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PEPPER RESPONSE TO FERTILIZATION WITH SOLUBLE AND CONTROLLED-RELEASE POTASSIUM FERTILIZERS

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Abstract. **An experiment was conducted on a commercial pepper (Capsicum annuum L.) farm in Delray Beach, FL to evaluate controlled-release K sources for pepper. In addition to controlled-release fertilizers, several N and P treatments involving University of Florida recommended fertilization practices were compared to the fertilization program used by the commercial grower. Pepper response to K was not as great as predicted by Mehlich-1 soil tests. Maximum yields resulted with 65 lb K/acre, however, 130 lb K/acre were recommended. Soluble K, broadcast at 65 lb/acre, was adequate for maximum yields on this very low K (18 ppm Mehlich-1 K) soil, however, up to 200 lb K/acre (soluble K) were needed for maximum yields when all K was banded in a furrow in the surface of the bed. With 130 lb K/acre and above, pepper yield responded positively to the inclusion of 30 lb K from controlled-release K in the total 65 lb K/acre applied broadcast. Pepper did not respond to more than 120 lb N/acre nor to P fertilization on this soil that tested very high in Mehlich-1 P. Fruit quality (wall thickness, fruit firmness and shrivel, and fruit percent dry matter) were not affected by fertilization practices except for degree of shriveling of fruit (second harvest) which increased (more shrivel) as K rate increased.**

Peppers are produced on 20,000 acres annually in Florida with the 1992-1993 crop valued at $179 million (Freie and Pugh, 1994). Total preharvest production costs for mulched pepper in Florida amount to $6500 per acre with about 4% of the costs due to fertilizer (Smith and Taylor, 1994). Although excessive fertilization of pepper in one test did not lead to groundwater pollution (Stanley and Clark, 1993), the use of inputs greater than required leads to a depletion of resources and to a reduction in profitability for the grower.

Studies of pepper fertilization have been ongoing at the University of Florida for more than 40 years and much of the research on pepper fertilization was summarized by Hochmuth and Hanlon (1989a). This summary of research led to revisions in pepper fertilization recommendations (Hochmuth, 1988; Hochmuth and Hanlon, 1989b). Recommendations, revised again in 1994 (Hochmuth and Hanlon, in press), are for 175, 70, and 130 lb N, P, and K/acre for pepper crops grown on soils testing very low in P and K.

Yield of pepper was usually optimized between 120 and 200 lb N/acre. Large increases in pepper yield resulted when N was increased from 50 to 120 lb/acre with small (8 to 10%) increases as N was further increased to 200 lb/acre (Locascio and Fiskell, 1977; Locascio and Fiskell, 1979). In a two-year study, pepper yield increased linearly to 200 lb N/acre in one year and to 275 lb N/acre in another year (Locascio et al., 1981). Pepper yield was the same with either 120 or 200 lb N/acre in two years of research (Locascio and Stall, 1994). The previous studies were all conducted with polyethylene mulch and sprinkler irrigation in Gainesville. In research with subirrigated pepper in southern Florida, yield was not increased with N rates above 150 lb/acre (Everett and Subramanya, 1983).

With drip irrigation, pepper yield was maximized with about 170 lb N/acre (Hochmuth et al., 1992a) and with 180 lb N/acre (Fletcher et al., 1993). Total pepper yield was higher with 200 lb N/acre compared with 100 lb N/acre (Locascio and Alligood, 1992).

Work with K fertilization of pepper has been infrequent. Work with mulched pepper showed that 175 lb K/acre were adequate for maximum pepper yield (Everett and Subramanya, 1983). More recently, peppers did not respond to more than 130 lb K/acre and rarely to more than 60 lb K/acre, even on soils testing low in Mehlich-1 K (Hochmuth et al., 1988).

P requirements of pepper have not been exhaustively studied. In one test in northern Florida, pepper yield was not influenced by P fertilization of a soil testing high (94 ppm Mehlich-1 P) in P (Hochmuth et al., 1992b).

Controlled-release sources of N and K fertilizers have been studied with pepper frequently in the past. In most studies, there was a slight benefit to inclusion of up to 25% of the N fertilizer from a controlled-release source (Everett, 1977; Fiskell et al., 1978; Locascio and Fiskell, 1979; Locascio et al., 1981) although not always (Locascio and Alligood, 1992). Controlled-release potassium nitrate fertilizer did not improve yields of pepper compared to soluble potassium nitrate in one study (Locascio and Alligood, 1992).

Although much is known about pepper fertilization requirements, only recently have recommended fertilization programs been demonstrated on commercial pepper farms. In all demonstrations, commercial pepper yields were not sacrificed by reducing N and K fertilization to the University of Florida recommendations (Hochmuth et al., 1987; 1988; Shuler and Hochmuth, 1988a; 1988b; 1989). In many cases, nearly halving the commercial fertilization rate did not negatively impact yield.

The studies reported here were conducted to evaluate two controlled-release K fertilizers for their effects on pepper

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yield and fruit quality, and to study subirrigated pepper response to N, P, and K fertilization on a soil testing very low in K and very high in P.

Materials and Methods

An experiment was conducted at Green Cay Farms in Delray Beach, Florida during the winter season of 1993-1994 to evaluate pepper response to fertilization. The test involved mainly an evaluation of K fertilization requirements using soluble and controlled-release K fertilizers. Additional treatments were used to evaluate pepper response to N and P application.

The soil was a Myakka sand (Arenic Haplaquods, sandy, siliceous, hyperthermic) which was disked to incorporate a summer cover crop of sorghum-sudangrass and mixed legumes. The cover crop received a total of 100 lb N/acre during the summer. Gypsum and slag were incorporated in the soil during late summer at 1 ton/acre each.

Prefertilization soil samples were taken on 29 Sept. 1993 from the upper 6 inches of soil. Soil samples were extracted with the Mehlich-1 extractant (Hanlon et al., 1994) and measurements were made of P, K, Ca, Mg, Cu, Mn, and Zn concentrations.

The first nine fertilizer treatments were a factorial arrangement of proportions of K supplied from a controlled-release K (CRK) potassium nitrate ('Multicote', Vicksburg Chem. Co., Vicksburg, MS) and total K rate. K from CRK made either 0, 50, or 100% of the broadcast K which totaled 65 lb K/acre. Total K applications were 65, 130, or 200 lb K/acre. Total N was 175 lb N/acre and no P or micronutrients were applied. N was supplied from CRK potassium nitrate, ammonium nitrate, soluble potassium nitrate (KN), and from controlled-release ('Multicoat') urea (to equalize the amount of N from a controlled-release source).

The next four treatments (10 through 13) involved a test of various fertilizer programs using a second CRK material, potassium sulfate ('Osmocote', Grace-Sierra Corp.) For all treatments, 50% of the broadcast K (30 lb K/acre) was supplied from CRK. For treatments 10 and 11, N was applied at 120 lb/acre and total K was 100 lb/acre. No P was applied for treatment 10 while 30 lb P/acre were applied broadcast for treatment 11. For treatment 12, total N and K were 180 and 150 lb/acre, respectively, while total N and K were 240 and 200 lb/acre, respectively, for treatment 13. Nitrogen was supplied from controlled-release urea and calcium nitrate. P was supplied from triple superphosphate, and K from CRK and KN. Treatment 14 was the grower program involving 288 lb N, 260 lb K, and 28 lb P/acre from sulfur-coated urea, potassium magnesium sulfate, potassium nitrate, single superphosphate, and potassium sulfate.

Treatments 15 through 18 involved a test of pepper response to banded K fertilization with soluble K from potassium nitrate. K was not included in the broadcast fertilizer. Treatment 19 was a zero-fertilizer control.

For treatments 1 through 13, the broadcast fertilizer contained 45 lb N and 65 lb K/acre. The remaining N and K was applied in a single band in a surface furrow in the center of the bed. The furrow was three inches wide and two inches deep. Banded fertilizer sources were ammonium nitrate, calcium nitrate, and KN. Broadcast N and K for treatment 14 were 64 and 48 lb/acre, respectively. For treatments 15 through 18, broadcast fertilizer contained only N at 45 lb/acre.

Broadcast fertilizers were applied by hand on 29 Sept. over the surface of the plot area (5.5 by 18 ft). Fertilizers were incorporated by bedding disks during the bed shaping and pressing operation. Beds 38 inches wide and 8 inches tall were fumigated with methyl bromide/chloropicrin mixture (98:2(%)), pressed, and covered with white-on-black polyeth-

Table 1. Effects of various combinations of K rate and source on early yield (first harvest) of subirrigated pepper in Delray Beach, FL, Winter, 1993-1994.

Treatment (lb/acre)[w]				Early pepper yield (25-lb ctn/acre)						
No.[x]	N	K	CRK[v]	Ex. large	Large	Medium	Cull	Ex. large + Large	Total mkt.	Avg. fr. wt (lb)
1	175	65	0	580 b[z]	420 abc	35 b	0	1000 a	1035 a	0.45 b
2	175	130	0	570 b	430 abc	25 b	0	1000 a	1025 a	0.44 b
3	175	200	0	515 b	425 abc	10 b	0	940 a	950 a	0.46 ab
4	175	65	30	500 b	430 abc	10 b	0	930 a	940 a	0.45 ab
5	175	130	30	550 b	445 abc	35 b	0	995 a	1030 a	0.45 ab
6	175	200	30	670 ab	340 abcd	15 b	0	1010 a	1025 a	0.46 ab
7	175	65	60	500 b	465 ab	15 b	0	965 a	980 a	0.45 ab
8	175	130	60	640 ab	435 abc	15 b	0	1075 a	1090 a	0.46 ab
9	175	200	60	555 b	485 a	20 b	0	1040 a	1060 a	0.44 b
10	120	100	30	680 ab	310 cd	5 b	0	990 a	995 a	0.47 ab
11	120	100[y]	30	800 a	325 bcd	15 b	0	1125 a	1140 a	0.49 a
12	180	150	30	640 ab	385 abcd	2 b	0	1025 a	1025 a	0.46 ab
13	240	200	30	625 ab	360 abcd	5 b	0	985 a	990 a	0.46 ab
14	288	260	0	565 b	355 abcd	10 b	0	915 a	925 a	0.45 ab
19	0	0	0	90 c	270 d	180 a	0	360 b	540 b	0.31 c
Significance[u]				*	*	*	NS	*	*	*

[z]Means in columns with same letter are not significantly different by Duncan's multiple range test (P = 0.05).
[y]30 lb P per acre included in broadcast fertilizer. Other treatments received no P.
[x]First nine treatments were Vicksburg Chemical Co. controlled-release K; Treatments 10-13 were Grace-Sierra Corp.
[w]K rate expressed as actual K, $K_2O = K \div 0.83$.
[v]CRK = Controlled-release K in lb of K from CRK source, applied broadcast in bed.
[u]Treatment effects significant at 5% (*) probability level or not significant (NS).

Table 2. Effects of various combinations of K rate and source on total yield of subirrigated pepper in Delray Beach, Fl, Winter, 1993-1994.

Treatment (lb/acre)[w]				Total pepper yield (25-lb ctn/acre)						
No.[x]	N	K	CRK[v]	Ex. large	Large	Medium	Cull	Ex. large + Large	Total mkt.	Avg. fr. wt (lb)
1	175	65	0	825 bcd	600 ab	80 b	5	1425 abc	1505 abc	0.40 b
2	175	130	0	760 bcd	605 ab	65 bc	2	1365 bc	1430 bc	0.40 b
3	175	200	0	770 bcd	600 ab	45 bc	2	1370 bc	1415 bc	0.43 ab
4	175	65	30	705 cd	590 ab	30 bc	2	1295 c	1325 c	0.40 b
5	175	130	30	805 bcd	625 ab	45 bc	0	1430 abc	1475 abc	0.42 ab
6	175	200	30	905 bc	580 ab	50 bc	1	1485 abc	1535 abc	0.41 ab
7	175	65	60	660 d	625 ab	55 bc	0	1285 c	1340 c	0.39 b
8	175	130	60	910 bc	620 ab	45 bc	1	1530 ab	1575 ab	0.43 ab
9	175	200	60	780 bcd	710 a	45 bc	2	1490 abc	1535 abc	0.41 ab
10	120	100	30	915 b	490 b	25 bc	0	1405 abc	1430 abc	0.42 ab
11	120	100[y]	30	1105 a	505 b	30 bc	0	1610 a	1640 a	0.44 a
12	180	150	30	870 bc	530 b	15 c	0	1400 abc	1415 bc	0.41 ab
13	240	200	30	785 bcd	540 b	20 bc	0	1325 bc	1345 c	0.42 ab
14	288	260	0	770 bcd	555 ab	30 bc	0	1325 bc	1355 c	0.41 ab
19	0	0	0	105 e	290 c	235 a	1	395 d	630 d	0.29 c
Significance[u]				*	*	*	NS	*	*	*

[z]Means in columns with same letter are not significantly different by Duncan's multiple range test (P = 0.05).
[y]30 lb P per acre included in broadcast fertilizer. Other treatments received no P.
[x]First nine treatments were Vicksburg Chemical Co. controlled-release K; Treatments 10-13 were Grace-Sierra Corp.
[w]K rate expressed as actual K. $K_2O = K \div 0.83$.
[v]CRK = Controlled-release K in lb of K from CRK source, applied broadcast in bed.
[u]Treatment effects were significant at 5% (*) probability level or not significant (NS).

ylene mulch (white surface up). The furrow to contain the banded fertilizer was formed in the surface of the bed during bed shaping.

On 13 Oct., the mulch was furled back from one side of the bed exposing the fertilizer furrow. Banded fertilizer materials were placed in the furrow and the mulch replaced on the bed.

On 26 Oct., 'Ssupersweet 860' bell pepper transplants were planted through the mulch in two rows per bed. The rows were 15 inches apart and the plants were 10 inches apart

Table 3. Main effects of K rate and amount of K supplied as controlled-release K on yield of subirrigated pepper in Delray Beach, FL, Winter, 1993-1994.

	Pepper yield (25-lb ctn/acre)						
Treatment	Ex. large	Large	Medium	Cull	Ex. large + Large	Total mkt.	Avg. fr. wt (lb)
K rate (lb/acre)[x]:	Early (first harvest)						
65	525	440	20	0	965	985	0.45
130	585	440	25	0	1025	1050	0.45
200	580	415	15	0	995	1010	0.45
Response[z]	NS	NS	NS	NS	NS	NS	NS
	Total (three harvests)						
65	730	605	55	2	1335	1390	0.45
130	825	615	50	1	1440	1490	0.45
200	820	630	45	2	1450	1495	0.45
Response[z]	NS	NS	NS	NS	*[y]	*[y]	NS
Controlled-release K rate (lb/acre):	Early (first harvest)						
0	555	425	25	0	980	1005	0.40
30	570	405	20	0	975	995	0.42
60	565	460	20	0	1025	1045	0.42
Response[z]	NS	NS	NS	NS	NS	NS	NS
	Total (three harvests)						
0	785	600	60	2	1385	1445	0.41
30	805	600	40	1	1405	1445	0.41
60	785	650	50	1	1435	1485	0.41
Response[z]	NS	NS	NS	NS	NS[y]	NS[y]	NS

[z]Response was significant at 5% (*) probability level or not significant (NS).
[y]Interaction of K rate and controlled-release amount was significant.
[x]Expressed as actual K. $K_2O = K \div 0.83$.

Table 4. Effects of various combinations of K rate and source on whole-leaf N and K concentrations through the season for pepper at Delray Beach, FL, Winter, 1993-1994.

Fertilizer treatment (lb/acre)[w]				Sampling date									
				29 Nov.		13 Dec.		7 Jan.		9 Feb.		25 Mar.	
No.[x]	N	K	CRK	N	K	N	K	N	K	N	K	N	K
				Whole-leaf concn. (%)									
1	175	65	0	6.2	6.1 a	5.7 ab	5.9 abc	4.9 a	3.8 cd	4.6 ab	3.1 g	5.1 bcd	2.9 d
2	175	130	0	6.0	5.7 a	5.5 ab	6.2 abc	4.9 a	4.6 ab	4.6 ab	4.4 cdef	5.0 bcd	4.3 c
3	175	200	0	6.0	5.8 a	5.5 ab	6.4 a	4.8 a	5.1 a	4.7 ab	5.1 ab	5.0 bcd	5.1 a
4	175	65	30	5.8	5.8 a	5.3 b	6.3 abc	5.0 a	4.0 bcd	4.6 ab	3.0 gh	5.4 b	3.1 d
5	175	130	30	6.1	5.8 a	5.3 b	6.2 abc	5.0 a	4.4 abc	4.7 ab	4.2 def	4.9 bcd	4.1 c
6	175	200	30	5.9	5.8 a	5.4 b	6.3 ab	4.8 a	5.0 a	4.8 ab	5.2 a	4.9 bcd	4.9 ab
7	175	65	60	5.9	5.4 a	5.6 ab	5.5 cd	4.7 a	3.3 de	4.7 ab	2.5 h	5.1 bcd	2.8 d
8	175	130	60	5.9	5.9 a	5.6 ab	5.8 abcd	4.8 a	4.2 bc	4.8 ab	4.0 ef	4.9 bcd	4.2 c
9	175	200	60	5.9	5.7 a	5.6 ab	5.6 cd	5.0 a	4.2 bc	4.6 ab	4.9 abc	4.8 bcde	5.0 a
10	120	100	30	5.7	5.6 a	5.3 b	5.9 abc	4.8 a	4.1 bc	4.3 b	3.9 f	4.6 de	4.2 c
11	120	100[y]	30	6.1	5.3 a	5.5 ab	5.6 bcd	4.5 a	3.8 cd	4.7 ab	4.0 ef	5.0 bcd	4.5 bc
12	180	150	30	5.8	5.8 a	5.7 ab	5.6 cd	4.9 a	4.4 abc	4.7 ab	4.7 abcd	5.0 bcd	4.9 ab
13	240	200	30	6.1	5.7 a	5.5 ab	6.0 abc	4.7 a	4.1 bc	4.9 a	4.6 bcde	4.8 cde	4.8 ab
14	288	260	0	5.8	5.6 a	5.9 a	5.2 d	4.5 a	3.8 cd	4.8 a	4.5 cdef	5.2 bc	5.1 a
19	0	0	0	5.7	3.7 b	4.6 c	3.6 e	3.2 b	3.0 e	2.7 c	2.8 gh	4.3 e	1.9 e
Significance[u]				NS	**	**	**	**	**	**	**	**	**

[z]Means in columns with same letter are not significantly different by Duncan's multiple range test (P = 0.05).
[y]30 lb P per acre included in broadcast fertilizer. Other treatments received no P.
[x]First nine treatments were Vicksburg Chemical Co. controlled-release K; Treatments 10-13 were Grace-Sierra Corp.
[w]K rate expressed as actual K, $K_2O = K \div 0.83$.
[v]CRK = Controlled-release K in lb of K from CRK source, applied broadcast in bed.
[u]Treatment effects significant at 1% (**) probability level or not significant (NS).

in the row. Crop maintenance was managed by the commercial farmer to include subsurface irrigation and pest control.

Samples of most-recently-matured leaves were collected five times for elemental analyses. The sampling dates were: 29 Nov. (plants had flowers and marble-size fruits), 13 Dec. (oldest fruits were 2.5 to 3 inches in diameter), 7 Jan. (five days prior to first harvest), 9 Feb. (at second harvest), and 25 Mar. (after third (last) harvest). Leaves were dried, ground, and digested in sulfuric acid/hydrogen peroxide, and analyzed for N by rapid-flow colorimetry and for P and K by plasma emission spectroscopy (Hanlon et al., 1994).

Peppers were harvested on 12 Jan., 9 Feb., and 24 Mar. 1994 and all fruits were graded into extra large, large, medium, and cull categories, counted, and weighed. Extra large fruits were ≥ 0.5 lb, large fruits were 0.34 to 0.49 lb, and medium fruits were 0.2 to 0.33 lb. Fruits weighing less than 0.2 lb or which were misshapen were considered culls.

Samples of extra large and large fruits (three each) from harvests one (12 Jan.) and two (9 Feb.) were taken to Gainesville for several postharvest evaluations. Three random fruits were cut at the equator and wall thickness of three fruit lobes for each fruit was measured (three measurements for each of three fruit). All fruit pieces were weighed, dried to constant dryness, then weighed again to calculate % dry matter. Remaining fruit were stored at 15C for two weeks after which the fruits were evaluated for firmness and shriveling on a rating scale of 1 (firm) to 10 (soft) or 1 (no shrivel) to 10 (wrinkled and soft).

At the end of the season (5 Apr.), soil samples were taken from the upper 6 inches from the soil in the fertilizer band area and the soil between the plants in the row. Soil was analyzed for Mehlich-1 K, water soluble nitrate-N, and for electrical conductivity (2 water:1 soil mixture) (Hanlon et al., 1994).

Data were analyzed by analysis of variance and regression (SAS, 1982). Treatment means were compared using Duncan's multiple range test.

Results and Discussion

The soil pH at the beginning of the season was 6.4 and the Mehlich-1 soil test indicies were (ppm): P(>120), K(18), Ca(1540), Mg(79), Cu(15), Mn(39), and Zn(6.5). Phosphorus was very high and K was very low.

First-harvest marketable fruit yield was not affected by K rate or proportion of K from CRK (Tables 1 through 3). Early yield averaged 1015 carton/acre with 565 cartons of extra large fruits (55%). There was no effect of K rate or proportion of K from CRK on most variables for total-season yield (three harvests) (Tables 2, 3). Leaf N and K concentrations (Table 4) were within the sufficiency range for plants with most fertilization treatments through 7 Jan. (Hochmuth et al., 1991). Leaf N remained above the sufficiency level but leaf K concentrations approached deficiency levels for the lowest K rate after 9 Feb. K rate and CRK proportion interacted in their effects on total-season marketable yield (Tables 3, 5). With zero CRK, K rate had no effect on yield of combined extra large and large fruits or on total marketable yield. With 30 lb K from CRK, there were linear increases with K fertilization for yield of combined extra large and large and for total-season fruit yield. With 60 lb K from CRK, there was a quadratic response to K fertilization for yield of combined extra large and large fruits and a linear increase with K fertilization for total-season yield (Table 5). The 15 fertilizer treatments (exclusive of treatments 15 through 18) had no significant effects on fruit quality parameters measured on 12 Jan. Averages for fruit dry weight (%), wall thickness (inch), and for firmness

Table 5. Interaction effects of controlled-release K rate and total K rate for yields of pepper in Delray Beach, FL, winter, 1993-1994.

Controlled-release K (lb/acre)[y]	Total K (lb/acre)[y] 65	130	200	Response[z]
	Extra large + large (ctn/acre)			
0	1425	1365	1370	NS
30	1295	1430	1485	L*
60	1285	1530	1490	L*Q*
Response[z]	NS	NS	NS	
	Total mkt. (ctn/acre)			
0	1505	1430	1415	NS
30	1325	1475	1535	L*
60	1340	1575	1535	L*
Response[z]	NS	NS	NS	

[z]Regression models contained significant (P = 0.05) linear (L) and quadratic (Q) terms.
[y]K fertilizer expressed as actual K. $K_2O = K \div 0.83$. Controlled-release K in lb of K from CRK source, applied broadcast in the bed.

and shrivel ratings measured on 12 Jan. were 4.0, 0.25, 3.6, and 2.6, respectively. For the 9 Feb. measurements, dry weight and fruit firmness rating were not affected by fertilization but fruit wall thickness and shrivel rating were (Table 6). Wall thickness for peppers receiving any fertilization program was greater than wall thickness with no fertilizer. One reduced

Table 6. Effects of various combinations of K rate and source on fruit quality of subirrigated pepper in Delray Beach, FL, Winter, 1993-1994.

Fertilizer treatment (lb/acre)[w]				9 Feb.			
No.[x]	N	K	CRK[v]	Dry wt.(%)	Wall thickness(inch)	Firm. rating[t]	Shrivel rating[t]
1	175	65	0	7.2	0.27 b[z]	5.3	5.0 bcd
2	175	130	0	6.5	0.30 a	5.3	6.3 abc
3	175	200	0	6.6	0.27 b	5.5	7.0 a
4	175	65	30	6.7	0.27 b	5.0	5.8 abcd
5	175	130	30	7.0	0.28 ab	5.0	5.8 abcd
6	175	200	30	6.5	0.28 ab	5.0	6.8 ab
7	175	65	60	7.0	0.27 ab	4.8	4.5 cd
8	175	130	60	6.8	0.28 ab	4.8	6.3 abc
9	175	200	60	6.7	0.28 ab	5.0	6.3 abc
10	120	100	30	6.4	0.28 ab	5.0	6.3 abc
11	120	100[y]	30	6.6	0.27 ab	5.3	5.8 abcd
12	180	150	30	6.7	0.28 ab	5.5	6.3 abc
13	240	200	30	7.1	0.28 ab	6.0	6.8 ab
14	288	260	0	7.2	0.27 b	5.0	4.8 cd
19	0	0	0	6.5	0.24 c	4.5	4.0 d
Significance[u]				NS	**	NS	**

[z]Means in columns with same letter are not significantly different by Duncan's multiple range test (P = 0.05).
[y]30 lb P per acre included in broadcast fertilizer. Other treatments received no P.
[x]First nine treatments were Vicksburg Chemical Co. controlled-release K; Treatments 10-13 were Grace-Sierra Corp.
[w]K rate expressed as actual K, $K_2O = K \div 0.83$.
[v]CRK = Controlled-release K in lb of K from CRK source, applied broadcast in bed.
[u]Treatment effects significant at 5% (*) probability level or not significant (NS).
[t]Firmness rating: 1 = firm, 10 = soft. Shrivel rating: 1 = none, 10 = fruit wrinkled, soft.

fertilizer treatment (No. 2) had thicker walls than fruit with the grower fertilization (treatment No. 14). Shrivel rating generally increased with increasing fertilization indicating reduced shelf life of peppers receiving larger amounts of fertilizer.

Main effects of K rate and CRK proportion had little effect on pepper fruit quality. Dry wt (4.2%), wall thickness (0.25 inch), firmness rating (3.5), and shrivel rating (2.6) for 12 Jan. sampling date were not affected by K rate. Dry wt (6.8%), wall thickness (0.28 inch), and firmness rating (5.1) for the 9 Feb. sampling date were not affected by K rate. Shriveling rating of fruit from the second harvest was increased in linear fashion from 5.1 to 6.7 as K rate increased. Amount of K from CRK did not affect any fruit quality parameter. Means for dry wt, wall thickness, firmness rating, and shrivel rating were 4.2%, 0.25 inch, 3.5, and 2.7, respectively for 12 Jan. and 6.8%, 0.28 inches, 5.1, and 6.0, respectively for 9 Feb. Amount of K from CRK source had little effect on leaf N and K concentrations of pepper leaves (Table 7), but K rate did. K rate had no effect on early-season leaf N or K concentrations but mid and late season leaf K concentrations, not N concentrations, increased linearly in response to increasing K (Table 7). Potassium fertilizer remained in the band at the end of the season where 130 or 200 lb K/acre were applied (Table 8). There was a linear increase in K remaining in the fertilizer band as K fertilization rate increased (Table 9). Soil-test K for the band and row soil was reduced to the starting soil test value where only 65 lb K/acre were broadcast.

Early yields with 'Osmocote' potassium sulfate were similar to early yields with 'Multicote' potassium nitrate (Table 1). Treatments 5 and 12 had similar N and K application rates differing mainly by CRK material. Total early yield with CRK potassium nitrate was 1030 cartons/acre and with CRK potassium sulfate was 1025 cartons/acre (Table 1). Total-season yields were 1475 and 1415 cartons/acre with the same treatments (Table 2).

Comparisons of means in Tables 1 and 2 reveal that reducing N from 180 lb/acre to 120 lb N/acre or increasing N to 240 lb/acre had no effect on early or total-season pepper yields. Comparison of treatments 10 and 11 showed that P fertilization had no significant effect on pepper yield (Tables 1 and 2). Yields with fertilization at the grower rates of N, P, and K did not improve yields over plants grown with 120 lb N, zero P, and 100 lb K/acre (treatment 10) (Tables 1 and 2).

Early yield was not affected by K rate with soluble K applied only in the surface furrow band (Table 10). There was a linear increase in yield of combined extra large and large fruits and for total-season yield as soluble K fertilization increased (Table 10). Fruit quality, measured on two dates, was not affected by soluble K fertilization. Dry weight (%), wall thickness (inch), and firmness and shrivel rating averaged 4.1, 0.26, 3.8, and 2.8, respectively, for 12 Jan. and 6.6, 0.26, 5.1, and 5.6, respectively, for 9 Feb. Leaf K, but not N concentrations, generally increased linearly in response to increasing K fertilization (Table 11). These results with soluble K in a band only (without broadcast K) are different from the results when 65 lb K/acre were applied broadcast (Treatments 1 through 3). Total-season yield with 65 lb K/acre broadcast (zero banded) was 1505 cartons/acre (treatment 1) whereas yields were only 1255 cartons/acre when the K was banded only (Tables 2 and 5). Large amounts of K were remaining in the band at the end of the season where all K was banded (Table 12). It is possible that the poorer performance of banded

Table 7. Main effects of K rate and amount of K supplied as controlled-release K on seasonal pepper whole-leaf N and K concentrations at Delray Beach, FL, Winter, 1993-1994.

	Sampling date									
	29 Nov.		13 Dec.		7 Jan.		9 Feb.		25 Mar.	
Treatment	N	K	N	K	N	K	N	K	N	K
K rate (lb/acre)[x]:	Whole-leaf concn. (%)									
65	6.0	5.7	5.6	5.9	4.9	3.7	4.6	2.9	5.2	2.9
130	6.0	5.8	5.5	6.1	4.9	4.4	4.7	4.2	4.9	5.0
200	5.9	5.8	5.5	6.1	4.9	4.7	4.7	5.1	4.9	5.0
Response[y]	NS	NS	NS	NS	NS	L**	NS	L**	NS	L*Q**
Controlled-release K rate (lb/acre):										
0	6.1	5.9	5.6	6.1	4.9	4.5	4.6	4.2	5.0	4.1
30	5.9	5.8	5.3	6.2	4.9	4.4	4.7	4.1	5.0	4.0
60	5.9	5.7	5.6	5.6	4.8	3.9	4.7	3.8	4.9	4.0
Response	NS	NS	L**Q**	L*	NS	L*	NS	NS	NS	NS

[y]Treatment effects were linear (L) or not significant (NS).
[x]Expressed as actual K. $K_2O = K \div 0.83$.

K compared to plants grown with some broadcast K was due to inefficient uptake of K from the fertilizer band by the plant.

In this research, pepper yields responded little to K fertilization on a commercial farm in Delray Beach, FL on a soil that tested low in Mehlich-1 K. Although soil test results predicted a yield response to 130 lb K/acre, observed yield response was to only 65 lb K/acre when the K was broadcast in the bed. Previous studies on soils with similar amounts of extractable K also showed that peppers responded to K fertilization at rates less than those predicted by the current interpretation of the Mehlich-1 soil test (Hochmuth et al., 1988; Hochmuth et al., 1990). Fruit shriveling was the fruit quality parameter most affected by K fertilization. Fruit shriveling increased as K rate increased. Larger amounts of K (up to 200 lb K/acre) were required for high yields when all K was banded in shallow furrows on the bed surface. These results are similar to previous work with N fertilization of pepper where yields were reduced when all N was banded compared to where at least 10% of the N was broadcast in the bed (Locascio and Fiskell, 1977).

Mehlich-1 extracts of soil from the band at the end of the season showed that large amounts of K fertilizer remained in the fertilizer bands after the crop was terminated. It is possible that not enough K was being supplied from these bands and that the nutrient gradient (Geraldson, 1974; 1977) was not adequate for maximum pepper yields. These results showed that K fertilizer efficiency with banded K was not as high as with broadcast K. With low rates of broadcast K, equal or better yields were obtained compared to peppers with all

Table 8. Effects of various combinations of K rate and source on end-of-season soil-test values for subirrigated pepper in Delray Beach, FL, Winter, 1993-1994.

Treatment (lb/acre)[z]				Soil NO_3-N (ppm)[w]		Mehlich-1 K (ppm)[v]		Elec. cond. (dS/m)[w]	
No.	N	K	CRK[y]	row	band	row	band	row	band
1	175	65	0	12	12	11	15	0.18	0.18
2	175	130	0	11	19	20	88	0.23	0.25
3	175	200	0	11	37	25	189	0.23	0.38
4	175	65	30	23	23	14	24	0.25	0.28
5	175	130	30	9	22	21	92	0.15	0.25
6	175	200	30	6	11	25	70	0.20	0.20
7	175	65	60	9	18	17	16	0.18	0.23
8	175	130	60	9	14	17	40	0.20	0.23
9	175	200	60	2	18	19	125	0.13	0.20
10	120	100	30	2	6	15	28	0.18	0.23
11	120	100[x]	30	7	15	16	74	0.18	0.20
12	180	150	30	13	18	30	59	0.20	0.23
13	240	200	30	18	56	20	263	0.28	0.50
14	288	260	0	40	57	58	255	0.45	0.58
15	175	0	0	35	39	8	16	0.38	0.40
19	0	0	0	2	3	10	10	0.13	0.25
	LSD(.05)			16	19	18	106	0.13	0.19

[z]First nine treatments were Vicksburg Chemical Co. controlled-release K; Treatments 10-13 were Grace-Sierra Corp. K expressed as actual K. $K_2O = K \div 0.83$.
[y]CRK = controlled-release K in lb of K from CRK source, applied broadcast in bed.
[x]30 lb P per acre included in broadcast fertilizer. Other treatments received no P.
[w]Water-soluble nitrate, EC measured in deciSiemens per meter, 2:1 water:soil extract.
[v]Starting prefertilization Mehlich-1 K was 18 ppm (very low).

Table 9. Main effects of K rate and amount of K supplied as controlled-release K on end-of-season soil-test values for subirrigated pepper in Delray Beach, FL, Winter, 1993-1994.

Treatment	Soil nitrate-N (ppm)[w]		Mehlich-1 K (ppm)[v]		Elec. cond. (dS/m)[w]	
	row	band	row	band	row	band
K rate (lb/acre)[y]:						
65	14	17	14	18	0.20	0.23
130	9	19	19	73	0.19	0.24
200	6	22	23	128	0.18	0.26
Response[z]	NS	NS	L*	L**	NS	NS
Controlled-release K rate (lb/acre)[x]:						
0	11	23	19	97	0.21	0.27
30	13	19	20	62	0.20	0.24
60	7	17	17	60	0.17	0.21
Response[z]	NS	NS	NS	NS	NS	NS

[z]Response was linear (L) at 5% (*) or 1% (**) probability level or not significant (NS).
[y]K expressed as actual K. $K_2O = K \div 0.83$.
[x]Controlled-release K in lb K from CRK source applied broadcast in bed.
[w]Water-soluble nitrate, EC measured in deciSiemens per meter, 2:1 water:soil extract.
[v]Starting prefertilization Mehlich-1 K was 18 ppm (very low).

banded K or with K supplied from both broadcasting and banding.

With high rates of K (> 130 lb K/acre), pepper yield responded positively to up to 60 lb K/acre supplied from a controlled-release K source. Overall, use of controlled-release K sources did not seem to substantially benefit pepper production since equal yields could be achieved with soluble K sources at low rates of K.

Yields were not reduced when N was reduced from the recommended rate of 175 lb N/acre to 120 lb N/acre. Yields tended to be reduced when N was increased to 240 lb N/acre or to the grower rate of N (288 lb N/acre). These results are similar to those of Hochmuth et al. (1987) where pepper yields were not increased with N rates above 160 lb N/acre.

Fertilization of this high-P soil with P did not significantly improve pepper yield. In another test on a high-P soil in northern Florida, fertilization with P did not affect pepper yield (Hochmuth et al., 1992b).

These results showed that maximum pepper yields and quality can be achieved using the University of Florida recommended N, P, and K fertilization program. Slight reductions can even be made in the recommended fertilization rates without sacrificing yield or quality. Highest yields were ob-

Table 10. Effect of K fertilization (all soluble K) on yield of subirrigated pepper in Delray Beach, FL, Winter, 1993-1994.

K Fert. (lb/acre)[y]	Pepper yield (25-lb ctn/acre)						
	Ex. large	Large	Medium	Cull	Ex. large + Large	Total mkt.	Avg. fr. wt (lb)
	Early (first harvest)						
0	330	470	10	1	800	810	0.40
65	365	365	30	0	730	760	0.44
130	495	340	30	10	835	865	0.45
200	450	410	2	0	865	865	0.46
Response[z]	NS	NS	NS	NS	NS	NS	NS
	Total (three harvests)						
0	440	605	20	6	1045	1065	0.38
65	580	580	95	1	1160	1255	0.40
130	705	505	60	10	1210	1270	0.41
200	660	620	25	1	1280	1305	0.42
Response[z]	NS	NS	NS	NS	L**	L*	NS

[z]Treatment effects linear (L) at 5% (*) probability level or not significant (NS) at 5% probability level.
[y]Expressed as actual K. $K_2O = K \div 0.83$.

Table 11. Effect of K fertilization (all soluble K) on pepper whole-leaf N and K concentrations over the season at Delray Beach, FL, Winter 1993-1994.

K fertilization (lb/acre)[y]	Sampling date									
	29 Nov.		13 Dec.		7 Jan.		9 Feb.		25 Mar.	
	N	K	N	K	N	K	N	K	N	K
	Whole-leaf concn. (%)									
0	5.8	4.4	5.5	3.3	4.6	1.4	4.9	1.2	5.7	1.9
65	5.8	4.4	5.6	3.9	5.0	2.6	4.7	2.5	5.5	3.5
130	6.2	4.5	5.7	4.5	4.6	3.6	5.0	4.5	5.0	4.7
200	6.0	4.7	5.8	4.5	4.9	3.9	4.6	4.5	3.2	5.4
Response[y]	NS	NS	NS	NS	NS	L**	NS	L**	NS	L*Q**

[z]Significant at 5% (*) or 1% (**) probability or not significant (NS). Treatment effects were linear (L) or quadratic (Q).
[y]Expressed as actual K.

Table 12. Effect of K fertilization (all soluble K) on end-of-season soil-test values for subirrigated pepper in Delray Beach, FL, Winter, 1993-1994.

K Fert. (lb/acre)[v]	Soil nitrate-N (ppm)[x]		Mehlich-1 K (ppm)[w]		Elec. cond. (dS/m)[x]	
	row	band	row	band	row	band
0	43	44	10	22	0.40	0.43
65	16	33	13	31	0.23	0.33
130	17	21	22	91	0.30	0.27
200	15	29	37	292	0.23	0.37
Response[z]	NS	NS	L**	L**	NS	NS

[z]Response was linear at 1% (**) probability level or not significant (NS).
[v]K Expressed as actual K. K_2O = K÷0.83.
[x]Water soluble nitrate, EC measured in deciSiemens per meter, 2:1 water:soil extract.
[w]Starting prefertilization Mehlich-1 K was 18 ppm (very low).

tained when 45 lb N and 65 lb K/acre were broadcast with 130 lb N/acre banded. Increasing N, P, or K rates above those recommended did not improve yields. Fruit quality, however, was reduced with high rates of K fertilizer. Pepper fruit wall thickness was reduced and fruit shriveling was increased with high K rates and with the grower rate of fertilization.

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YIELD RESPONSE OF TOMATO, CV. AGRISET 761, TO SEAWEED SPRAY, MICRONUTRIENT, AND N AND K RATES

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Abstract. **The effects of two foliar seaweed-spray applications (four times per season at 28 fl oz/acre per application and seven times per season at 24 fl oz/acre per application), two micronutrient applications (21 lb/acre F503 and no micronutrients), and two N and K rates (1X and 1.5X; 1X = 174N and 289K lb/acre) on 'Agriset 761' tomato (*Lycopersicon esculentum*) Mill.) yields were investigated in spring 1993. In the first harvest, marketable fruit yield was higher with the H_2O control than with seaweed sprays ($P \leq 0.05$), and extra large fruit yield was higher with residual than with added micronutrients. Seasonal total yields of extra large and marketable fruits were greater with**

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