# Row & Nozzle Control: Where does it pay and what are the problems?

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## Machinery costs are important in explaining profitability differences across farms …

| Kansas Farm Management Association Enterprise Analysis<br>Nonirrigated Crops -- State Averages, 2002-2006 | | | | | | |
|---|---|---|---|---|---|---|
| | Corn | Irr Corn | Sorghum | Wheat | Soybean | Alfalfa |
| Number of Farms | 45 | 15 | 85 | 178 | 74 | 34 |
| Machinery Costs, $/acre | | | | | | |
| High profit farms | $59.28 | $73.77 | $51.08 | $51.54 | $54.10 | $74.13 |
| Mid profit farms | $62.57 | $82.49 | $60.09 | $55.48 | $62.84 | $79.48 |
| Low profit farms | $90.82 | $104.98 | $73.22 | $75.72 | $75.98 | $109.15 |
| **High less low, $** | **-$31.53** | **-$31.21** | **-$22.14** | **-$24.18** | **-$21.88** | **-$35.02** |
| **High less low, %** | **-34.7%** | **-29.7%** | **-30.2%** | **-31.9%** | **-28.8%** | **-32.1%** |
| **Differences between high profit farms and low profit farms in …** | | | | | | |
| **Net returns** | **$91.30** | **$138.74** | **$81.43** | **$65.74** | **$73.87** | **$133.79** |
| **Total costs** | **-$93.54** | **-$125.79** | **-$50.96** | **-$53.84** | **-$53.15** | **-$65.86** |
| **Cost/net returns** | **102.5%** | **90.7%** | **62.6%** | **81.9%** | **72.0%** | **49.2%** |
| **Mach/total costs** | **33.7%** | **24.8%** | **43.4%** | **44.9%** | **41.2%** | **53.2%** |
| **Mach/net returns** | **34.5%** | **22.5%** | **27.2%** | **36.8%** | **29.6%** | **26.2%** |



- **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

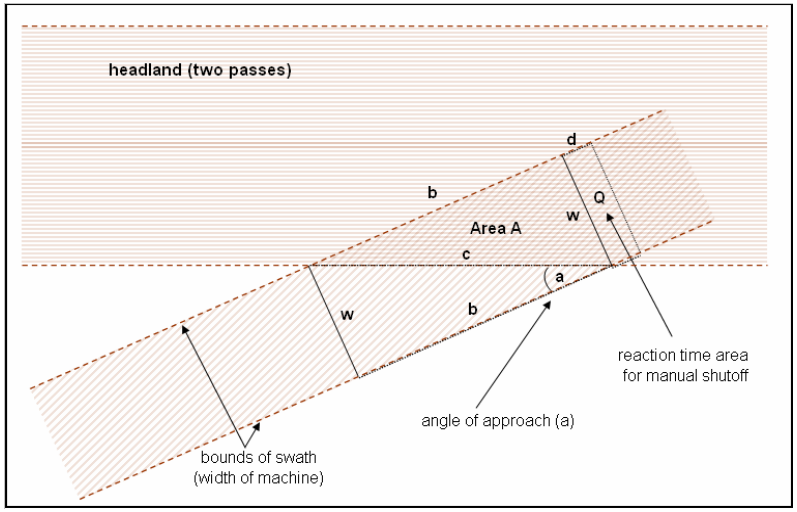
- Need large turnaround area, increasing headland size
- Can we make the larger machines behave as though they were smaller, at least in terms of the portion of a headland affected by input doubling-up?
  - boom or section shut-offs





- 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)

# Field headland

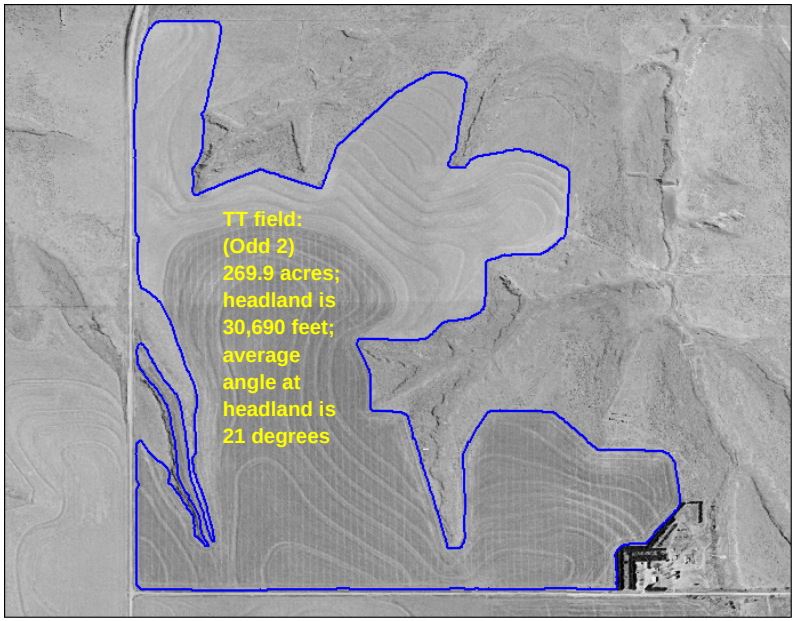



Areas A and Q and turnaround counterparts will have a) doubling-up of inputs and b) possible yield losses due to this doubling-up.
After the turnaround there will be overlap along b, also accounted for.




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!






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



## Over the last two years . . .

- We've developed and used *KSU-GPSguidance.xls* to show to many audiences that:
  - Autoguidance generally pays
  - Boom & section control really pays:
    - When equipment is large
    - When fields are odd-shaped
- Autoguidance is a "duh" technology
- Some aspects of boom/section control not at all "duh"

# Putting everything together on a corn planter (Kastens Farm example)

- How much can we spend?
- Which components should we use?
- What will the limitations be?
- What problems will there be "in the field?"



## Planter Section Control – Seeding from *KSU-GPSguidance.xls*

***Only considering seed input costs and Yield loss***

| width (ft) | Description of type of control system | planting cost ($/ac) | inv. Support ($/ac) | Acres | Total Potential Investment ($) |
|---|---|---|---|---|---|
| 40 | *2 section manual control* | *$13.32* | *$10.94* | 3000 | **$32,820** |
| 40 | 2 section automatic control | $13.32 | $13.39 | 3000 | $7,350 |
| 40 | 4 section automatic control | $13.32 | $18.86 | 3000 | $23,760 |
| 40 | 8 section automatic control | $13.32 | $21.60 | 3000 | $31,980 |
| 40 | 16 section automatic control | $13.32 | $22.97 | 3000 | $36,090 |
| *60* | *2 section manual control* | *$13.66* | *$16.41* | 3000 | **$49,230** |
| 60 | 2 section automatic control | $13.66 | $18.86 | 3000 | $7,350 |
| 60 | 4 section automatic control | $13.66 | $27.07 | 3000 | $31,980 |
| 60 | 6 section automatic control | $13.66 | $29.81 | 3000 | $40,200 |
| 60 | 8 section automatic control | $13.66 | $31.17 | 3000 | $44,280 |
| 60 | 12 section automatic control | $13.66 | $32.54 | 3000 | $48,390 |
| 60 | 24 section automatic control | $13.66 | $33.91 | 3000 | $52,500 |

**Potential Investment (except for two bolded numbers) dollars are relative to 2 section manual, control as Kastens are willing to do that and it requires no special investment.**

**Given a base custom rate of $12.50/acre (triangle field), our odd-shaped fields should have the custom rate (planting cost) shown given the width of planter selected.**



## Planter Section Control – Fertilizer from *KSU-GPSguidance.xls*

***Only considering Fertilizer input costs***

| width (ft) | Description of type of control system | planting cost ($/ac) | inv. Support ($/ac) | Acres | Total Potential Investment ($) |
|---|---|---|---|---|---|
| 40 | *2 section manual control* | *$13.27* | $4.57 | 3000 | **$13,710** |
| 40 | 2 section automatic control | $13.27 | $5.59 | 3000 | $3,060 |
| 40 | 4 section automatic control | $13.27 | $7.87 | 3000 | $9,900 |
| 40 | 8 section automatic control | $13.27 | $9.01 | 3000 | $13,320 |
| 40 | 16 section automatic control | $13.27 | $9.58 | 3000 | $15,030 |
| *60* | *2 section manual control* | *$13.61* | $6.85 | 3000 | **$20,550** |
| 60 | 2 section automatic control | $13.61 | $7.87 | 3000 | $3,060 |
| 60 | 4 section automatic control | $13.61 | $11.30 | 3000 | $13,350 |
| 60 | 6 section automatic control | $13.61 | $12.44 | 3000 | $16,770 |
| 60 | 8 section automatic control | $13.61 | $13.01 | 3000 | $18,480 |
| 60 | 12 section automatic control | $13.61 | $13.58 | 3000 | $20,190 |
| 60 | 24 section automatic control | $13.61 | $14.15 | 3000 | $21,900 |

**Potential Investment (except for two bolded numbers) dollars are relative to 2 section manual, control as Kastens are willing to do that and it requires no special investment.**

**Given a base custom rate of $12.50/acre (triangle field), our odd-shaped fields should have the custom rate (planting cost) shown given the width of planter selected.**



## From the *KSU-GPSguidance.xls* Evaluation

- There are BIG dollars at play!
- Manually controlling two-sections on a planter has huge per acre cost savings.

**Annual value to manually control 2 planter sections**

| Planter | Ann. Sav. $/ac | Tot acres | Total Annual Value ($) |
|---|---|---|---|
| 40' Planter | $2.74 | 3000 | $8,220.00 |
| 60' Planter | $4.11 | 3000 | $12,330.00 |

**These are the ANNUAL savings numbers associated with the previous two slides.**

**Note the big difference between a 40- and 60-foot planter.**

# Planter Section Control – Investment

**Seed Equipment Cost Section**
**John Deere Planter**

| | | |
|---|---|---|
| *GS2 2600 Console* | $5,200.00 | 1 |
| *Swath-Control Pro* | $2,500.00 | 1 |
| *GS2 Rate Controller* | $1,195.00 | 1 |
| *Tru-count (ea)* | $354.16 | 24 |
| *Installation* | $500.00 | 1 |
| *Extra stuff* | $500.00 | 1 |
| ***Total*** | **$18,394.84** | |

**Fertilizer Equipment Cost Section**
**Ag Leader Insight**

| | | |
|---|---|---|
| Insight | $3,995.00 | 1 |
| Direct Command | $2,700.00 | 1 |
| Ball Valve Shutoff | $150.00 | 12 |
| Installation | $500.00 | 1 |
| Extra Stuff | $500.00 | 1 |
| **Total** | **$9,495.00** | |



# From the Evaluation

- **In all configurations (except automatic control of only two sections) the investment in section shut-off technology clearly pays for Kastens' fields under their assumptions.**
- **It is quite clear that using section shut-off technologies becomes more valuable as equipment size increases.**
- **Potential investment goes up proportionately if the example planter is used on more than 3000 acres.**



# Assemble the R&D team

**These are the folks whose brains we rely on during both the planning and implementation processes:**

- **The many great folks at Southwest Implement (John Deere) in McCook, Nebraska**
- **The guys at SureFire Ag Systems in Atwood, KS**
- **The many "internet" associates that willingly provide free advice and information to all**



# Can we do it? -- Seed

- **Planter section control on the seed side was straight-forward on up to 12 sections (row-pairs)**
- **Tru-Count air clutches were installed on all rows, although only controlled in pairs for 2008.**
- **JD GS2 2600 Display with 12-section control and VRA seeding (we expect JD to have 24+ section control for 2009)**

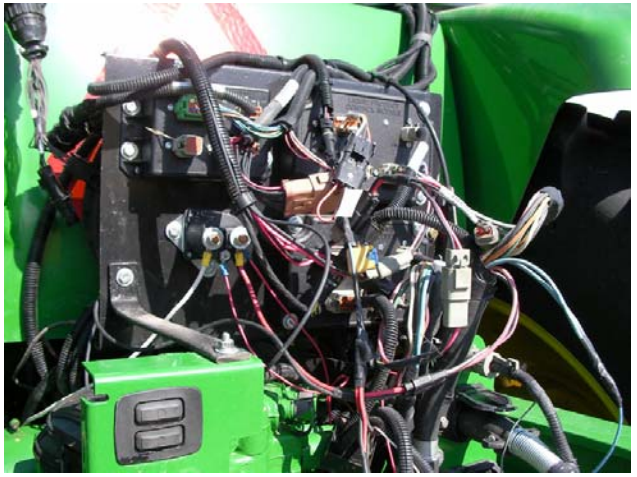
John Deere Electric Clutch
(available in 2009?)

Tru-Count Air Clutch



## Can we do it? -- Fertilizer

AgLeader Insight with dual-product and section control. This was the "easy" part.





## Can we do it? -- Fertilizer

The fertilizer side posed some other issues that were analyzed before "section size" was determined. There are limitations on gpa/gpm requirements for both the pump and the nozzle side of things when one starts analyzing section control.



## Fertilizer VRA system

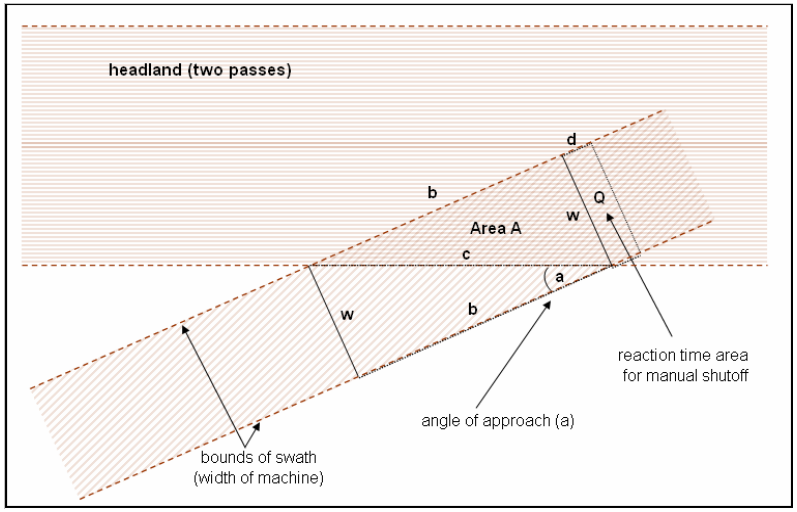
- Most fluid delivery systems rely on pressures behind nozzles somewhere
  - Not all (e.g., Capstan, squeeze pumps)
- Liquids have the usual problems associated with pressure-volume relationship
  - Volumes proportional to the square roots of pressures (4x pressure to get 2x volume; 9x pressure to get 3x volume)
  - Often limits effective range of system to 2x volume
  - Problem greatly magnified for row shutoffs

## Can we do it? -- Fertilizer

- **Consider the following example:**
  - **A 16-row planter traveling at 5.5 mph and putting on 25 gpa of fertilizer, which amounts to a total pumping requirement of 11.11 gpm, and which breaks down to 0.69 gpm per row.**
  - **Start shutting down sections until only 1 row left on. We have created a situation where a 16-fold decrease in volume (11.11/0.69) must be realized in a few seconds. That would be like going from 160 gpa to 10 gpa in a "traditional" whole-toolbar VRA framework. WOW!**
  - **It will mean constant-displacement pumps spinning at their lowest possible rpm while maintaining their highest pressures because pumps become "over-sized" as sections are shut down.**



## Field headland




**Nozzles along "w" shut off as go into headland – nozzles that remain on may have to over-apply, causing a small triangle of over-application just south of headland.**



| Rows On (#) | Equivilant Min System (gpa) | System Over % | System Over (gpa) | System Over ($) | TrueSys (psi) |
|---|---|---|---|---|---|
| 23 | 6.78 | 0 | 0 | $0.00 | 39.20 |
| 22 | 7.09 | 0 | 0 | $0.00 | 39.20 |
| 21 | 7.43 | 0 | 0 | $0.00 | 39.20 |
| 20 | 7.80 | 0 | 0 | $0.00 | 39.20 |
| 19 | 8.21 | 0 | 0 | $0.00 | 39.20 |
| 18 | 8.67 | 0 | 0 | $0.00 | 39.20 |
| 17 | 9.18 | 0 | 0 | $0.00 | 39.20 |
| 16 | 9.75 | 0 | 0 | $0.00 | 39.20 |
| 15 | 10.40 | 0 | 0 | $0.00 | 39.20 |
| 14 | 11.14 | 0 | 0 | $0.00 | 39.20 |
| 13 | 12.00 | 0 | 0 | $0.00 | 39.20 |
| 12 | 13.00 | 0 | 0 | $0.00 | 39.20 |
| 11 | 14.18 | 0 | 0 | $0.00 | 39.20 |
| 10 | 15.60 | 0 | 0 | $0.00 | 39.20 |
| 9 | 17.33 | 0 | 0 | $0.00 | 39.20 |
| 8 | 19.50 | 0 | 0 | $0.00 | 39.20 |
| 7 | 22.29 | 0 | 0 | $0.00 | 39.20 |
| 6 | 26.00 | 0.04 | 1 | $0.32 | 40.41 |
| 5 | 31.20 | 0.248 | 6.2 | $1.97 | 46.82 |
| 4 | 39.00 | 0.56 | 14 | $4.45 | 56.44 |
| 3 | 52.00 | 1.08 | 27 | $8.58 | 72.48 |
| 2 | 78.00 | 2.12 | 53 | $16.85 | 75.00 |
| 1 | 156.00 | 5.24 | 131 | $41.65 | 75.00 |
| xxx | xxx | xxx | xxx | xxx | xxx |



## Overcoming Orifice limitations

**VeriFlow Nozzles**

**Capstan N-Ject LF**

| Average System Running | | |
|---|---|---|
| Range gpa | 15 | 30 |
| Total gpm | 10 | 20 |
| per row gpm | 0.42 | 0.83 |
| oil gpm | 4.44 | 8.89 |
| | | |
| **Min/Max System Capabilities** | | |
| Range gpa | 6.5 | 50 |
| Total gpm | **4.33** | 33.33 |
| per row gpm | 0.18 | 1.39 |
| oil gpm | 1.93 | 14.81 |



| Product 1 (10-34-0) | | | Product 2 (32-0-0) | | |
|---|---|---|---|---|---|
| Hypro D70 | | | Hypro D115 | | |
| Percent of Total Product | 25% | | Percent of Total Product | 75% | |
| Speed (mph) | 5.5 | | Speed (mph) | 5.5 | |
| Row spacing (in) | 30 | | Row spacing (in) | 30 | |
| number of rows | 24 | | number of rows | 24 | |
| Total Rate (gpa) | **6.5** | | Total Rate (gpa) | 6.5 | |
| Total lbs P205 Applied | 6.46 | | Total lbs N Applied | 19.22 | |
| | | | | | |
| Total Rate Prod 1 (gpa) | 1.625 | | Total Rate Prod 2 (gpa) | 4.875 | |
| Total Rate Prod 1 (gpm) | 1.08 | | Total Rate Prod 2 (gpm) | 3.25 | |
| | | | | | |
| motor disp | 4.9 | | motor disp | 4.9 | |
| pump disp | 0.03 | | pump disp | 0.05 | |
| M2P Ratio | 1 | | M2P Ratio | 1 | |
| Flow Divide (#) | 1 | | Flow Divide (#) | 1 | |
| Planter width (ft) | 60 | | Planter width (ft) | 60 | |
| Rows acre/in | 83.48 | | Rows acre/in | 83.48 | |
| Total Flow (gpm) | 1.08 | | Total Flow (gpm) | 3.25 | |
| Flow per row (gpm) | 0.05 | | Flow per row (gpm) | 0.14 | |
| Flow per divide (gpm) | 1.08 | | Flow per divide (gpm) | 3.25 | |
| Hyd motor rpm | 31.40 | OK | Hyd motor rpm | 59.4 | OK |
| Hyd motor Oil (gpm) | 0.67 | | Hyd motor Oil (gpm) | 1.26 | |

| | |
|---|---|
| **Total Fertilizer delivered (gpm)** | **4.33** |
| **Total Fertilizer per row (gpm)** | **0.18** |
| **Total Tractor oil required (gpm)** | **1.93** |

1.66

**. . . can become complex when two products are involved**



## How did it work?

**As a whole, very few problems with the technology side of the planter.**

- The Tru-Count system worked well but we did fry an air compressor and had a few sticky clutches.
- The fertilizer system worked well, but we did blow a seal out of one of the pumps and had some issues (rate would never settle out) at low rates when only one or two sections were on.
- The in-cab technology worked very well with no glitches.
- We had more problems with the planter itself than we did with the extra "technology" components we added.



## The Future

- Will continue to upgrade all farm equipment to better utilize section control and VRA control of inputs.
- Will continue to upgrade technology to increase the number of sections controlled and the technology used to control the sections.
- All of this technology projected to easily pay at 2007 input prices. It will pay even more now. Likely, we should look at even fancier more-expensive technologies given today's higher input prices.



## Broader Comments

- Many aspects of precision ag are far from rote
  - Guidance and seed shutoff no problem, but VRA and section control of fertilizer not yet routine
- Profits for "duh" technologies like guidance (and probably section control for seed and herbicide) are short-lived. Are you ready to invest in slow-moving technologies such as VRA and section control of fertilizer?
  - Will it ever be "off the shelf?"
  - Can you locate or command the necessary team of folks to successfully analyze and make such investments?