Table 5. Correlation coefficients[z] of the 3 major cations and nitrate anion on soil test values for pH, I & B survey, 1976-77.

Position	Depth, in.	K	Ca	NO_3	Mg
Between rows	0-2	NS[y]	NS	.17	NS
	2-4	NS	NS	.31	NS
	4-8	.27	.18	NS	NS
Fertilizer band	0-2	–.27	–.25	NS	–.24
	2-4	–.50	–.71	–.77	–.71
	4-8	–.57	–.47	–.51	–.56
Near plant row	0-2	–.30	NS	–.46	–.37
	2-4	–.37	–.60	–.65	–.59
	4-8	–.18	–.24	–.48	–.31
Plant row	0-2	–.27	NS	–.45	NS
	2-4	–.20	–.51	–.42	–.51
	4-8	–.27	–.49	–.43	–.42

[z]Correlations significant at the .01 level of significance.
[y]Entries denoted by NS were not significant at the 0.05 level.

pollution. Perhaps the increasing cost of fertilizer will provide this needed governance.

Table 6. Bed mean values, intensity and balance survey, 276 commercial tomato soil tests, southwest Florida, 1976-77.

Factor evaluated	Value noted	Percent of total	Acceptable range[z], or percent of total
Total soluble salts	10,269 ppm	100.0	4500-5500
pH	6.5	—	5.5-6.5
Potassium	1,270	12.4	8-10
Calcium	353	3.4	8-10
Sodium	255	2.5	0-10
Nitrate nitrogen	463	4.5	3-10
Ammonium nitrogen	143	1.4	0-10
Magnesium	265	2.6	3-5
Chlorine	321	3.1	0-10

[z]Acceptable range for tomatoes from Geraldson (2).

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CONTROLLED RELEASE FERTILIZERS: EFFECT OF RATES AND PLACEMENTS ON PLANT STAND, EARLY GROWTH AND FRUIT YIELD OF PEPPERS[1]

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Abstract. **Osmocote (15-5-21)[2] and a blended fertilizer (10-12-11)[3] containing 50% Osmocote were used in 2 tests as starter fertilizer to evaluate their effect at different rates and placements on plant stand, early plant growth and yield of mulched sweet pepper (*Capsicum annum* L.). Included for comparison was 1 rate and 1 placement of a highly soluble fertilizer. In the first test (fall 1976), early plant growth was retarded with the soluble fertilizer and yields were significantly influenced by source, rate and placement of starter fertilizer. Plant stand was not affected by any treatment. In the second test (spring 1977), only the rate of controlled release starter fertilizers had a significant influence on yield. Both plant stand and yield were lower with soluble fertilizer than with either of the controlled release fertilizers.**

Two problems have become evident with the advent of the plastic mulch system for pepper production where seep-irrigation is used. Both problems, which appear to be associated with source and placement of starter fertilizer, have their main effect when plants are in the seedling stage.

The first problem, which is most serious during dry weather, results when excessive salts from readily soluble starter fertilizers are placed too close to the seedling and are held there by water moving upward from a perched water table (2). This causes injury and/or death of the seedling, which necessitates considerable re-setting, nonuniformity of plant growth and yield reduction. Excessive salts near seedlings have been successfully reduced by overhead or top watering, but this requires extra expense in equipment, labor and energy (3, 5).

The second problem, which develops mainly during wet weather, occurs when water from frequent rains enters the planting holes and moves soluble plant nutrients down and away from the limited root system of seedlings (unpublished data). With this situation the seedlings usually do not die but become chlorotic and early growth is retarded. If not corrected, this stunted condition can last for several weeks during the rainy season. When the frequency of rains decreases and seep-irrigation is applied, soluble nutrients move upward nearer the roots and the seedlings resume growth. However, by this time, plants seldom attain a desired size prior to fruit-set.

Although the 2 problems outlined above are opposite in their effect on seedlings, both are associated with soluble nutrients (excess or deficiency) early in the life of the plant. Since controlled release fertilizers have both the properties

[1]Florida Agricultural Experiment Stations Journal Series No. 841.
[2]Furnished by Sierra Chemical Company, Milpitas, CA.
[3]Furnished by Florida East Coast Fertilizer Company, Homestead, FL.

of low salt index and resistance to leaching, it seemed that their use as starter fertilizers might help solve both problems.

Materials and Methods

In the first test (fall 1976), 4 rates and 3 placements of Osmocote (15-5-21, 4 months release) and a blended fertilizer (10-12-11) containing 50% Osmocote (14-14-14) were used as starter fertilizers to evaluate their effect on plant stand, early growth and yield of mulched pepper. The remaining plant nutrients in the 10-12-11 fertilizer were derived from ammonium nitrate, urea-form, activated sludge, triple superphosphate, potassium carbonate and sulfate, sulfate-potash-magnesia, and fritted micronutrients. Included for comparison was 1 rate and 1 placement of 18-0125, a highly soluble fertilizer derived from potassium and ammonium nitrates. Starter fertilizer rates for the controlled release materials were equivalent to 0, 30, 60, or 90 lb N/acre. These amounts of fertilizer were divided with one-half applied to each plant row on the double-row bed. For example, at the 30 lb N/acre rate, Osmocote (15% N) would be applied at 1.4 lb/100 row ft. Fertilizer placements were: (a) narrow band 2 inches below plant row, (b) narrow band 2 inches below and 2 inches to 1 side of plant row, and (c) 4 inch band on bed surface directly over the plant row. The 18-0-25 soluble fertilizer was broadcast in a 24 inch wide band on the bed surface at a rate equivalent to 36 lb N/acre. This placement has been suggested when using highly soluble fertilizer as a starter under mulch (4). In the second test (spring 1977), the highest rate of each controlled release material was eliminated. Otherwise, treatments in the 2 tests were the same. Superphosphate and micronutrients were mixed in the plant bed for all plots except the non-fertilized check. Plots were arranged in randomized complete blocks with 3 replications of each treatment.

To isolate the salt effect of starter fertilizer on plant stand, no fertilizer except the starter was applied in the first test. In the second test, 18-0-25 equivalent to 180 lb N/acre was applied in bands on the bed shoulders on all treatments receiving starter fertilizer. If no starter fertilizer was applied, 18-0-25 on the bed shoulder was increased to compensate for the N supplied by the starter.

Container grown pepper (cv. 'Early Cal Wonder') seedlings were transplanted in double rows on beds spaced 6 ft apart on September 7 and February 28 for the fall and spring tests, respectively. In-row spacing of pepper was 10 inches, giving a plant population equivalent to 17,428 plants/acre. Four plant stand counts were made at weekly intervals beginning approximately 1 week after transplanting. After each count, dead and damaged plants were removed but not replaced. A final count was made just prior to first harvest. Plant height measurements were made 3 weeks after transplanting and just prior to first harvest. Two harvests of pepper fruit were made from each test.

Total soluble salt (T.S.S.) was determined by the saturated paste extract method (1) on soil samples (0-2 inch and 2-4 inch depths) from the planting hole near the seedlings. Prior to analysis, all samples were screened to remove non-reacted fertilizer particles, particularly Osmocote pellets.

Results and Discussion

Plant stand. In the fall 1976 test, which was started during the rainy season, there was no significant effect on seedling mortality due to rate or placement of starter fertilizer regardless of source, i.e. controlled release or highly soluble. At first harvest plant stands ranged from 94 to 100%. In the test conducted in the spring 1977, a dry season in which seep-irrigation was applied continuously, there was no significant difference in plant stand among any of the controlled release fertilizer treatments. Plant stands varied from 92 to 100%. However, stands were reduced to 80% with the highly soluble 18-0-25 fertilizer as compared to 100% in the check plots as well as several other treatments.

Plant growth. Plant ht measurements made 3 weeks after transplanting in the fall season indicated a significant growth reduction when either of the controlled release fertilizers was placed 2 inches below and 2 inches to the side (Placement b) of each plant row and a highly significant reduction with the 18-0-25 starter fertilizer broadcast in 24 inch band on bed surface. Plants in the latter treatment averaged 5.5 inches, while those in the better treatments and check plots (no fertilizer) averaged 8.1 and 4.9 inches, respectively. Starter fertilizer rates did not significantly affect plant ht except in the check plots where the plants were significantly shorter. Just prior to first harvest the relationship between treatments and plant height was the same as found at 3 weeks after transplanting, except there was no significant difference between the controlled release fertilizers and the highly soluble 18-0-25. In the spring season there was no significant difference in the plant ht, early or late, among the various treatments. However, plants tended to be slightly shorter where either of the controlled release fertilizers was banded on the bed surface directly over the plant row (Placement c).

Yield. Table 1 shows the main effects of rate and placement of controlled release starter fertilizers on yield and fruit size for the fall 1976 and spring 1977 seasons. Although yield evaluation was not the primary objective in the fall of 1976, when no fertilizer other than starter was applied, the yields did reflect the influence of early growth on obtaining good production. In general those treatments producing higher yields also showed a better early growth and less lag time after transplanting. The almost linear effect of rate may be expected since only starter fertilizer was applied. This was confirmed in the spring 1977 test when there was no significant yield difference between the 30 and 60 lb N/acre rates.

Table 1. Main effect of source, rate and placement of starter fertilizer on marketable yield and average weight of pepper.

Treatment	Fall 1976[z]		Spring 1977[y]	
	bu/acre[x]	oz/fruit	bu/acre[x]	oz/fruit
Source				
Osmocote (15-5-21)	411	3.9	1289	5.1
10-12-11 (50% Osmocote)	444	4.0	1246	4.9
L.S.D. .05	21	N.S.	N.S.	N.S.
Rate (lb N/acre)				
0	111	2.7	1067	4.7
30	360	3.7	1289	4.9
60	455	4.1	1247	5.0
90	483	4.3		
L.S.D. .05	30	0.3	88	0.2
Placement[w]				
a	463	4.1	1246	5.1
b	407	3.9	1267	5.1
c	428	4.1	1232	4.9
L.S.D. .05	27	N.S.	N.S.	N.S.

[z]No fertilizer applied except starter.
[y]18-0-25 at 1000 lb/acre applied on bed shoulder in addition to starter.
[x]1 bu = 27 lb.
[w]a—2 in. below plant row. b—2 in. below and 2 in. to one side of plant row. c—4 in. band on bed surface directly over plant row.

Table 2 shows the effect on yield, fruit size and plant stand of the controlled release starter fertilizers and the highly soluble 18-0-25 all applied at approximately 30 lb N/acre. In the fall test (rainy season), lower yield with the highly soluble 18-0-25 was associated with slow early growth rather than reduction in plant stand. The lag time between transplanting and growth initiation with 18-0-25 starter was much longer than with either of the controlled release materials. Transplants receiving the soluble 18-0-25 were just beginning to green-up and initiate growth 2-3 weeks after transplanting. The reverse was true in the spring test (dry season) when low yields with 18-0-25 starter were associated with a reduction in plant stand (Table 2) rather than slow early growth. Both yield and plant stand were reduced by approximately 15% with 18-0-25 starter. This indicates that yield per plant was approximately the same for all sources.

Total soluble salts (T.S.S.). Tables 3 and 4 show T.S.S. concentrations in the soil of the planting hole near the seedlings during the fall 1976 and spring 1977, respectively.

Table 2. Effect of 3 sources of starter fertilizer on marketable yield, fruit size and final plant stand.

Source[z]	Fall 1976[y]			Spring 1977[x]		
	Marketable yield		Plant stand	Marketable yield		Plant stand
	bu/acre[w]	oz/fruit	%	bu/acre[w]	oz/fruit	%
Osmocote (15-5-21)	380	3.7	97	1259	5.0	98
10-12-11 (50% Osmocote)	413	3.9	95	1232	4.9	95
18-0-25 (soluble)	320	3.5	92	1086	4.9	81
L.S.D. .05	26	0.3	N.S.	143	N.S.	5

[z]18-0-25 applied on bed surface at 36 lb N/acre, others applied 2 in. below plant row at 30 lb N/acre.
[y]No fertilizer applied except starter.
[x]18-0-25 at 1000 lb/acre applied on bed shoulder in addition to starter.
[w]1 bu = 27 lb.

At the first sampling in the fall 1976 (Table 3), T.S.S. concentration was considerably higher at the 0-2 inch depth with the soluble 18-0-25 than with the controlled release materials. This was reversed at the 2-4 inch depth. This resulted from placement of starter fertilizer since the 18-0-25 was surface applied and the controlled release materials were 2 inches below the surface, directly under the plant row. This sampling was made immediately after cutting planting holes and transplanting, consequently no rain water had moved downward through the bed. During the first 2 weeks after transplanting, frequent rains resulted in water moving into the planting holes and down through the bed. This caused leaching of soluble plant nutrients (salts) out of the root zone of the small seedlings. This was so severe with the highly soluble 18-0-25 fertilizer that by the second week the soluble plant nutrient concentration (salts) was no higher than in the check plots (no starter fertilizer). This created a zone of infertile soil around the limited root system of the small seedlings and early growth was reduced. Because of the frequent and sometimes intense rains, seep-irrigation was not used during the first 2 weeks after transplanting. After this the weather became dry and seep-irrigation was applied, which resulted in an upward movement of water soluble plant nutrients. This is reflected in the data at the 5 week sampling. The slowly soluble controlled release materials maintained a much better nutrient environment near the root system both early and late in the season as evidenced by better early growth and yields.

Table 3. Soluble salt concentrations in soil near roots of container grown transplants (fall 1976)[z].

Starter fertilizer source[x]	Depth sampled	Soluble salt concentration[y]			
		Weeks after transplanting			
		0[w]	1	2	5
	inches	ppm			
Osmocote (15-5-21)	0-2	1820	1640	1710	4250
	2-4	2840	2650	2920	3890
10-12-11 (50% Osmocote)	0-2	1960	1560	1590	4620
	2-4	3450	2830	2480	4100
18-0-25 (soluble)	0-2	8720	410	180	7240
	2-4	1040	630	250	2580
0 (no fertilizer)	0-2	610	320	210	1010
	2-4	550	350	100	970

[z]No fertilizer applied except starter.
[y]All soil samples taken from planting hole.
[x]18-0-25 applied on bed surface at 36 lb N/acre, others applied 2 in. below plant row at 30 lb N/acre.
[w]Samples taken on day planting holes cut and seedlings transplanted.

The spring 1977 (Table 4) was very dry with only .06 inch of rain during the first 6 weeks after transplanting. Seep-irrigation was applied continuously which caused soluble salts to accumulate in the 0-2 inch portion of the bed. Salt concentrations were about 3 times greater with the 18-0-25 starter than with the controlled release materials. Salt injury was evident on seedlings with 18-0-25 starter fertilizer. This injury was mainly stem-girdling (3), as opposed to root damage, and was most severe during the second and third weeks after transplanting. Plant stands were reduced by 18% when compared to those with no starter fertilizer.

Table 4. Soluble salt concentrations in soil near roots of container grown transplants (spring 1977)[z].

Starter fertilizer source[x]	Depth sampled	Soluble salt concentration[y]			
		Weeks after transplanting			
		0[w]	1	2	5
	inches	ppm			
Osmocote (15-5-21)	0-2	1050	2690	3130	3450
	2-4	3260	3110	2760	3620
10-12-11 (50% Osmocote)	0-2	1620	4250	4120	3870
	2-4	3150	2960	3090	3410
18-0-25 (soluble)	0-2	9820	10400	10120	9940
	2-4	2730	1720	2250	2250
0 (no fertilizer)	0-2	800	1840	1460	1980
	2-4	780	1620	1040	1670

[z]18-0-25 at 1000 lb/acre applied on bed shoulder in addition to starter.
[y]All soil samples taken from planting hole.
[x]18-0-25 applied on bed surface at 36 lb N/acre, others applied 2 in. below plant row at 30 lb N/acre.
[w]Samples taken on day planting holes cut and seedlings transplanted.

Results from these experiments, using the gradient-mulch system (4), emphasize 2 points. First, when rains are frequent during a 2-3 week period after transplanting and seep-irrigation is not applied, highly soluble starter fertilizers are leached from the soil surrounding the root system of small seedlings. This creates an infertile buffer zone which limits root growth. Seedlings develop an overall chlorosis which can persist until rains become less frequent and seep-irrigation is applied which moves nutrients back into the buffer zone. This condition can and has been erroneously diagnosed as excess salt, when in fact it is just the reverse. The problem has become more widespread in commercial pepper fields, even with container grown transplants, since many plant production houses no longer include any fertilizer in their seeding mix (personal communication). Until recently some fertilizer, usually a controlled release material, was incorporated into the seeding mix. This could supply nutrients to the seedling even though nutrients in the soil around the root-ball may be deficient. Secondly, in a dry season, when seep-irrigation is applied continuously, excess salts accumulate near the soil surface of the planting hole causing a reduction in plant stand and yield.

Since controlled release materials resist leaching and have a low salt index, the use of these as starter fertilizer placed in close proximity to seedling roots can substantially reduce both the lack of nutrients during wet weather and excess salt during dry weather.

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THE EFFECTS OF FERTILIZER COMPONENTS ON YIELD, RIPENING, AND SUSCEPTIBILITY OF TOMATO FRUIT TO POSTHARVEST SOFT ROT

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Abstract. **The effects of supplementary components of fertilizer on harvested tomato fruit were determined. The nitrate anion applied with either the potassium or calcium cation significantly increased the susceptibility to soft-rot decay of tomatoes grown on plastic mulched or uncovered beds. The chloride anion applied with the same cations had no significant effect on susceptibility to decay or rate of ripening. Plants given supplementary nitrate had significantly higher yields and longer ripening times for mature-green fruit than plants given supplementary chloride. The cations had no effect on yield, rate of ripening, or development of decay.**

In Florida, one of the most important recent changes in tomato growing is the use of plastic mulch covering for the planting beds (2). Also, the cultivar 'Walter' has become dominant, primarily because of its high-quality fruit and resistance to the races of Fusarium wilt present in Florida (4). With the use of plastic mulch and the 'Walter' tomato, the incidence of postharvest decay, especially bacterial soft rot due to *Erwinia carotovora* Jones, increased (3). Part of this increase might be due to the relatively high susceptibility of the 'Walter' to bacterial soft rot (1). However, this high susceptibility did not explain the differences in the incidence of decay between lots of 'Walter' tomatoes from various growers. It has been found that mulching increased the susceptibility to soft rot (3). Fertilizer components might influence this susceptibility. We conducted these tests to determine the effects of supplementary components of fertilizer on harvested tomatoes.

[1]Dr. Segall, Research Plant Pathologist, ARS, USDA, Orlando, Florida, died August 1977.

Materials and Methods

'Walter' tomatoes were grown from transplants at the Agricultural Research and Education Center, Bradenton, on beds covered with a plastic mulch and on uncovered conventional beds.

On the plastic mulch beds, all fertilizers (1000 lb of 18-0-25-2 and 500 lb superphosphate/A) were applied before the beds were covered. On uncovered beds, the same fertilizer treatments were added at the rate of 1000 lb/A split into 3 side-dressings at 2- to 3-week intervals. Treatments applied to both the mulched and uncovered beds included the basic (18-0-25-2) application and the basic application mixed with 1000 lb/A of one of the following supplements: calcium nitrate, potassium nitrate, calcium chloride, or potassium chloride. Each treatment was replicated, and the test was repeated for 3 growing seasons: spring and fall of 1973 and spring of 1974. Two harvests were made each season. Tomatoes were picked at the mature-green stage and the yields recorded. Following each harvest, the tomatoes were brought to the U.S. Horticultural Research Laboratory in Orlando for postharvest treatment and holding. Tomatoes from each field plot were graded to eliminate culls, and 50 fruits from each plot were randomly selected for inoculation. The tomatoes were washed in tapwater and sprayed with a suspension of *Erwinia carotovora* at a concn of 1×10^8 cells/ml, which simulated packinghouse contamination. A petroleum-based vegetable wax was brushed on in a commercial waxer. All lots of fruit were held for 3 weeks at 70°F (21°C) and 90% relative humidity. Inspections were made twice weekly during this holding period, and decaying fruit were identified, counted, and then removed to reduce secondary infection. Data were recorded as percentage of fruit decayed during the 3-week holding period. The ripening rate of the tomatoes was calculated by determining the percentage of green fruit in each lot at the first inspection,