

CONSERVATION INNOVATION GRANTS

Final Report

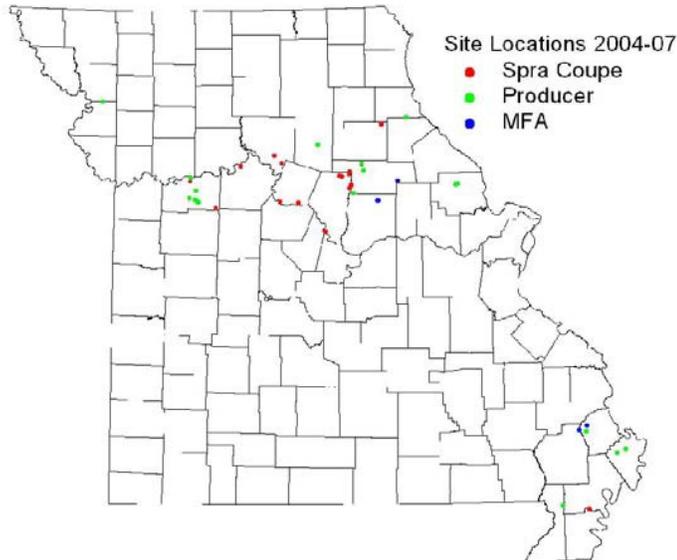
Grantee Name: University of Missouri
Project Title: Demonstration of Innovative Technology for Optimizing Nitrogen Application on Corn
Period Covered by Report: May 1, 2005 – September 30, 2007
Project End Date: September 30, 2007

Summarize the work performed during the project period covered by this report:

Even though the three-year project ended on 9/30/07, the demonstration sites were harvested, geo-referenced yield data were analyzed, and a final nitrogen workshop was held during 10/07 through 01/08.

In spite of losing a couple demonstrational sites to weather conditions, we managed to conduct 18 field studies in 2007. This brings the three-year total to 49 studies. Seven related research studies in 2004 via the IFAFS project served as a basis for this NRCS-CIG project.

Field-Scale Studies				
Application Equipment	2004	2005	2006	2007
USDA-ARS Spra-Coupe	7	5	5	5
Producer Rigs		7	8	9
Service Provider Rigs			6	4



We continued to demonstrate the sensor-based, variable-rate nitrogen technology to match the wide array of scenarios of applying nitrogen on corn in MO and much of the Midwest. The varying conditions included:

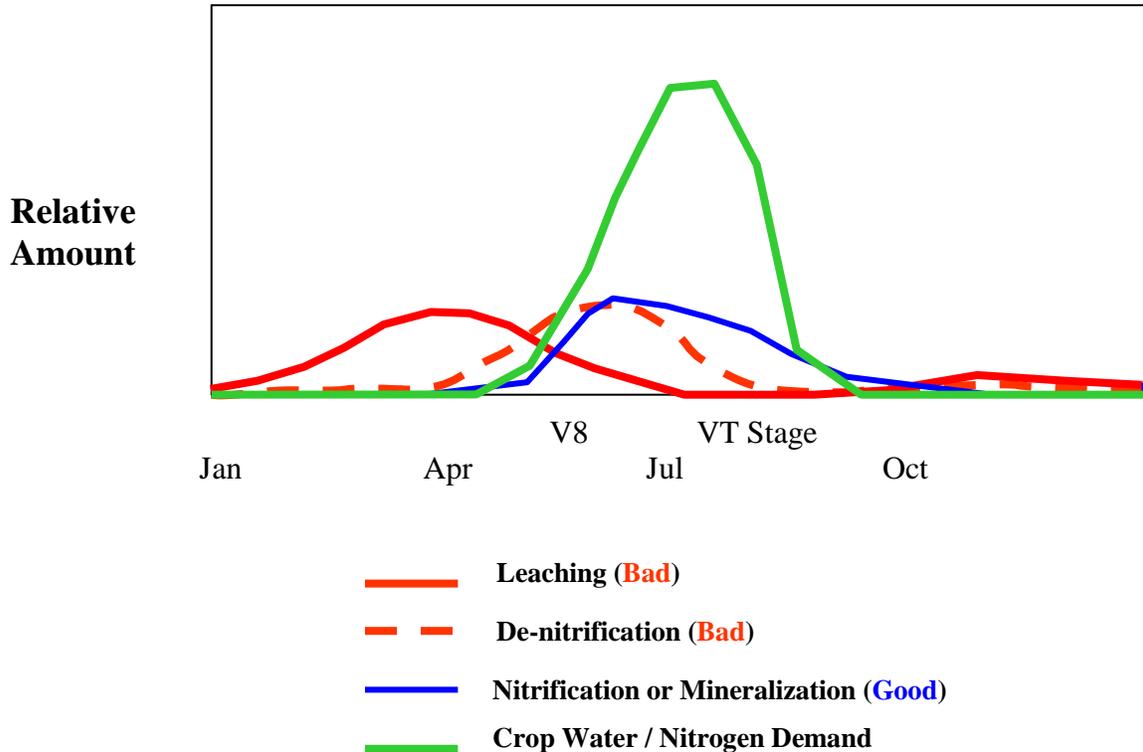
- Tractor-drawn anhydrous ammonia or UAN injection and self-propelled equipment that apply liquid UAN or dry urea
- Anhydrous ammonia, urea ammonium nitrate, or dry urea formulations
- Claypan, loess, or river bottom soil
- Irrigated and non-irrigated corn
- Pre-plant or in-season fertigation of manure (pit or lagoon respectively)
- Corn-Soybean-Corn or Corn-Corn rotations
- Single vs. split applications of nitrogen
- Corn stage at treatment (15" to initial tassel)
- Good crop years and some "not-so-good" (local weather conditions)

Yield monitor data have been post processed and analyzed according to treatments within studies and summarized across studies. Individual test results have been provided to the respective host or cooperating producer. Summarizations of all studies were shared and discussed at our second annual nitrogen workshop on January 18. Producers, crop consultants, extension, and service providers attended. Several wish to be involved in further field demonstrations and a couple of early adopters indicated they are committed to purchasing the sensors, cabling, computer, and rate controller so they can implement this new on-the-go variable-rate nitrogen application on their farms in 2008.

Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

While the following figure is a simplistic illustration, it has been very helpful as an introductory way of showing the dynamics of nitrogen availability in the soil and the relatively short period of time that corn really needs the nitrogen. The amount of leaching, runoff, denitrification, and mineralization of nitrogen is going to vary spatially within a field because of variations in landscape as to topsoil infiltration rates, soil texture, organic matter content, aspect, slope, and position on the slope (run-off or run-on catchment area). There will also be year-to-year variation at any given spot on a field due to climatic differences.

Schematic Dynamics of Nitrogen



Producers realize from this illustration that nitrogen application in advance of when the corn needs it (ie. fall or early spring pre-plant) is vulnerable to loss. Since the dynamic curves can not be controlled by the producer, there is greater assurance or efficiency if the nitrogen is applied close to the time that the corn really needs it. Corn needs some nitrogen as a seedling but demand increases rapidly about V8-VT as illustrated.

Knowing this, producers feel most comfortable if they can apply at least a small part of the total nitrogen as a pre-plant or at-emergence timing and then hopefully adopt this new technology to feed the corn the majority of the nitrogen at mid-season. We have been demonstrating this with our split application treatments by applying no more than a total of 60 lbs of N down at emergence (includes any nitrogen that was applied pre-plant via MAP, DAP dry fertilizer, or starter fertilizer).

Results from our work indicate the producer should limit the pre-plant rate to 60 lbs of N so that the corn does not give a false read as to the temporary sufficiency of nitrogen available to it at V6 to V9 and then run out of nitrogen when it really needs it during the growth surge and reproductive stages.

The basis of the new technology is to use active-light sensors to measure the biomass and greenness of the corn to be fertilized. The values of the "target corn" are compared to the biomass and greenness of "reference corn" that was given ample dosage of nitrogen at or before emergence. As explained in the attached Agronomy Technical Note MO-35, the Missouri algorithms determine the on-the-go rate of nitrogen that the corn needs to reach its yield potential. The determined rate will spatially vary because of the dynamics of the nitrogen cycle illustrated above.

The “reference corn” has had sufficient nitrogen during the early growth stages so these plants are as green and robust as that given hybrid can be for that planting date, soil, and weather conditions. Most of our field studies have utilized a relatively small (30 x 50 feet) area as the reference area. At our first nitrogen workshop with producers on 1/26/07, discussion about the limitations of selecting a single reference area pointed out that soils and the nitrogen dynamics vary in large fields resulting in the risk that the reference area is not representative of the whole field. Out of the discussion came an excellent idea from one of the producers that we should prepare a reference strip that transcends across soil types and that the reference value gets spatially updated in the algorithm as the mid-season nitrogen is applied to the field.

This idea also potentially answers another concern we have uncovered. During the several hours or parts of two days that it may take to fertilize a large field, the weather conditions change (in amount of dew on corn leaves or a light sprinkle) which in turn change the reflectance values the sensors record.

The number of sensors mounted on the equipment is a practical question. The expense of multiple sensors is one consideration. The width of the boom or swath covered by the applicator varies considerably. Narrow swaths made by anhydrous or liquid UAN injection toolbars are commonly only 30 feet wide. We feel three sensors spaced about 7.5 feet apart are adequate. Rigs that apply liquid UAN via drop nozzles cover as much as 80-90 feet should have three sensors.

Two Sensors on 80' Boom – Note the Spatial Variability



Need more sensors and variable-flow, sectional boom



More than three sensors will give a more accurate average of what the corn looks like within the wide swath but then the limiting factor becomes the delivery system of the wide boom and line-volume of the equipment. If one rate controller serves the whole boom, only one rate can obviously be applied at a time. Another limiting factor is that these rigs travel 7 to 12 miles per hour which causes considerable lag from the time the controller adjusts the flow rate until the delivery rate changes at the end of the boom.

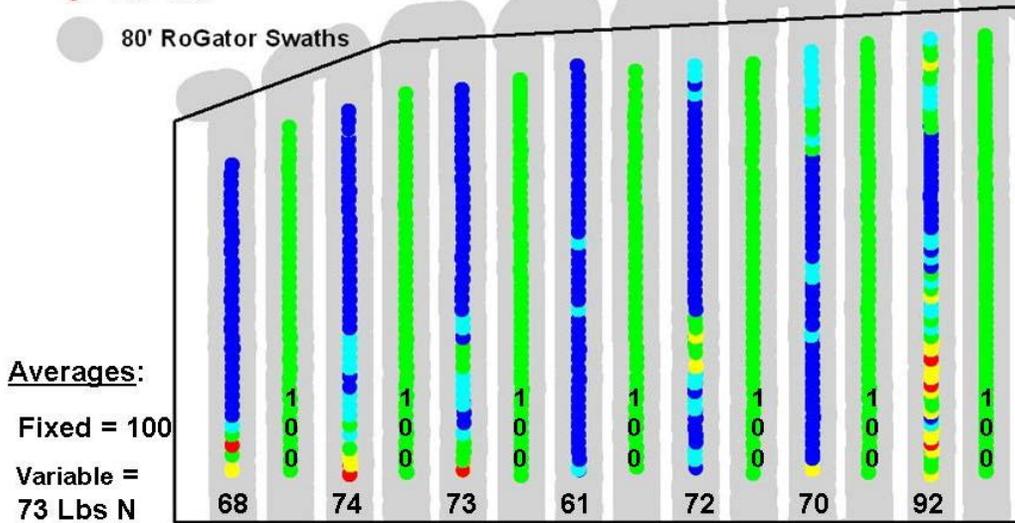
We do not encourage interested producers to adopt this new technology on all of their corn acreage. Risk is the issue. If a given producer equips his/her toolbar rig with sensors, etc. to apply anhydrous or UAN to all the corn at V6-V7; rainy weather may interrupt and the corn quickly gets too tall for the low-profile equipment. The producer would then be forced to hire a service provider with higher clearance equipment that would be more expensive to the producer.



Two figures on the following page show a fixed rate of 100 lbs of N as UAN versus sensor-based, variable-rate N on a field that received hog manure from a pit during the previous fall.

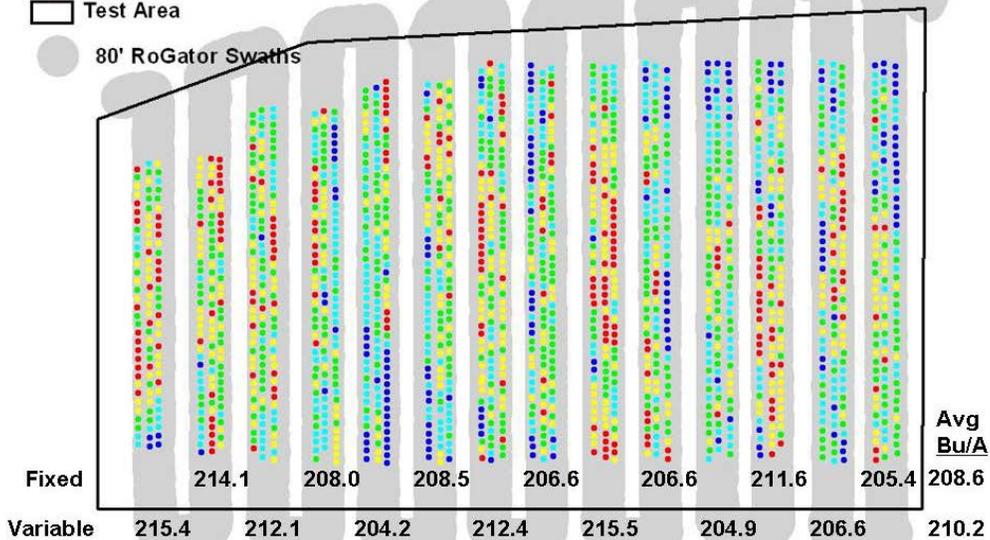
- Test Area
- Lbs N As Applied
 - 60 - 68
 - 69 - 87
 - 88 - 111
 - 112 - 139
 - 140 - 180

Alternating Fixed Rate of 100 Lbs N and Sensor-Based Variable-Rate N to V8 Corn



- Bu/A
 - 156 - 192
 - 192 - 204
 - 204 - 213
 - 213 - 222
 - 222 - 247
- Test Area

Yield of Three Combine Passes Per 80 Ft Swath of the RoGator



The following table summarizes 41 demonstrations that were not adversely affected by severe drought or some other factor that compromised the value of some studies. They averaged a net gain of \$9/acre. Even though the modest gain is not more impressive, some producers that attended our recent workshop expressed commitment to adopting the new technology.

Producers anticipate that nitrogen prices will inflate further commensurate with escalating natural gas prices that may remain high while corn prices may weaken in a year or two. Also, these monetary assessments do not put a dollar value on the environmental benefit of reducing the average application rate of nitrogen as shown in the table.

**Summation of 41 On-Farm, Sensor-Based Demonstrations
2004-2007
Based on \$4.00 Corn and \$.50 Nitrogen**

Treatments	Average Bu/A	Average Lbs N/A
Producer's Normal Fixed Rate	157	145
Sensor-Based Variable Rate	156.5	123
\$ Loss or Gain If Sensors are used	-\$2.00	\$11.00

Given that the average monetary savings have been modest across the array of conditions; river bottom fields, as a landscape, offer the greatest return on investment in adopting this new technology. River bottom fields commonly have notable variability in soil texture. Texture can vary from virtual blow sand to tight gumbo clay within a hundred yards. Soil lenses or layers vary in thickness and composition. Shallow water tables play a role. A higher percentage of river bottom corn fields are irrigated than on Missouri's upland fields. Portions of a given field are covered by the pivot while corners may not be. Some producers inject UAN into the irrigation line. All these characteristics can cause with-in field variability and spatially influence the dynamics of the nitrogen cycle. Within such fields, corn will find varying amounts of available nitrogen and the sensors will discern the differences.

Another field scenario that is apt to provide considerable with-in field variation in available nitrogen is a manure-treated field. These are limited almost exclusively to the

upland fields on loess or claypan soils. Inherent in most any manure application is variability in nutrient deposition. Producers that apply manure should consider trying this new technology.

Accompanying this report is a copy of the Agronomy Technical Note MO-35. This technical note explains much of the scientific and practical background of this technology in a way that will help producers, service providers, and consultants adopt this innovative practice.