with the 3 tunnel treatments, the polypropylene cover, and the heavier polyester cover. Fruit yields were not influenced by time the covers were in place with the wide weave, non-woven and woven cover, and the lighter polyester cover.

A possible explanation for this response may be the effect of treatment on heat build-up and/or retention under the covers. The covers with the wider weave did not reduce yields as did the more heat retentive heavier materials and the tunnels.

Peppers. As with tomatoes, plant growth was similar with all treatments. Yields were significantly influenced by cover removal date (Table 4). Removing the covers and tunnels 5 weeks after application significantly reduced yields. This was consistent among all fruit size categories. The use of covers also delayed harvest (Table 5). Yields with the non-covered check were significantly higher than with all covered treatments at the first harvest. The larger harvests were delayed with the clear tunnels and the poly non-woven covers. Here as in tomatoes, temperature differences under the covers appeared to be implicated in yield reactions.

Row covers can increase early yields in strawberries and muskmelons when used in north Florida under cool conditions. Total yields may not be increased by the use of tunnels or covers. When used under warmer conditions total yield can be reduced by leaving the row covers on extended periods of time in tomatoes and peppers. Yield can also be delayed in peppers.

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LIQUID FERTILIZATION OF SQUASH AND MUSKMELON GROWN AS A SECOND CROP FOLLOWING TOMATOES

A. A. CSIZINSZKY AND D. N. MAYNARD
IFAS, University of Florida
Gulf Coast Research and Education Center
Bradenton, FL 34203
G. J. HOCHMUTH
IFAS, University of Florida
Vegetable Crops Department
Gainesville, FL 32611
P. R. GILREATH
IFAS, University of Florida
Manatee County Cooperative Extension Service
Palmetto, FL 33561
R. L. MITCHELL
IFAS, University of Florida
Hillsborough County Cooperative Extension Service
Seffner, FL 33584

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Abstract. **Squash (*Cucurbita pepo* L. cv. Seneca Zucchini) and muskmelon (*Cucumis melo* L. FL85-2M) transplants were established as a second crop in the Spring of 1985 following a Fall 1984 tomato crop. Soil tests prior to planting indicated low residual fertility. Liquid fertilizer was applied with an injection wheel at 0, 75-13-62, 150-27-125, or 225-40-187 lb. N-P-K/7500 linear bed feet (lbf). Seven beds, 30 inches wide and 9 inches high, were formed on 4.5-ft centers between irrigation furrows 40.5 ft apart. The fertilizer was applied 100% preplant; 50% preplant and 50% at midgrowth; or 33% preplant, 33% at midgrowth, and 33% just prior to first harvest. Fruit yield increased with fertilizer rate and was higher with split applications as compared to a single preplant application. Early yields were highest with the 150-27-125 applied in 2 applications. Later, yields were higher with the 225-40-187 applied in 2 or 3 applications.**

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Utilization of residual fertilizers and polyethylene mulch by a second crop of vegetables following the main vegetable crop would be desirable for economical and environmental reasons. Several studies have been conducted in Florida on the use of mulch and residual nutrients by a second vegetable crop (2,3,4,8). Much of the effort in the earlier studies emphasized the quantity of fertilizers necessary for optimum yields by the second crop and the placement of dry fertilizers in relation to the plant row (2,4). Application of liquid fertilizers by the IFAS tractor-mounted squarebar applicator also was studied (8). Dry fertilizers were applied by hand in a hole punched through the mulch (4), or by a modified automatic plug-mix planter(8). Placement of dry fertilizers by hand is a labor intensive, expensive process.The modified plug mixer gave good performance, but could be used only for pre-plant fertilizer application. Liquid fertilizers, applied by the square bar applicator, were placed too deep in the bed which made them unavailable to seedlings, and later in the season, the nutrients were leached by heavy rainfall.

Yields of second crops increased with increased fertilizer rates used for the primary crop (3,8) or with an increase of fertilizer rate from residual fertilizer to the lowest rate of additional fertilizers (4). On Rockdale soils, complete or partial incorporation of fertilizer in mulched beds gave a higher yield of second-crop butternut squash than banding all fertilizer on the top of the bed (2). In Immokalee, fertilizer placement in one hole 8 inches to one side of the plant, one hole 8 inches to each side of the plant, or one hole in the drill halfway between the plants, had no significant effect on yield of tomatoes and cucumbers (4).

Fertilizer management for mulched muskmelon and zucchini squash has not been determined. Muskmelon fertility requirements in other cultural systems has been studied. In California, highest muskmelon yields were recorded with 80 or 130 lb./acre N in one year, while in the following year muskmelon yields were similar with 30, 80, and 130 lb./acre N (5). In Florida, Lazin and Simmonds (9) found no difference in honeydew melon yields with 1500, 2000, or 2500 lb./acre of a 6-8-8 analysis fertilizer.

Recently, a liquid fertilizer injection wheel was developed to provide fertilizers when needed for mulched crops. The purpose of our study was to evaluate the effect of liquid fertilizer rates and number of applications using the injection wheel on cucurbit crops following a primary tomato crop.

Materials and Methods

Experiments were conducted in Spring 1984 at the GCREC-Bradenton on EauGallie fine sand (Alfic haplaquod) with a spodic horizon at 34 inches. Cultural methods for the fall tomato (*Lycopersicon esculentum* Mill.) crop preceding the second crops were described earlier (7). In this case, the tomato precrop received 300-49-498 lb./7500 lbf. After the tomato harvest, the cucurbit crops [zucchini squash, *Cucurbita pepo* cv. Seneca Zucchini (Harris Moran) and muskmelon, *Cucumis melo* FL85-2M (G. W. Elmstrom, AREC-Leesburg)] were cultured similarly. Tomato crop residues were removed in Dec. 1984, but the polyethylene mulch was left on the raised beds which were 8 inches high and 30 inches wide. There were 7 beds on 4.5-ft centers between irrigation furrows 40.5 ft apart.

Soil samples were taken on 4 Mar. from 4 locations diagonally in the length of the plot to 9 inches depth. Soil was extracted by the saturated paste method (10) and pH in the soil solution was determined by a pH meter, total soluble salts (TSS) by a solubridge, N by the modified Kjeldahl method, P colorimetrically and K by atomic absorption spectrophotometry (1,10). Residual soluble salt and mineral concentrations in the soil solution, in ppm, were TTS: 3450, NO_3:29, NH_4:5.2, P:9.3, and K:183.0. The pH was 6.9. Seedlings of both crops were set in plots 15 ft long with 2 ft between plots. Experimental design was a 3 × 3 factorial of fertilizer rates and timing, arranged in a randomized complete block with 3 replications. Fertilizer was applied at 75-13-62 (1x), 150-27-125 (2x), or 225-40-187 (3x) lb., N-P-K/7500 lbf. Unfertilized plots served as controls. The fertilizer source was a 6-1.1-5 N-P-K analysis liquid (People's Fertilizer, Lake Alfred, FL) applied with the injection wheel (Liquid Ed, Inc., Lake Worth, FL). Fertilizers were applied at 3 different schedules: 100% preplant; 50% preplant and 50% at midgrowth; or 33% preplant, 33% at midgrowth and 33% just prior to first harvest. During the season, plants were sprayed with labeled pesticides to control insects and plant pathogens.

Muskmelon. Seeds were sown on 11 Mar. 1985 in containerized planter flats (Todd model #150, Speedling, Inc., Sun City, FL) containing peat and vermiculite (1:1), v:v) amended with dolomite (16.9 lb.), superphosphate (5.6 lb.) and Micromax (1.1 lb.) per yd^3 of media. Seedlings were set in the field on 9 Apr. at 24 inches within row spacing in a single row per bed. Fertilizer was injected on both sides of the bed at a distance from the plant row as determined by plant size. The first application was placed 4 inches from bed center and made prior to planting on 8 Apr. The second application was placed 8 inches from the bed center and made at first bloom on 25 Apr. The third application was placed 12 inches from the bed center and made at fruit set on 20 May. Fruit was harvested 3 times per week, from 10 to 28 June. At harvest, number and weight of marketable fruits were recorded (11). Concentration of soluble solids (Brix°) was determined by a handheld refractometer.

Zucchini squash. Seeds were sown on 8 Mar. 1985 as described above for muskmelon. Seedlings were set in the field on 25 Mar. at 24 inches within-row spacing in a single row per bed. Fertilizer was injected as described for muskmelon on 13 Mar., 10 Apr., and 25 Apr. Fruit was harvested 3 times per week, from 26 Apr. to 5 June, and number and weight of marketable fruit were recorded (12).

Results

Residual soil total soluble salt concentrations and concentrations of selected nutrients in the tomato land, except for K, were low. In spite of the low soil nutrient status, there was no visible difference in growth or leaf color between plants in the fertilized and unfertilized plots and among plant grown with the various fertilizer rates during the first 2 weeks after transplanting.

Muskmelon were harvested 3 times per week for 3 consecutive weeks, beginning on 10 June. Yield and weight per fruit were affected by fertilizer rates and number of applications (Tables 1 and 2). For week 1, no single experimental factor affected yields. However weight per fruit was affected by the interaction between fertilizer rates and number of applications (Table 3). The highest (3x) rate applied in 2 or 3 equal proportions resulted in the heaviest fruit, 2.64 and 2.68 lb., respectively, for the 2 application times. During the second week of harvest, interaction of experimental factors affected weight and number of fruit per 7500 lbf (Table 3). Both weight, 289.4 cwt/7500 lbf, and number, 7.99 thousand/7500 lbf, were highest with the 2x fertilizer rate applied in 2 equal amounts. Weight per fruit increased linearly with increasing fertilizer rates (Table 2). The weight increase was best described by the equation:

$$\text{Weight/fruit (lb.)} = 0.997 + 0.101 \text{ (fertilizer rate)} \times 2.2.$$

For week 3, weight per 7500 lbf was significantly affected by both experimental factors, but their effects were independent (Tables 1 and 2). Weight increased linearly with fertilizer rates according to the relationship:

$$\text{Weight/7500 lbf (cwt)} = 3.496 + 4.701\ (\text{fertilizer rate}) \times 13.75.$$

Fruit yields were higher with split than with a single fertilizer application, but there was no difference between 2 and 3 applications (Table 2). The rate × number of applications interaction was significant for the number of fruit per 7500 lbf but there was no clear trend, since 2x or 3x fertilizer rate applied in 2 or 3 equal proportions had equivalent effects. Weight per fruit during the 3rd week was not affected by fertilizer rates although the means suggested a linearly increasing trend (Table 1). Individual fruit weight during the 3rd week was higher with split application of liquid fertilizers (Table 2). For the seasonal totals, the rate × number of applications interaction was significant for both weight and number of fruit per 7500 lbf (Tables 3 and 4). Weight per 7500 lbf was 598.5 cwt with the 2x rate applied in 2 equal amounts. Number of fruit per 7500 lbf followed a similar trend to weight per 7500 lbf yields. Average weight per fruit for the season increased linearly with fertilizer rate (Table 1). The estimated equation is:

$$\text{Weight/fruit (lb.)} = 0.935 + 0.132\ (\text{fertilizer rate}) \times 2.2.$$

Maximum weight per fruit was obtained by applying the fertilizer in either 2 or 3 equal applications (Table 2).

Soluble solids concentrations (°Brix) in fruits from liquid-fertilizer-treated plots were similar (Table 5). All fertilizer rates and application times resulted in marketable quality fruits, whereas soluble solids concentrations in fruits from the control plots were below that of U.S. standards for muskmelon (10).

Zucchini was harvested 3 times per week for 6 consecutive weeks, beginning on 26 Apr. Weight and number of fruit per 7500 lbf were affected by fertilizer rates and number of applications, respectively (Tables 6 and 7). In the first week, weight per 7500 lbf varied quadratically with fertilizer rates according to the relationship:

$$\text{Weight/7500 lbf (bu)} = -1.857 + 5.308\ (\text{rate} - 1.242\ (\text{rate}^2 \times 43.65.$$

Maximum yield of 165.6 bu/7500 lbf was obtained at the tx rate, applied in 2 equal applications (Tables 6 and 7). During week 2, both fruit weight and numbers per 7500 lbf increased linearly with fertilizer rates (Table 6). The equations were:

$$\text{Weight/7500 lbf (bu)} = 2.211 + 1.007\ (\text{rate}) \times 43.65$$

$$\text{Number/7500 lbf} = 11.07 + 4.222\ (\text{rate}) \times 833.33.$$

Table 1. Effect of liquid fertilizer rates on muskmelon yields.

Fertilizer rate[z]	Week 1	Week 2	Week 3	Season's total
		Cwt/7500 lbf[w]		
0	32.7	48.5	48.7	129.9
1x	59.0	160.5	106.6	326.0
2x	60.6	222.8	189.6	473.0
3x	60.9	176.1	235.8	472.8
L[y]	NS	NS	**	**
Q[y]	NS	*	NS	**
Contrast[x]	NS	**	**	**
		Number/7500 lbf (× 1000)		
0	1.88	2.81	1.67	6.36
1x	2.99	6.94	3.82	13.75
2x	3.06	7.99	6.46	17.50
3x	2.64	6.46	7.50	16.60
L[y]	NS	NS	*	*
Q[y]	NS	NS	NS	*
Contrast[x]	NS	**	**	**
		Weight/fruit (lb.)		
0	1.74	1.67	2.61	2.02
1x	1.94	2.36	2.70	2.33
2x	1.85	2.78	2.87	2.68
3x	2.29	2.80	3.20	2.91
L[y]	NS	*	NS	*
Q[y]	NS	NS	NS	NS
Contrast[x]	NS	**	NS	**

[z]Fertilizer rate: 0 = residual fertilizers only; 1x = 75-13-62 (N-P-K) lb./7500 lbf.
[y]Fertilizer rate effects were linear (L), quadratic (Q), or nonsignificant (NS).
[x]Contrast is the comparison of the mean of treated plots with the mean of control plots, and is significant at the 1% (**) level or nonsignificant (NS).
[w]lbf = linear bed feet.

Table 2. Effect of number of liquid fertilizer applications on muskmelon yields.

Number of applications	Week 1	Week 2	Week 3	Season's total
		Cwt/7500 lbf[w]		
0	32.7	48.5	48.7	129.9
1	54.8	172.0	108.2	335.0
2	65.5	207.6	203.1	476.2
3	60.2	179.6	220.8	460.6
$LSD_{0.05}$[z]	NS	NS	80.7	96.5
Contrast[y]	NS	**	**	**
		Number/7500 lbf (× 1000)		
0	1.88	2.81	1.67	6.36
1	2.92	7.08	4.31	14.31
2	2.92	7.50	6.18	16.60
3	2.85	6.81	7.29	16.95
$LSD_{0.05}$[z]	NS	NS	2.54	NS
Contrast[y]	NS	**	**	**
	Weight/fruit (lb.)			
0	1.74	1.64	2.61	2.02
1	1.88	2.45	2.50	2.31
2	2.20	2.84	3.22	2.92
3	2.00	2.65	3.05	2.70
$LSD_{0.0f}$[z]	NS	NS	0.41	0.26
Contrast[y]	NS	**	NS	**

[z]LSD is significant at the 5% level of probability (*) or nonsignificant (NS).
[y]Contrast is the comparison of the mean of treated plots with the mean of control plots, and is significant at the 1% (**) level or nonsignificant (NS).

Table 3. Interaction of liquid fertilizer rate and number of applications on muskmelon yield.

Parameter	Week 1	Week 2	Week 3	Season's total
Wt of fruit/7500 lbf[z]	NS	**	NS	**
No. of fruit/7500 lbf[z]	NS	**	*	**
Wt/fruit[z]	*	NS	NS	NS

[z]Interaction is significant at the 5% (*), 1% (**) level, or nonsignificant (NS).

Table 4. Interaction of number of fertilizer applications and fertilizer rates on marketable muskmelon fruit yield.

Fertilizer rate[y]	Fruit yield (cwt/7500 lbf)[z] Application times 1	2	3
1x	177.9	431.2	369.1
2x	398.0	598.5	422.3
3x	428.9	399.0	590.4

[z]$LSD_{0.05}$ = 96.5 cwt.
[y]1 × = 75-13-62 lb. N-P-K/7500 lbf.

For both bushels and fruit number per 7500 lbf, fertilizer applied in split applications was best with no difference between 2 and 3 applications interacted for weight and fruit number per 7500 lbf yields (Table 8). Yield responses for both weight and number of fruit were similar. Yield was 275 bu/7500 lbf and 20.83 thousand fruit/7500 lbf with the 3x rate applied in 2 equal applications; 259.4 bu/7500 lbf and 20.83 thousand/7500 lbf with the 2x rate applied in 3 equal applications and 262.8 by/7500 lbf and 20.33 thousand fruits with the 3x rate applied in 3 equal applications. In the 4th week, fertilizer rates and number of applications again interacted in their effect on zucchini yields (Table 8). In this case the optimum combination was the 2x rate in 2 applications which yielded 200.8 bu/7500 lbf and 16.39 thousand fruit. For the 5th week, weight and number of fruit per 7500 lbf yields increased linearly with increasing fertilizer rates (Table 6). The estimated regression equations were:

$$\text{Weight/7500 lbf (bu)} = -0.210 + 0.615\ (\text{rate}) \times 43.65$$

$$\text{Number/7500 lbf} = -0.148 + 3.056\ (\text{rate}) \times 833.33.$$

Fertilizer application time did not affect yields in fertilized plots, but the contrast between unfertilized and fertilized plots was significant (Table 7). In the sixth and last week of harvest weight per 7500 lbf was influenced by the interactions of fertilizer rates and number of applications

Table 5. Main effect of liquid fertilizer rate and number of applications on soluble solids concentrations of muskmelon.

	Fertilizer rate^z	Soluble Solids (°Brix)	No. of applications	Soluble Solids (°Brix)
	0	7.88	0	7.88
	1x	9.54	1	9.35
	2x	9.45	2	10.17
	3x	10.19	3	9.67
L^y		NS		—
Q^y		NS		—
Contrast^x		**		**

^{z}Fertilizer rate: 0 = residual fertilizers only; 1x = 75-13-62 lb. N-P-K/7500 lbf.
^{y}Linear (L) and quadratic (Q) regressions were nonsignificant (NS) for treated plots.
^{x}Contrast is the comparison of the mean of treated plots with the mean of control plots, and is significant at the 1% (**) level.

Table 6. Effect of liquid fertilizer rates on zucchini yields.

Fertilizer rate^z	Week 1	2	3	4	5	6	Season's total
				Bu/7500 lbf			
0	8.9	38.0	28.6	10.6	7.9	25.8	119.8
1	96.5	130.0	56.0	38.2	17.2	22.4	360.3
2	165.6	205.3	163.9	77.1	45.5	50.2	707.6
3	126.3	217.9	194.7	119.2	70.9	104.6	833.6
L^y	NS	**	**	**	*	**	**
Q^y	*	NS	NS	NS	NS	NS	NS
Contrast^x	**	**	**	**	**	NS	**
				Number/7500 lbf (× 100)			
0	1.25	7.08	4.44	1.81	1.81	1.67	18.06
1	10.47	12.22	7.33	5.37	2.50	3.89	41.78
2	13.06	17.32	13.15	8.32	4.82	5.92	62.60
3	11.85	19.26	15.47	11.94	7.59	7.97	74.08
L^y	NS	**	**	**	*	*	**
Q^y	NS	NS	NS	NS	NS	NS	NS
Contrast^x	**	**	**	**	**	**	**

^{z}Fertilizer rate: 0 = residual fertilizers only; 1x = 75-13-62 lb. N-P-K/7500 lbf.
^{y}Fertilizer rate effects were linear (L), quadratic (Q), or nonsignificant (NS).
^{x}Contrast is the comparison of the mean of treated plots with the mean of control plots, and is significant at the 1% (**) level or nonsignificant (NS).

Table 7. Effect of number of liquid fertilizer applications on zucchini yields.

No. of fertilizer applications	Week 1	2	3	4	5	6	Season's total
				Bu/7500 lbf			
0	8.9	38.0	28.6	10.6	7.9	25.8	119.8
1	110.6	107.7	47.8	29.1	14.5	24.9	334.6
2	162.9	226.0	167.7	110.8	55.5	62.3	785.2
3	114.8	219.5	199.1	94.6	63.6	90.1	781.7
$LSD_{0.05}$^{z}	84.6	79.7	94.9	66.6	69.8	65.0	323.4
Contrast^y	**	**	**	**	**	**	**
				Number/7500 lbf (× 1000)			
0	1.25	7.08	4.44	1.81	1.81	1.67	18.06
1	10.92	10.92	5.47	5.83	2.77	3.80	39.72
2	14.35	18.98	13.24	9.82	5.47	6.48	68.34
3	10.09	18.89	16.57	10.00	6.67	7.50	69.72
$LSD_{0.05}$^{z}	5.41	6.24	5.18	4.72	4.16	5.50	22.16
Contrast^y**	**	**	**	**	**	**	

^{z}LSD is significant at the 5% level of probability (*) or nonsignificant (NS).
^{y}Contrast is the comparison of the mean of treated plots with the mean of control plots, and is significant at the 1% (**) level.

Table 8. Interaction of liquid fertilizer rate and number of applications on zucchini yield.

Parameter	Week 1	2	3	4	5	6	Season's total
Wt of fruit/7500 lbf[z]	NS	NS	*	**	NS	*	NS
No. of fruit/7500 lbf[z]	NS	NS	**	**	NS	NS	NS

[z]Interaction is significant at the 5% (*), 1% (**) level, or nonsignificant (NS).

(Table 7). Optimum yield, 165.3 bu/7500 lbf occurred with the 3x rate with 3 equal applications. Fruit number per 7500 lbf increased linearly (Table 6), according to the equation:

Number of fruit per 7500 lbf = 2.222 + 2.444 (rate) × 833.3

For the season, fertilizer rates influenced weight and number of fruit per 7500 lbf (Table 6). Fruit weight and number increased linearly with increasing fertilizer rates. The regression equations for the yield parameters are:

Weight/7500 lbf (bu) = 3.681 + 5.420 (rate) × 43.65

Number/7500 lbs = 31.56 + 19.78 (rate) × 833.33.

Zucchini, at the 3x fertilizer rate yielded 833.6 bu and 74.08 thousand fruit per 7500 lbf. Split application of liquid fertilizer was better than a single application (Table 7). Yield was 334.6, 785.2, and 781.7 bu/7500 lbf for 1, 2, and 3 applications, respectively. Results were similar for fruit number. More fruit were harvested from plots which received split fertilizer applications than from plots that received all the fertilizer in a single preplant application.

Discussion

In our results, muskmelon yields were above the estimated Florida yields of 80 cwt/7500 lbf. Zucchini yields are not reported separately for Florida, but the average yield of all summer squash is about 175 42-lb. bu/7500 lbf (6). Average yields of both crops depend partly on market conditions. When prices are low, the crop will not be harvested, therefore, grower's yields are usually lower than yields under experimental conditions.

Muskmelon and zucchini yields were lowest in the control plots with residual fertilizers. Without additional fertilizers, muskmelon fruit were unmarketable due to their low, 7.88° Brix, soluble solids.

In production systems where the injection wheel will be used for fertilizer application, fertilizer rates and number of applications during the season will depend on the crop and on market conditions. Crops, with short harvest periods, might be grown with lower fertilizer rates, and fewer applications than crops with an extended harvest season. In our study, muskmelon yields during the first 2 weeks, and zucchini yields during the first week of the harvest season, were highest with the 2x fertilizer treatment. For the rest of the season, both crops had highest yields with the 3x fertilizer rate. Number of applications had a similar effect on yields. Split application of fertilizer during the growing season resulted in higher yields than a single application before planting. For muskmelon, fertilizers applied in 2 equal amounts resulted in highest yields in the first 2 weeks of harvest. In the third week, yields were best with 3 applications. Zucchini yields were also higher with 2 applications than with 3 applications, during the first, second and fourth week of the harvest. As the harvest season progressed, yields increased in plots which received 3 fertilizer applications.

Use of the injection wheel therefore adds flexibility to fertilizer management especially with the full-bed mulch system. Application of very high amounts of dry fertilizers prior to planting will not be necessary if the injection wheel is used to provide fertilizers during the season when needed for the crop. It also will be easier to plant a second crop to utilize any residual fertilizers from the main crop and use the injection wheel to apply fertilizers as dictated by the nutritional status of the second crop demands. These management alternatives need to be further investigated for individual crops.

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