Response of Warm-Season Vegetable Crops to Controlled-Release N in the Low Desert Southwestern U.S. (Year 2)

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Simplot

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Introduction

Nitrogen (N) is the nutrient most limiting to crop production in the southwestern United States. Because of the rigid produce quality standards enforced by the market, vegetable crops receive appreciable amounts of N fertilizer for optimal yield and quality. There is concern that N fertilization of vegetables in Arizona and California may be contributing excess amounts of nitrate in ground water. One survey indicated that Arizona ranked third among the 50 states in the percentage of wells testing above the EPA standard of 10 ppm nitrate-N (Fedkiw, 1991). California ranked fifth in this survey. The Arizona Legislature has recently mandated the implementation of Best Management Practices (BMPs) by Arizona growers to reduce the potential risk of N fertilization to ground water (State of Arizona Revised Statutes, Arizona Environmental Quality Act, 1987). The State of California has called for voluntary implementation of BMPs. These practices generally involve timing, amounts, and placement of N and irrigation water application (Doerge et al., 1991). The use of slow-release N fertilizer sources is another promising option.

Controlled-release N (CRN) sources have shown positive results for vegetable production. Maynard and Lorenz (1979) concluded that the higher cost of CRN sources currently limits their use to high-value crops under conditions of high leaching and denitrification. Early work in Arizona has shown CRN sources to be highly effective for lettuce under some conditions (Pew et al., 1983, 1984). Recent work in the low desert of Arizona evaluated the response of lettuce, broccoli, and cauliflower to CRN fertilizer. The use of CRN was compared to soluble N fertilizers applied preplanting and soluble N fertilizers applied in split-side-dress applications (Sanchez and Doerge, 1999). Additionally, alternative N management practices were evaluated. Rates of N fertilizer ranged from 0 to 300 kg N ha^{-1}. When conditions for N losses were high, CRN and SD management were superior. There was also variation in the efficacy of the various CRN technologies. Under several production scenarios, the use of CRN strategies was economically favorable. The objective of this experiment was to evaluate two Simplot-formulated CRN management programs (GAL-Xe® 43 and 44) for tomato, watermelon, chili pepper, and sweet corn.

Materials and Methods

Tomato

These studies were conducted on soil mapped as Superstition sand (sandy, mixed, hyperthermic Typic Calciorthid). The treatments included an untreated control, two rates (100 and 200 kg N/ha) of urea applied in two applications (33% preplanting and 66% in one side-dress application), and the same two rates of two CRN products (GAL-Xe 43 and 44) applied preplanting. In 2013 we split the soluble N in three applications, but in 2014 we did it in two applications to simulate the more common practice by growers. These N rates did not include the 45 kg N/ac that was applied with the MAP (11-52-0) for preplant P fertilization. All preplant fertilizers were applied to listed beds and power-mulched into the beds. The experiment design was randomized complete block with four replications. Individual plots were 60 m^2. Other than the N treatments, the tomato was fertilized and pests were controlled using standard practices.

Tomato transplants (cv. Mountain Fresh Plus) were seeded in a commercial greenhouse in January. These transplants were placed in the field with a mechanical transplanter on March 11, 2014. The plants were set on a 45 cm spacing and in the center of 1 m wide elevated beds. The stands were established by sprinkler irrigation. After establishment, all required irrigations were applied by level (no slope) furrows. Soil samples were collected midseason to determine residual ammonium and nitrate N. Petiole samples were collected at the same time to determine N nutritional status.

Tomato harvest began at maturity (May 23) by picking and weighing all marketable fruit from 4 m of row. Harvests continued through June 27. Marketable yield was determined after grading using standard practices. Statistical analyses were performed using SAS (SAS Institute, 1999a and 1999b).

Watermelon

These studies were conducted on soil mapped as Superstition sand (sandy, mixed, hyperthermic Typic Calciorthid). The treatments included an untreated control, two rates (100 and 200 kg N/ha) of urea applied in two applications (33% preplanting and 66% in one side-dress application), and the same two rates of two CRN products (GAL-Xe 43 and GAL-Xe 44) applied preplanting. These N rates did not include the 45 kg N/ac that was applied with the MAP (11-52-0) for preplant P fertilization. All preplant fertilizers were applied to listed beds and power-mulched into the beds. The experiment design was randomized complete block with four replications. Individual plots were 60 m^2. Other than the N treatments, the watermelon were fertilized and pests were controlled using standard practices.

Watermelon transplants (cv. Millionaire) were seeded in a commercial greenhouse in January. These transplants were placed in the field with a mechanical transplanter on March 11, 2014. The plants were planted on a 60 cm spacing and centered on 2 m wide elevated beds. The stands were established by sprinkler irrigation. After establishment, all required irrigations were applied by level (no slope) furrows. Soil samples were collected midseason to determine residual ammonium and nitrate N. Midrib samples were collected at the same time to determine N nutritional status.

Watermelon harvest began at maturity (May 23) by picking and weighing all marketable fruit from 6 m of row. Harvests continued through June 27. Marketable yield was determined after grading using standard practices. Statistical analyses were performed using SAS (SAS Institute, 1999a and 1999b).

Sweet Corn

This study was a demonstration-experiment conducted in a grower's field in the Coachella Valley, California. The field was mapped as Coachella very fine sand (sandy, mixed, hyperthermic Typic Torrifluvent). The treatments included the grower standard practice (GSP), which was frequent applications of soluble fertilizer applied through the drip lines (115 gal AN20 or 245 kg N/ha) and mixed programs containing two rates (100 and 200 kg N/ha) GAL-Xe 43 and 44 CRN fertilizers. Due to grower anxiety, these CRN treatments also received 28 gal/ac AN20 (another 60 kg N/ha).

Phosphorus fertilizer was applied preplanting as 50 gallons of 3-35-0. The acid P material was banded below the seed. All preplant CRN fertilizers were applied to listed beds and power-mulched into the beds.

Sweet corn was seeded February 20. The crop was established by sprinklers. Thereafter, plots were irrigated by buried drip line where the plots with CRN products only received a subset of the fertigations by closing the valve on the rows containing CRN fertilizers.

The corn leaves opposite and below the primary ear were collected midseason, dried, and ground for analyses. Soil samples were also collected from each plot midseason to determine exchangeable ammonium and nitrate-N.

Corn was harvested at maturity (May 9, 2014), graded, and weighed. Statistical analyses were performed using SAS (SAS Institute, 1999a and 1999b).

Chili Peppers

These studies were conducted on soil mapped as Casa Grande (fine-loamy, mixed, hyperthermic, Typic Natriargid (reclaimed)). The treatments included an untreated control, two rates (100 and 200 kg N/ha) of urea applied in three applications (33% preplanting and 33% in each of two side-dress applications), and the same two rates of two CRN products (GAL-Xe 43 and 44) provided by Simplot and applied preplanting. These N rates did not include the 40 kg N/ac that was applied with the MAP (11-52-0) for preplant P fertilization. The CRN products were banded with a calibrated Clampco dry fertilizer applicator. This was in contrast to the last year (2013) when the CRN products were power-mulched into the beds.

The experiment design was randomized complete block with four replications. Individual plots were 60 m^2. Other than the N treatments, the peppers were fertilized and pests were controlled using standard practices.

Chili transplants (cv. Sandia Hot) were planted in a commercial greenhouse in January. These transplants were placed in the field with a mechanical transplanter on March 29, 2012. The plants were planted on a 30 cm spacing and on 1 m wide elevated beds. The stands were established by sprinkler irrigation. After establishment, all required irrigations were applied by drip irrigation.

Red chilis were harvested once over on August 18, 2014. Marketable yield was determined after grading using standard practices. Statistical analyses were performed using SAS (SAS Institute, 1999a and 1999b).

Results

Tomato

There were trends for petiole N and soil N to increase to N rate and CRN management but the differences were not always statistically significant (Tables 1 and 2). Marketable tomato yield significantly increased to N rate (Tables 3 and 4). Further, early yields and cumulative yields were appreciably higher for tomato plants receiving CRN sources compared to the standard approach of split application with soluble N fertilizers. Although cumulative yields for conventional programs and the CRN programs were similar by the fifth harvest, early yields have more value and the CRN programs consistently increased yield through the fourth harvest compared to the soluble N management.

N (kg/ha)	N Management	Petiole N (%)
0		2.01
100	GSP	1.84
200	GSP	1.97
100	CRN 44	1.70
200	CRN 44	2.31
100	CRN 43	1.86
200	CRN 43	2.33
LSD (P=0.05)		0.44

Table 1. Petiole N content of tomato to N rate and N management.

N (kg/ha)	N Management	NH_4-N (mg/kg)	NO_3-N (mg/kg)
0		6.6	5.2
100	GSP	6.9	4.3
200	GSP	6.5	7.2
100	CRN 44	6.8	10.9
200	CRN 44	7.4	9.5
100	CRN 43	6.7	3.2
200	CRN 43	8.2	11.6
LSD (P=0.05)		0.8	NS

Table 2. Soil ammonium and nitrate-N midseason to N rate and N management.

N (kg/ha)	N Management	Harvest Date					
		5/23	5/30	6/6	6/13	6/20	6/27
		MT/ha					
0		0.37	0.91	3.89	3.98	3.36	7.37
100	GSP	0.29	0.88	4.96	9.65	6.71	5.89
200	GSP	0.26	1.03	6.47	10.58	12.39	12.02
100	CRN 44	1.34	1.32	8.53	12.22	4.35	4.25
200	CRN 44	0.89	1.33	8.27	11.31	8.53	9.77
100	CRN 43	2.29	1.88	7.90	12.03	5.37	6.00
200	CRN 43	1.38	1.76	8.77	7.02	7.37	8.50
LSD (P=0.05)		1.09	NS	4.86	3.94	4.47	4.96

Table 3. Marketable tomato yield each harvest date to N rate and N management.

N (kg/ha)	N Management	Harvest Date					
		5/23	5/30	6/6	6/13	6/20	6/27
		MT/ha					
0		0.37	1.29	5.17	9.15	12.51	19.88
100	GSP	0.29	1.16	6.13	15.78	22.49	28.38
200	GSP	0.26	1.29	7.76	18.34	30.73	42.76
100	CRN 44	1.34	2.65	11.18	23.41	27.76	32.00
200	CRN 44	0.89	2.21	10.49	21.79	30.32	40.09
100	CRN 43	2.29	4.16	12.06	24.09	29.47	35.47
200	CRN 43	1.38	3.14	11.91	18.93	26.29	34.80
LSD (P=0.05)		1.09	1.54	5.48	8.01	7.96	9.14

Table 4. Cumulative tomato yield by each harvest date to N rate and N management.

Watermelon

Overall watermelon petioles collected midseason showed few meaningful differences (Table 5). However, inorganic soil N showed a consistent trend to increase with N rate and CRN programs (Table 6). Watermelon yields increased by N rate and early yields were higher for the CRN programs compared to the split application of soluble N fertilizer (Tables 7 and 8). It seems the cumulative yields for the soluble N programs caught up later in the season. However, it should be noted that markets are much better for watermelon harvested prior to the Memorial Day holiday, and the early yields associated with the CRN programs are of economic importance.

N (kg/ha)	N Management	Petiole N (mg/kg)
0		0.88
100	GSP	0.90
200	GSP	0.95
100	CRN 44	0.69
200	CRN 44	1.13
100	CRN 43	0.81
200	CRN 43	0.88
LSD (P=0.05)		0.41
LSD (P=0.10)		

Table 5. Petiole nitrate-N of watermelon to N rate and N management.

N (kg/ha)	N Management	NH_4-N (mg/kg)	NO_3-N (mg/kg)
0		6.8	5.6
100	GSP	7.1	7.5
200	GSP	7.2	8.5
100	CRN 44	7.2	15.8
200	CRN 44	8.5	24.2
100	CRN 43	7.1	14.6
200	CRN 43	8.3	20.9
LSD (P=0.05)		1.5	17.9

Table 6. Soil ammonium and nitrate-N midseason to N rate and N management in watermelon experiment.

N (kg/ha)	N Management	Harvest Date					
		5/23	5/30	6/6	6/13	6/20	6/27
		MT/ha					
0		3.0	6.2	10.5	2.6	0.6	6.5
100	GSP	3.5	7.6	8.7	6.4	0	11.0
200	GSP	3.3	5.1	8.6	3.3	0.3	14.5
100	CRN 44	5.9	4.5	6.2	3.8	1.8	8.1
200	CRN 44	6.8	8.9	9.9	0.8	0.6	10.5
100	CRN 43	5.1	5.2	11.8	4.9	0.3	5.9
200	CRN 43	8.7	6.2	8.7	1.2	0.2	10.4
LSD (P=0.05)		4.7	NS	NS	4.9	1.8	NS

Table 7. Marketable watermelon yield each harvest date to N rate and N management.

N (kg/ha)	N Management	Harvest Date					
		5/23	5/30	6/6	6/13	6/20	6/27
		MT/ha					
0		3.0	9.3	19.8	22.3	22.9	29.4
100	GSP	3.5	11.1	19.8	26.3	26.3	37.3
200	GSP	3.4	8.5	17.1	20.4	20.6	35.2
100	CRN 44	5.9	10.4	16.6	20.4	22.2	30.3
200	CRN 44	6.8	15.7	25.6	26.4	27.0	37.5
100	CRN 43	5.1	10.2	22.0	27.0	27.3	33.1
200	CRN 43	8.7	14.9	23.6	24.8	25.0	35.4
LSD (P=0.05)		4.7	NS	7.7	NS	NS	NS

Table 8. Cumulative watermelon yield by each harvest date to N rate and N management.

Sweet Corn

Overall, differences in ear quality were of minimal importance (Table 9). Although GAL-Xe 44 seemed to produce larger ears, it also slightly increased unfilled tips. Unfortunately, we lost the soil samples for the GSP treatment. Among the CRN treatments there were no differences in inorganic N. Yields increased to CRN management compared to the grower practice of 100% AN20 applied through the drip. There were no differences among the CRN treatments. Thus, 100 kg/ha CRN and 28 gal AN20 produced yields superior to 115 gal AN20.

N (kg/ha)	N Management	Ear Length (cm)	Unfilled tip (cm)	Leaf N (%)	NH_4-N (mg/kg)	NO_3-N (mg/kg)	Marketable yield (MT/ha)
GSP	AN20	18.4	0.7	1.22	nd	nd	33.9
100	CRN 43	18.5	1.0	1.30	4.4	23.8	43.8
200	CRN 43	18.5	1.1	1.14	5.1	36.6	48.3
100	CRN 44	19.0	1.4	1.17	7.1	28.2	49.9
200	CRN 44	19.3	1.3	1.52	4.8	28.5	46.1
LSD (P=0.05)		0.7	0.6	0.59	NS	NS	9.8

Table 9. Average ear length, unfilled tip, leaf N, inorganic soil N, and marketable yield of sweet corn to fertilizer N.

Chili Peppers

Leaf N midseason generally increased to N rate and CRN program (Table 10). Further, soil inorganic N levels midseason were affected by N rate and source in the chili pepper experiment (Table 10). The conventional soluble program showed higher ammonium-N, reflecting a recent side-dress application (Table 11). Generally, the CRN programs had higher available nitrate-N midseason.

Despite a general trend for increased N availability to CRN, there were no statistically significant differences in chili yield to treatments (Table 12).

N (kg/ha)	N Management	Leaf N (mg/kg)
0		2.29
100	GSP	2.34
200	GSP	2.75
100	CRN 44	2.52
200	CRN 44	2.74
100	CRN 43	2.60
200	CRN 43	2.71
LSD (P=0.05)		0.36

Table 10. Leaf-N of chili to N rate and N management.

N (kg/ha)	N Management	NH_4-N (mg/kg)	NO_3-N (mg/kg)
0		4.1	13.4
100	GSP	17.9	13.1
200	GSP	16.7	14.8
100	CRN 44	4.2	13.6
200	CRN 44	4.5	46.3
100	CRN 43	4.1	39.3
200	CRN 43	5.1	47.0
LSD (P=0.05)		11.4	31.0

Table 11. Soil ammonium and nitrate-N midseason to N rate and N management in chili experiment.

N (kg/ha)	N Management	MT/ha
0		5.2
100	GSP	5.0
200	GSP	5.8
100	CRN 44	3.1
200	CRN 44	5.8
100	CRN 43	6.1
200	CRN 43	5.4
LSD (P=0.05)		NS

Table 12. Marketable red chili yield each harvest date to N rate and N management.

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