.4%	-3.7%

Marginal payback (sprayer with 60 sections versus sprayer with 5 sections)

		Additional investment, \$/machine					
		\$5,000	\$10,000	\$15,000	\$20,000	\$25,000	\$30,000
Acres covered annually	5,000	7.7	29.4	won't pay	won't pay	won't pay	won't pay
	10,000	3.3	7.7	14.5	29.4	won't pay	won't pay
	15,000	2.1	4.6	7.7	11.8	17.8	29.4
	20,000	1.5	3.3	5.3	7.7	10.7	14.5
	25,000	1.2	2.6	4.1	5.8	7.7	10.0
	30,000	1.0	2.1	3.3	4.6	6.1	7.7

If we assume \$0.50/ac additional crop yield improvement (NWKS)...

Marginal ROI (sprayer with 60 sections versus sprayer with 5 sections)

		Additional investment, \$/machine					
		\$5,000	\$10,000	\$15,000	\$20,000	\$25,000	\$30,000
Acres covered annually	5,000	21.5%	-4.7%	-16.0%	-22.8%	-27.4%	-31.0%
	10,000	63.1%	21.5%	4.9%	-4.7%	-11.2%	-16.0%
	15,000	100.4%	43.2%	21.5%	9.3%	1.2%	-4.7%
	20,000	136.2%	63.1%	36.2%	21.5%	11.8%	4.9%
	25,000	171.5%	82.0%	50.0%	32.7%	21.5%	13.5%
	30,000	206.4%	100.4%	63.1%	43.2%	30.5%	21.5%

Marginal payback (sprayer with 60 sections versus sprayer with 5 sections)

		Additional investment, \$/machine					
		\$5,000	\$10,000	\$15,000	\$20,000	\$25,000	\$30,000
Acres covered annually	5,000	3.4	8.1	15.4	34.0	won't pay	won't pay
	10,000	1.6	3.4	5.5	8.1	11.2	15.4
	15,000	1.0	2.2	3.4	4.8	6.3	8.1
	20,000	0.8	1.6	2.5	3.4	4.4	5.5
	25,000	0.6	1.3	1.9	2.7	3.4	4.2
	30,000	0.5	1.0	1.6	2.2	2.8	3.4

Should I invest in auto-row controllers for my planter?

If so, what level of precision is most profitable?

Base Assumptions for Planter Analysis

Precision guidance	Differential GPS		
Width of machine	30 feet (12-row, 30")		
Cost of machine operation	\$18.00 / acre		
Average cost of seed -- corn	\$110.00 / acre		
Average cost of seed -- sorghum	\$15.00 / acre		
Total use annually	1,500 acres		
Interest rate	8.0%		
Amortization period	5 years		
	<u>Manual control</u>	<u>Two sections</u>	<u>Six sections</u>
Planter control	Entire planter controlled manually	Two 6-row sections controlled automatically	Six 2-row sections controlled automatically
Reaction distance in headlands	5 feet	0 feet	0 feet
Investment for row controllers	\$0	\$6,500	\$10,000

Value of wasted seed with no auto-row controllers across regions and crops (\$/ac across the whole field)

District	Corn	Sorghum
NWKS	\$2.69	\$0.37
WCKS	\$1.21	\$0.16
SWKS	\$2.02	\$0.28
NCKS	\$3.23	\$0.44
CKS	\$3.00	\$0.41
SCKS	\$2.65	\$0.36
NEKS	\$3.14	\$0.43
ECKS	\$5.58	\$0.76
SEKS	\$3.96	\$0.54

Assumptions:

Corn - \$4.00/bu, seed @ \$110/ac, yield @ 200 bu/ac, 25% yield loss where doubled-up
 Sorghum - \$3.50/bu, seed @ \$15/ac, yield @ 80 bu/ac, 25% yield loss where doubled-up

Value of yield loss with no auto-row controllers across regions and crops (\$/ac across the whole field)

District	Corn	Sorghum
NWKS	\$4.54	\$1.62
WCKS	\$2.00	\$0.71
SWKS	\$3.39	\$1.21
NCKS	\$5.47	\$1.95
CKS	\$5.08	\$1.81
SCKS	\$4.47	\$1.59
NEKS	\$5.33	\$1.89
ECKS	\$9.79	\$3.45
SEKS	\$6.79	\$2.41

Assumptions:

Corn - \$4.00/bu, seed @ \$110/ac, yield @ 200 bu/ac, 25% yield loss where doubled-up
 Sorghum - \$3.50/bu, seed @ \$15/ac, yield @ 80 bu/ac, 25% yield loss where doubled-up

Net Benefits, ROI, and Payback 12-row Planter -- CORN

Region	Annual Benefit, \$/ac			Return on Investment (ROI)			Payback Years		
	Two 6-row sections	Six 2-row sections	Marginal Change	Two 6-row sections	Six 2-row sections	Marginal Change	Two 6-row sections	Six 2-row sections	Marginal Change
NWKS	3.47	5.02	1.56	101.9	97.0	87.9	1.0	1.1	1.2
WCKS	0.95	1.30	0.35	37.3	34.3	28.7	2.4	2.6	2.9
SWKS	2.32	3.34	1.01	73.7	69.8	62.5	1.4	1.5	1.6
NCKS	4.28	6.36	2.08	121.4	118.0	111.7	0.9	0.9	0.9
CKS	3.95	5.80	1.85	113.6	109.2	101.0	0.9	1.0	1.0
SCKS	3.40	4.92	1.52	100.2	95.3	86.1	1.0	1.1	1.2
NEKS	4.22	6.16	1.94	120.0	114.9	105.4	0.9	0.9	1.0
ECKS	8.26	12.50	4.24	215.0	211.8	205.8	0.5	0.5	0.5
SEKS	5.59	8.26	2.68	152.5	147.4	137.9	0.7	0.7	0.8

Assumptions:

Corn - \$4.00/bu, seed @ \$110/ac, yield @ 200 bu/ac, 25% yield loss where doubled-up
Sorghum - \$3.50/bu, seed @ \$15/ac, yield @ 80 bu/ac, 25% yield loss where doubled-up

Net Benefits, ROI, and Payback 12-row Planter -- SORGHUM

Region	Annual Benefit, \$/ac			Return on Investment (ROI)			Payback Years		
	Two 6-row sections	Six 2-row sections	Marginal Change	Two 6-row sections	Six 2-row sections	Marginal Change	Two 6-row sections	Six 2-row sections	Marginal Change
NWKS	0.16	0.17	0.00	13.5	11.7	8.2	4.2	4.5	5.0
WCKS	-0.53	-0.86	-0.33	-13.1	-14.5	-17.1	12.6	13.8	16.9
SWKS	-0.15	-0.30	-0.15	2.6	1.0	-2.0	6.0	6.4	7.2
NCKS	0.39	0.53	0.15	20.7	19.5	17.2	3.5	3.6	3.8
CKS	0.30	0.38	0.08	17.8	16.2	13.2	3.8	3.9	4.3
SCKS	0.14	0.14	-0.01	12.9	11.0	7.5	4.3	4.5	5.1
NEKS	0.37	0.48	0.11	20.2	18.3	14.8	3.5	3.7	4.1
ECKS	1.48	2.22	0.74	51.8	50.8	48.9	1.9	1.9	2.0
SEKS	0.74	1.05	0.31	31.5	29.7	26.5	2.7	2.8	3.0

Assumptions:

Corn - \$4.00/bu, seed @ \$110/ac, yield @ 200 bu/ac, 25% yield loss where doubled-up
Sorghum - \$3.50/bu, seed @ \$15/ac, yield @ 80 bu/ac, 25% yield loss where doubled-up

ROI planter (sorghum) with 6 x 2-row control vs. manual control in NWKS

		Lost yield due to double planting					
		0%	10%	25%	50%	75%	100%
Acres covered annually	750	-44.7%	-27.3%	-11.3%	8.1%	24.0%	38.3%
	1,000	-40.6%	-21.1%	-2.8%	20.0%	39.3%	57.0%
	1,250	-37.1%	-15.8%	4.8%	31.0%	53.6%	74.7%
	1,500	-34.0%	-11.0%	11.7%	41.3%	67.3%	91.9%
	1,750	-31.3%	-6.5%	18.2%	51.1%	80.6%	108.6%
	2,000	-28.7%	-2.4%	24.4%	60.7%	93.6%	125.2%

Implications for farmers and custom applicators

- Majority of benefits will be derived from input cost savings for sprayers and yield improvements for planters
- Without guidance and ASC, amount of input used varies drastically across regions
- Machine efficiency will vary considerably across different shapes and field sizes
- Suppose a custom rate for spraying of \$5/ac based on fields of 125 acres and 40° average angle of approach
- Theoretically, a rate of \$5.72/ac should be charged for the smaller ECKS fields and \$4.53/ac should be charged for an average WCKS field

Implications for farmers and custom operators

- Adoption rates of these technologies likely will vary geographically
- Important to evaluate at the margin
- Economies of scale
- Changes in input costs and/or output prices
- Changes in costs of technology
- Views on yield losses from double planting
- Did not consider value of variable rate application

Many thing to consider for an analysis

- Base machine operation cost or custom rate
- Machine size
- Which machines, which operations?
- Machines share investment components?
- Accuracy of GPS wish to consider
- Crop input/output cost
- Field size
- Field shape
- Farm/operation size (mostly a fixed cost investment)
- How do you value personal comfort?

Other opportunities for cost savings...

- Minimizing harvest loss from combine/header

Loss	Value of Loss (\$/ac)	
	Corn	Sorghum
1%	\$8.00	\$2.80
2%	\$16.00	\$5.60
3%	\$24.00	\$8.40
4%	\$32.00	\$11.20
5%	\$40.00	\$14.00
6%	\$48.00	\$16.80
7%	\$56.00	\$19.60
8%	\$64.00	\$22.40
9%	\$72.00	\$25.20
10%	\$80.00	\$28.00

Other opportunities for cost savings...

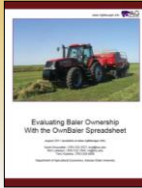
- Minimizing harvest loss from combine/header with 1,500 acres harvested

Loss	Value of Loss (\$/yr)	
	Corn	Sorghum
1%	\$12,000	\$4,200
2%	\$24,000	\$8,400
3%	\$36,000	\$12,600
4%	\$48,000	\$16,800
5%	\$60,000	\$21,000
6%	\$72,000	\$25,200
7%	\$84,000	\$29,400
8%	\$96,000	\$33,600
9%	\$108,000	\$37,800
10%	\$120,000	\$42,000

Is it worth your time (or paying someone else) to get your machine correctly adjusted, repaired, or replaced?

Machinery decision-tools available from KSU... www.AgManager.info

- OwnSeries (Excel spreadsheets)
-- Sprayer, Tractor, Combine, Baler



Sprayer, Tractor, and Baler models recently updated. Combine model to be updated in near future. Models estimate the cost of owning and operating equipment given user input for annual usage, age, purchase price, tax rates, etc.

- Guidance and section controller calculators
-- Excel spreadsheets and web dashboard
- Excel spreadsheets for trucks and buildings
- KSU-MachCost – benchmarking spreadsheet
- Custom rate projections (paper & spreadsheet)



Questions & Discussion

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