Controlled-Release Fertilizers for Potato Production in Florida[1]

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Controlled-release fertilizers (CRFs) are often called slow-release fertilizers (SRFs) or timed-release fertilizers. However, the terms CRF and SRF should not be used interchangeably. The Association of American Plant Food Control Officials defines CRFs as fertilizers that contain a plant nutrient in a form in which the plant uptake is delayed after application, or that provide a longer duration of nutrient availability compared to other quick-release fertilizers, such as urea. The main difference between CRF and SRF is that in CRF (usually coated fertilizer), the factors affecting the rate, pattern, and duration of release are well known and controllable, whereas in SRF, they are not well controlled. At soil temperatures under 25°C, a CRF must meet three criteria: (1) less than 15% of the CRF nutrients should be released in 24 hours, (2) less than 75% should be released in 28 days, and (3) at least 75% should be released by the stated release time (40–360 days) (Trenkel 1997). Widely used CRFs include Nutricote®, Osmocote®, Polyon®, andurea-formaldehyde. This publication discusses the use of CRFs—namely, coated fertilizers for potato production in Florida. Energy costs and thus fertilizer costs have escalated dramatically since 2005; therefore, costs for both traditional and CRF fertilization in potato production should be updated accordingly.

The recent emphasis on the development of vegetable production best management practices (BMPs) has prompted a re-examination of fertilization practices in Florida potato production. Considering the goals of the BMP programs, the use of CRFs has the potential to meet the production and environmental goals of both growers and regulatory agency personnel. Past IFAS research has demonstrated that a CRF program can reduce nitrogen (N) rates by 25–50 lb/acre without reducing crop yield or quality when compared to a traditional soluble N fertilizer program (uncoated urea and/or ammonium nitrate). Although CRF technology can improve N use efficiency, the high cost of the material has limited the adoption of CRF technology in potato production. However, the development of BMPs coupled with the cost-share potential of CRFs at the national, state, and/or local level has improved the chances for CRF use in potato production.

This publication compares the costs and benefits of a nitrogen CRF program with those of a traditional soluble N program in potato production. The cost of a soluble N fertilizer program can vary from grower to grower and from year to year based on manufacturing costs, N sources, and application rates. A range of possible costs and rates are detailed in Table 1. The BMP N rate for a soluble program is 200 lb N/acre and is included for comparison. Table 2

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lists several cost and rate combinations for a CRF program. There are several unknowns with the CRF program, the most important of which is material cost per ton. Other critical unknowns include the unpredictable climatic influences that may affect release timing of CRFs and their resulting effects on yield, as well as the number of leaching events, which can affect the efficacy of soluble source comparisons.

Soluble Nitrogen Source

Table 1 lists estimated costs for fertilizer application rates of traditional soluble N fertilizers in northeastern Florida over the past few years. A survey conducted in Flagler County in early 2011 indicated that the total production cost has sharply increased because of price increases in fuel and fertilizers. For example, the price of UAN-32 (urea ammonium nitrate solution 32-0-0) has increased from $152/ton in 2005 to $410/ton in 2008. In March 2011, the same fertilizer formula was sold for $440/ton in Putman County. The N costs range from $158 to $192/acre, which is equivalent to 6.2%–7.5% of the total cost for potato production ($3,057 for chipping potato to $4,148 for russet potato). To find the N cost for a specific farm or program, locate the cost of N per acre for the previous season at the top of the chart and move down the column to the appropriate N fertilizer rate.

CRF Nitrogen Source

IFAS research indicates that potato tuber quality and yield with a CRF program of 150–175 lb N/acre are comparable to those with a standard soluble fertilizer program at the BMP rate (200 lb N/acre). CRF prices used in this article are based on the fertilizer market in Florida. According to the listed prices from suppliers in Putman County, in March 2011 the prices of CRFs ranged from $1,200 to $1,300 per ton. Accordingly, the per-acre cost would be $209–$265 (Table 2). Published data from the IFAS Food and Resource Economics Department's website indicates that the total cost of potato production is $3,057 and $4,148, respectively, for chipping and russet potatoes. Therefore, the projected cost of N from a CRF program is in the range of 6.9%–8.0% of the total cost of potato production (Table 2).

Benefits of CRF use

Tables 1 and 2 show the potential costs for both the soluble and CRF fertilizer programs. The most expensive highlighted CRF program ($285/acre) is 1.4 and 0.6 times more expensive than the least and most expensive highlighted traditional fertilizer programs ($120 and $180/acre), respectively. These have changed much since 2003 (Hutchinson and Simonne 2003). Although the costs are not yet comparable, the benefits of a CRF program compared to a traditional fertilizer program are as follows:

1. A CRF program requires only one preplant fertilizer application. However, a traditional fertilizer program needs multiple applications (application number dependent on season). The Florida BMP program recommends at least a single split application (two trips) when traditional N sources are used. Each trip for fertilization across the field costs between $5 and $7/acre for broadcasting.

2. A polymer-coated CRF releases nutrients at a rate that is dependent upon soil temperature rather than soil moisture. Therefore, during potato growing seasons with substantial rain, N in the CRF prill remains in the field and does not leach into the watershed. The current BMPs for the traditional fertilizer program allow up to 30 lb N/acre to be added during the season after each leaching rain event to replace leached fertilizer. In the 2003 season, some growers applied an extra 90 lb N/acre as part of the BMP program because of the substantial rainfall (total 290 lb N/acre for BMP program in 2003). No additional N was necessary with the CRF program (150–175 lb N/acre in 2003). In the Hastings area, the use of CRFs can ensure that potatoes receive sufficient nutrients regardless of heavy rain events.

3. The CRF program improves N use efficiency and potentially reduces N leaching risk. A greater percentage of applied N makes it into the crop when fertilized with a CRF as compared to a traditional N fertilizer source. This is because CRFs release N slowly over the season as the crop needs it. Accordingly, there is less opportunity for N to leach into the groundwater with a CRF program. CRF N rates of 175 and 150 lb/acre translate into a yearly N savings of 450,000–900,000 lb in the St. Johns River watershed production area compared to the BMP N rate of 200 lb/acre. By reducing the CRF N rate below the BMP rate, potato producers and manufacturers can develop goodwill with the public while reducing the potential for nitrate to enter the watershed, thus improving water quality in the Lower St. Johns River Basin.

4. The CRF program reduces the potential for ammonia volatilization and nitrous oxide emissions and improves air quality and operational efficiencies of N fertilization. With fewer trips across the field to apply fertilizer and less worry during rainy seasons, the producers can spend more time marketing potatoes and doing other things to improve the profitability of potato production. Appropriate soil placement of CRF is critical to ensuring the crop's

effective use of it and to preventing CRF prills from being washed away during heavy rain events.

5. Under the same amount of nitrogen, compared with soluble N, CRFs increased marketable tuber yield by 69%–80% (Table 3). Tuber yield produced by using equal amount of the three CRFs at total N of 168 kg/ha (150 lb/acre) was as much as 26% more than that obtained with conventional N fertilizer, ammonium nitrate, at total N of 224 kg/ha (200 lb/acre). At 168 kg/ha N rate, the margin marketable tuber yield was only 89 kg/kg N for the conventional soluble fertilizer. The corresponding margin yield was as much as 201 kg/kg N for CRFs. The margin marketable yield means that marketable tuber yield increment is produced by an additional unit of N after a particular N rate. These data suggest that CRFs may increase potato yield potential under the same growth conditions.

In Florida at the beginning of the growing season, soil temperature is low. This can slow nutrient release from CRFs, but traditional soluble N fertilizers work well. Recent research results show that using half traditional fertilizer and half CRFs can reduce leaching potential, enhance potato tuber yield, and may be more affordable than the full CRF application rate.

CRF is more expensive than a traditional soluble fertilizer on a per unit basis, which limits adoption of the new technology. The use of CRF would likely increase if CRF costs were shared by all parties that have a stake in improving water quality in the St. Johns River watershed. In this simple model, the cost of a traditional N fertilizer program in most years falls between $120 and $180/acre based on the current N fertilizer price (Table 1). Estimated CRF program costs (Table 2) would be approximately $29–$105/acre more than the most expensive soluble N cost ($180/acre, Table 1). If this cost difference were supported 100% by local, state, or national regulatory agency funds, the cost-share program would require between $522,000 and $1,890,000 annually to be fully funded. The Northeast Florida potato crop is valued at approximately $163 million. The cost-share program costs would be a relatively small cost to keep a Northeast Florida business with a potential $163 million annual return solvent.

These numbers serve as a starting point for discussion regarding the value of using CRFs in potato production in the St. Johns River watershed. There are approximately 18,000 acres of potatoes in the St. Johns River watershed that can benefit from a CRF program. There are also well over 100,000 acres of other vegetable crops on seepage irrigation across Florida that could benefit from a CRF program. This acreage increases greatly if one considers all the production areas in the United States where N may be negatively impacting surrounding watersheds. A CRF program can be a win-win-win opportunity for producers, manufacturers, and regulatory agencies by helping all meet their production, business, and environmental goals.

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Table 1. Traditional soluble fertilizer program costs per acre using a blend of urea and ammonium nitrate with a final grade of 32-0-0

Rate	Price ($/ton product)[z]			% total potato
(lb N/acre)	440	450	460	production costs[y]
	Traditional fertilizer cost (per acre)			
150	103	105	108	-
175	120	123	126	3.0–3.9
200	138	141	144	3.5–4.5
225	155	158	162	3.9–5.1
250	172	176	180	4.3–5.6
275	189	193	198	-
300	206	211	216	-[x]

[z]One ton of 32-0-0 material would fertilize 3.2 acres at the BMP nitrogen rate (200 lb N/acre).
[x]Total production costs range from $3,057 to $4,148.[y]Some potato producers may use up to 300 lb/acre in total when there are heavy rain events in the growing season.

Table 2. Alternative CRF program costs per acre using a polymer-coated urea with a final grade of 43-0-0

Rate	Price ($/ton product)[z]			% total potato
(lb N/acre)	1,200	1,300	1,400	production costs
	Controlled-release fertilizer cost (per acre)			
125	174	189	203	
150	209	227	244	5.9–6.8
175	244	265	285	6.9–8.0
200	279	302	326	
225	314	340	366	

[z]One ton of 43-0-0 material would fertilize 5.7 and 4.9 acres at 150 and 175 lb N/acre, respectively.

Table 3. Differences in yield and tuber quality of 'Atlantic' potato grown with either conventional or CRF fertilizers at different N rates (Hutchinson 2005)

N source	N rate	Total yield	Marketable yield	Relative yield[z]	Yield increment	Tuber size	Specific gravity
	(kg/ha)	(Mt/ha)	(Mt/ha)	(%)	(%)	(> 6.4 cm %)	
Control	0	11.5	8.4	35.9	0	3	1.060
Ammonium nitrate	168	29.0	23.4	100.0	178.6	43	1.072
Ammonium nitrate	224	40.8	36.1	154.3	329.8	53	1.078
42-42-16[y]	168	43.2	39.5	168.8	370.2	55	1.080
0-67-33	168	43.8	40.5	173.1	382.1	56	1.082
33-33-33	168	45.8	42.2	180.3	402.4	57	1.082

[z]Relative yield is defined as a percentage of the tuber yield produced with CRFs or 0 or 200 lb/acre (224 kg/ha) ammonium nitrate compared to the yield with 150 lb/acre (168 kg/ha) ammonium nitrate.
[y]Three CRFs—A, B, and C—designed to release N at approximately 45, 75, and 120 days, respectively, were used at the University of Florida's Plant Science Research and Education Unit in Hastings, Florida. The three CRFs were blended in the proportions indicated.