**AGRICULTURAL RESEARCH FOUNDATION**
**FINAL REPORT**
FUNDING CYCLE 2013 – 2015

**TITLE:** Enhanced efficiency fertilizer technologies for improved production in sweet corn

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**SUMMARY:** Enhanced efficiency fertilizer (EEF) technologies have the potential to improve the crop N use efficiency as well as minimize negative environmental losses compared to conventional fertilizers. They can potentially reduce nitrate leaching either by retaining the fertilizer in the form of ammonium (which sticks to the soil and does not leach) or by releasing the fertilizer in a controlled manner. Field trials in 2013 and 2014 demonstrated that the products tested (ESN, SuperU, and Instinct) were all effective. In general, about 20 to 50% of the urea-N applied was protected from conversion to nitrate-N for the first 3 to 6 weeks after fertilizer application. We conclude that EEF products had measurable efficacy in slowing the rate of conversion of urea-N to leachable nitrate-N. However, even under a "worst case" leaching scenario on a medium-textured soil, the use of inhibitors was ineffective in achieving a corn ear yield response. These products are most effective when used on well drained, sandy soils planted in the spring when the threat of leaching is greatest.

**OBJECTIVES:**

1. Quantify the amount of applied fertilizer N that can be protected from leaching by the EEF products ESN, SuperU, and Instinct.
2. Determine if and by how much the EEF products tested can increase yield/product quality under high leaching conditions (sandy soil with frequent, high intensity irrigations) early in the growth cycle (2-5 weeks).

**PROCEDURES:**
**Note: Only methods from 2014 are shown. Methods from 2013 are available in the interim report.**
*Description of EEF fertilizers*

- **ESN® (Environmentally Smart Nitrogen)** manufactured by Agrium Advanced Technologies, Inc. This product is a polymer coated urea and contains 44%N. The coating allows water to move into the granule and dissolve the urea, which then diffuses into the soil. The rate at which the urea solution moves out through the coating is determined by soil, temperature, and moisture. In cool soils when the crop is growing slowly and N demand is minimal, N release is slow, but as the soil warms and crop growth increases, the granules release N more rapidly. At current urea market prices, using ESN costs an additional ~$0.15/lb N.
- **SuperU®** manufactured by Agrotain International (a subsidiary of Koch Agronomic Services). This product is a granular urea product containing both a urease inhibitor (NBPT) and nitrification inhibitor (DCD), and contains 46%N. The combined action of the inhibitors can reduce ammonia volatilization losses and slow the conversion of ammonium into nitrate. As a result, the fertilizer-N should be less susceptible to leaching in the early part of the season when crop N uptake is minimal.

- **Instinct™ (formulation used very similar to Instinct™ II)** is manufactured by Dow Agrosciences. It contains the nitrification inhibitor nitrapyrin in an encapsulated form. This encapsulation is designed to prevent loss from volatilization and fixation on clay particles and organic matter. This allows it to remain on the soil surface longer before incorporation. This product is registered for use in sweet corn in Oregon and has the following replant restrictions: "Corn (field, sweet, pop), sorghum, wheat, other cereals, oilseed crops (including soybeans), and leafy vegetables, may be rotated 120 days from the last application of N-Serve 24 [a formulation of nitrapyrin]. All other crops are not to be rotated in less than one year after the last application." The nitrapyrin (0.5 lb A.I. per acre) was sprayed on urea that had been broadcast, which was then immediately incorporation.

**Table 1.** Fertilizers and N rates used in EEF field trial.

| Treatment | Fertilizer | N rate *lb/acre* |
|---|---|---|
| 1 | None | 0 |
| 2 | Urea | 25 |
| 3 | Urea | 50 |
| 4 | Urea | 75 |
| 5 | Urea | 100 |
| 6 | Urea | 125 |
| 7 | ESN | 50 |
| 8 | ESN | 75 |
| 9 | SuperU | 50 |
| 10 | SuperU | 75 |
| 11 | Instinct | 50 |
| 12 | Instinct | 75 |

*Field trial: Ear yield response and product efficacy in protecting N from leaching*. This trial was located at OSU's Vegetable Research Farm in Corvallis. The soil (0-12 inches) had the following properties: pH 6.3, 1.8% OM (LOI), estimated CEC of 16 meq/100g, Bray 1P 51 ppm, and 220 ppm K. Using the hydrometer method for measuring soil particle size distribution, the soil texture from 0-12 inches was a sandy loam (15% clay and 59% sand) and from 12-24 inches was also a sandy loam (17% clay and 57% sand). On May 7, fertilizer was broadcast by hand in plots 10 x 40 ft. See Table 1 for treatments and rates. Following application, the fertilizer was incorporated with a power harrow to a depth of ~3-4 inches. Walking in front of the tractor that was incorporating the fertilizer, Instinct was applied at a rate of 0.5 lb A.I. per acre @ 35 gal per acre using a boom with 5 nozzles (80-03VS XR TeeJet @ 20 psi) on 20 inch spacing. Time between Instinct application and incorporation was less than 3 minutes. A soil temperature probe (Hobo pendant) was installed at a depth of 3 inches. The treatments were arranged in a randomized complete block design with 5 replications.

Seven days after application, sweet corn var. 'Captain' was seeded and ~4 weeks after application doubles and plants spaced closer than 4-6 inches were removed. The final stand was ~21,000 plants/acre. At planting 34 lb P2O5 (from TSP) and 26 lb K2O (from KCl and K-Mag) was banded. Soil was sampled every 2 weeks after the fertilizer application for 6 weeks from 0-10 and 10-20 inches just in the treatments receiving 50 or 75 lb N/acre in 4 replications. Samples were extracted with 2M KCl and analyzed for ammonium and nitrate by OSU Central Analytical Laboratory. To increase nitrate leaching, we applied ~5.0 inches of irrigation water (as measured by placing 6 buckets randomly in the field) over 6 weeks. The total amount of water on the field from rain and irrigation was 8.6 inches.

At harvest on August 25 (103 days after planting), ears from forty feet of row (20 ft. from the middle two rows in each plot) were hand harvested. Gross ear weight, dry matter, and other parameters (tip fill, length, width, unhusked wt) were measured.

*Aerobic soil EEF fertilizer incubation:*

The top 6 inches of soil was collected from the field where the EEF field trial was located and sieved through a 2 mm mesh screen. Fertilizer (urea, ESN, and SuperU) was added to 450 g of oven dry soil at a rate of 400 lb N/acre (assumptions: 5-inch incorporation depth with a bulk density of 1.33 g/cm3). After incorporating into the soil, deionized water was added with a spray bottle while mixing the soil until a gravimetric moisture content of ~17% was reached (near field capacity for this soil). For the product

Instinct, field moist soil was placed in pots and urea was distributed over the soil surface. The pots were placed randomly in a 5 by 20 ft. area and Instinct was sprayed over top (0.5 lb A.I. per acre @ a rate of 35 gal per acre) using a wand with the same nozzles and spacing described in the field trial below.

After fertilizer application, soil was placed in zippered plastic bags with a straw inserted into the top corner of each bag to facilitate air exchange. Soil was incubated in the dark at 71.0±0.4 degrees F. Additional DI water was added to the bags weekly to make up for moisture loss. Three replicates of each bag per treatment were destructively sampled at Week 1, 2, 3, 4, 5, and 6 after application. On each sampling date, the bags were thoroughly mixed and a 10-15 g soil subsample was extracted with 2M KCl for ammonium-N and nitrate-N determination at the OSU Central Analytical Laboratory.

**SIGNIFICANT ACCOMPLISHMENTS:**

From this research we have verified that the products tested actually work, how long they are most effective for, how best to use them and in what situations they may be effective. A summary of the performance of each product tested is given below. A more detailed report can be found here: http://horticulture.oregonstate.edu/content/improving-fertilizer-p-and-n-use-efficiency-sweet-corn-2013 and http://horticulture.oregonstate.edu/content/enhanced-efficiency-fertilizer-technologies-improved-production-sweet-corn-2014

*ESN:*

- In a laboratory soil incubation, recovery of N from the polymer coated urea was significantly less than conventional urea over the entire study period (6 weeks), demonstrating that the product was effective at slowly releasing urea. From Week 2 to 6, ESN was protecting 25-35% of added N from leaching.
- By Week 6 in the lab incubation, ESN prills had released 83% of added urea-N. Although 60% of the prills were fully "intact" at Week 6 (plump with no dimpling), they were full of liquid and much of the urea-N had diffused out of the prill.
- Under field conditions ESN was measured to be effective up to the Week 4 sampling period, protecting between 43 and 37% of applied N from leaching at Week 2 and 4, respectively.
- Some agronomic service companies recommend applying conventional urea with ESN to prevent an early season crop N deficiency, based on the idea that ESN might reduce nitrate-N too slowly to meet crop needs.. Based on the 2014 data, this practice is not warranted. Nitrogen uptake by sweet corn is minimal in the first month after planting. ESN released enough N to meet early season crop N needs.

*SuperU:*

- In the lab incubation, the nitrification inhibitor in SuperU was effective for 6 weeks at preventing the conversion of ammonium to nitrate. At Week 6, 51% of added SuperU-N was in the form of ammonium compared to 13% for Urea-N. From Week 3 to 6, SuperU was protecting between 47-53% of added SuperU-N from leaching compared to urea-N.
- Under field conditions SuperU was measured to be effective up to the Week 4 sampling period, protecting between 53 and 51% of applied N from leaching at Week 2 and 4, respectively. By Week 6 there were no differences between urea alone vs urea + SuperU.

*Instinct:*

In 2014, the urea was broadcast and Instinct sprayed over the soil surface followed by immediate incorporation. Unlike the other products tested, Instinct performed better in the field than in the lab

incubation. Possibly we were unable to sufficiently replicate the field spray conditions for the lab incubation.

- In the lab Instinct was most effective around Week 2 to 3. At Week 2 and 3, Instinct was protecting 12 and 27%, respectively, of added N from leaching compared to urea. After Week 3 it did not perform much better than urea.
- Under field conditions Instinct was measured to be effective up to 6 weeks and possibly beyond. At Week 2, 4, and 6 an average of 53, 51, 50%, respectively of total N applied was potentially protected against leaching compared to urea.

**BENEFITS & IMPACT:**
From this work we are able to give growers guidance on if they should use these products, and if so, how to do so to maximize their benefit. Some growers are already using these products, but we have found that they are unnecessary in most situations (medium textured soils) and they can save money by not using them where they are not effective. For growers who are planting early spring sweet corn on very sandy soils, these products are insurance against fertilizer N losses.

**ADDITIONAL FUNDING RECEIVED:**
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