On-Farm Evaluation of Polymer Coated Urea Rates and Blends on Potato Yield and Quality

Carl Rosen, Matt McNearney, and James Crants
Department of Soil, Water, and Climate, University of Minnesota
crosen@umn.edu

Summary: An on-farm field experiment in Perham MN was conducted in 2012 to evaluate the effects ESN rate, and an ESN/Duration blend on Russet Burbank potato tuber yield and quality. Seven treatments were evaluated in a randomized complete block design with four replications. All treatments included liquid N applications of 110 lb N/A - 40 lb N/A at planting, 40 lb N/A at emergence and 30 lb N/A through fertigation in June. Treatments included five ESN rates from 90 to 210 lb N/A at emergence. Two additional treatments at the 230 lb N/A rate were conventional urea at 120 lb N/A and a 50/50 blend of ESN and Duration at 120 lb N/A applied at emergence. Yield and size distribution were not significantly affected by treatment. Total yield ranged from a low of 390 cwt/A with the conventional urea treatment to a high of 410 cwt/A with ESN applied at 290 lb N/A (Table 1). There was a trend (but nonsignificant) for increasing tuber size with increasing ESN rate up to 290 lb N/A. At the 230 lb N/A rate, total and marketable yield were numerically highest with the blend followed by ESN and then conventional urea. Specific gravity, internal disorders, and scab were not significantly affected by treatment. Petiole nitrate-N increased with increasing N rate at all three sampling dates. In contrast, SPAD reading increased with increasing N only at the latter two sampling dates. These results indicate that SPAD readings lag behind petiole nitrate readings and therefore may not be as useful for predictive purposes. In general, the lack of significant yield response to N treatments suggests that N was not the limiting factor in this study. The crop died back early, presumably due to verticillium infection and possibly water stress that occurred between the 15th and 24th of July.

Background: Research conducted over the past number of years with coated urea fertilizers such as ESN (Environmentally Smart Nitrogen, Agrium, Inc.) has shown that a onetime application can be as cost effective as multiple applications of conventional N with fertigation. As a result, use of ESN for potato production in Minnesota has increased rapidly. Most of the N is released from ESN within about 60-80 days after application. In addition to ESN, a coated urea called Duration, also manufactured by Agrium, is available. Duration has a slightly thicker coating, and therefore, N release is slower – about 100-120 days. A blend of ESN and Duration may provide an efficient use of N for long season processing potatoes. Because the release characteristics of ESN and Duration can affect tuber set and bulking of potatoes, evaluation of various rates and blends is essential to gain a better understanding of how best to use these products. Most of the calibration research with ESN has been conducted on small plots at the Sand Plain Research Farm in Becker. Additional studies are needed on growers’ fields to validate the rates, timing, and blends suggested.

The overall goal of this research was to evaluate ESN and Duration as N sources for irrigated potato production in Minnesota under grower field conditions. The specific objective is to determine the effects of various ESN rates and an ESN/Duration blend on potato yield and quality.

Materials and Methods

The study was conducted on a center pivot near Perham, MN on a Hubbard loamy sand using the potato cultivar Russet Burbank. The previous crop was edible beans and the field was fumigated with Vapam along with an application of 600 lbs of 0-0-60 the fall before planting. Selected soil
chemical properties before planting were as follows (0-6"): water pH, 7.2; organic matter, 1.3%; Bray P1, 115 ppm; and ammonium acetate extractable K, 124 ppm.

Whole “B” seed was machine planted in furrows on April 26, 2012. Each plot consisted of 6, 40 ft rows, with the middle four rows used for sampling and harvest. Spacing was 36 inches between rows and 14 inches within each row. Seven treatments were replicated four times in a randomized complete block design. Weeds, diseases, and insects were controlled using standard practices. Rainfall was supplemented with center pivot irrigation using the checkbook method of irrigation scheduling. The seven treatments tested are listed below (Table 1).

A starter fertilizer of 34 gallons/A of 10-34-0; 0.75 gallons/A of Borosol, and 1.6 quarts/A of 20% Zn was applied to all plots at planting, supplying an initial XX lbs N/A. On May 17 (approximately emergence), ESN or ESN + Duration was applied at the rates listed in Table 1 followed by a sidedress of 8.5 gallons/A of ammonium thiosulfate and 8.5 gallons/A of 32% UAN and then hilled in. On June 25, 6 gallons of 32% and 6 gallons of ammonium thiosulfate were applied as fertigation. The liquid applications supplied approximately 110 lb N/A to all plots. The ESN was applied in 30 lb N/A increments, starting at 90 lb N/A up to 210 lb N/A, providing total N rates of 200 to 320 lb N/A in 30 lb N/A increments. At the 230 lb N/A rate, two additional treatments were tested: 120 lb N/A as urea and 120 lb N/A as a 50/50 blend of ESN and Duration.

Table 1. Treatments tested at Perham in 2012.

<table>
<thead>
<tr>
<th>Treatment Number</th>
<th>Total N rate</th>
<th>Emergence N rate</th>
<th>N Source at Emergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200</td>
<td>90</td>
<td>ESN</td>
</tr>
<tr>
<td>2</td>
<td>230</td>
<td>120</td>
<td>ESN</td>
</tr>
<tr>
<td>3</td>
<td>260</td>
<td>150</td>
<td>ESN</td>
</tr>
<tr>
<td>4</td>
<td>290</td>
<td>180</td>
<td>ESN</td>
</tr>
<tr>
<td>5</td>
<td>310</td>
<td>210</td>
<td>ESN</td>
</tr>
<tr>
<td>6</td>
<td>230</td>
<td>120</td>
<td>Urea</td>
</tr>
<tr>
<td>7</td>
<td>230</td>
<td>60+60</td>
<td>ESN / Duration</td>
</tr>
</tbody>
</table>

WaterMark sensors were installed to measure soil moisture at the three inch depth (simulating where the ESN prills were located). Soil temperature at 3 inches and air temperature were also monitored on a daily basis. Nitrogen release from ESN and Duration were measured using the mesh bag technique. Petiole samples were collected from the fourth leaf from the terminal on June 22, July 9, and July 25. Petioles were analyzed for nitrate-N on a dry weight basis. At the same time petioles were collected, chlorophyll readings were measured with a Minolta SPAD chlorophyll meter on the terminal leaflet of the leaf sampled for petioles. On Sept. 19, plots were machine-harvested and total tuber yield, graded yield, tuber specific gravity, and the incidence of scab, hollow heart, and brown center were measured.
All trials of the experiment were statistically analyzed using ANOVA procedures on SAS and means were separated using a Waller-Duncan LSD test at $P = 0.10$.

**Results**

**Weather:** Rainfall and irrigation amounts and soil moisture at 3” are presented in Figure 1. The 2012 growing season was relatively wet early with three significant leaching events: May 26, June 21, and July 26. Soil moisture at the 3” depth was dry in mid June and mid July. Soil temperature at the 3” depth and air temperature are presented in Figure 2. In general, soil and air temperatures were above average over most of the growing season.

**Nitrogen Release from ESN and ESN/Duration Blend:** Nitrogen release from ESN and the blend is presented in Figure 4. As expected, the release was slower with the blend compared with 100% ESN. For 90% of the N to be released from the prills, it took approximately 47 days for ESN and 70 days for the blend.

**Tuber Yield and Size Distribution:** Yield and size distribution were not significantly affected by treatment. Total yield ranged from a low of 390 cwt/A with the conventional urea treatment to 410 cwt/A with ESN applied at 290 lb N/A (Table 1). There was a trend (but nonsignificant) for increasing tuber size with increasing ESN rate up to 290 lb N/A. At the 230 lb N/A rate, total and marketable yield were numerically highest with the blend followed by ESN and then conventional urea. However, tuber size tended to be larger with conventional urea than the coated N sources. In general, the lack of significant N response suggests that N was not the limiting factor in this study. The crop died back early, presumably due to verticillium infection and possibly water stress between the 15th and 24th of July (Figure 1).

**Tuber Quality:** Specific gravity, internal disorders, and scab were not significantly affected by treatment (Table 2). In general, internal disorders and scab incidence were low. Specific gravity was generally in the ideal range for processing.

**Petiole Nitrate-N Concentrations:** At the 230 lb N/A rate, petiole nitrate concentrations were significantly lower with the blend as the N source compared with ESN or conventional urea on the first sampling date (Table 3). In addition, petiole nitrate tended to increase with increasing ESN rate. In contrast, chlorophyll SPAD readings were not consistently affected by treatment on the first sampling date. At the second and third sampling dates, petiole nitrate-N increased with increasing ESN rates; however at the 230 lb N/A rate petiole nitrate was not significantly affected by N source. At the second and third sampling dates, SPAD readings also increased with increasing ESN rate. Similar to petiole nitrate-N, differences in SPAD reading among N sources at the 230 lb N/A rate were not significant. The lack of significance in SPAD readings at the first sampling date indicates that SPAD readings lag behind petiole nitrate readings and therefore may not be as useful for predictive purposes.

**Conclusions:** Yield and size distribution were not significantly affected by N treatments. Total yield ranged from a low of 390 cwt/A with the conventional urea treatment to a high of 410 cwt/A with ESN applied at 290 lb N/A. In general, the lack of a significant response to treatments suggests that N was not the limiting factor in this study. The crop died back early,
presumably due to verticillium infection and possibly water stress that occurred between the 15th and 24th of July.

Figure 1. Rainfall and irrigation amounts and soil moisture at Perham during the 2012 growing season.

Figure 2. Daily air and 3” soil temperatures at Perham during the 2012 growing season.
Figure 3. Nitrogen release from ESN and a 50/50 ESN/Duration blend starting on May 16 at Perham.
Table 1. Effects of ESN rate and ESN/Duration Blend on Russet Burbank tuber yield and size distribution.

<table>
<thead>
<tr>
<th>Treatment #</th>
<th>N Source1</th>
<th>N Timing2 (P, E, C, F)</th>
<th>N Rate (lbs N/A)</th>
<th>Tuber Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0-3 oz.</td>
</tr>
<tr>
<td>1</td>
<td>ESN (90)</td>
<td>40, 90, 40, 30</td>
<td>200</td>
<td>32.4</td>
</tr>
<tr>
<td>2</td>
<td>ESN (120)</td>
<td>40, 120, 40, 30</td>
<td>230</td>
<td>29.2</td>
</tr>
<tr>
<td>3</td>
<td>ESN (150)</td>
<td>40, 150, 40, 30</td>
<td>260</td>
<td>29.1</td>
</tr>
<tr>
<td>4</td>
<td>ESN (180)</td>
<td>40, 180, 40, 30</td>
<td>290</td>
<td>26.1</td>
</tr>
<tr>
<td>5</td>
<td>ESN (210)</td>
<td>40, 210, 40, 30</td>
<td>320</td>
<td>27.6</td>
</tr>
<tr>
<td>6</td>
<td>Urea (120)</td>
<td>40, 120, 40, 30</td>
<td>230</td>
<td>31.6</td>
</tr>
<tr>
<td>7</td>
<td>ESN+Duration (60 + 60)</td>
<td>40, 60+60, 40, 30</td>
<td>230</td>
<td>31.2</td>
</tr>
</tbody>
</table>

Treatment significance1

<table>
<thead>
<tr>
<th>Treatment significance1</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
<th>NS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment MSD (0.1)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Linear Contrast</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Quadratic Contrast</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Contrast Trmt 2 vs. 6, 230 N (120 ESN) vs. 230 N (120 Urea)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Contrast Trmt 2 vs. 7, 230 N (120 ESN) vs. 230 N (120 Blend)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Contrast Trmt 6 vs. 7, 230 N (120 Urea) vs. 230 N (120 Blend)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

1ESN (Environmentally Smart Nitrogen, Agrium, Inc.) = 44-0-0; Duration (Agrium, Inc.) = 43-0-0; Urea = 46-0-0.
2P=Planting, E=Emergence, C=Cultivation, F=Fertigation.
3NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.
Table 2. Effects of ESN rate and ESN/Duration Blend on Russet Burbank tuber quality.

<table>
<thead>
<tr>
<th>Treatment #</th>
<th>N Source$^1$</th>
<th>N Timing$^2$ (P, E, C, F)</th>
<th>N Rate (lbs N/A)</th>
<th>Tuber Quality</th>
<th>Treatment significance$^1$</th>
<th>Treatment MSD (0.1)</th>
<th>Linear Contrast</th>
<th>Quadratic Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Specific Gravity</td>
<td>Internal Disorders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>ESN (90)</td>
<td>40, 90, 40, 30</td>
<td>200</td>
<td>1.0833</td>
<td>1.07</td>
<td>0.45</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>2</td>
<td>ESN (120)</td>
<td>40, 120, 40, 30</td>
<td>230</td>
<td>1.0808</td>
<td>0.57</td>
<td>0.19</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>3</td>
<td>ESN (150)</td>
<td>40, 150, 40, 30</td>
<td>260</td>
<td>1.0790</td>
<td>1.38</td>
<td>0.11</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>4</td>
<td>ESN (180)</td>
<td>40, 180, 40, 30</td>
<td>290</td>
<td>1.0835</td>
<td>0.93</td>
<td>0.06</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>5</td>
<td>ESN (210)</td>
<td>40, 210, 40, 30</td>
<td>320</td>
<td>1.0843</td>
<td>0.71</td>
<td>0.08</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>6</td>
<td>Urea (120)</td>
<td>40, 120, 40, 30</td>
<td>230</td>
<td>1.0813</td>
<td>0.39</td>
<td>0.37</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>7</td>
<td>ESN+Duration (60 + 60)</td>
<td>40, 60+60, 40, 30</td>
<td>230</td>
<td>1.0815</td>
<td>0.36</td>
<td>0.10</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Treatment significance$^1$: NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

1ESN (Environmentally Smart Nitrogen, Agrium, Inc.) = 44-0-0; Duration (Agrium, Inc.) = 43-0-0; Urea = 46-0-0;

2P=Planting, E=Emergence, C=Cultivation, F=Fertigation.

3NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.
Table 3. Effects of ESN rate and ESN/Duration Blend on Petiole Nitrate-N and SPAD readings.

<table>
<thead>
<tr>
<th>Treatment #</th>
<th>N Source¹</th>
<th>N Timing² (P, E, C, F)</th>
<th>N Rate (lbs N/A)</th>
<th>Petiole Nitrate-N</th>
<th>SPAD Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22-Jun 9-Jul 25-Jul</td>
<td>22-Jun 9-Jul 25-Jul</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>1</td>
<td>ESN (90)</td>
<td>40, 90, 40, 30</td>
<td>200</td>
<td>15614 9738 7894</td>
<td>41.0 39.8 37.3</td>
</tr>
<tr>
<td>2</td>
<td>ESN (120)</td>
<td>40, 120, 40, 30</td>
<td>230</td>
<td>15737 11546 7823</td>
<td>42.0 40.5 37.2</td>
</tr>
<tr>
<td>3</td>
<td>ESN (150)</td>
<td>40, 150, 40, 30</td>
<td>260</td>
<td>15810 12816 9694</td>
<td>40.6 40.5 37.7</td>
</tr>
<tr>
<td>4</td>
<td>ESN (180)</td>
<td>40, 180, 40, 30</td>
<td>290</td>
<td>16220 13147 11044</td>
<td>42.2 42.2 39.2</td>
</tr>
<tr>
<td>5</td>
<td>ESN (210)</td>
<td>40, 210, 40, 30</td>
<td>320</td>
<td>16071 14893 12642</td>
<td>41.7 41.7 38.4</td>
</tr>
<tr>
<td>6</td>
<td>Urea (120)</td>
<td>40, 120, 40, 30</td>
<td>230</td>
<td>15740 11789 8590</td>
<td>42.9 40.3 37.6</td>
</tr>
<tr>
<td>7</td>
<td>ESN+Duration (60 + 60)</td>
<td>40, 60+60, 40, 30</td>
<td>230</td>
<td>14783 10786 7698</td>
<td>41.8 40.2 36.6</td>
</tr>
</tbody>
</table>

| Treatment significance¹ | * | ** | ** | ++ | * | * |
| Treatment MSD (0.1)     | 747 | 1192 | 1924 | 1.4 | 1.3 | 1.4 |
| Linear Contrast         | * | ** | ** | NS | ** | ** |
| Quadratic Contrast      | NS | NS | NS | NS | NS | NS |

¹ESN (Environmentally Smart Nitrogen, Agrium, Inc.) = 44-0-0; Duration (Agrium, Inc.) = 43-0-0; Urea = 46-0-0;
²P=Planting, E=Emergence, C=Cultivation, F=Fertigation.
³NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.