Table 5. Effect of ethephon concentration on sex expression of two cultivars of slicing cucumbers.

Cultivar	Ethephon concentration (ppm)[z] 0	125	250	500
		No. male flowers		
Gemini	3.4b[y]	0.7a	0.4a	1.3a
Poinsett	7.5b	2.0a	2.5a	2.1a
		No. female flowers		
Gemini	3.7a	5.1b	4.8b	3.3a
Poinsett	1.4a	5.8c	5.5bc	4.9b

[z]Data summarized for all N rates.
[y]Mean separation within rows by Duncan's multiple range test, 5% level.

The spring of 1977 was unusually dry. Under these conditions excessive preplant N fertilizer delayed seedling emergence and, thereby, delayed harvst of slicing cucumbers even when adequate irrigation water was available. High rates of N fertilizer did not appear to improve early or total yields when ethephon was used to increase female flower production. Ethephon effectively increased early yields of cucumbers but did not increase total yield. Ethephon increased the number of female flowers produced during the physiological flowering phase where there is normally a higher tendency to produce male flowers. This probably led to the higher early yields in the ethephon treatments. Later in the season, as the plants became older and they physiologically produced more female flowers, yields improved regardless of ethephon application.

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TOMATO YIELDS AFFECTED BY CULTURAL MANAGEMENT[1]

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Abstract. **The effect of control practices on pest populations and yield was measured on tomatoes grown under different cultural methods. Main variables were plant seedling size (2" and 1"), two cultivars ('Fla MH-1', 'Homestead 24') set in untreated or fumigated soil (Vorlex) and maintained under one of four pesticide spray programs: insecticide and fungicide weekly at maximum rate, weekly use of 1/2 maximum (minimum), treatment with maximum rate on demand and a control.**

Larger (2") seedlings produced greater total yield weight and greater amount of insect damaged fruit than did the smaller 1" seedlings. 'Florida MH-1' produced a greater yield weight and greater amounts of insect damage but less percent marketable fruit weight than did 'Homestead 24'. Fumigation with Vorlex resulted in yields consistently greater than no fumigation for total weight of fruit, total insect damaged fruit and percent weight of fruit culled due to insect damage.

All yield measurements were influenced by spray treatment. More yield weight was obtained under the demand program. However, percent marketable fruit was greatest with minimal treatment. Smallest loss of fruit to insects was obtained where the maximum program was followed.

The current preoccupation of crop protection scientists with the principles and philosophy of interdisciplinary pest management has pointed out the need to optimize manipulation of several variables governing crop yields. Identification of determinant or key production variables as well as their relationship to pest populations is a first step in developing a sound protection management system.

Several cultural variables involved in vegetable production in Florida have been demonstrated to be of value to tomato yields. Recommendations for full bed mulches (3, 4) proper fertilization rates (3, 7) plant density (7) and vine culture (1) are made to assure realization of the greatest potential yield of tomatoes. In addition, sound programs must be implemented to protect the plants and fruit from insect (2, 5), nematode (8) and plant pathogen (6) pests. The beneficial effect of resistant cultivars, mulches, and fumigation on soil pathogen control and nematode damage (6, 9) integrates cultural practices with crop protection. Yield data obtained from plants grown under selected use of pesticides (10) indicate that pesticides can be applied most advantageously when tomato fruit are present; applications to non-fruiting plants may not be necessary. Ideally, a production management program should be constructed around the use of a high yielding cultivars resistant to key pests but complemented by pest supressive cultural

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techniques and selected chemical pesticides used at rates and times appropriate to maintain yield and quality.

The research reported here was undertaken to demonstrate a crop management program for tomato production through an interdisciplinary approach utilizing optimum strategies standard for tomato production in Florida. Chemical pesticide use programs were then superimposed to determine how optimum protection could be obtained in the different cultures.

Materials and Methods

The tomato crop was grown in spring, 1974, at the University of Florida, AREC, Bradenton, Florida. The full bed mulch system was used as a standard production culture method. The field, a Leon fine sand, was prepared with 600 lb/A of superphosphate containing 5 lbs of fritted trace elements. After beds (10″ high by 28″ wide) were formed, 1500 lb/A of an 18-0-25-2 fertilizer was placed in bands on the shoulder atop each bed prior to mulching. Where fumigation was used, Vorlex (35 gpa) was injected into the beds. Irrigation was supplied by a seep ditch system in which seven 54″ beds were separated by a water ditch. Two seedling sizes, 2″ and 1″, were selected for each of two cultivars, 'Florida MH-1' and 'Homestead 24'. Plants were set on February 19, 1974 and reset where needed until March 11. Each plot was 50′ long with a 7′ alleyway between plots.

Four pesticide spray regimes were established: 1) control, no treatment, 2) maximum—weekly application of 2.0 lbs ai chlorothalonil for foliar plant pathogen control, plus 0.5 lb ai of methomyl and 1.5 lb ai diazinon for insect control, as 100 gal of finished spray/A. 3) minimum weekly application of the same pesticides used in the maximum program but at only one half the rate, and 4) demand-application of the maximum rate of the same pesticides but based on observed need. The demand application was to be made when 50% of leaves sampled were mined by vegetable leafminer (*Liriomyza sativae* Blanchard) or when larvae of the tomato pinworm (*Keiferia lycopersicella* Walsh) or noctuids were present and a threat to the fruit (10). Ten trifoliate terminal leaflets were selected from the lower portion of the plant and the number of leaves containing mines as well as the total number of mines present determined. Foliar estimates of disease were made from field observation and counts of similar samples. The first application of pesticide was made on March 12, 1974 and weekly thereafter to designated plots.

Results and Discussion

The transplants endured ca 14 days of cold windy conditions before warm weather in the spring permitted growth. In addition, 1.7% of the plants in the experiment were lost due to mole cricket inqury. Checks of the demand plots in March and April, during establishment and vegetative growth, led to saving of 5 applications of insecticide and 8 applications of fungicide. Fungicide was sprayed on 'Homestead 24' in the demand plots on March 19 and both cultivars in demand plots were sprayed on March 26, April 2, and again on April 9.

The spray program for the season was:

Control—untreated

Maximum—weekly on March 12, 19, 26, April 2, 9, 16, 23, May 1, 7, 14

Minimum—weekly on March 12, 19, 26, April 2, 9, 16, 23, May 1, 7, 14

Demand—Fungicide only for 'Homestead 24' on March 19 and April 9, insecticides and fungicides on March 26, April 2, and insecticides only on April 23, May 1 and 7. The first 3 applications of insecticide included leptophos which was replaced by methomyl when the former material was found to be phytotoxic.

Data in Table 1 show that leafminer damage exceeded 50% of leaves on March 25, (when plants were small) and on April 1 and 24 and that pinworms and caterpillars, (*Trichoplusia ni* Hub., *Heliothis zea* Boddie, *Spodoptera eridania* Cramer), were present in low numbers on those dates. Consequently the decision was made to apply chemicals to the demand plots.

Use of 2-in. seedlings as transplants produced ca 63% more fruit than the 1-in. seedlings regardless of the treatment program (Table 2). Of the treatment programs, greater yield was obtained from the demand plots. However, this difference was not thought to be due solely to differences in crop protection but from the effect of the chemical pesti-

Table 1. Insects present in demand plot samples during early development, spring 1974, Bradenton, Florida.

Date of sample	Leafminer[z] % Mined leaves	Leafminer[z] Total mines/plot	Pinworm[x] % Damaged leaves	Pinworm[x] No. larvae/plot	Caterpillars[y] % Damaged leaves	Caterpillars[y] No. larva/plot
March 25	86.2	16.8	15.0	0.75	31.2	0.12
April 1	54.3	2.9	10.0	0.43	18.1	0.06
April 8	10.7	2.0	0.004	0.03	0.007	0.0
April 15	29.8	6.3	0.003	0.03	0.04	0.0
April 24	65.6	4.3	30.6	1.53	0.03	0.15

[z]*Liriomyza sativae* Blanchard.
[x]*Keiferia lycopersicella* (Walsh).
[y]*Trichoplusia ni* Hubner, *Heliothis zea* Boddie, *Spodoptera eridania* (Cramer).

Table 2. Yield of tomatoes grown with different cultural variables, spring 1974, Bradenton, Florida.

Treatment program[z]	Gross wt (lb) of fruit produced: Seedling size 1″	Seedling size 2″	Cultivar Fla. MH-1	Cultivar Homestead 24	Fumigation Vorlex	Fumigation Control	Average
Control	58	79	96	41	78	59	68.4
Maximum	51	92	96	47	78	64	71.4
Minimum	59	107	107	59	89	77	83.0
Demand	78	123	136	64	99	101	100.2**
Total	246	400	434	211	345	301	
Average	61.4	100**	108.6**	52.8	86.3**	75.2	

[z]Control = no treatment. Maximum = 2.0 lb chlorothalonil, 0.5 lb methomyl, 1.5 lb diazinon, ai/100 gal weekly. Minimum = 1.0 lb chlorothalonil, 0.25 lb methomyl, 0.75 lb diazinon, ai/100 gal weekly. Demand = maximum rates applied as needed.
**Values differ significantly P = 0.01.

cides themselves on the crop. Not only was less pesticide applied to these plants, but the early phytotoxicity due to leptophos observed on the maximum and minimum plants was largely avoided on the demand plants because they received only one application of the chemical. Among the other variables, 'Fla MH-1' consistently outyielded 'Homestead 24' regardless of treatment program. No fumigation was equal to fumigation only when plants were treated on demand.

Comparison of the percent of weight lost to insects (Table 3) for the respective variables indicates that seedling size and cultivar did not significantly affect the level of fruit loss but that loss was significantly less where no fumigation was used. The reason for this was not apparent. Pesticide treatment programs reduced loss to less than 10 per cent, all significantly better than the control. The lowest amount of loss among the plots was 1.1% in a maximum treated plot, the greatest amount of loss was 67.6% in a control plot.

Neither fumigation nor seedling size had a significant effect on the percent of fruit which was marketable (Table 4). 'Florida MH-1' had less marketable fruit by percentage than did 'Homestead 24', apparently due to the greater volume of fruit (Table 2) and greater loss to insects (Table 5). Among treatments there was a general marked lower percentage (less than 40%) of marketable fruit, much of which was due to effects other than insect damage. Fruits were culled if small, scarred, sand damaged, cracked or otherwise blemished. Only the minimum sprayed plants had a reduced marketable yield differing from other treatments (Table 4), which might reflect the absence of stresses imposed by higher rates of toxic chemical pesticides.

The proportion of fruit lost to three species of insects, tomato pinworm, stinkbugs and a complex of fruitworm species, is given in Table 5. The average loss of fruit to pinworm and stinkbugs was significantly less in the control plots than in the treated plots but the reverse was true for fruitworms (Table 5). The greater loss in the control to fruitworms undoubtedly influenced the numbers damaged by stinkbugs and pinworms. Fruit loss due to rot and decay subsequent to insect damage made true estimates of losses in control plots difficult.

Seedling size apparently had no influence on percentage of fruit lost to any pest although when protection was maximum less fruit was lost to pinworm on plants that began as one-in. seedlings. Losses to pinworms were 18.0% and 23.7% for the one-inch and two-inch plants sizes respectively (Table 5). 'Florida MH-1' appeared to be slightly favored by stinkbugs although actual fruit damaged was significant only where no pesticides were applied, 30.6 to 20.4% loss respectively.

When the pesticide management program was minimal the effect of fumigation appeared to be important and to enhance the degree of protection afforded by limited pesticide use in stinkbug control. This might be due to indirect effects of weeds which were less abundant in fumigated plots.

Table 6 shows the level of leafminer parasitism on 3 dates during the crop season. Although values varied among plots and at times of the season, the percent parasitism was apparently reduced less than 10% by the treatment programs. These data compare favorably to other data from small plot studies (11) and are subject to the same interpretation. Where plots are small and parasite movement is un-

Table 4. Yield of marketable tomato fruit grown with different cultural variables, spring 1974, Bradenton, Florida.

Treatment program[y]	Percent of weight lost to insects[x]						
	Seedling size		Cultivar		Fumigation		
	1"	2"	Fla. MH-1	Homestead 24	Vorlex	Control	Average
Control	49.2	53.3	51.0	51.5	56.7	45.7	51.2**
Maximum	7.4	4.7	5.6	6.5	5.9	6.2	6.0
Minimum	6.5	7.6	7.3	6.8	7.8	6.3	7.0
Demand	8.5	8.5	7.9	9.1	9.9	7.1	8.5
Average	17.9	18.5	17.9	18.5	19.8**	16.2	
	NSD		NSD				

[x]*Keiferia lycopersicella, Feltia subterranea, Heliothis zea, Spodoptera eridania, S. exigua.*
[y]Control = no treatment. Maximum = 2.0 lb chlorothalonil, 0.5 lb methomyl, 1.5 lb diazinon, ai/100 gal. weekly. Minimum = 1.0 lb chlorothalonil, 0.25 lb methomyl, 0.75 lb diazinon, ai/100 gal weekly. Demand = maximum rates applied as needed.
**Values differ significantly P = 0.01 level.

Table 4. Yield of marketable tomato fruit grown with different cultural variables, spring 1974, Bradenton, Florida.

Treatment program[z]	Percent by Weight of Marketable Fruit						
	Seedling size		Cultivar		Fumigation		
	1"	2"	Fla. MH-1	Homestead 24	Vorlex	Control	Average
Control	48	43	47	45	42	50	38.8
Maximum	37	39	36	41	37	39	38.3
Minimum	32	37	32	37	34	36	34.6**
Demand	47	49	45	51	50	46	39.6
Average	41.2	42.0	40.0*	43.5	40.7	42.7	
	NSD				NSD		

[z]Control = no treatment. Maximum = 2.0 lb chlorothalonil, 0.5 lb methomyl, 1.5 lb diazinon, ai/100 gal weekly. Minimum = 1.0 lb chlorothalonil, 0.25 lb methomyl, 0.75 lb diazinon, ai/100 gal weekly. Demand = maximum rates applied as needed.
*Values differ significantly P = 0.05 level.
**Values differ significantly P = 0.01 level.

Table 5. Loss to insects of tomatoes grown under different cultural variables, spring 1974, Bradenton, Florida.

	Percent of fruit lost due to damage by insects							
		Seedling size		Cultivar		Fumigation		
Treatment program[z]		1"	2"	Fla. MH-1	Homestead 24	Vorlex	Control	Average
	PW[y]	10.3	9.9	10.9	8.0	10.4	9.8	9.8**
Control	STB	27.1	27.9	30.6	20.4*	26.4	29.1	26.9**
	FW	64.1	62.2	58.4	71.6	63.8	60.9	63.5**
	PW	18.0	23.7	20.8	26.3	23.0	20.8	22.1
Maximum	STB	45.9	36.3	46.9	36.8	44.5	43.7	42.3
	FW	36.1	40.9	32.2	36.8	32.4	35.4	35.6
	PW	16.6	15.9	16.0	16.9	18.4	13.4	16.2
Minimum	STB	37.6	49.8	42.8	50.7	39.3	54.4	45.7
	FW	45.8	34.2	41.0	32.3	42.2	32.7	32.7
	PW	21.3	20.8	21.9	18.6	20.1	21.2	20.6
Demand	STB	39.3	40.8	40.3	43.1	41.1	41.8	41.1
	FW	39.4	38.3	37.8	38.5	39.0	36.9	38.3

[z]Control = no treatment. Maximum = 2.0 lb chlorothalonil, 0.5 lb methomyl, 1.5 lb diazinon, ai/100 gal weekly. Minimum = 1.0 lb chlorothalonil, 0.25 lb methomyl, 0.75 lb diazinon, ai/100 gal weekly. Demand = maximum rates applied as needed.
[y]PW= tomato pinworm *Keiferia lycopersicella*, STB = stinkbugs *Nezara viridula*, *Aerosternus hilare*, and *Euchistus servus*. FW = noctuid complex of *Spodoptera exigua* Hubner (ca 8%); *Feltia subterranea* (ca 5%); *Heliothis zea* (Bod.) (ca 2%); *S. eridania* (ca 85%).
**Values differ significantly P = 0.01 level for each respective species.
*Values differ significantly P = 0.05 level for each respective species.

Table 6. *Liriomyza sativae* Blanchard and parasites reared from foliage of tomatoes.

	Collected 4/17/74		Collected 5/1/74		Collected 5/21/74		
Treatment[z]	N	% Parasites	N	% Parasites	N	% Parasites	Avg.
Control	58	69	15	47	17	71	62.3
Maximum	50	40	27	70	41	49	53.0
Minimum	51	55	32	41	15	67	54.3
Demand	62	68	48	27	14	71	55.3
Total	221	—	122	—	87	—	
Average	55.2	58.0	30.5	46.2	21.7	64.5	

[z]Control = no treatment. Maximum = 2.0 lb chlorothalonil, 0.5 lb methomyl, 1.5 lb diazinon, ai/100 gal weekly. Minimum = 1.0 lb chlorothalonil, 0.25 lb methomyl, 0.75 lb diazinon, ai/100 gal weekly. Demand = maximum rates applied as needed.
**Values differ significantly P = 0.01.

restricted the effect appears to be similar regardless of treatment.

Based on the data obtained from this experiment, the optimum strategy for tomato production would include use of 2" seedlings of 'Florida MH-1' grown in fumigated soil under a demand spray program. At the present time, however, commercial production of 2" size seedlings may not be practical and refinement of methods to detect and monitor fields for populations of pests are needed to implement the treat on demand program. Furthermore, the presence of severe foliar diseases, not a factor in this work, might alter the outcome of production as well as protection variables. The use of a cultivar having multigenic pathogen resistance, accepted fumigation and weed control practices, standard in tomato crop management options appears to hold the most promise as a base for integrated management system of tomatoes. What is most needful then is a sound insect and disease monitoring technique during the growing seasons which will permit pest detection and therapeutic treatment with selective chemicals before economic damage occurs.

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