Hand-Crafted Site Specific Management Systems:

6th Annual Precision Agriculture Conference, Great Bend, Kansas
January 15-16, 2003

I. Introduction:

Located in Rawlins Co., Kansas, the Kastens farm principally has silt loam soils that are easily eroded. Virtually all of the farm has been terraced with contour terraces. The crop rotation for the Kastens farm (Rawlins Co., KS) is principally wheat-corn-fallow where the wheat was typically conventionally farmed and the corn no-till. Beginning this season the Kastens farm will be 100% no-till with chem-fallow replacing conventional fallow practices.

"Maybe put a slide of our sale bill here"

This talk will discuss the research and development that accompanied the construction of a fertilizer applicator designed to meet our growing no-till and intense management needs. Many challenges were overcome during this process and the final result was a low-maintenance, two-liquid variable rate, no-till fertilizer applicator. The applicator uses straight coulters on 15" centers and direct injection for moving product under ground. Research was began in 1998 and the final machine was completed and operating in March 2002. During those four years huge changes in technology and machinery caused the elimination of some problems, and in many cases created some new ones.

II. One Major Assumption

A. This talk is primarily focused on the hardware and software issues regarding the physical placement of variable rates of fertilizer**.** To prevent getting side-tracked, I must request that everyone works off my assumption that:

"We have developed an agronomically and economically sound system for determining site-specific fertilizer needs"

For our farm we have determined that building STP has the greatest long-run economic potential. Consequently, the ability to variably apply P (P205) was a core focus throughout this process.

III. System Requirements

A. Farm Management

1. Able to work in different field management systems

    a. Conventional summer fallow
        (1) tilled ground
        (2) August application
        (3) typically 20gpa

    b. Chem-till summer fallow
        (1) Same as conventional except no-tillage

    c. Wheat and corn stubble
        (1) Wanted to reduce amount of N placed at corn planting
        (2) typically around 30gpa

    d. Alfalfa
        (1) spring application

    e. Growing wheat
        (1) provide minimum disturbance top-dressing in spring

B. Fertilizer Machine

1. Fast ground speeds (7 - 10 mph)

2. Large coverage (at least 40' – 250+ acres per day)

3. High capacity (large storage to minimize fill times)

4. Easy transportation (narrow transport)

5. Low annual maintenance (minimize bearings, other high wear components)

6. Efficient tendering (Fertilizing should be no more than a two-person job, and wanted to use existing equipment)

C. Fertilizer Components
1. Capable of VRA application and rates from 0 - 30 gpa (equivalent)
2. Capable of end-row shutoff
3. As-applied mapping
4. Good technical support

D. Electronics

1. Guidance System

2. User friendly, flexible rate controllers

3. Console able to VRA two-products simultaneously and record as-applied data.

IV. The Research Process

A. Dry, NH3 and Liquid

1. Dry
    - a. No cost advantage to Dry N over liquid N
    - b. 30% cost advantage to Dry P over liquid P
    - c. Required a dry cart, air system, specific openers, tendering truck and equipment to handle dry fertilizer

2. NH3
    - a. 30% cost advantage to NH3 over liquid N
    - b. Higher safety hazard
    - c. Logistics problems
        - (1) often we have a 15 - 20 mile run to town for nurse tanks
        - (2) covering the acres we want would tie one man up pulling tanks all day
        - (3) safety concerns
        - (4) delivery concerns
            - (a) Exactrix, Raven, other cold flow
            - (b) knife to knife accuracy has been bad historically
            - (c) loss in no-till because of “closing” issues
            - (d) loss due to “time applied”

3. Liquid
    - a. No cost advantage over Dry or NH3
    - b. Easier transportation and tendering
        - (1) 1 semi trailer can hold all almost 5000 gal of product in multiple containers
        - (2) simple pumps and valves, easy to regulate
        - (3) We are familiar with handling liquid fertilizers
        - (4) already had all of the tendering equipment in place for liquid
    - c. Delivery concerns
        - (1) historic experience with squeeze pumps and manifolds and to

their associate knife to knife accuarcy

(2) historic experience with piston pumps and electric pumps for fertilizer delivery

(3) low pressure deep-banded or high pressure direct injection

B. Toolbars and Openers

Our ideal machine would have been a 54' undercutter (size and flexibility) frame running Flexicoil FSO openers (deep banding) with VRA systems for delivering Dry P (cost advantage over liquid and NH3 (cost advantage over liquid.

1. 9x6 FK XL undercutter frame (54')
   a. Good size, lots of weight for opener penetration and on-frame tanks
   b. LOTS of Modifications needed (lots of shop time)
   c. Cumbersome machine to transport (18' wide) and get into tight spots
   d. Low potential of resale value

2. Quinstar Ultra-jector (40')
   a. Low production (new at that time), bugs to work out
   b. Higher cost and less flexibility and size than the 9x6
   c. Too many unknowns

3. Flexicoil FSO Opener
   a. Good reputation as an opener that stays in the ground
   b. Capable of delivering all three potential types of fertilizer
   c. High cost

4. DMI 2800-16 Nutra-placer (40')
   a. Low cost
   b. Straight single coulters, very simple
   c. Direct Injection (limited to liquid)
      (1) Research (although not 100% conclusive at this point) shows direct injection to be closer to deep banding than to surface broadcast regarding fertilizer longevity and availability
      (2) Lower knife-to-knife variability

   d. Design allowed for adequate toolbar flexibility and for constant down-pressure
   e. High resale value in our area

We considered other machines and openers, but these most closely matched our needs (on paper at least).

5. Our Machine Decision
   a. The 9x6 was a behemoth and required a lot of work
   b. The FSO opener moved to much soil in top-dressing
   c. The DMI Nutra-placer was chosen
      (1) The cost advantages to dry and NH3 were foregone for the improvements in tendering efficiency associated with an all liquid system. Additionally, the equipment to go liquid was already in place
      (2) The straight coulter direct injection machine was shown to work in all of our necessary field management systems.
      (3) Transportation is easy with only a 14' wide footprint.
      (4) The machine was equipped with a 1300 gallon tank on-board and a 1000 gallon tank could be pulled
      (5) If the machine did not work, it would be easy to get rid of

C. Fertilizer Hardware

Determining the fertilizer hardware setup required a lot of time and thinking because we were asking for a lot of flexibility and variability. We knew that we needed two different systems (for N and P) that had to work somewhat together and independently at the same time. Since a 2-fold change in fluid rate requires a 4-fold increase in pressure, (i.e., from 15psi to 60psi), designing a delivery system that gave us a lot of variability was problematic until **Terry Kastens** discovered that by blending the two products before the nozzles large variability could be attributed to one product, assuming that the other product is held in a narrow range of applied rates. Because our main goal was to build STP and simply put on N at removal rates , we could accomplish a wide range of application rates for P.

We worked directly Brothers Equipment out of Friend, Nebraska. Brothers was to setup our machine with two independent fertilizer delivery systems.

1. Basics (flow meters, plumbing)
   Flow meters and the core plumbing was straightforward

2. Pumps
   a. Initially we had thought to go hydraulic centrifugal pumps running full speed and then valves would be used to change application rates

b. On the advice of Brothers, we opted to go with two Hypro centrifugal pumps that could be slowed down or sped up through the use of pulse width modulating (PWM) values.

c. A simple in-line ball-valve shutoff was plumbed in and controlled by an implement switch for end row shutoff

3. A hydraulic pig
   a. The down-pressure requires around 15 gpm
   b. Each Hypro pump setup requires 7-8 gpm
   c. Total gpm is around 31 gpm

D. Controllers, Consoles and Software

1. Controllers
   a. We opted to go with Raven 440's because of cost, user-friendliness and ability to control with external console
   b. Our setup required two Raven 440's and their associated wiring

2. Consoles
   a. We looked at two commercial two-product systems: The Falcon and Raven AIMS.
      (1) High cost systems
      (2) good reputation
      (3) The problem was that each system would only allow the use of VRA maps processed in a proprietary data format (SGIS).
      (4) Many hours were spent on the phone to both Raven and AgChem trying to establish the costs of each system (initial costs, software costs and per-acre charge). We could never get two different people to agree on what the "costs" were, so we abandoned those options
   b. We opted instead to take a less-clean approach and use two PDA's, each would control one side of the system. Two Ipaq 3600's were purchased

3. Software
   a. The best software available for doing VRA fertilizing through PDA's was Farmworks SiteMateVRA. Farmworks has a low cost, highly useful software package and their technical support has been second to none.
   b. SiteMateVRA takes ESRI shapefiles for input and also does as-applied mapping

4. Lightbar and GPS
    a. A JD Starfire SFII provides input to the lightbar as well as to both running copy's of SiteMateVRA.
    b. A Raven LB5 (formally Starlink) is used for navigation

5. Wiring
    a. Because we opted for a "build at home" system, there is twice as much wiring in the cab compared to other commercial products.

V. Operation

The machine was built and delivered March 2002. A full day was spent in the cab figuring out the wiring and placement of all of the components

A. Troubles
  1. Hardware
    a. Could only get one side of the system working (after a day of dinking around)
    b. Finally identified the problem was in plumbing the pumps in series rather than in parallel
    c. After a couple of days (and visits from the good people at Brothers), the machine was finally made fully operational

  2. Software
    a. Had trouble communicating with the 440's. A software update corrected this problem

B. Testing
  1. We have operated this machine for the following tasks
    a. Top-dressing growing wheat
    b. Fertilizing alfalfa
    c. Fertilizing conventional summer fallow ground

As a whole the machine has worked very well.

VI. Changes in technology

As of this past summer, many aftermarket console/controller combo's offer multi-product VRA using shapefiles as inputs. Although these systems have a higher initial cost than our "home built" system, they offer a greater level of ease regarding system wiring and installation, system setup and system operation. Our system requires a thorough understanding of how everything works, what gets turned on when, what is plugged in to what, etc.

VII. Conclusion

We are very satisfied with our fertilizer applicator regarding it's ability to deliver accurate rates of fertilizer in various field conditions and in it's ability to variable apply two liquids in real-time. Down-time is minimized with a "simple" machine (not a lot of moving parts), through large product storage (2300 gal of product onboard), and low tendering needs (maybe two semi-loads per day). Because of our desire to continue to move towards a 100% no-till program, a fertilizer machine such as this was required anyway. The costs to add the VRA capabilities were marginal in this regard. My only complaint is in navigating this rig using only a lightbar at 9mph. I know that I have a lot of variability in my guess row widths, however I strongly feel that Auto-Trac will significantly improve my application efficiency.