Machinery Ownership and Leasing

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MAST Program
www.agmanager.info

Purpose of module

- Develop an understanding of the costs associated with owning and operating machinery
- Trying to reduce decisions to numbers
  - Custom hire
  - Own vs. rent
  - Lease vs. purchase
  - Trading strategies
- … targeting the decision tools:
  - *OwnBaler.xls*
  - *OwnCombine.xls*
  - *OwnSprayer.xls*
  - *OwnTractor.xls*
  - *KSU-MachCost.xls*
  - *KSU-GPSguidance.xls*

Module:
Machinery Ownership and Leasing

Session:
Economics of autoguidance and boom/section control

Recorded fall of 2008

- **Adopting new machinery technologies is an important way that farm managers lower their machinery costs to distinguish themselves from others for the purpose of increasing profit.**
  - **Using GPS to assist machinery operations is an especially important new technology.**

General machinery overlap issues

- **Extra machine operation**
  - **Increases machinery costs since overlap areas are covered more than once, so more acres have to be farmed than which are in the field**
- **May affect applied input usage**
  - **Increases crop input cost since overlap areas are covered more than once and thus get more seed, fertilizer, herbicide, etc.**
- **These are *cost* issues**

Field headland issues (where the action is)

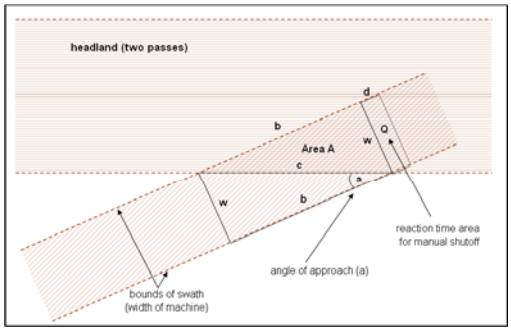
- **Headlands cause economic problems:**
  - **Increase cost of machine operations**
    - **Doubling up of machine operations**
    - **Machines need to slow down for turnaround**
  - **Increase crop input costs due to doubling up**
  - **Double-planting, -applying, -tilling, and extra compaction can reduce crop yield, thus revenue**
- **Portion of field covered by headlands:**
  - **Affects *costs* and *revenues***
  - **Greatly affected by field size and shape**
  - **Especially affected by width of machine**

Large (wide) machine issues

- Need large turnaround area, increasing headland size
- Can we make the larger machines behave as though they were smaller, at least in terms of the portion of a headland affected by input doubling-up?
  - boom or section shut-offs

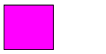
- Regardless, all situations are quite site- and machine-specific
  - Hard to make general rules of thumb across farms
  - Requires individual-situation analysis
    - So, we developed a decision tool (an Excel spreadsheet) to aid such decisions, called
    - KSU-GPSguidance.xls (at www.agmanager.info)
- To get some understanding, economic results for an example farm will be reported

Field headland

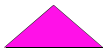


Areas A and Q and turnaround counterparts will have a) doubling-up of inputs and b) possible yield losses due to this doubling-up.
After the turnaround there will be overlap along b, also accounted for.

Various field shapes of interest (farm left to right)



Square; hit ends at 90 degree angles
5,280 feet of headlands in 160 acre field



Isosceles right triangle; hit ends at 60 degree angles
7,467 feet of headlands in 160 acre field

Equilateral triangle; hit ends at 45 degree angles
8,024 feet of headlands in 160 acre field

Circle; hit ends at angles varying from 0 to 90 degrees (avg. 40 degrees) 9,359 feet of headlands in 160 acre field

Kastens fields average hitting headlands at around 24 degrees

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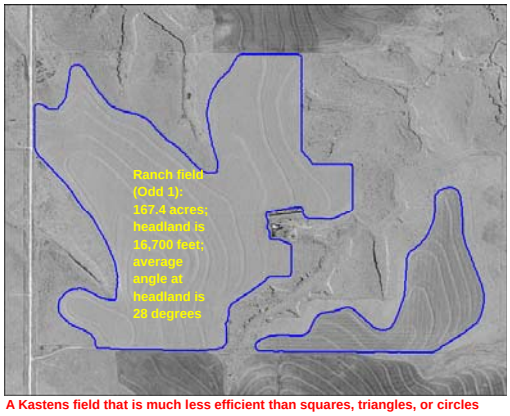

A Kastens field that is much less efficient than squares, triangles, or circles
a single 90' pass with a sprayer gets 20% of the field!

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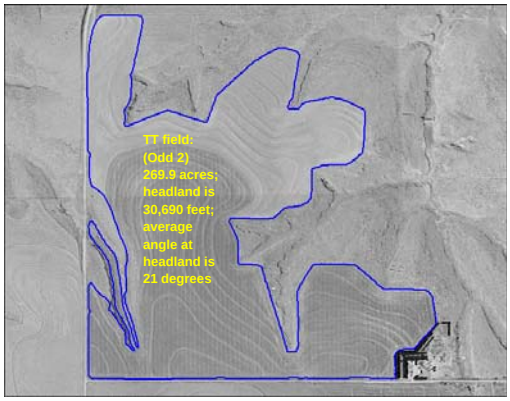

Another extremely inefficient Kastens field – 90' pass = 23% of field!

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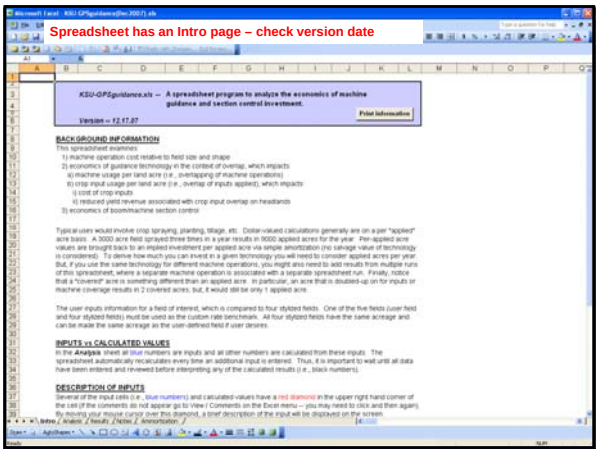
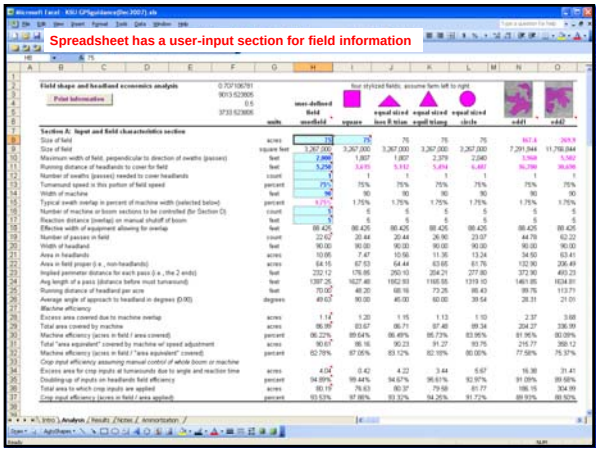
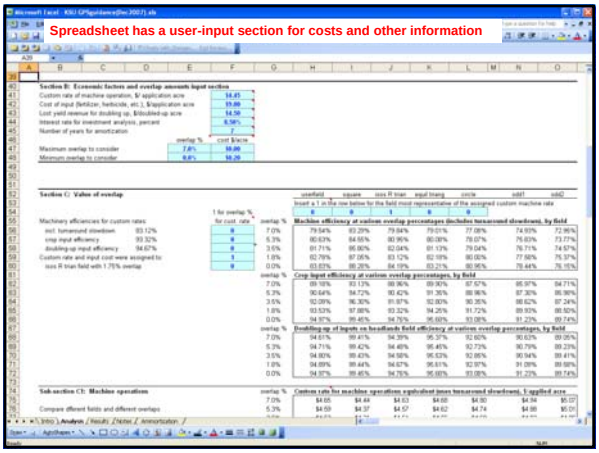
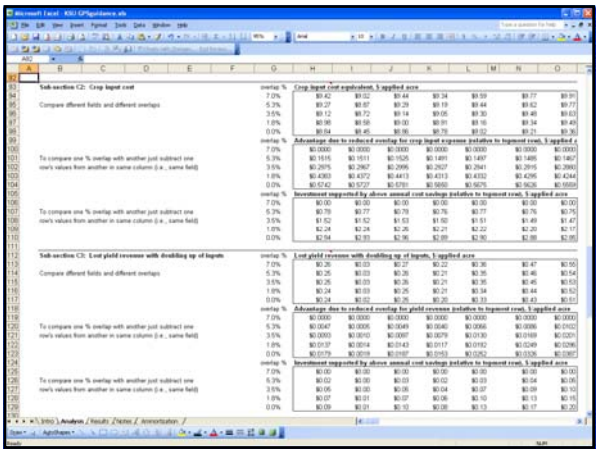
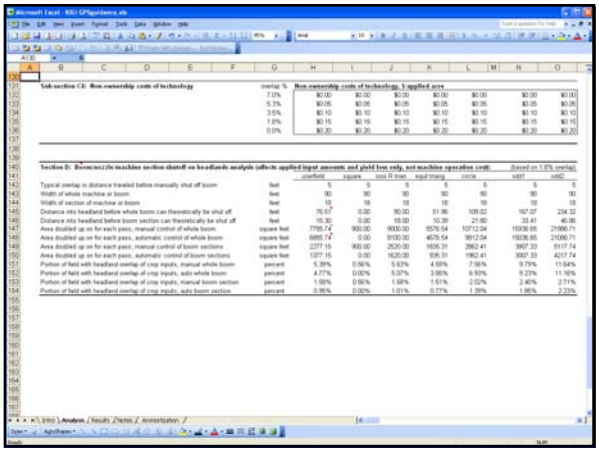

Spreadsheet has an Intro page – check version date


Spreadsheet has a user-input section for field information


Spreadsheet has a user-input section for costs and other information





A word about amortization…

Amortization factors — **Print information**

Years	Interest Rate 6.00%	7.00%	8.00%	9.00%
1	1.0600	1.0700	1.0800	1.0900
2	0.5454	0.5531	0.5608	0.5685
3	0.3741	0.3811	0.3880	0.3951
4	0.2886	0.2952	0.3019	0.3087
5	0.2374	0.2439	0.2505	0.2571
6	0.2034	0.2098	0.2163	0.2229
7	0.1791	0.1856	0.1921	0.1987
8	0.1610	0.1675	0.1740	0.1807
9	0.1470	0.1535	0.1601	0.1668
10	0.1359	0.1424	0.1490	0.1558

payment factor>	int[1-(1+int)^(-N)]
interest rate>	8.00%
number of years>	7
payment factor>	0.1921
investment>	$13,000
annual payment>	$2,496.94
acres used on annually>	15,000
investment per acre>	$0.8667
annual cost per acre>	$0.1665

At 8.00% and 7 years could invest about 5x the annual amount per acre

Reporting a few results from example farm

- "Typical field" is 75 acres
  - 2000 feet distance perpendicular to line of travel
    - Same-sized square field 1807 feet
  - 5250 feet running distance of headlands
    - Same-sized square field 3615 feet
  - Headland angle 50 degrees
    - Same-sized square field 90 degrees
- Other universal assumptions:
  - Base custom rate is for iso R triangle shaped field
    - Other fields would have higher/lower base costs
  - amortization of 8.50% interest over 7 years
  - Manual reaction distance (machine up) 5 feet
  - Turnaround speed 75% of down-row speed
  - GPS subscription fee (or hassle factor) cost $0.20/acre at 0% overlap to $0.00/acre at top overlap considered

- Sprayer example
  - 90 foot wide
  - 1 pass to cover headland
  - $4.45/acre custom rate
  - $9.00/acre/application of chemical used
  - Assume lost yield revenue on doubled-up headland acres is $36/acre/year on corn (10 bu/acre at $3.60)
    - Assign loss 1/4 to spraying excess chemicals and 3/4 to double-planting with planter, so $9 for sprayer/yr.
    - But, apply 2 times per acre per year, so yield revenue lost per application on doubled-up acres is $4.50/acre.

90-ft sprayer example

Field shape and headland economics analysis

four stylized fields; assume farm left to right

	units	user-defined field userfield	square	equal sized isos R trian	equal sized equil triang	equal sized circle
Section A: Input and field characteristics section						
Size of field	acres	75	75	75	75	75
Number of swaths (passes) needed to cover headlands	count	1	1	1	1	1
Width of machine	feet	90	90	90	90	90
Area in headlands	acres	10.85	7.47	10.56	11.35	13.24
Average angle of approach to headland in degrees (0-90)	degrees	49.63	90.00	45.00	60.00	39.54
Number of machine or boom sections to be controlled (for Section D)	count	5	5	5	5	5

Sub-section C5: Summed net benefits to overlap-reducing technology		overlap %	**Sum of net annual benefits, $/applied acre (relative to topmost row)**				
Percent of category to include in net benefits total		7.0%	$0.0000	$0.0000	$0.0000	$0.0000	$0.0000
Machine costs	1	5.3%	$0.0628	$0.0661	$0.0631	$0.0623	$0.0605
Input costs	0	3.5%	$0.1234	$0.1299	$0.1239	$0.1224	$0.1188
Yield revenue	0	1.8%	$0.1818	$0.1914	$0.1826	$0.1804	$0.1750
Non-ownership costs	0	0.0%	$0.2381	$0.2507	$0.2392	$0.2363	$0.2293
		overlap %	**Investment supported by above annual cost savings (relative to topmost**				
		7.0%	$0.00	$0.00	$0.00	$0.00	$0.00
		5.3%	$0.32	$0.34	$0.32	$0.32	$0.31
		3.5%	$0.63	$0.66	$0.63	$0.63	$0.61
		1.8%	$0.93	$0.98	$0.93	$0.92	$0.90
		0.0%	$1.22	$1.28	$1.22	$1.21	$1.17

Benefit to reducing overlap is similar across field shapes (given assumed benefits)

Ignoring everything else, save $0.1818/acre taking overlap from typical foam-marker value of 7% to say, 1.8% with a reasonable autoguidance setup. This would allow an investment of $0.93/acre, or $9,300 on 10,000 acres of annual sprayings.

90-ft sprayer example

Field shape and headland economics analysis

four stylized fields; assume farm left to right

	units	user-defined field userfield	square	equal sized isos R trian	equal sized equil triang	equal sized circle
Section A: Input and field characteristics section						
Size of field	acres	75	75	75	75	75
Number of swaths (passes) needed to cover headlands	count	1	1	1	1	1
Width of machine	feet	90	90	90	90	90
Area in headlands	acres	10.85	7.47	10.56	11.35	13.24
Average angle of approach to headland in degrees (0-90)	degrees	49.63	90.00	45.00	60.00	39.54
Number of machine or boom sections to be controlled (for Section D)	count	5	5	5	5	5

Sub-section C5: Summed net benefits to overlap-reducing technology		overlap %	**Sum of net annual benefits, $/applied acre (relative to topmost row)**				
Percent of category to include in net benefits total		7.0%	$0.0000	$0.0000	$0.0000	$0.0000	$0.0000
Machine costs	1	5.3%	$0.2143	$0.2172	$0.2156	$0.2114	$0.2102
Input costs	1	3.5%	$0.4209	$0.4266	$0.4235	$0.4152	$0.4129
Yield revenue	0	1.8%	$0.6201	$0.6285	$0.6239	$0.6117	$0.6082
Non-ownership costs	0	0.0%	$0.8123	$0.8234	$0.8173	$0.8013	$0.7968
		overlap %	**Investment supported by above annual cost savings (relative to topmost**				
		7.0%	$0.00	$0.00	$0.00	$0.00	$0.00
		5.3%	$1.10	$1.11	$1.10	$1.08	$1.08
		3.5%	$2.15	$2.18	$2.17	$2.13	$2.11
		1.8%	$3.17	$3.22	$3.19	$3.13	$3.11
		0.0%	$4.16	$4.21	$4.18	$4.10	$4.08

Bringing in the input cost savings increases the investment that could be made to support going from 7% to 1.8% overlap to $3.17/acre (almost $32,000 on 10,000 acres/yr sprayed).

90-ft sprayer example

Field shape and headland economics analysis

four stylized fields; assume farm left to right

	units	user-defined field userfield	square	equal sized isos R trian	equal sized equil triang	equal sized circle
Section A: Input and field characteristics section						
Size of field	acres	75	75	75	75	75
Number of swaths (passes) needed to cover headlands	count	1	1	1	1	1
Width of machine	feet	90	90	90	90	90
Area in headlands	acres	10.85	7.47	10.56	11.35	13.24
Average angle of approach to headland in degrees (0-90)	degrees	49.63	90.00	45.00	60.00	39.54
Number of machine or boom sections to be controlled (for Section D)	count	5	5	5	5	5

Sub-section C5: Summed net benefits to overlap-reducing technology		overlap %	**Sum of net annual benefits, $/applied acre (relative to topmost row)**				
Percent of category to include in net benefits total		7.0%	$0.0000	$0.0000	$0.0000	$0.0000	$0.0000
Machine costs	1	5.3%	$0.2191	$0.2177	$0.2206	$0.2154	$0.2169
Input costs	1	3.5%	$0.4302	$0.4276	$0.4332	$0.4231	$0.4259
Yield revenue	1	1.8%	$0.6338	$0.6300	$0.6382	$0.6233	$0.6275
Non-ownership costs	0	0.0%	$0.8303	$0.8252	$0.8360	$0.8166	$0.8220
		overlap %	**Investment supported by above annual cost savings (relative to topmost**				
		7.0%	$0.00	$0.00	$0.00	$0.00	$0.00
		5.3%	$1.12	$1.11	$1.13	$1.10	$1.11
		3.5%	$2.20	$2.19	$2.22	$2.17	$2.18
		1.8%	$3.24	$3.22	$3.27	$3.19	$3.21
		0.0%	$4.25	$4.22	$4.28	$4.18	$4.21

Accounting for yield revenue impact increases the investment that could be made, going from 7% to 1.8% overlap, to $3.24/acre (slightly over $32,000 on 10,000 acres/yr sprayed).

90-ft sprayer example

Field shape and headland economics analysis

four stylized fields; assume farm left to right

	units	user-defined field userfield	square	equal sized isos R trian	equal sized equil triang	equal sized circle
Section A: Input and field characteristics section						
Size of field	acres	75	75	75	75	75
Number of swaths (passes) needed to cover headlands	count	1	1	1	1	1
Width of machine	feet	90	90	90	90	90
Area in headlands	acres	10.85	7.47	10.56	11.35	13.24
Average angle of approach to headland in degrees (0-90)	degrees	49.63	90.00	45.00	60.00	39.54
Number of machine or boom sections to be controlled (for Section D)	count	5	5	5	5	5

Sub-section C5: Summed net benefits to overlap-reducing technology		overlap %	**Sum of net annual benefits, $/applied acre (relative to topmost row)**				
Percent of category to include in net benefits total		7.0%	$0.0000	$0.0000	$0.0000	$0.0000	$0.0000
Machine costs	1	5.3%	$0.1691	$0.1677	$0.1706	$0.1654	$0.1669
Input costs	1	3.5%	$0.3302	$0.3276	$0.3332	$0.3231	$0.3259
Yield revenue	1	1.8%	$0.4838	$0.4800	$0.4882	$0.4733	$0.4775
Non-ownership costs	1	0.0%	$0.6303	$0.6252	$0.6360	$0.6166	$0.6220
		overlap %	**Investment supported by above annual cost savings (relative to topmost**				
		7.0%	$0.00	$0.00	$0.00	$0.00	$0.00
		5.3%	$0.87	$0.86	$0.87	$0.85	$0.85
		3.5%	$1.69	$1.68	$1.71	$1.65	$1.67
		1.8%	$2.48	$2.46	$2.50	$2.42	$2.44
		0.0%	$3.23	$3.20	$3.26	$3.16	$3.18

Bringing in everything we consider changes the investment that could be made to support going from 7% to 1.8% overlap to $2.48/acre ($24,800 on 10,000 acres/yr sprayed).

Moving from guidance to section control…

- **Sprayer example – boom shutoff**
  - We now consider the benefits for automatic boom section shutoff at the headlands
  - We start with the assumption of a default overlap percentage of 1.8% as the one determining custom rates, and then consider:
    - Automatic (GPS) control of whole boom
    - Manual control of each of 5 boom sections independently (you'd better be fast acting)
    - Automatic (GPS) control of 5 boom sections

90-ft sprayer example – boom shutoff control, 5 sections

Field shape and headland economics analysis

four stylized fields; assume farm north to south

	units	user-defined field userfield	square	equal sized isos R trian	equal sized equil triang	equal sized circle
Section D: Boom/nozzle/machine section shutoff on headlands analysis (affects applied input amounts and yield loss only, not machine operation cost):						
Insert a 1 here to consider input cost savings >		1				
Insert a 1 here to consider reductions in yield losses >		1				
Input cost and yield revenue savings relative to manual whole boom control, expressed as $/applied acre in whole field and associated with:						
automatic control of whole boom	$/acre	$0.0841	$0.0760	$0.0760	$0.1000	$0.0858
manual control of boom sections	$/acre	$0.5148	$0.0000	$0.5473	$0.4159	$0.7481
automatic control of boom sections	$/acre	$0.5990	$0.0760	$0.6234	$0.5159	$0.8339
Investment supported by annual input savings for:						
automatic control of whole boom	$/acre	$0.4306	$0.3891	$0.3891	$0.5121	$0.4391
manual control of boom sections	$/acre	$2.6353	$0.0000	$2.8016	$2.1287	$3.8294
automatic control of boom sections	$/acre	$3.0658	$0.3891	$3.1907	$2.6408	$4.2685

Field shape matters

Going to automatic boom shutoff control saves $0.599/acre per year, supporting an investment of $30,000+ in this 10,000 acres/year example. Note, that the GPS component of this technology may not have to be "covered" by savings here if it is already justified via the autoguidance investment.

If yield loss component is ignored, the justified investment is $20,000+.

Notice the benefits to this technology for more irregular fields (compare circle with square field).

Keep in mind that most of this "gain" could come from manual control of the 5 sections, which typically the sprayer already comes with. But, can you really manually control 5 sections effectively? If not, then the investment noted above is merited. Also, gain to automatic control ($0.0841/ac is directly proportional to reaction distance, e.g., if distance = 10' gain = $0.1683/ac).

- **It is most difficult to generalize results, but we can if we hold most things constant**
- **We use example field of 75 acres but vary shape by considering different headland lengths**

90-ft sprayer example

Field shape and headland economics analysis

four stylized fields; assume farm left to right

	units	user-defined field userfield	square	equal sized isos R trian	equal sized equil triang	equal sized circle
Section A: Input and field characteristics section						
Size of field	acres	75	75	75	75	75
Number of swaths (passes) needed to cover headlands	count	1	1	1	1	1
Width of machine	feet	90	90	90	90	90
Area in headlands	acres	10.85	7.47	10.56	11.35	13.24
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Number of machine or boom sections to be controlled (for Section D)	count	5	5	5	5	5

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Percent of category to include in net benefits total		7.0%	$0.0000	$0.0000	$0.0000	$0.0000	$0.0000
Machine costs	1	5.3%	$0.1691	$0.1677	$0.1706	$0.1654	$0.1669
Input costs	1	3.5%	$0.3302	$0.3276	$0.3332	$0.3231	$0.3259
Yield revenue	1	1.8%	$0.4838	$0.4800	$0.4882	$0.4733	$0.4775
Non-ownership costs	1	0.0%	$0.6303	$0.6252	$0.6360	$0.6166	$0.6220
		overlap %	**Investment supported by above annual cost savings (relative to topmost**				
		7.0%	$0.00	$0.00	$0.00	$0.00	$0.00
		5.3%	$0.87	$0.86	$0.87	$0.85	$0.85
		3.5%	$1.69	$1.68	$1.71	$1.65	$1.67
		1.8%	$2.48	$2.46	$2.50	$2.42	$2.44
		0.0%	$3.23	$3.20	$3.26	$3.16	$3.18

Focus on this number

Bringing in everything we consider changes the investment that could be made to support going from 7% to 1.8% overlap to $2.48/acre ($24,800 on 10,000 acres/yr sprayed).

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90-ft sprayer example – boom shutoff control, 5 sections

Field shape and headland economics analysis

four stylized fields; assume farm north to south

	units	user-defined field userfield	square	equal sized isos R trian	equal sized equil triang	equal sized circle
Section D: Boom/nozzle/machine section shutoff on headlands analysis (affects applied input amounts and yield loss only, not machine operation cost):						
Insert a 1 here to consider input cost savings >	1					
Insert a 1 here to consider reductions in yield losses >	1					
Input cost and yield revenue savings relative to manual whole boom control, expressed as $/applied acre in whole field and associated with:						
automatic control of whole boom	$/acre	$0.0841	$0.0760	$0.0760	$0.1000	$0.0858
manual control of boom sections	$/acre	$0.5148	$0.0000	$0.5473	$0.4159	$0.7481
automatic control of boom sections	$/acre	$0.5990	$0.0760	$0.6234	$0.5159	$0.8339
Investment supported by annual input savings for:						
automatic contn	$/acre	$0.4306	$0.3891	$0.3891	$0.5121	$0.4391
manual control	$/acre	$2.6353	$0.0000	$2.8016	$2.1287	$3.8294
automatic contn... of boom sections	$/acre	$3.0658	$0.3891	$3.1907	$2.6408	$4.2685

And this number

Going to automatic boom shutoff control saves $0.599/acre per year, supporting an investment of $30,000+ in this 10,000 acres/year example. Note, that the GPS component of this technology may not have to be "covered" by savings here if it is already justified via the autoguidance investment.

If yield loss component is ignored, the justified investment is $20,000+.

Notice the benefits to this technology for more irregular fields (compare circle with square field).

Keep in mind that most of this "gain" could come from manual control of the 5 sections, which typically the sprayer already comes with. But, can you really manually control 5 sections effectively? If not, then the investment noted above is merited. Also, gain to automatic control ($0.0841/ac is directly proportional to reaction distance, e.g., if distance = 10' gain = $0.1683/ac).

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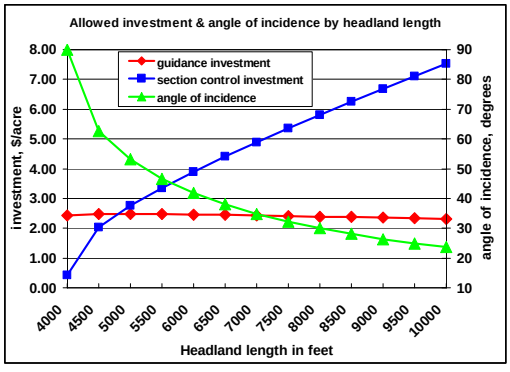
Moving from guidance to section control…



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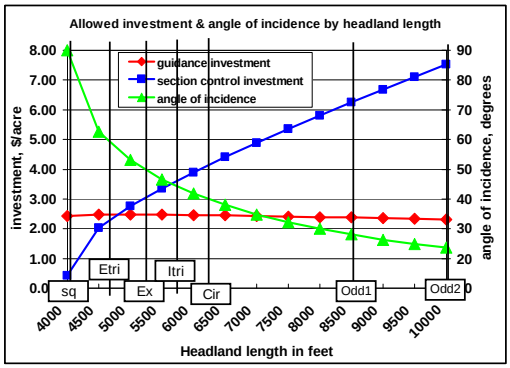

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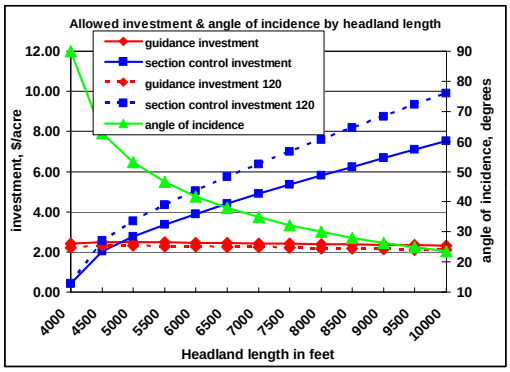
Comparing a 120-foot sprayer with the 90-foot one



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Many things to consider for a farm 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 cost
- Field size
- Field shape
- Farm size (mostly a fixed cost investment)
- How would you value personal comfort?

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Economics of automatic row shutoff on planters like sprayer . . .

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Economics of automatic row shutoff on planters like sprayer . . .

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Summary

- Lowering machinery costs is where the action is.
- Keep in mind that a tractor is multi-purpose, so GPS benefits can be additive.
- Think carefully about expected yield losses on doubled-up headland acres.
- Field size and shape doesn't much impact benefits to GPS autoguidance,
  - but really impacts benefits to section shutoff.
  - Autoguidance and section control share GPS items.
- GPS technologies should help to differentiate custom rates and ultimately land rental rates by field size and shape.
  - Section control may help stabilize these numbers.
- We didn't account for reduced operator fatigue.

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End of Session:

Economics of autoguidance and boom/section control