100 lb/acre (6). Various studies conducted throughout the United States and Europe have shown that lettuce always shows a larger response to P than to N and K when all 3 nutrients were limiting (1,2,3,4). Perhaps, in accordance with Liebig's "Law of minimum" response to N and K would only have been expressed if the P requirement of lettuce was satisfied.

Results clearly indicate that sidedress fertilization is not a viable strategy for meeting the P nutritional requirements of lettuce. However, because the limitation of P was severe relative to N and K the possibility of using sidedress fertilization to correct N and K deficits cannot be ruled out. Past research has shown that sidedress N is effective for lettuce (7). Also, since sidedress K has been effective for celery, it is commonly practiced for lettuce following large amounts of rainfall. Additional work is needed to evaluate the effectiveness of sidedress fertilization for meeting the N and K requirements of lettuce.

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FOLIAR AND SOIL-APPLIED BIOSTIMULANT STUDIES WITH MICROIRRIGATED PEPPER AND TOMATO

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Additional index words. Capsicum annuum, Lycopersicon esculentum, trickle irrigation, cytokinin, foliar sprays, full-bed mulch.

Abstract. **Bell pepper, (*Capsicum annuum* L. cv. Bell Captain), and tomato (*Lycopersicon esculentum* Mill., cv. Summer Flavor 5000) were treated with foliar, soil, and the combination of soil and foliar applied product containing cytokinin as kinetin (Triggrr) and macro and micronutrients. Bell peppers and tomatoes were grown in the summer-fall (Aug.-Dec.) in microirrigated full-bed polyethylene mulch culture. The combination of 2 soil-applied kinetin treatments and 9 applications of foliar applied kinetin, amended with macronutrients (designated as 'Crop Product Guide'), increased the total marketable fruit yield of bell pepper compared to the water-treated control. The biostimulant treatments did not increase early yields or fruit size of bell peppers compared with water control. In tomatoes, the 'Crop Product Guide' treatment increased the early yield of medium size (6x6) fruit. Early and seasonal total yields of large and marketable grade fruits of tomatoes were similar or lower with biostimulants than with the water control treatment. Tomato yields were adversely affected by the infection of the whitefly, *Bemesia tabaci* (Glenn), transmitted geminivirus. Biostimulant treatments had little or no effect on plant height and on macro and micronutrient concentrations in bell pepper leaves and fruits.**

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Several commercially available biostimulant products have been evaluated in Florida for their effect on tomatoes (2,3,6,7), bell peppers (4,8,9,12), and on strawberries (1). Biostimulants that were evaluated contained phytohormones, humates, or amino acids. Many also contained essential macro and micronutrients in various quantities and proportions. Other products contained only macro and micronutrients from inorganic sources. The main interest in the studies was whether biostimulants had a beneficial effect on early and total yields and on fruit size of vegtables.

In south Florida, Bryan (2) reported increased growth and yield of tomatoes from α-keto acid and humate treatments. In west central Florida, seaweed based foliar sprays increased early yield and fruit size of tomatoes, but total yields were lower than with the water-control treatment (6). In other studies conducted for 3 seasons at Bradenton (7), foliar applied ∝-keto acid and cytokinin sprays increased large fruit yields of tomatoes but seaweed and inorganic nutrient sprays reduced yields. In north Florida, Castro et al. (3) reported a 17% yield increase of large tomato fruits with 1 qt/acre application of humic acid compared to the control treatment in microirrigated culture.

In bell peppers, biostimulant effects were either inconsistent from season to season or yield increase depended on the cultivar. For example, seaweed-based spray increased early yield of 'Early Calwonder' in 1 of 3 seasons but the same seaweed based spray had little or no effect on 'Shamrock' yields (8). Stoffella et al. (12) reported improved early yield in one of two seasons with foliar application of a cytokinin-complex based product (Burst). In studies with soil and foliar applied biostimulants on 'Early Calwonder' and 'Jupiter' peppers, Csizinszky (9) obtained increased early yield of U.S. Fancy grade fruit of 'Early Calwonder' compared to a water-treated control but yields of 'Jupiter' were similar to the control. In the same studies, macro and micronutrient based sprays reduced the yield of U.S. Fancy grade peppers of 'Early Calwonder' and the total marketable yield of 'Jupiter'. Cox and Nelson (4) found no yield increase of 'Early Calwonder' with macro and micronutrient sprays. In the studies where biostimulants increased yield, the increase was the result of a greater number of fruit set rather than an increase in weight per fruit (5,8), although Stoffella (loc. cit.) found that 1, 2 or 3 applications of a cytokinin complex (Burst) increased both the number of fruit per plant and weight per fruit.

The study reported here was initiated to evaluate soil and foliar-applied cytokinin biostimulants (Triggrr) for their effect on yields of microirrigated bell peppers and tomatoes.

Materials and Methods

Experiments were conducted in fall (Aug.-Dec.) 1989 at the Gulf Coast Research and Education Center in Bradenton on an EauGallie fine sand. Plots were arranged in a randomized complete block design and were 25-ft long on 24 inches wide and 8 inches high beds formed on 5-ft. centers. Prior to land preparation, soil samples were taken and analyzed at the Analytical Research Laboratory at Gainesville. Nutrient concentrations in the soil solution were (in ppm): 1.7 NO_3-N; o.2 NH_4-N; 26.8 P; 12.4 K; 540 Ca., and 78 Mg; and the pH was 7.05. For the bell peppers, nutrients from dry 0-8.74-0 (N-P-K) and 15-0-24.9 (N-P-K) sources at rates listed in Table 1 were applied in a 6-inch wide band in the bed center and incorporated approximately 3 inches in the soil. The 0-8.74-0 fertilizer also contained micronutrients (F503) at 26 lb/acre (A = 8712 linear bed feet). The remaining amounts of N and K from a liquid 6-0-4.98 (N-P-K) source were injected with the irrigation during the season (Table 1). Soil was fumigated with 66% methylbromide and 33% chloropicrin (Terro-O-Gas) at 213 lb/acre. Irrigation tube (Roberts row-drip, high output (40 gal/hr/100 ft) with 8 inches emitter spacing), was laid in the bed center 2 inches below the soil surface, then the beds were covered with a 1.25 mil thick white polyethylene. Two weeks later on 1 Sept. five-week-old 'Bell Captain' seedlings, raised in 1.5 inch cell size trays by a commercial company were planted in double row per bed, 6 inches from the center on each half of the bed at 12-inch in-row spacing. Soil and foliar biostimulants were applied at rates and frequencies as described in Table 2. Soil-applied kinetin was diluted in water and 3.38 oz of the

Table 1. Nutrients applied for bell peppers and tomatoes. Fall 1989.

	Rate /lb/acre)[y]		
	N	P	K
Bell pepper			
Pre-plant dry	72	61	119
Liquid	226	–	188
Total	298	61	307
Tomato			
Pre-plant dry	72	61	119
Liquid	165	–	271
Total	237	61	390

[z]Acre = 8712 linear bed feet.

Table 2. Biostimulants and application rates for bell peppers.

Treatment no.	Biostimulant	Application rate	Number of applications
1	*Soil-applied* (ST)		
	Soil Triggrr, cytokinin (as kinetin)	10 oz/A	Once at transplanting in plant holes
	and M.S.E. 511 (Zn, Cu, Fe)[z]	64 oz/A	
2	*Foliar-applied* (FT)		
	Foliar Triggrr, cytokinin (as kinetin)	2 oz/A	At first bloom (21 DAT) then 5 more
	and M.S.E. 5-0-5 5 Ca[y]	64 oz/A	applications at 14 day intervals
	alternately with M.S.E. 8-8-8[x]	64 oz/A	
3	*Soil plus Foliar applied* (S + FT)		
	Soil Triggrr	As above for soil-applied Triggrr	
	and Foliar Triggrr	As above for foliar-applied Triggrr	
4	*Crop Product Guide* (CPG)		
	Soil Triggrr and M.S.E. 511[z]	As above for soil-applied Triggrr then 30 days later with soil Triggrr only.	
	Foliar Triggrr and M.S.E.[y]	As above for foliar-applied Triggrr at first bloom, then 8 more	
	5-0-5 5 Ca alternatly with M.S.E. 8-8-8[x]	applications at 10 day intervals	

[z]M.S.E. 511 = Micro Second Element 5-1-1 Zn Fe Cu.
[y]M.S.E. 5-0-5 5 Ca = Macro Second Element 5-0-5 (N-P-K) and 5 Ca.
[x]M.S.E. 8-8-8 = Macro Second Element 8-8-8 (N-P-K)
[w]For tomatoes M.S.E. 8-8-8 was applied in the first foliar kinetin spray and alternated with 5-0-5 5 Ca in subsequent treatments.

solution was poured into the plant hole. Foliar kinetin diluted in water and water in the control plots were applied with a stainless steel sprayer with a hollow-cone nozzle at 40 psi. First foliar applications started at first bloom, on 20 Sept., and last applications were made on 29 Nov. Plant heights were measured on 6 plants in each plot at 31 and 54 days after transplant (DAT). Soil samples for nutrient analyses were taken at 10, 63 and 110 DAT. Leaf samples (young mature leaves) for macro- and micronutrient analyses were collected from each plot at full bloom (42 DAT), at first harvest (62 DAT) and towards the end of the harvest (90 DAT). Fruit for dry matter determination and macro and micronutrient analyses were also collected at 90 DAT. Plant fresh weight was measured on 6 plants from each plot at the end of the harvest, 108 DAT. Soil, leaf, and fruit samples were analyzed at the Analytical Research Labortory at Gainesville. Soil moisture was monitored by tensiometers placed 6 inches deep in the plant row in each replication. Pesticides, approved for use on bell peppers were applied weekly. Fruits from a 5-feet long center section (10 plants) in each plot were harvested on 2, 16, and 27 Nov. and 8 and 18 Dec. Fruits were separated into marketable and cull, then marketable fruits were graded as U.S. Fancy, U.S. #1, and U.S. #2 (13), counted and weighed.

Land preparation for tomatoes was similar to that described for bell peppers above, except pre-plant dry fertilizers were applied 4 inches off center. The remaining amounts of N and K from a liquid 6-0-6.64 (N-P-K) source were injected with the irrigation water during the season (Table 1). Five-week old tomato seedlings of cv. Summer Flavor 5000, grown in 1.5 in cell size trays by a commercial firm, were planted on 1 Sept. at 24 inch spacing, 4 inches from the drip tube and opposite to the dry fertilizer band. Plant heights were measured on 6 plants in each plot at 21 and 32 DAT. Tomatoes were harvested from a 12-ft long center section (6 plants) in each plot on 30 Nov., 7, 14, and 21 Dec. Fruits were separated into marketable and cull, then marketable fruits were graded by a machine into large (5x6), medium (6x6) and small (6x7) sizes, weighed and counted. An analysis of variance was performed on the data (SAS Institute, Inc., Cary, NC).

Results and Discussion

Bell peppers. Irrigation, rainfall and pan evaporation data during the crop cycle are presented in Table 3. During Sept., 13.66 inches of rain were recorded at the GCREC-Bradenton but Oct. and Nov. were very dry. Temperatures were above average in Sept. and in Nov. and below average in Dec. There was no significant difference in plant heights among the various treatments. The average plant heights in inches at 31 DAT were 8.46 and at 54 DAT 15.67 (data not presented).

Table 3. Irrigation, rainfall and pan evaporation (PE) for bell peppers and tomatoes. Fall 1989.

	Bell pepper	Tomato
	----------- inch -----------	
Irrigation[z]	11.69	11.81
Rain	17.91	18.93
Pan E.	14.12	14.17

[z]108 irrigation days for bell pepper and 100 days for tomato.

Early and total yields of U.S. Fancy, U.S. #1, and U.S. #2 were similar with all treatments (Table 4). Yield of early marketable fruit with the crop product guide (C.P.G.) treatment was higher, 537 28-lb. ctn/acre, than with the soil, 471 ctn/acre; foliar, 441 ctn/acre; and soil + foliar, 473 ctn/acre; treatments, but it was similar to the water-treated control, 527 ctn/acre. The yield increase with the C.P.G. treatment compared with the other biostimulant treatments was due to increased yields in the U.S. Fancy and U.S. #2 grade fruits. Marketable total yield for the season was also higher, 1427 ctn/acre, with the C.P.G. treatment than with soil kinetin, 1221 ctn/acre, and with the water control, 1323 ctn/acre. Cull fruit and marketable + cull yields were similar with all treatments. Number of fruits with the various treatments were similar to the carton/acre yields and data on fruit numbers are not presented.

Soil pH and macro and micronutrient concentrations varied between sampling dates, but there was little or no difference in soil nutrient concentrations between treatments within the same sampling date. At last harvest, the mean values of soil pH and micronutrients in ppm were: pH 6.5; NO_3-N: 9.10; NH_4N:2.68; P:49.8; K:29; Ca:533, and Mg:63.5 (data not presented).

Macronutrient concentrations in pepper leaves at full bloom, at first harvest, and towards the end of the harvest (Table 5) were at or above the sufficiency level with all treatments (11). Differences between treatments in N concentrations at full bloom, Ca concentrations at first harvest, and in K and Mg concentrations near the end of the harvest did not influence marketable yields. Micronutrient

Table 4. Yield of microirrigated bell pepper, cv. Bell Captain with soil and foliar-applied biostimulants. Fall 1989.

Grade and harvest	Treatment[z]					
	Control	ST	FT	S+FT	CPG	$LSD_{0.1}$[x]
	(28-lb ctn/A[y])					
U.S. Fancy						
Early	278	230	212	237	287	NS
Total	464	313	458	446	446	NS
U.S. #1						
Early	214	196	163	176	167	NS
Total	631	647	658	611	660	NS
U.S. #2						
Early	35	45	65	60	84	NS
Total	228	261	287	309	321	NS
Marketable						
Early	527	471	441	473	537	36
Total	1323	1221	1403	1365	1427	83
Cull						
Early	14	11	8	6	20	NS
Total	162	172	196	146	155	NS
Marketable + Cull						
Early	541	482	449	486	557	NS
Total	1485	1393	1599	1511	1582	NS

[z]Treatment: ST = soil Triggrr; FT = foliar Triggrr; S+FT = soil + foliar Triggrr; CPG = crop product guide.
[y]Acre = 8712 linear bed feet.
[x]LSD was significant at the 10% level of probability or nonsignificant (NS).

Table 5. Elemental concentrations in biostimulant-treated 'Bell Captain' pepper leaves. Fall 1989.

Treatment	Element (% dry wt)				
	N	P	K	Ca	Mg
At full bloom (DAT 42)					
Control	5.77 a[z]	0.49 a	4.13 a	1.26 a	0.91 a
ST	5.28 b	0.53 a	4.70 a	1.25 a	0.90 a
FT	5.74 a	0.52 a	5.31 a	1.34 a	0.95 a
S+FT	5.55 ab	0.53 a	4.69 a	1.18 a	0.86 a
CPG	5.80 a	0.52 a	4.88 a	1.26 a	0.94 a
At first harvest (62 DAT)					
Control	5.45 a	0.40 a	4.90 a	1.77 a	1.06 a
ST	5.31 a	0.44 a	4.74 a	1.71 ab	1.06 a
FT	5.50 a	0.42 a	5.35 a	1.67 ab	1.00 a
S+FT	5.50 a	0.44 a	4.79 a	1.54 b	0.96 a
CPG	5.43 a	0.44 a	4.74 a	1.68 ab	1.03 a
Near end of harvest (90 DAT)					
Control	5.47 a	0.33 a	5.45 ab	2.14 a	1.15 a
ST	5.50 a	0.36 a	5.80 a	2.14 a	1.14 a
FT	5.54 a	0.35 a	5.58 ab	1.99 a	1.05 ab
S+FT	5.59 a	0.35 a	5.79 a	1.98 a	1.03 b
CPG	5.38 a	0.34 a	5.40 b	2.17 a	1.16 a

[z]Mean separation between biostimulant treatments by Duncan's multiple range test, 5% level.

concentrations were similar with all treatments and data are not presented.

Weight per plant and dry matter content in plants were also similar at the end of the harvest. The average plant weight was 0.79 lb and the average dry matter was 13.7%.

Pepper yields in this study were above the average yield of 673 ctn/acre reported for Florida in the 1988-89 season (10). Higher yields in this study may have been the result of differences in production system, cultivars, nutritional treatments, and number of harvests.

The increased yield of the early and total marketable yields with the C.P.G. treatment may be due to the increased number of soil and foliar kinetin applications with the C.P.G. than with soil or foliar kinetin alone or the combination of soil + foliar kinetin (Table 2). Both soil and foliar treatments contained cytokinins. Endogenous cytokinin production in plants may be limited during stress conditions. During Sept., plants were stressed by high rainfall and high temperatures and during Nov. by high temperatures. The repeated applications of cytokinin containing biostimulants with the C.P.G. treatment may have helped fruit set and fruit growth in pepper plants during periods of limiting endogenous cytokinin supply due to stress conditions.

In earlier studies, the effect of cytokinin based biostimulants on bell pepper yields was inconsistent from season to season (12), or the observed yield increase depended on the cultivar (9). For example, in a spring trial at the GCREC-Bradenton, a single pre-plant application of granular soil Triggrr resulted in an approximately threefold increase of U.S. Fancy fruit of 'Early Calwonder' in the first harvest compared to water control, but the same biostimulant had no effect on 'Jupiter' pepper yields (9). In the present study, a single application of soil applied kinetin in the liquid form resulted in the lowest total yields of U.S. Fancy and marketable grade fruits (Table 4). It is possible that microirrigated vegetables may require different rates and timing of biostimulants to achieve a yield increase.

Tomatoes. Tomato plant growth was adversely affected by the sweetpotato whitefly transmitted geminivirus(es). Plant heights at 21 and 32 DAT were similar with all treatments. At 21 DAT, the mean height per plant (inches) was 9.81 and at 32 DAT 19.71. Virus symptoms on the plants developed rapidly during the 5th week after transplanting and plant height measurements were discontinued. Early yield of large fruit was higher with the water control than with soil, foliar, or the soil + foliar Triggrr treatments, but similar to the C.P.G. treatment (Table 6). Early yield of medium fruit was higher with the C.P.G. than with water control and foliar Triggrr, but it was similar to yields with the soil and with the soil + foliar biostimulant treatments. Early yields of small and marketable fruits and cull grade and the total seasonl yields of all grades and sizes were similar with all treatments.

Yields have been adversely affected by geminivirus infection which also contributed to the unusually large amounts of cull fruits in the study (Table 6). Cull grade fruits were small, many had color defects and a distorted shape.

Due to the severe virus infection, leaf and fruit samples were not taken from the plants. Soil nutrients were similar with all treatments (data not presented here).

In summary, seasonal marketable yield of 'Bell Captain' pepper increased by 104 ctn/acre compared to water control, when plants were treated with 2 applications of soil kinetin followed by 9 applications of foliar kinetin. The same biostimulant treatment also increased the early yield of medium fruit of 'Summer Flavor 5000' tomato by 88 ctn/acre compared to water control. Biostimulant treat-

Table 6. Yield of microirrigated tomato, cv. Summer Flavor 5000 with soil and foliar-applied biostimulants. Fall 1989.

Size and harvest	Treatment				
	Control	ST	FT	S+FT	CPG
	25-lb ctn/A[y]				
Large (5x6)					
Early	148 a[x]	52 b	87 b	70 b	96 ab
Total	697 a	488 a	549 a	610 a	505 a
Medium (6x6)					
Early	52 b	70 ab	44 b	70 ab	140 a
Total	732 a	714 a	662 a	610 a	714 a
Small (6x7)					
Early	17 a	35 a	26 a	9 a	35 a
Total	183 a	192 a	183 a	183 a	209 a
Marketable					
Early	217 a	157 a	157 a	149 a	271 a
Total	1612 a	1394 a	1394 a	1403 a	1428 a
Cull					
Early	87 a	70 a	78 a	70 a	96 a
Total	880 a	845 a	1001 a	767 a	923 a
Marketable					
Early	304 a	227 a	235 a	219 a	367 a
Total	2492 a	2239 a	2395 a	2170 a	2351 a

[z]Treatment: ST = soil Triggrr; FT = foliar Triggrr; S+FT = soil + foliar Triggrr; CPG = crop product guide.
[y]Acre = 8712 linear bed feet (lbf); 4356 plants/A.
[x]Mean separation between biostimulant treatment by Duncan's multiple range test, $P \leq 0.05$.

ments did not increase fruit size or resulted in earlier yields of large size fruits compared with water control in bell peppers or in tomatoes. Tomato yields were adversely affected by a severe infection of geminivirus that reduced fruit size and overall yields.

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ENDOSULFAN AND SILVER REFLECTIVE MULCH EFFECTS ON SWEET POTATO WHITEFLY POPULATIONS AND YIELDS OF ZUCCHINI SQUASH AND TOMATOES

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Additiona index words. Cucurbita pepo, Lycopersicon esculentum, Bemisia tabaci.

Abstract. **Sweet potato whitefly (*Bemisia tabaci* Gennadins) populations were monitored weekly during the spring growing season in zucchini squash (*Cucurbita pepo* L.) and tomato (*Lycopersicon esculentum* Mill.) plots treated with endosulfan and/or silver reflective mulch, or left untreated. Adult sweet potato whitefly populations increased in squash 50 days after seeding and were retarded by application of endosulfan. In tomatoes, buildup began 32 days after transplanting and was retarded by the endosulfan in combination with silver reflective mulch treatment. Sweet potato whitefly populations increased faster in the squash than in tomatoes. Endosulfan sprays in combination with silver reflective mulch delayed silver leaf symptoms on squash, but had no effect on fruit yield. The endosulfan sprays increased tomato yields and decreased internal fruit irregular ripening symptoms.**

The squash silver leaf disease was first reported on squash (*Cucurbita pepo* L.) in Florida during 1987 (2). Since that time the disease has become prevalent throughout the state and can cause significant economic losses (6). Squash silver leaf has also been reported in Israel (1). The symptoms first appear by the development of a silver coloration along the veins of younger leaves. The silvering becomes more intense as the leaves mature until the entire upper surface of the leaf is silver. In severe outbreaks fruit can also become lighter green or pale in color.

A related disease of tomatoes (*Lycopersicon esculentum* Mill.) is called irregular ripening (IR) (2). Irregular ripening symptoms are limited to the fruit which have irregular ripened areas on the exterior surface and/or white or yellow discoloration on the interior walls. Irregular ripening also causes considerable economic losses due to the unmarketability of many affected fruit.

Both the squash silver leaf and irregular ripening diseases are associated with the presence of the sweet potato whitefly, *Bemisia tabaci* Gennadius (2), and the involvement of the sweet potato whitefly in squash silver leaf has recently been documented (7). Control of the diseases, therefore, requires management of the sweet potato whitefly. Management of the sweet potato whitefly by a variety of insecticides has been extensively studied (3, 5). However, sweet potato whitefly can rapidly develop resistance to most chemicals (3); therefore, an integrated management strategy is a necessity. One additional component of an integrated management strategy that has been reported to reduce sweet potato whitefly populations is the use of aluminum-painted polyethylene mulch (4). The purpose of this investigation was to determine the influence of the insecticide endosulfan and aluminum-painted polyethylene mulch on zucchini squash and tomato yields, sweet potato whitefly populations, and incidence of squash silver leaf and irregular ripening diseases.

Materials and Methods

Tomato experiment: 'Sunny' transplants (5 weeks old) were planted on 23 Feb. 1990 at the Agricultural Research and Education Center, Fort Pierce, FL. Raised beds, 8 inches in height and 44 inches wide, were spaced at 7-foot centers. Nutrients at 27-48-23 (lb N-P-K/acre) were incor-

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