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# CONTROLLED RELEASE FERTILIZER POTATO PRODUCTION SYSTEM FOR FLORIDA

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*Abstract.* **Irish potato (*Solanum tuberosum* L.) is one of the top five valued vegetable crops in Florida. The majority of planted potato acres in the state are irrigated with seepage irrigation. The type of irrigation used, weather conditions during the potato season, and fertilization practices led to the development of best management practices that limit the application of nitrogen fertilizers during the season. BMPs reduce the potential movement of nitrate from potato fields into surrounding watersheds. A controlled release fertilizer (CRF) system was evaluated for potato production in Florida that helps growers meet the nitrogen BMPs while improving nitrogen use efficiency compared to conventional fertilizer practices. Over the past four seasons, 54 'CRF product by rate' combinations were evaluated and compared to a conventional fertilizer program. Two multi-acre grower trials in 2002 and 2003 validated successful treatments. The CRF treatments produced equal or better tuber yields and higher tuber quality while reducing nitrogen application rate by at least 25% compared to conventional fertilizer treatments at the BMP rate (N at 224 kg ha$^{-1}$). Although no firm product cost is yet set, product cost has dropped from over $1,200.00/acre to a range between $100 and $200/acre in 2003. In comparison, the grower conventional nitrogen program has ranged from $50 to $75/acre.**

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In 1987, the Florida legislature implemented the Surface Water Improvement and Management Act (Florida Statutes, Chapter 373.451-373.4595). This enabled the St. Johns River Water Management District (SJRWMD) to declare the St. Johns River in need of restoration. The SJRWMD, in collaboration with the University of Florida, multiple state government agencies, and the North Florida Grower's Exchange has developed "Best Management Practices" (BMP) for potato (*Solanum tuberosum* L.) production in the Tri-County (St. Johns, Putnam, and Flagler Counties) Agricultural Area (TCAA) (Livingston-Way et al., 2000). The purpose of BMP is to reduce the nitrate ($NO_3$) run-off from approximately 9,000 ha in potato production in the St. Johns River watershed.

Mean nitrogen (N) rate applied to potato in the TCAA is 285 kg ha$^{-1}$. This rate is between a high of 390 kg ha$^{-1}$ on some chip potato to a low of 195 kg ha$^{-1}$ on fresh market potatoes. The University of Florida's Institute of Food and Agricultural Science (IFAS) recommended N rate (224 kg ha$^{-1}$) be adopted as the BMP rate for the TCAA (Hochmuth et al., 2001). Provisions in the BMP program allow for additional N fertilization during seasons with leaching rains (Livingston-Way et al., 2002). However, depending on when leaching rains occur, growers may not be able to side-dress the crop prior to the critical bulking period resulting in reduced yields.

Controlled release fertilizer (CRF) technology could overcome the concerns of both growers and regulatory agencies by supplying nutrients to the crop while reducing the potential for off-site movement of nutrients. However, before a CRF can be used successfully in commercial potato production, a product or products need(s) to be identified or developed that releases nutrients at a rate that matches the uptake by the potato plant. Previous small plot research has demonstrated equal or improved yields and improved quality using similar CRF technology (Hutchinson et al., 2003). Therefore, the objective of this project was to evaluate the ability of CRFs to produce a potato crop of similar quality and quantity as conventional soluble fertilizers in an on-farm trial.

## Materials and Methods

The trial was conducted in 2002 and 2003 at a grower's farm in Hastings, Fla. Soil at the site was Ellzey fine sand (sandy, siliceous, hyperthermic Arenic Ochraqualf; sand 90-95%, < 2.5% clay, < 5% silt). The experiments were arranged in a randomized complete block design with four replications. Potato plants were grown on beds consisting of 16 rows with a between-row spacing of 102 cm; length of beds ranged from 150 m to 250 m. All data were collected from the center 12 rows of each plot to avoid the two rows on each side closest to the water furrow. Potato (var. 'Atlantic') seed pieces (approx. 0.07 kg) were planted using commercial equipment at 17.5 cm in-row spacing on 6 Feb. 2002 and 18 Feb. 2003.

Fertilizer treatments consisted of the grower standard program (GSP) and either one CRF treatment in 2002 (CRF1) or two CRF treatments in 2003 (CRF1 and CRF2). CRF1 in both seasons was a 50:50 blend of 37-0-0 (NPK) and 43-0-0 (NPK) polymer coated urea products designed to completely release by 120 and 75 d after application, respectively. CRF2 was a single polymer coated urea product applied at an N rate of 168 kg $ha^{-1}$ at hilling in 2003. Release characteristics for CRF2 were unknown except to note that it was designed to release early in the potato season. At this time, CRF manufactures cannot be identified. In both seasons, $K_2O$ and $P_2O_5$ at approximately 300 kg $ha^{-1}$ and 103 kg $ha^{-1}$, respectively, were incorporated pre-plant in all plots.

In 2002, the GSP totaled 207 kg $ha^{-1}$ of N (32-0-0, NPK) applied at hilling and in a single split when the plants were approximately 20-25 cm. CRF1 was broadcast at hilling and incorporated into the row (approximately 10 d after planting; DAP) at an N rate of 166 kg $ha^{-1}$.

In 2003, two CRF programs were compared to the GSP. The grower program totaled 334 kg $ha^{-1}$ of N (32-0-0, NPK) applied at hilling and in a double split prior to final working (approximately 50 DAP). CRF1 and CRF2 were applied at 166 and 164 kg $ha^{-1}$ of N at hilling in 2003, respectively, as described above. Because of leaching rains received in 2003 (7.5 cm in 3 d or 10 cm in 7 d), additional N was applied in the GSP as recommended by the BMP program (Livingston-Way et al., 2000).

The potato crop was managed following standard production practices for the area (Hochmuth et al., 2001). A perched water table was maintained between 46 and 71 cm below the top of the potato row during the season. Eight subplots were mechanically harvested from each plot on 22 May 2002 and 29 May 2003 (3.6 m each). Tubers were washed and graded with commercial equipment into five size classes (1 = < 4.8 cm, 2 = 4.8 to 6.4 cm, 3 = 6.4 to 8.3 cm, 4 = 8.3 to 10.2 cm, 5 = > 10.2 cm) and culls. Specific gravity (SG) was measured by the weight-in-air/weight-in-water method. Twenty tubers from each plot were cut into quarters and scored for percent hollow heart and internal heat necrosis (IHN). Data were analyzed with ANOVA using SAS (SAS Institute, Inc., Cary, N.C., USA) in 2003. Treatment means were separated using the least significant difference mean separation test and t-test.

## Results and Discussion

Plants in CRF1 in 2002 produced significantly more total and marketable tubers than plants in the grower fertilizer program (Table 1). Tubers in the CRF1 treatment were generally larger than tubers in the GSP with a similar specific gravity. There was no significant difference for hollow heart occurrence among treatments (Table 1). However, tubers from the CRF1 treated plants exhibited 28% less IHN than tubers in the GSP treatment (Table 1). In 2003, there was no significant difference between treatments for total yield, marketable yield, or tuber size (Table 2). Tubers from both CRF treatments had significantly lower specific gravities than GSP tubers. In addition, CRF treated tubers developed significantly more IHN than tubers in the GSP. There was no significant difference in the occurrence of hollow heart.

Environmental conditions were relatively similar between years except for a four week period from 3 to 6 weeks after planting. During this period, plots received 4.4 cm and 15.8 cm of rainfall in 2002 and 2003, respectively. In addition, during the same period, growing degree day accumulation was 386 and 562 [45 °F (7 °C) base] for both seasons, respectively.

In 2002, the CRF program resulted in a 20% savings in N fertilizer use and an improvement in tuber yield and quality. In 2003, the CRF program resulted in a 51% savings in N fertilizer use and a similar yield. Unfortunately, potatoes from the entire experiment, both GSP and CRF treatments, were unmarketable due to poor quality from IHN as were potatoes from approximately 25% of the Hastings potato acreage. IHN is a stress disorder exacerbated by high temperatures and low N availability (Ojala et al., 1990). In 2003, CRF N release rate was possibly not fast enough to discourage the development of IHN. However, no data were taken in the on-farm studies to prove or disprove this hypothesis. Nitrogen in the GSP was

Table 1. Production and quality statistics for 'Atlantic' potato grown using conventional and controlled release fertilizers at different nitrogen rates on a farm in Hastings, Fla. in 2002.

| | Total yield | Market yield[z] | Size class range (%)[y] | | | Internal tuber defects[w] (%) | |
|---|---|---|---|---|---|---|---|
| Fertilizer program (N rate) | MT $ha^{-1}$ | MT $ha^{-1}$ | 2 to 4 | 3 to 4 | SG[x] | HH | IHN |
| GP[v] (207 kg $ha^{-1}$) | 38.4 | 37.6 | 95.8 | 49.2 | 1.080 | 2.1 | 2.5 |
| CRF1 (166 kg $ha^{-1}$) | 40.7 | 40.2 | 96.7 | 54.7 | 1.078 | 0.4 | 1.8 |
| *p*-value | 0.039 | 0.025 | 0.031 | 0.046 | 0.129 | 0.088 | 0.025 |

[z]Marketable yield: size classes A1-A3.
[y]Size class range: A1 to A3 = 4.8 to 10.2 com; A2 to A3 = 6.4 to 10.2 cm.
[x]Specific gravity.
[w]HH, hollow heart; IHN, internal heat necrosis.
[v]Grower program.
[u]Means separated within columns by t-test.

Table 2. Production and quality statistics for 'Atlantic' potato grown using conventional and controlled release fertilizers at different nitrogen rates on a farm in Hastings, Fla. in 2003.

| | Total yield | Market yield[z] | Size class range (%)[y] | | | Internal tuber defects[w] (%) | |
|---|---|---|---|---|---|---|---|
| Fertilizer program (N rate) | MT ha$^{-1}$ | MT ha$^{-1}$ | 2 to 4 | 3 to 4 | SG[x] | HH | IHN |
| GP[v] (334 kg ha$^{-1}$) | 37.1 | 28.6 | 81.03 | 24.2 | 1.072 | 11.7 | 65.8 |
| CRF1 (166 kg ha$^{-1}$) | 35.7 | 26.0 | 78.8 | 19.3 | 1.068 | 4.2 | 87.7 |
| CRF2 (164 kg ha$^{-1}$) | 35.8 | 25.9 | 80.4 | 19.9 | 1.064 | 6.3 | 87.5 |
| LSD[u] | ns | ns | ns | ns | 0.006 | ns | 11.0 |
| *p*-value | 0.803 | 0.433 | 0.572 | 0.389 | 0.027 | 0.090 | 0.001 |

[z]Marketable yield: size classes A1-A3.
[y]Size class range: A1 to A3 = 4.8 to 10.2 com; A2 to A3 = 6.4 to 10.2 cm.
[x]Specific gravity.
[w]HH, hollow heart; IHN, internal heat necrosis.
[v]Grower program.
[u]Means separated within columns by t-test.

leached from the production area also resulting in N stress during this actively growing period for the potato. However, even with the ability to apply additional N in the BMP program, GSP and CRF program yields were not significantly different at harvest.

In conclusion, over four seasons of trials in the Hastings area, progress has been made in developing a CRF program for potatoes that significantly reduces costs but maintains production. Future research with the formulations used in this experiment should focus on CRF placement to maximize uptake by the potato plant and combinations of CRF and soluble nitrogen sources to improve early season N availability.

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