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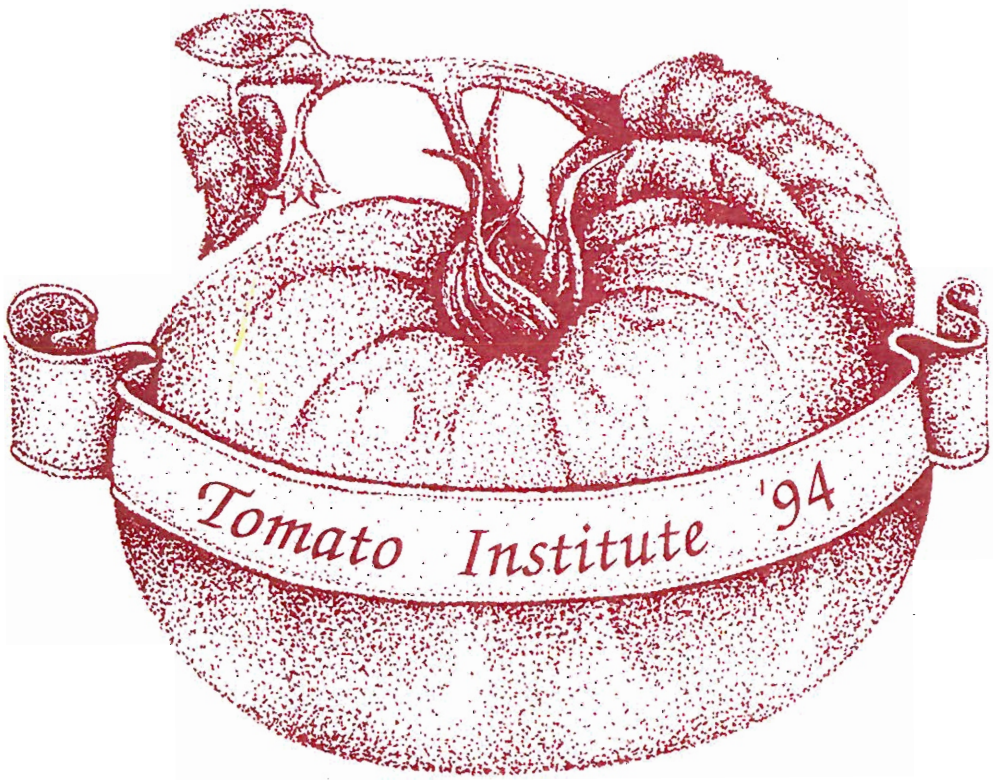

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Alternatives to Methyl Bromide for Nematode Control

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Traditionally, soil borne pest and disease control in Florida tomato production has been achieved with broadspectrum soil fumigants. One by one these fumigants have been lost, oftentimes due to toxicological and or environmental problems. Most recently, methyl bromide, used almost exclusively as a soil fumigant within the Florida tomato industry, was identified as an ozone depleter, and is currently mandated for a complete phaseout of production and use by January 1, 2001. As a result, there is an urgent need to develop alternative soil pest control strategies, particularly those which are as effective, and worker, food, and environmentally compatible and safe.

Due to the likely impacts of methyl bromide withdrawal, there has been intense focus within the state of Florida to identify and evaluate possible chemical and nonchemical alternatives to methyl bromide soil fumigation. In Florida, concerted efforts by University of Florida, IFAS research faculty, sponsored in part by the Florida Fruit & Vegetable Association (FFVA) is currently underway to conduct comparative tomato yield and pest efficacy trials using a number of different chemical compounds at four locations within the state. These locations include University of Florida research and education facilities at Quincy, Bradenton, Gainesville, and Immokolee. These experimental sites were chosen to reflect regional variation in tomato production practices and previous histories of pest problems including nematode, fungal, bacterial, or common weed infestations.

With continued funding, it is hoped that this statewide project will be carried out in 6 month cropping cycles (spring/fall) over a 3 year period. After each experimental trial or cycle, appropriate modifications to the treatment lists will be made to maximize evaluations of promising alternative compounds and their combinations. A listing of treatments which were evaluated in the initial trial of spring 1994 are listed in Table 1. A brief description of the chemical alternatives follows.

Table 1.

Treatment List					
TRT #	Compound	Rate/A Product*	Rate AI/Acre	Calibration Rate	Application Method***
1	Untreated				
2	Methyl Bromide 98/2	400 lb	392 lb MBR	0.92 lbs/100 ft²	Injection at bed formation and tarped immediately
3	Methyl Bromide/ chloropicrin 67/33	350 lb	234.5 lb MBR 115.5 lb chloropicrin	0.80 lbs/100 ft²	Injection at bed formation and tarped immediately
4	Chloropicrin	350 lb	350 lb	0.80 lbs/100 ft²	Injection at bed formation and tarped immediately
5	Vapam	100 gal	318 lb metham sodium	869 mls/100 ft²	Broadcast prior to false bed and tarped
6**	Vapam	100 gal	318 lb metam sodium	869 mls/100 ft²	Injected through drip tube, 9 inch emitters
7	Telone C-17	35.0 gallons	176.12 lb 1-3-D 37.24 lb chloropicrin	304 mls/chisel/ 100 l. ft	Injected at bed formation and tarped immediately
8	Basamid	400 lb	396 lb dazomet	0.92 lbs/100 ft²	Rototilled into bed, bedded and tarped at application
9**	Enzone - Pre-plant	200 gallon	680 lb tetrathio-carbonate		Injected through drip tube 3 weeks before transplanting
	+ 2 Post plant	2X application @ 20 gallons	68 lb tetrathiocarbonate		Injected post planting through drip tube

* Application rate determined by area of treated bed on a broadcast acre rate.
** Injection will be made over a minimum of 2 hours irrigation period.
*** All treatments will be applied at least 3 weeks before transplanting.

ALTERNATIVE CHEMICALS EVALUATED DURING SPRING 1994

Basamid is a granular broadspectrum fumigant which must be incorporated, preferably with rotary cultivation, to a soil depth of 8 inches. Upon contact with moist soil, the bioactive ingredient, Dazomet, is tranformed into methylisothiocyanate (MITC). Diffusion through soil occurs as a gas, killing nematodes and other organisms on contact. Soil moisture and temperature can dramatically influence the rate of breakdown, diffusion, and effectiveness. Preliminary studies in Florida suggest that broadcast application rates of at least 300 to 400 lb/a will be required for satisfactory nematode control. A waiting period of 3 weeks or more may be required to aerate the soil before planting to prevent crop phytoxicity. At present, Basamid is not federally registerd for use on tomatoes in Florida.

Both **Telone II** and **Telone** C17 are formulated as liquids with 1,3-dichloropropene as the primary active ingredient. Both are soil injected to a depth of 10-12 inches via knife type shanks spaced 12 inches apart. Telone II is an effective nematicide with limited fungicidal and herbicidal activity. Telone C17 is a mixture of 1,3-D fortified with 17% Chloropicrin to enhance funigicidal activity. As with all fumigants, soil conditions which permit rapid diffusion thorugh soil air spaces are required to maximize effectiveness. A waiting period of 3 weeks or more may be required to aerate soil before planting to prevent crop phytoxicity. For mineral soils, broadcast application rates of 9 -18 gallons per acre are generally required for satisfactory nematode control. At present, the manufacturer of Telone products (DowElanco) has suspended sale and distribution in all of south Florida.

Vapam (metham sodium) is formulated as a liquid and may be applied to soil by either direct shank or chisel injection, drip or sprinkler irrigation, or sprayed on the soil surface and incorporated via rotary cultivation. Like Basamid, Vapam is a MITC generator, which after redisolving in water kills nematodes upon contact. Broadcast application rates of at least 50 to 100 gallons per acre are generally required for satisfactory nematode control. Depending on temperature and soil moisture conditions, a waiting period of 3 weeks or more may be required to aerate soil before planting to prevent crop phytoxicity.

Chloropicrin (teargas) is a liquid and soil injected via shanks or chisels. It is highly effective for soilborne pathogen control but is a weak nematicide and herbicide. Because of its cost, chloropicrin is usually combined with other fumigant compounds to enhance nematode and weed control.

Enzone is a water soluble soil fumigant used for nematode and soilborne disease control. The primary active ingredient is carbon disulfide (CS2). Applications are made by metering Enzone into irrigation water or by direct soil injection. Enzone controls only those pests that are in the wetted zone at the time of treatment. Data available on Enzone are very limited, the results of which suggest however, variable fungicidal and nematicidal activity. At high concentrations Enzone is phytoxic and post-treatment planting delays of at least 7 days may be required to sufficiently aerate soil. At present, Enzone is <u>not</u> federally registerd for use on tomatoes in Florida.

METHODS FOR NEMATODE CONTROL EVALUATIONS

All plots at each experimental location were prepared according to standard commercial practice. At each experimental site (Quincy, Gainesville & Bradenton) where root-knot nematode (<u>Meloidogyne</u> spp.) had been identified as a potential soilborne pest problem, soil samples to assess population densities were collected before chemical treatment and again at planting so as to determine nematicidal effectiveness. In addition to soil samples, visual estimates of root-gall severity were assessed after final harvest to provide another measure of nematicidal activity. After final harvest, plants within each plot were uprooted and indexed for root gall severity based on a scale of 0 to 10, to assess the proportion of the root system galled. Previous work in Florida has also indicated that root-gall information can be effectively used to characterize within field distribution of root-knot nematode, to evaluate pesticide efficacy, and to provide estimates of crop loss attributable to root-knot nematode.

In an attempt to evaluate and identify next best alternative chemical treatments to methyl bromide for nematode control on an experimentwide basis, three separate analyses were performed. In the first analysis (Table 2), a standard multiple range test was performed to determine whether any significant differences existed between treatments at each experimental location. As a second analysis, a simple rank ordering of increasing root gall severity, from lowest to highest, was then numerically assigned to the treatment means. The ranks for each treatment were then summed across the four experimental locations to obtain a cumulative score. The cumulative score was then ranked again to establish an overall experimentwide ranking for nematode control.

Since the ranking analysis was qualitative in nature, a third analysis was performed to quantify the actual numerical differences in root gall severity between chemical treatments and the untreated control at each of the four experimental locations. Average root gall severity values for each chemical treatment were divided by the value of the untreated control to establish proportional differences between treatments on a relative scale of 0 to 1. Relative root gall severity ratings were then averaged across all experimental locations to derive an overall, experimentwide, comparison of chemical treatments on nematode control. Using the relative scale, locational effects could be largely removed and treatments evaluated and compared on their own merits.

RESULTS and DISCUSSION

Enzone, ranked as the worst treatment (Table 3), did not produce a significant reduction in root gall severity compared to the untreated control at any experimental location where it was applied. This occurred even though Enzone applications were made under the plastic covered bed using two parallel drip lines per bed. On average, relative root gall severity on an experimentwide basis was 7% greater for the Enzone treatment than the untreated control (Table 4).

Table 2. Final harvest tomato root gall severity values for nine chemical treatments at each of four state locations during spring 1994.

Treatment	Broadcast Rate[2]	Bradenton GCREC[3]	Quincy NFREC[4]	Gainesville Hort. Farm[4]	Gainesville Green Acres[4]
MBC[1] (98/2)	400 lbs	.020	2.100	1.000	4.056
MBC (67/33)	350 lbs	.010	1.000	1.167	3.583
Telone C17	35 gals	.060	.700	1.194	6.306
Chloropicrin	350 lbs	.030	3.300	4.333	8.444
Vapam (Drip)	100 gals	.700	5.000	3.806	4.917
Vapam (Spray)	100 gals	1.080	6.500	3.194	9.056
Basamid	400 lbs	.480	6.200	3.222	7.361
Enzone	200 Gals	.830	—	4.278	9.667
Check	—	.720	4.200	4.500	8.833

[1] MBC = Methyl bromide (%) / chloropicrin (%) formulation.
[2] Actual application rate determined by area of treated bed on a broadcast acre rate.
[3] Based on a scale from 0 (no galling) to 5 (most severe).
[4] Based on a scale from 0 (no galling) to 10 (100% galled).

Application of Vapam as a prebedded soil spray which was then incorporated via rotovation following application resulted in root gall ratings which were on average 20% greater than the untreated control (Table 4). This Vapam spray treatment was ranked as the 2nd worst treatment of the nine evaluated with regard to nematode control (Table 3). Use of Vapam applied as a chemigation treatment, or the Basamid treatment resulted in a reduced level of root galling, which in most cases (3 of 4) could not be discerned from the untreated control. On average only a 10% reduction in final harvest root gall severity was achieved with either treatment (Table 4).

With the exception of the Bradenton study, Chloropicrin demonstrated only weak nematicidal activity. It was intermediately, but equivalently, ranked with the Vapam chemigation treatment with regard to nematode control (Table 3). In general, the poor performance of Chloropicrin at the four experimental locations suggest that chloropicrin alone cannot be relied upon to provide a satisfactory level of nematode control. Given its weak nematicidal activity, future research efforts with this material should focus on combination treatments with other materials possessing acceptable nematicidal and or herbicidal activity.

Table 3. Final harvest root gall severity index rankings, ordered from lowest to highest gall severity, for nine chemical treatments at each of four state locations during spring 1994.

Treatment	Broadcast Rate[2]	Bradenton GCREC	Quincy NFREC	Gainesville Hort. Farm	Gainesville Green Acres	Overall Ranking
MBC[1] (98/2)	400 lbs	2	3	1	2	2
MBC (67/33)	350 lbs	1	2	2	1	1
Telone C17	35 gals	4	1	3	4	3
Chloropicrin	350 lbs	3	4	8	6	4.5
Vapam (Drip)	100 gals	6	6	6	3	4.5
Vapam (Spray)	100 gals	9	8	4	8	8
Basamid	400 lbs	5	7	5	5	6
Enzone[3]	200 Gals	8	—	7	9	9
Check	—	7	5	9	7	7

[1] MBC = Methyl bromide (%) / chloropicrin (%) formulation.
[2] Actual application rate determined by area of treated bed on a broadcast acre rate.
[3] Missing value at Quincey estimated using averaging method.

Table 4. Tomato root gall severity values relative to the untreated control for nine chemical treatments at each of four state locations during spring 1994.

Treatment	Broadcast Rate[2]	Bradenton GCREC	Quincy NFREC	Gainesville Hort. Farm	Gainesville Green Acres	Average Rating
MBC[1] (98/2)	400 lbs	.028	.500	.222	.459	.302
MBC (67/33)	350 lbs	.014	.238	.259	.406	.229
Telone C17	35 gals	.056	.167	.265	.714	.301
Chloropicrin	350 lbs	.042	.786	.962	.956	.687
Vapam (Drip)	100 gals	.972	1.191	.846	.557	.892
Vapam (Spray)	100 gals	1.5	1.548	.710	1.025	1.196
Basamid	400 lbs	.667	1.476	.716	.833	.923
Enzone	200 Gals	1.153	—	.951	1.094	1.066
Check	—	1.000	1.000	1.000	1.000	1.000

[1] MBC = Methyl bromide (%) / chloropicrin (%) formulation.
[2] Actual application rate determined by area of treated bed on a broadcast acre rate.

In most studies, the level of root galling was significantly reduced by either formulation of methyl bromide and chloropicrin. In both the ranking (Table 3) and relative root galling (Table 4) analyses, methyl bromide and chloropicrin formulations were ranked as the best overall treatments of the nine evaluated. Based on both analyses, Telone C17 assumed the next best alternative treatment to methyl bromide with respect to nematode control. On average a 70-75% reduction in final harvest root gall severity was achieved with either the methyl bromide or Telone C17 treatments (Table 4).

CONCLUSIONS

In general, the results from these four studies indicated that the alternative chemicals to methyl bromide which were evaluated during the spring trials of 1994 were generally less effective than that of the current industry standard, methyl bromide. Since all of the alternative chemicals require a longer period for soil areation, grower planning horizons will also have to be extended to prevent crop phytoxicity and subsequent yield losses.

Most of the alternative chemical treatments did not prevent a late season population buildup of the root-knot nematode. This would suggest that small, but possibly significant crop losses will oftentimes occur in the fumigated primary crop. More importantly, it further suggests that double-cropping, planting a second and oftentimes susceptible crop such as squash, cucumber, or melons after the methyl bromide crop, may not be economically possible with many of the alternative chemicals currently identified. Further research with these compounds may determine more effective ways to utilize these chemicals and escape thier shortcomings.

In addition to the chemical alternatives being evaluated for soil pest control, there are a number of other nonchemical alternatives to methyl bromide which are also being evaluated, including the use of soil amendments, cover crops and resistant varieties, solarization, and use of hot water soil injections. The potential for combining soil solarization with soil fumigants or hot water treatments, specific organic amendments, or biological antagonists is also being explored at a number of different locations within the state for nematode or plant disease control.

NUTSEDGE AND SOIL-BORNE PATHOGEN CONTROL WITH ALTERNATIVES TO METHYL BROMIDE

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The approaching loss of methyl bromide dictated by the 1990 Clean Air Act has produced a surge in research into alternatives to methyl bromide for soil fumigation. Throughout the United States scientists are investigating old and new products to find potential replacements and are re-discovering why methyl bromide combined with chloropicrin became the preferred material for soil fumigation. Although a number of other fumigants exists, few can be considered alternatives on their own. Whereas methylbromide/chloropicrin combinations control most of the soil-borne pests (weeds, soil-borne diseases and nematodes), alternative products require application in conjunction with other chemicals to provide the broad spectrum control required by growers. Nowhere is there more effort being made to identify alternatives than here in Florida. University of Florida scientists in cooperation with the Florida Fruit and Vegetable Association and the Florida Tomato Committee have organized a research team which is evaluating alternatives under the diverse conditions of the state. Research sites in Quincy, Gainesville, Immokalee and Bradenton have just completed the first season of data collection from what is referred to as the "FFVA experiment", so designated because FFVA provided the leadership in developing the protocol. This experiment, plus other related work at these locations, have established some baseline data which identify the strengths and weaknesses of the various alternative fumigants. This paper presents some of those results to inform growers and other interested individuals of the current status of this statewide effort.

Specific pests being evaluated in this research are yellow and purple nutsedge, Fusarium wilt incited by <u>Fusarium oxysporum</u> f.sp. <u>lycopersici</u>, Fusarium crown and root rot incited by <u>Fusarium</u> <u>oxysporum</u> f. sp. <u>radicis-lycopersici</u> and nematodes. These pests are the most widespread and troublesome for producers. Plots were either established in areas with the pests of concern or the pests were introduced. Each location evaluated the same core of treatments with additional treatments being evaluated at some locations (Table 1). Gainesville and Quincy used drip irrigation, while Bradenton and Immokalee used subsurface (seepage) irrigation to grow the tomatoes and provided drip irrigation as a delivery system for two of the treatments. The experiment was initiated at Immokalee in early January and at the other three locations in early March. Plot size ranged from 30 to 60 feet with treatments assigned to plots arranged in a randomized complete block design and replicated 6 times at each location. Methyl bromide, chloropicrin and Telone C-17 were injected 7 to 9 inches into the soil through 3 chisels per bed and beds were covered immediately with black polyethylene mulch. Basamid was applied to the soil as a fine granule, rototilled in 6 inches deep, then covered with mulch film, except in one case where it also was applied, rototilled, then watered with 0.25 inches of water prior to mulch application. In one treatment Vapam was sprayed on the soil surface and 1) rototilled 6 inches deep, then the bed was formed and covered with mulch, or 2) incorporated with bedding disks prior to bed formation. In the other treatment, Vapam was applied through the drip tubing with one tube per bed. Enzone was applied in this same fashion with one large application made 3 weeks before planting and two smaller applications made during the season. Tillam herbicide was applied with several fumigants at two locations by spraying on the soil surface and incorporating it 2 to 3 inches deep prior to fumigant application. Tomato plants were transplanted 3 weeks after application of fumigants. Posttransplant applications of Admire were made in several locations to reduce whitefly populations during the season. Conventional cultural and pest management practices were employed at each location. Nutsedge populations and soil-borne disease incidence were monitored during the experiments. Nematodes in the rhizosphere were determined during the season. Fruit were harvested, counted and weighed. After the last harvest, plants were dug up and evaluated for root knot nematode galling and Fusarium crown rot symptoms.

Nutsedge proved to be the most damaging pest in most of these tests and one of the more difficult to control with fumigants alone (Table 1). Results from 4 experiments indicate that none of the alternatives provide control which would be acceptable to a grower; however, addition of Tillam herbicide provides nutsedge control equal to that obtained with methyl bromide/chloropicrin combinations. Several important observations were made during these experiments regarding nutsedge control. Firstly, early results can be deceiving as can be illustrated by Table 2. Most treatments provided some control for the first month, but control with chloropicrin and Vapam declined rapidly after this time.

Secondly, soil moisture is important not only with regard to fumigant performance but also as it relates to nutsedge growth (Table 3). Nutsedge numbers on the dry side of a drip irrigated bed were lower than those on the wet side and indicate that application method is not important with Vapam; however, data from the wet side indicate that chemigation of Vapam provided more control than spray/rototill application. Unfortunately, the level of control with either application method was not acceptable.

Plant stand was affected by fumigant in at least one trial (Table 4). More plants survived the season in plots fumigated with 35 gal. of Telone C-17 per acre than where no fumigant was used or a tank mix of Vapam + Tillam was incorporated with bedding disks prior to bed formation. The stunting and plant loss in the Vapam + Tillam plots was probably due to the Tillam being too deep in the resultant bed.

Fusarium wilt was observed on 61% of the untreated plants which survived the season at Bradenton (Table 4). All of the fumigant treatments reduced the incidence of Fusarium wilt compared to the control and chemigated Vapam was the only treatment which was less efficacious than methyl bromide/chloropicrin.

Fusarium crown rot has become a major problem in the Immokalee area and was the primary focus of the trial conducted there. Crown rot also was present at Bradenton, but to a much lesser extent than Immokalee. All of the tomato plants in the untreated plots at Immokalee were infected with crown rot and some differences existed among treatments for control, but even with the best of these, methyl bromide/chloropicrin, incidence was very high (Table 5). Similar results were obtained at Bradenton, only the incidence was lower. Disease severity followed the same trend as incidence at both locations. The least severe occurrence of crown rot at Immokalee occurred in areas fumigated with 35 gal. of Telone C-17 per acre, but this was not significantly different from most of the fumigant treatments.

Tomato production was reduced varying amounts depending upon location among the two south Florida sites. Production at Immokalee was reduced by Enzone when compared to 98/2 or Telone C-17 (Table 6). There were more differences among treatments at Bradenton. Marketable fruit production at this location was less with all fumigants which did not control nutsedge, underscoring the importance of nutsedge as a soil pest. Addition of Tillam to Telone C-17 provided yields equal to methyl bromide/chloropicrin. Although Tillam provided nutsedge control when combined with Vapam, the negative impact of this treatment on the tomato plants reduced marketable yields.

Based on the results to date, it appears that Telone C-17 combined with Tillam herbicide is the most promising substitute for methyl bromide/chloropicrin. Enzone does not appear promising. Results from other research with Basamid suggest that it might have a place, but the results have been erratic. Chloropicrin alone would be very expensive. Vapam works in some areas of the U.S., but results seem to be erratic here in Florida. Identifying the right application method might provide better and more consistent results with Vapam. Additional trials will be conducted over the next several years as will supporting research to identify additional herbicides with promise for use under polyethylene mulch.

Acknowledgements

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Table 1. Effect of fumigant treatments on yellow and purple nutsedge growing through the plastic mulch at Bradenton, Gainesville, and Quincy at harvest time.

Fumigant		Number/ft^2			Control (%)
	Rate/A	Brad.	Brad.	Gnvl.	Quincy
None (UTC)	0	53ab[z]	25ab	30abc	20
Methyl Bromide/ Chloropicrin (98/2)	400 lb.	8d	0f	7e	80
Methyl Bromide/ Chloropicrin (67/33)	350 lb.	4d	---	9e	75
Chloropicrin	200 lb.	---	9def	---	---
Chloropicrin	350 lb.	60ab		22bcd	40
Chloropicrin + Tillam	350 lb. 4 lb.ai	---	---	11e	---
Vapam (pre-bed)	100 gal.	56ab	34a	---	---
Vapam (tilled)	100 gal.	---	13de	32ab	35
Vapam (drip)	100 gal.	51b	---	22cd	10
Telone C-17	35 gal.	66a	---	34a	45
Basamid	350 lb.	---	14cd	---	---
Basamid (tilled)	400 lb.	37c	---	31abc	15
Basamid (til & water)	400 lb.	---	---	22cd	---
Basamid	450 lb.	---	10def	---	---
Enzone + Enzone (drip)	200 gal. 20 gal.-2X	54ab	---	33a	---
Telone C-17 + Tillam	35 gal. 4 lb.ai	5d	1f	15de	---
Telone C-17 + Tillam	21.4 gal. 4 lb.ai	4d	2ef	---	---
Vapam + Tillam (pre-bed)	100 gal. 4 lb.ai	7d	8def	---	---

[z] Means within columns followed by the same letter are not significantly different at the 5% level as determined by Duncan's new multiple range test.

Table 2. Effect of fumigant treatment on nutsedge population 33, 55, 77, and 99 days after application. Bradenton, Spring 1994.

Fumigant	Rate/A	Number of plants/ft² 33 DAT	55 DAT	77 DAT	99 DAT
None (UTC)	0	19 a[z]	19 a	43 ab	53ab
Methyl Bromide/ Chloropicrin (98/2)	400 lb.	0 e	1 b	5 d	8d
Methyl Bromide/ Chloropicrin (67/33)	350 lb.	1 e	1 b	5 d	4d
Chloropicrin	350 lb.	8 cd	23 a	46 ab	60ab
Vapam (pre-bed)	100 gal.	11 bc	18 a	41 ab	56ab
Vapam (drip inject)	100 gal.	15 ab	21 a	37 b	51b
Telone C-17	35 gal.	14 ab	26 a	50 a	66a
Basamid (rototill)	400 lb.	4 de	9 b	22 c	37c
Enzone + Enzone (drip inject)	200 gal. 20 gal.-2X	16 a	24 a	44 ab	54ab
Telone C-17 + Tillam	35 gal. 4 lb.ai	1 e	1 b	4 d	5d
Telone C-17 + Tillam	21.4 gal. 4 lb.ai	1 e	1 b	4 d	4d
Vapam + Tillam (pre-bed)	100 gal. 4 lb.ai	1 e	2 b	7 d	7d

[z] Means within columns followed by the same letter are not significantly different at the 5% level as determined by Duncan's new multiple range test.

Table 3. Effect of position in bed on nutsedge control with fumigants in drip irrigated tomatoes 95 days after application. Gainesville, Spring 1994.

Fumigant	Rate/A	Number/ft^2 Dry side	Wet side
None (UTC)	0	18a[z]	30abc
Methyl Bromide/ Chloropicrin (98/2)	400 lb.	3b	7e
Methyl Bromide/ Chloropicrin (67/33)	350 lb.	6b	9e
Chloropicrin	350 lb.	22a	22bcd
Chloropicrin + Tillam	350 lb. 4 lb.ai	6b	11e
Vapam (tilled)	100 gal.	25a	32ab
Vapam (drip)	100 gal.	17a	22cd
Telone C-17	35 gal.	18a	34a
Basamid (tilled)	400 lb.	21a	31abc
Basamid (til & water)	400 lb.	17a	22cd
Enzone + Enzone (drip)	200 gal. 20 gal.-2X	18a	33a
Telone C-17 + Tillam	35 gal. 4 lb.ai	8b	15de

[z] Means within columns followed by the same letter are not significantly different at the 5% level as determined by Duncan's new multiple range test.

Table 4. Effect of fumigant treatments on plant stand and Fusari wilt of surviving tomato plants at the end of the seasc Bradenton, Spring 1994.

Fumigant	Rate/A	No. of plants plants/plot	Fusarium wilt % infected
None (UTC)	0	15bc[z]	61a
Methyl Bromide/ Chloropicrin (98/2)	400 lb.	16abc	0c
Methyl Bromide/ Chloropicrin (67/33)	350 lb.	17ab	0c
Chloropicrin	350 lb.	20ab	7c
Vapam (pre-bed)	100 gal.	16abc	13bc
Vapam (drip inject)	100 gal.	20ab	30b
Telone C-17	35 gal.	22a	12bc
Basamid (rototill)	400 lb.	20ab	4c
Enzone + Enzone (drip inject)	200 gal. 20 gal.-2X	18ab	14bc
Telone C-17 + Tillam	35 gal. 4 lb.ai	17abc	3c
Telone C-17 + Tillam	21.4 gal. 4 lb.ai	19ab	8c
Vapam + Tillam (pre-bed)	100 gal. 4 lb.ai	12c	4c

[z] Means within columns followed by the same letter are not significantly different at the 5% level as determined by Duncan's new multiple range test.

Table 5. Effect of fumigant treatments on incidence and severity of Fusarium Crown Rot on surviving tomato plants at the end of the season. Immokalee and Bradenton, Spring 1994.

Fumigant	Rate/A	Incidence (%)		Severity (%)	
		Immok.	Brad.	Immok.	Brad.
None (UTC)	0	100a[z]	58a	30a	26a
Methyl Bromide/ Chloropicrin (98/2)	400 lb.	73b	28a	20bc	10a
Methyl Bromide/ Chloropicrin (67/33)	350 lb.	85b	16a	20bc	8a
Chloropicrin	350 lb.	79b	24a	20bc	10a
Vapam (pre-bed)	100 gal.	75b	16a	22ab	6a
Vapam (drip inject)	100 gal.	92ab	17a	24ab	8a
Telone C-17	35 gal.	73b	24a	12c	10a
Basamid (rototill)	400 lb.	88ab	36a	20bc	16a
Enzone + Enzone (drip inject)	200 gal. 20 gal.-2X	98a	45a	20bc	16a
Telone C-17 + Tillam	35 gal. 4 lb.ai	---	34a	---	14a
Telone C-17 + Tillam	21.4 gal. 4 lb.ai	---	36a	---	22a
Vapam + Tillam (pre-bed)	100 gal. 4 lb.ai	---	32a	---	16a

[z] Means within columns followed by the same letter are not significantly different at the 5% level as determined by Duncan's new multiple range test.

Table 6. Effect of fumigant treatments on production of marketak tomatoes. Bradenton and Immokalee. Spring 1994.

Fumigant	Rate/A	Bradenton (cartons/acre)	Immokalee (Tons/A)
None (UTC)	0	60d[z]	40.5ab
Methyl Bromide/ Chloropicrin (98/2)	400 lb.	1327a	42.4a
Methyl Bromide/ Chloropicrin (67/33)	350 lb.	1324a	39.2ab
Chloropicrin	350 lb.	702b	39.0ab
Vapam (pre-bed)	100 gal.	249cd	38.9ab
Vapam (drip inject)	100 gal.	616bc	36.7ab
Telone C-17	35 gal.	733b	41.7a
Basamid (rototill)	400 lb.	720b	36.4ab
Enzone + Enzone (drip inject)	200 gal. 20 gal.-2X	96d	35.3b
Telone C-17 + Tillam	35 gal. 4 lb.ai	1341a	----
Telone C-17 + Tillam	21.4 gal. 4 lb.ai	1549a	----
Vapam + Tillam (pre-bed)	100 gal. 4 lb.ai	638bc	----

[z] Means within columns followed by the same letter are not significantly different at the 5% level as determined by Duncan' new multiple range test.

An Economic Analysis of a Ban on Methyl Bromide in the Florida Tomato Industry

by

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Abstract

Methyl bromide is a critical pesticide that is used in producing many fruit and vegetable crops grown in Florida and the nation. It is a broad spectrum pesticide serving as an insecticide, nematicide, herbicide and fungicide. The environment which prevails in Florida makes the use of methyl bromide critical to the competitiveness of these crops in the U.S. and international markets. The Montreal Protocol declared at their November 1992 meeting that methyl bromide was a Class I ozone depletor, and as such must be phased out of use by the year 2000. Because no known alternatives exist

that will effectively substitute for methyl bromide, Florida is estimated to lose over 50 percent of the current tomato acreage with a loss of more than 60 percent of production. All production in Districts 1 and 2 of the Florida Tomato Marketing Order (Dade County and other Southeast producing areas) will cease. The primary beneficiary of this policy will be Mexico who, as a developing country, will have 10 additional years to use methyl bromide in producing and marketing their crops. Production of tomatoes will increase significantly in Mexico, by more than 80 percent.

Introduction

Methyl bromide is a broad spectrum pesticide used on a number of agricultural crops. As a soil fumigant it serves as an insecticide, nematicide, herbicide and fungicide. It also serves as a fumigant for stored commodities for protection against pests such as fruit fly and rodents. Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer (commonly referred to as the Montreal Protocol) declared at their November 1992 meeting that methyl bromide had an ozone depletion potential (ODP) of 0.7. This level is well above the 0.2 ODP required to classify it as a Class I ozone depletor. As such, it must be phased out of production by the year 2000 with a plan in place by the member countries to phase out its use.

In Florida, methyl bromide has been important to the production of several fruit and vegetables. 'Old land disease' became a problem for many farmers in the 1950's and 1960's because of the buildup of pests in soils when cultivated intensively for several years. Farmers initially solved this problem by becoming 'nomadic' farmers. They would farm land until old land disease set in and then rent different land to farm which had not been farmed recently. Land pressures from urban encroachment and protection of the environment made this type of farming more difficult and new farming practices had to be developed to take advantage of the declining agricultural land base. New farming practices were developed that farmers were able to use which included using plastic mulch and methyl bromide for control of many of the soilborne pests. As a result, much of the land was able to be farmed intensively for several years without having to rotate for several seasons into less intensive, lower profit cropping systems. As methyl bromide was adopted for use in Florida, it became ever more critical because of its broad spectrum control in an environment conducive to natural borne pests.

The importance of methyl bromide as a fumigant and the problems it has been associated with in the environment have led to a current critical situation in the Florida industry. Because of the success farmers realized in using methyl bromide since the 1960's, little research has been conducted for finding alternatives which can be used as an effective substitute to methyl bromide. The alternative identified as having the most potential for succeeding methyl bromide, Vorlex, (USDA, NAPIAP, 1993) is being voluntarily removed from the market by its manufacturer (NOR-AM Chemical Company) because of the tests and expense required for reregistration by the U.S. Environmental Protection Agency (EPA) to keep it available to farmers and others. Other chemical and non-chemical alternatives have been identified, but those alternatives are not as economically effective as methyl bromide in controlling the broad spectrum of pests that can affect Florida growers.

The USDA NAPIAP (1993) estimated the impact a removal of methyl bromide would have on agriculture. Their results indicated that removal of methyl bromide would result in an economic loss of approximately $850 million to $1 billion for U.S. agriculture, depending on whether Vorlex was available as a substitute. Another $500 million loss would be imposed on imported items that could not use methyl bromide for quarantine treatment. The food product produced in the U.S. that would be impacted the most was identified as fresh market tomatoes ($160 million with Vorlex/ $340 million without).

The Evolution and Use of Methyl Bromide in the Vegetable Industry

Methyl bromide is marketed as a broad spectrum pesticide that acts as an insecticide, nematicide, herbicide, and fungicide when used in the fumigation of soils (Noling and Overman, 1988). The chemical plays an important role when used as a preplant fumigant which reduces soilborne pests and enables continued cropping of the same land year after year. It is also used as a fumigant in greenhouses, transplant beds, and potting soils. Methyl bromide is also used as an acaricide and rodenticide in the treatment of nondwelling space and packaged materials. The intended purpose for the chemical dictates which formulation is used. Methyl bromide can be applied as a liquid, however at room temperature the chemical converts to a gas which is considered odorless, tasteless, and colorless (Noling, 1993). This chemical is registered as a restricted use pesticide due to its acute toxicity.

Methyl bromide is sold in various formulations. These can range from a 100% methyl bromide formulation to a mixed formulation with varying proportions of chloropicrin. Due to the odorless characteristic of methyl bromide, lower concentrations of chloropicrin (2 percent) are used as a marker for detection of escaping methyl bromide fumes (Noling, 1993). Combined with methyl bromide, chloropicrin at higher concentrations (such as 33%) serves as a fungicide to aid in the control of soilborne diseases.

The Impact on the Production of Vegetables from a Ban on Methyl Bromide

Methodology

Methyl bromide has been identified as a critical soil fumigant used in the production of several vegetable and fruit crops, those being tomatoes, bell peppers, cucumbers, eggplant, squash, strawberries and watermelons. While methyl bromide may not be critical to all crops in all production systems, it is currently used in each of these crops in some production systems within some production areas in Florida.

Production of these crops are economic enterprises that growers produce in expectation of a positive return to their investments. These crops compete with each other and other crops and enterprises for resources used in their production. Growers of these crops also compete with other producers who can produce and ship these same products during the season that Florida growers have them available.

A partial equilibrium model can be used to evaluate the effects a change in the industry may have on the production and marketing of various crops from various regions. For the model used in this analysis (see Spreen et al. for a more detailed discussion of the model), these crops were modeled in a monthly model considering production from each of the major producing regions in Florida and from other regions in the U.S. and Mexico which grow and sell during Florida's season.

The model was developed to characterize production of the crops from these regions for the winter months of production in which Florida ships these commodities. The commodities were assumed to be shipped to one of four demand regions of the U.S., including the northeast, southeast, midwest and west. These demand regions were represented by the New York City, Atlanta, Chicago and Los Angeles wholesale markets, respectively (Scott).

Production costs were determined for each of the producing regions based on budgets developed for each of the crops from each of the producing regions in the 1990/91 season (VanSickle, et al.). The mathematical programming model was solved using the GAMS software.

After solving the model for a base solution for current specifications within the industry, the production costs and yields were changed to reflect the production of these crops without methyl bromide and using the next best alternative given today's technology. The results were compared to determine the impact a ban on methyl bromide may have in Florida on the production and marketing of these crops.

Empirical Results

The results of the analysis are summarized in Tables 1-6. It is important to note the method which was used to determine these results. A model of the vegetable and fruit industry was developed that replicates the industry as closely as possible using current technology and production practices and costs. These gave solutions for a base model. The base model was then adjusted by changing production costs and yields to represent production without methyl bromide to provide a quantitative assessment of a ban on methyl bromide on the industry. Production practices, costs and yields were changed according to recommendations of production scientists and economic analysts familiar with the industry. The important

Table 1. Acres of selected vegetable and fruit crops produced in Florida with and without methyl bromide, by area.

Area	With Methyl Bromide	Without Methyl Bromide	Percent Change
Dade Co.	14,364	9,692	(32.5)
Palm Beach Co.	25,637	--0--	(100.0)
West Central	35,108	24,944	(29.0)
Southwest	51,247	36,886	(28.0)
All Florida	**126,356**	**71,522**	**(43.4)**

Table 2. Acres of selected vegetable and fruit crops produced in Florida with and without methyl bromide, by crop

Crop	With Methyl Bromide	Without Methyl Bromide	Percent Change
Tomatoes	61,613	30,861	(49.9)
Bell Peppers	17,763	7,800	(56.1)
Cucumbers	15,689	11,679	(25.6)
Squash	9,245	9,692	4.8
Eggplant	2,598	--0--	(100.0)
Strawberries	5,159	2,150	(58.3)
Watermelons	14,289	9,340	(34.6)

Table 3. Production of selected vegetable and fruit crops in Florida with and without methyl bromide, by crop.

Crop	With Methyl Bromide	Without Methyl Bromide	Percent Change
Tomatoes[a]	80,203.3	30,921.7	(61.4)
Bell Peppers[b]	17,223.9	6,294.6	(63.5)
Cucumbers[c]	8,223.4	4,410.2	(46.4)
Squash[d]	2,542.4	2,665.3	4.8
Eggplant[e]	3,897.0	--0--	(100.0)
Strawberries[f]	10,318.0	3,225.0	(68.7)
Watermelons[g]	4,484.1	2,689.9	(40.0)

[a]Thousands of 25 pound cartons
[b]Thousands of 28 pound bushels
[c]Thousands of 55 pound bushels
[d]Thousands of 42 pound bushels
[e]Thousands of 33 pound bushels
[f]Thousands of 12 pound trays
[g]Thousands of hundredweight

Table 4. Production area of selected fruits and vegetables in California, Texas, and Mexico with and without methyl bromide, by crop.

Crop-Area	With Methyl Bromide	Without Methyl Bromide	Percent Change
	------------ acres	-------------	
Tomatoes			
Mexico	55,068	100,598	82.7
Bell Peppers			
Mexico	12,236	18,895	54.4
Texas	5,865	14,258	143.1
Total	18,101	33,143	83.1
Cucumbers			
Mexico	13,720	14,738	7.4
Squash			
Mexico	14,491	13,531	(6.6)
Eggplant			
Mexico	1,916	4,277	123.2
Strawberries			
California	7,608	5,971	(21.5)

Table 5. Production of selected vegetable and fruit crops in California, Texas and Mexico with and without methyl bromide, by crop

Crop-Area	With Methyl Bromide	Without Methyl Bromide	Percent Change
Tomatoes[a]			
Mexico	48,459.8	88,526.2	82.7
Bell Peppers[b]			
Mexico	9,299.4	14,360.2	54.4
Texas	2,346.0	5,703.2	143.1
Total	11,645.4	20,063.4	72.3
Cucumbers[c]			
Mexico	7,546.0	8,105.9	7.4
Squash[d]			
Mexico	3,188.0	2,976.8	(6.6)
Eggplant[e]			
Mexico	2,356.7	5,260.7	123.2
Strawberries[f]			
California	18,753.7	10,747.8	(42.7)

[a]Thousands of 25 pound cartons
[b]Thousands of 28 pound bushels
[c]Thousands of 55 pound bushels
[d]Thousands of 42 pound bushels
[e]Thousands of 33 pound bushels
[f]Thousands of 12 pound trays

Table 6. Total production of selected fruit and vegetables in Florida, California, Texas, and Mexico with and without methyl bromide, by crop.

Crop	With Methyl Bromide	Without Methyl Bromide	Percent Change
Tomatoes[a]	128,663.1	119,447.1	(7.2)
Bell Peppers[b]	28,869.3	26,358.0	(8.7)
Cucumbers[c]	15,769.4	12,516.1	(20.6)
Squash[d]	5,730.4	5,642.1	(1.5)
Eggplant[e]	6,253.7	5,260.7	(15.9)
Strawberries[f]	29,071.7	13,972.8	(51.9)
Watermelons[g]	4,484.1	2,689.9	(40.0)

[a]Thousands of 25 pound cartons
[b]Thousands of 28 pound bushels
[c]Thousands of 55 pound bushels
[d]Thousands of 42 pound bushels
[e]Thousands of 33 pound bushels
[f]Thousands of 12 pound trays
[g]Thousands of hundredweight

points to note from the analysis are the changes that are expected from a methyl bromide ban. The highlights of the analysis focus on the differences in the industry when using methyl bromide and when not using methyl bromide.

The results show that removal of methyl bromide will have a devastating effect on the Florida vegetable and fruit industry. Acreage devoted to the production of the seven major vegetables and fruit using methyl bromide are expected to decline by 43 percent from 126,356 acres to 71,522 acres (Table 1). Within individual production areas, Palm Beach County will lose the most, as all vegetable production that currently benefits from the use of methyl bromide will no longer be produced, a total loss of 25,637 acres. All other areas will lose approximately 30 percent of their acreage in production.

Planted acres and production of tomatoes in Florida will decline by approximately 50 and 61 percent, respectively (Tables 2 and 3). All production areas currently produce tomatoes, but a ban on methyl bromide use will cease production of tomatoes in Dade County and Palm Beach County. The number of acres planted to tomatoes in West Central Florida will remain about the same and acreage in southwest Florida will decline by about 50 percent. Production will decrease in both areas as yields decrease by 20 percent, resulting in a decrease in production of 20 percent in west central Florida and 60 percent in southwest Florida. Most of the reduction in production in southwest Florida will be in the spring production of tomatoes, losing about 15,800 acres.

Crop production in Florida that will be lost because of a ban on the use of methyl bromide will be offset partially by increased production in other areas. Mexico will increase crop production acreage by 56 percent, with the largest increase occurring in tomatoes, from 55,068 acres to 100,568 acres.

The reason for the substitution of production in Florida to production in Mexico is because a ban on methyl bromide will not impact Mexican productivity. Mexican producers currently use methyl bromide on only a limited number of acres. Even with their limited use of methyl bromide, the Montreal Protocol gives developing countries an additional 10 years to use methyl bromide before being forced to switch to alternative production practices, and Mexico carries the developing country designation.

Summary and Conclusions

Summary

Methyl bromide is an important chemical which is used as a soil fumigant for many of Florida's commercial vegetables. The fruit and vegetable crops which have been identified as having the most potential for being impacted by a methyl bromide ban are tomatoes, bell peppers, eggplant, squash, cucumbers, strawberries and watermelons. Florida is a major supplier of these products in the winter market, and a methyl bromide ban would adversely affect the competitive position of Florida in the market for these commodities. In 1992-93, land allocated to these crops exceeded 130,000 acres and produced a shipping point value of approximately $1 billion for Florida agriculture.

The analysis first involved consultation with horticultural scientists and commodity specialists familiar with the crops. The prevalent production practices for these crops and the role methyl bromide plays was defined. Alternatives to methyl bromide were presented and the next best alternative identified as a replacement to methyl bromide. The alternatives considered for the vegetables and fruit included chemical and non-chemical alternatives.

An economic model of the fruit and vegetable industry was developed and used to determine the projected impact of a methyl bromide ban. The results indicate that a methyl bromide ban would cause a reduction of 43 percent in the acres of fruit and vegetables planted in Florida, and an estimated reduction of $610 million in shipping point value to the state of Florida. Production of these crops in Palm Beach County would be eliminated, and total production of tomatoes in Florida would decrease by more than 60 percent.

These losses would devastate Florida agriculture and adversely impact the nation. Much of the lost production would move to Mexico. Production of tomatoes would increase more than 80 percent in Mexico. Mexico would also increase production of bell peppers (54 percent), cucumbers (7 percent) and eggplant (123 percent). Mexico would become the major supplier of these vegetables in the winter market, and the sole supplier of eggplant.

Conclusions

While Mexico does not currently use methyl bromide on all of their vegetables, there has been a trend of increasing use of methyl bromide in producing vegetables in Mexico. Because the Montreal Protocol allows developing countries such as Mexico to use methyl bromide for 10 additional years beyond the 2001 cutoff date for developed countries, Mexico will be the primary beneficiary of this ban for these crops in the winter market, and they will likely use methyl bromide to produce this increased production. The result could be only a small reduction in the overall use of methyl bromide, but a large shift in production away from Florida to Mexico.

Not considering the impact this may have on food security for the U.S., a ban on methyl bromide would have a devastating impact on Florida, given current technology. The schedule for eliminating the use of methyl bromide currently freezes consumptive levels at 1991 baseline levels in 1994, and total phaseout by January 1, 2001. This gives Florida growers little time to develop a suitable substitute. The alternatives outlined in this project (see Spreen et. al.) do not effectively substitute for methyl bromide. At present, research has not identified a likely candidate for substitution.

A ban on methyl bromide use appears inevitable at this time. Knowing the impact this policy will have on Florida growers, and knowing that much of Florida's loss will move to Mexico where methyl bromide use will continue and probably increase, policy makers should develop programs that will speed the search for alternatives. An intense research agenda should be developed to find feasible alternatives. In the interim, policy makers should consider programs that can help growers survive until better alternatives can be found.

The U.S. regulatory environment has not been kind to Florida growers over the last several years. Growers have struggled to survive in an environment of increasing regulation in the production and marketing of fruit and vegetables. With current technology, however, a methyl bromide ban will be more devastating to Florida agriculture than any previous regulatory or natural event. It appears rational to believe that an intense research program should be developed to find better substitutes than are currently known. Policies that change the rules of the game and devastate thriving economic enterprises should also contain instruments to help those impacted.

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Methyl Bromide: The Montreal Protocol and the Clean Air Act

William Hayes

Methyl bromide is controlled as an ozone depleting substance by two processes:

1) The Clean Air Act (CAA) (1990 Amendments), a U.S. law enacted under George Bush and administered by the Environmental Protection Agency (EPA).

2) The Montreal Protocol, an international treaty controlling ozone depleting chemicals, administered in a gross sense by the United Nations Environmental Programme (UNEP) and in detail by each signatory nation.

Today I will review the history and current status of these regulatory processes and offer a look to the future.

First, let me offer the opinion that there is no environmental threat because of agricultural uses of methyl bromide. This is not meant as a challenge to or denial of the theories on chlorine and ozone destruction. It is merely recognition that already in-place restrictions on CFC's, Halons, and other major contributors to ozone loss are already solving the problem.

It will take time to achieve full resolution because CFC's and Halons have very long atmospheric lifetimes, all in excess of 50 years. Figure 1, prepared by scientists active in promoting ozone protection, shows what will happen to stratospheric halogens, projected on the basis of the 1992 Montreal Protocol amendments. By 2050 the level should drop below the ozone threatening level of 2000 ppb. Note that this projection assumes continued production of methyl bromide.

Unfortunately, this comforting view is not at all accepted by EPA or other non-government environmental activists. They remain dedicated to the pursuit and capture of any ozone active molecules. Listen to this warning: The regulatory struggle is not over. There is an active effort for more and earlier limitations on the use of methyl bromide. Its makers and users would like less regulation. They must work to prevent more.

It may seem to methyl bromide users that regulation has come in a rush. All too true! Atmospheric measurements of methyl bromide have been made for over twenty years. Apparently it was assumed to be of natural origin. To the best of my knowledge, recognition of a man-made source came to potential regulators in 1990 or early 1991. By the end of 1992 there was an international regulation and a year later, the much more restrictive U.S. rule was published.

In recognition of impending regulatory action, the first organizational meeting of the Methyl Bromide Working Group (MBWG) was held in December, 1991. Coincidentally, on that same day a group of environmental activist organizations filed a petition with EPA calling for an almost instantaneous ban on U.S. production and use of methyl bromide. We were prepared for the battle to follow. With help of hundreds of users, we were able to avoid the petitioners' objective, although not the CAA ruling which will be discussed later.

The international regulation of ozone depleting substances (ODS) began with the Vienna Convention of 1985, when a small group of countries agreed to agree on ozone protection measures. They convened again in Montreal in 1987 to establish the first "protocol," or regulatory procedure. This first step, like baby's, was small but important, because it led to the real regulatory breakthrough, the London Amendments of 1990. At that time the parties to the protocol agreed not just to limit, but to cease production of several major ozone depleting chemicals. It was then a much simpler move to accelerate the phase-out dates as was done in Copenhagen in 1992.

My suspicion is that the major 1990 victory over the worst big volume chemicals prompted the ozone defenders then to look for secondary targets, what a military command would call a mopping-up action. In any event, that's when methyl bromide came to the attention of the Montreal Protocol Science advisers (who, incidentally are also EPA's primary scientific sources).

The Montreal Protocol process and the parties to it have grown a great deal over the past decade. There are now about 130 countries participating to some degree. Each is only bound by the level it has ratified. Only about half have, for example, accepted the London Amendments, and not more than thirty the 1992 Copenhagen Amendments, which cover methyl bromide. Because the bulk of production and consumption are in nations which have or soon will ratify, this may not be significant.

The countries of the Montreal Protocol are divided into a small minority of "developed" nations and a hugh majority of "developing" nations. Mexico and all other countries of South and Central America are in the latter category. Leadership for control of ODS comes from the industrial countries. They promote compliance by the developing countries with these devices:

1) A ten-year delay in compliance with the controls that apply to developed countries.

2) An extra production allowance to producers in developed countries for sale to developing

3) The "Multilateral Fund" (MLF), financial assistance to developing countries switching away from ODS.

Would it surprise you to learn that half or more of the deliberatory time at Montreal Protocol meetings is devoted to collection, control and distribution of the MLF? I suspect that favorable promises about MLF payments may have influenced some decisions in Copenhagen.

These are the specifics of the 1992 Amendments regarding methyl bromide:

1) Identified its ozone depletion potential as 0.7

2) Beginning in 1995, limit production and consumption for each country to 1991 levels.

Consumption is defined as production plus imports minus exports.

EPA has published the annual quotas for the USA in the Federal Register as follows:

METHYL BROMIDE ANNUAL PRODUCTION AND CONSUMPTION ALLOWANCES (millions of pounds)

Company	Production	Cons.	Difference (export only)
Great Lakes	44.0	34.2	9.8
Albemarle	18.1	14.1	4.0
Ameribrom	-	7.8	-
Trical	-	0.24	-

These quotas can be traded between companies. Thus, the individual slices of the pie may change in size, but the size of the whole pie can't change, at least in the upward direction. Note that U.S. producers <u>must</u> export or forego the production allowance.

I have covered this production/consumption matter under the Montreal Protocol, but it is already in 1994 a control measure in the USA by way of the Clean Air act. We have the restriction now, the rest of the world will have it next year except for developing countries, who have the ten year delay in regulation, as mentioned earlier.

EPA has gone far beyond the Montreal protocol requirements in their rule-making under the Clean Air Act.

1) The limit on production and consumption was begun in 1994, not 1995.

2) All U.S. production and consumption must cease January 1, 2001.

They argue that the CAA compelled them to take the second step, the ban, because the ozone depletion potential (ODP) of methyl bromide was defined by the Montreal Protocol parties as 0.7, making it a Class I ozone depleting chemical. The Act directs EPA to ban such chemicals within at most seven years of determining Class I status. They claim they were responsive to farmers' pleas in that full use of methyl bromide is allowed until the phase-out date. So be grateful!

Several food growers and processors and the MBWG have appealed the current ruling claiming EPA went too far too fast. Concurrently, environmental activist groups have appealed on the grounds that EPA did too little. During the appeal process, the rule is in force as written. We don't expect a decision on the matter anytime soon.

These competing appeals are just one example of the continuing efforts to modify methyl bromide regulations. There are plenty of early warnings of what to expect from the Montreal protocol parties. Non-binding resolutions have been circulated at each year's meeting since 1992, calling for a twenty-five percent reduction from 1991 production and consumption volumes. Canada has announced this as a national policy with the target date of 1998 for implementation. A law to this effect is in the works for the twelve European Community countries. Denmark wants to go even further.

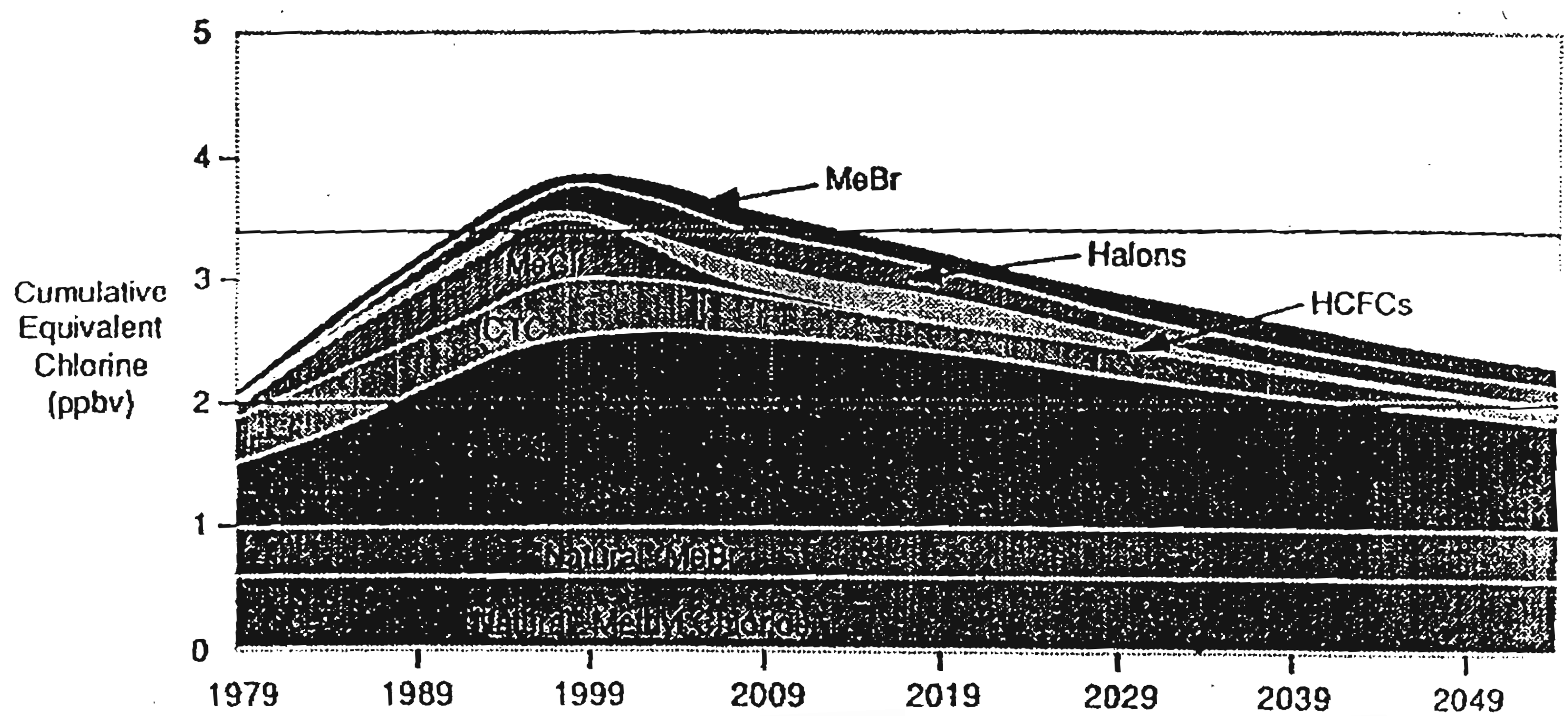
Several technical committees are scheduled to report this year to the parties their newest findings on methyl bromide, with the intent of major regulatory decisions in late 1995. The proposal for 25% reduction is sure to get strong consideration at that time. If the Montreal Protocol adopts that or any other restriction, the U.S. must and will comply by revising the current CAA rule.

You should have by now detected a "back door" process by which your friendly government can go back on its pre-NAFTA promise of "no further restrictions on methyl bromide." In the 1992 Montreal Protocol meetings, the U.S. delegation pressed loud and hard for the very ban which is now in place here. In the 1993 meeting, they signed the non-binding resolution for a 25% reduction. I understand that they continued to give behind-the-scenes support to that idea in a preliminary meeting held this July.

So what will the U.S. position be at the 1995 Montreal Protocol meeting? Personally, I expect a renewed effort to get a worldwide ban to coincide with the existing U.S. regulation. This will be rationalized to America's farmers as an effort to get a "level playing field" for them. Of course, with the ten year delay for effectiveness in "developing" countries, the leveling process may not come soon enough to suit you. Keep in mind this is just my prediction. Apparently, the policy decision on this matter has not yet been made.

The MBWG is striving to educate the uncommitted countries among the Montreal Protocol parties about the benefits of methyl bromide and its minimal effect on the ozone layer. In a little more than a year, we will know if the effort has paid off, or if more restrictions are on the way.

Stratospheric Chlorine: Copenhagen Agreements



YIELD LOSSES ASSOCIATED WITH FOLIAR DISEASES OF FRESH-MARKET TOMATOES IN FLORIDA AND THE BENEFITS OF PROTECTANT FUNGICIDES

Ken Pernezny and Lawrence Datnoff
Everglades Research and Education Center, Belle Glade

Tom Mueller
Collier Growers, Immokalee

INTRODUCTION

Experimental data showing yield, quality, and dollar losses from posts are essential for setting research, educational, and policy priorities. Surprisingly, little data exists which relates measurements of disease in commercial tomato crops and subsequent yield and economic losses. At present, lack of these data are hampering efforts by those in the EPA and other government agencies to carry out risks/benefits analysis for fungicides used on tomato and other vegetable crops.

Tomato was identified by a committee of USDA land grant university scientists as a model crop for development of crop loss models. Florida was in turn identified as a potentially important contributor to the database needed for fresh-market tomatoes. Using funds provided by the USDA NAPIAP program, four field trials were conducted from Fall 1992 through Spring 1994 to document yield losses due to foliar diseases and to document clearly the benefits of protectant fungicides.

MATERIALS AND METHODS

Large-scale field tests were planted; 5 September 1992 (Experiment I), 23 January 1993 (Experiment II), 11 September 1993 (Experiment III), and 26 January 1994 (Experiment IV). All tests were conducted on a portion of a commercial farm in Immokalee, and all cultural practices followed were those standard for southwest Florida. Five treatments were replicated five times in a randomized complete block design. Individual plots were three rows 50 feet long. In the Fall 1992 and Spring 1993 tests, treatments were:

Copper hydroxide (Kocide 101, 2 lb/100 gal) + mancozeb (Manzate 200, 1.5 lb/100 gal), 1 x per week.

Copper hydroxide + mancozeb as above, 2 x per week.

Chlorothalonil (Bravo 720, 1.5 qt/100 gal), 1 x per week.

Chlorothalonil as above, 2 x per week.

Control (no fungicide).

In Fall 1993 and Spring 1994, treatments were:

Chlorothalonil (Bravo 720, 1.5 qt/100 gal), 1x per week

Chlorothalonil + copper hydroxide + mancozeb (Bravo CM, 5 lb/100 gal), 1x per week

Copper hydroxide (Kocide 101, 2 lb/100 gal) + mancozeb (Manzate 200, 1.5 lb/100 gal), 1x per week

Copper hydroxide + mancozeb as above, 2x per week

Control (no fungicide)

Plants were rated for foliar disease severity weekly beginning approximately 1 month after transplanting. The sampling unit was all the plants in the center row of each plot. An estimate of the percentage of foliage covered by disease lesions and tissue abscised due to disease were combined into one rating. The proportion of plants with at least one lesion was determined based on a count of the number of plants in a plot. This fraction was multiplied by another representing the average amount of foliar damage per infected plant in order to arrive at a final proportion of diseased plant material per plot.

Plots were harvested twice in each experiment. All fruits considered to be of sufficient size and maturity to make USDA grades were picked from eight plants in the center row. Culls were sorted out and assigned to several defect catagories. Marketable fruits were passed through hand-held templates with circular openings corresponding to size grades. Data from the two harvests were combined for analysis. Economic values of harvested fruit were calculated based on typical prices for mature green tomatoes on a date between the two harvests taken in each of our experiments (Florida Condition and Supply Report, US Crop and Livestock Reporting Service, Orlando). Fungicide costs were those quoted from a local pesticide supply house. Application costs were based on estimates of fuel, equipment depreciation, and labor costs.

RESULTS AND DISCUSSION

The benefits to Florida tomato farmers of fungicide use were amply demonstrated in Experiment I (Fall 1992). Total marketable yield was reduced 30% when no fungicides were used, compared to the best treatment (Table 1). This same trend was also recorded for the extra-large fruit. Based on typical market prices, net returns were substantially increased by investing in chemical crop protection. When chlorothalonil was sprayed twice a week (the best treatment), the value of the crop was estimated at $12,693/acre. In contrast, the control treatment, heavily damaged by target spot, was valued only at $9,132/acre. When account was taken of fungicide and application costs, net returns were over $3,000 higher in chlorothalonil-treated plots.

In Experiment III (Fall 1993), there was also strong evidence of the benefits of protectant fungicides (Table 2). Total marketable yield was reduced 43% when no fungicide was used compared to the best treatment (chlorothalonil, 1x/wk). Yield losses were again quite high in the extra-large fruit category. As in Experiment I, most of this loss was attributable to a late season epidemic of target spot. As a result of this disease, 62% of all fruit harvested from control plots had to be culled because of target spot blemishes. Only 18% were culled for target spot in chlorothalonil-treated plots.

The benefits gained from protectant fungicides were less clear in the two spring tests. In Experiment II (Spring 1993), an epidemic of bacterial speck, caused by *Pseudomonas syringae* pv. *tomato*, caused uniformly high levels of damage in all treatments. About 60% of the fruit had to be culled due to severe speck damage. Total yields were only one-third to one-half of those recorded in fall tests.

In the Spring 1994 trial, target spot was not a major factor in defoliation or direct fruit injury. Bacterial spot was present throughout the crop. There was a higher marketable yield associated with copper/maneb treatments, twice a week (Table 3). However, as a whole, in this trial, little return on investment could be shown with the use of fungicides.

Target spot and bacterial spot were often involved in defoliation in the same experiment. However, rates of target spot epidemics usually increased dramatically as first harvest approached. Much of the loss associated with target spot was the result of direct damage to fruit. Since much of the defoliation early in crop development was the result of bacterial spot infection, disease progress curves did not necessarily correspond to marketable yield losses. For example, in Experiment I, the chlorothalonil 1x/week treatment was associated with relatively high disease ratings (Figure 1). However, yields were quite good (Table 1). Chlorothalonil alone is relatively ineffective for control of bacterial spot, but is an excellent choice for control of the target spot that developed late in the cropping season. Similar results were recorded in Experiment IV (Spring 1994); copper/maneb treatments reduced defoliation (Figure 3) and were associated with a modest increase in yield (Table 3).

In summary, we now have clear evidence, gathered under commercial growing conditions, that fungicide sprays contribute substantially to the productivity and economic viability of th Florida tomato industry. Copper and maneb are needed to reduc defoliation from bacterial spot, especially in the early portion of fall crops. Later in the season, applications of chlorothaloni seem prudent for management of target spot, especially in regard t direct damage to fruit. In some cases, (as in our Experiment II) returns may not justify input costs for fungicides. However, a present, we do not have disease forecasting systems with the degre of reliability necessary to determine when risks are minimal an protectant-fungicide applications can be reduced or eliminated.

Table 1. Value of tomato crop harvested from experimental plots, cost of control, and net returns for fall, 1992 field trial, Immokalee, FL.

Treatment	Yield of extra-large fruit (tons)[a]	Value of extra-large fruit ($)	Total marketable yield (tons)	Total value of crop ($)	Cost of fungicides ($)	Estimated application costs ($)	Total costs ($)	Net return($)[b]
Chlorothalonil 2x/wk	9.07 a[c]	7,836	18.4 a	12,693	349	39	388	12,305
Chlorothalonil 1x/wk	8.73 ab	7,543	18.2 ab	12,467	192	21	213	12,254
Copper/maneb 2x/wk	7.51 ab	6,489	17.5 ab	11,699	152	39	191	11,508
Copper/maneb 1x/wk	6.84 b	5,910	14.3 ab	9,779	84	21	105	9,674
Control	6.70 b	5,789	13.1 b	9,132	---	--	0	9,132

[a]All data reported on a per acre basis.

[b]Grower can realize a net return increase of up to ($12,305 - $9,132) = $3,173/acre from using fungicides. For an 800 acre farm, net return = $2,539,000.

[c]Means followed by the same letter are not significantly different, according to Waller-Duncan's procedure at $P \leq 0.05$.

Table 2. Value of tomato crop harvested from experimental plots, cost of control, and net returns for fall 1993 field trial, Immokalee, FL.

Treatment	Yield of extra-large fruit (tons)[a]	Value of extra-large fruit ($)	Total marketable yield (tons)	Total value of crop ($)	Cost of fungicides ($)	Estimated application costs ($)	Total costs ($)	Net return($)[b]
Chlorothalonil 1x/wk	10.2 a[c]	6,528	23.2a	13,450	214	21	235	13,215
Chlorothalonil 2x/wk	9.0 ab	5,760	19.3 b	10,704	220	21	241	10,463
Copper/maneb 1x/wk	8.8 ab	5,632	17.9 b	10,344	92	21	113	10,231
Copper/maneb 2x/wk	7.6 b	4,864	15.9 bc	9,160	185	42	227	8,933
Control	4.8 c	3,072	12.8 c	7,200	---	--	0	7,200

[a]All data reported on a per acre basis.

[b]Grower can realize a net return increase of up to ($13,215 - $7,200) = $6,015/acre from using fungicides. For an 800 acre farm, net return = $4,812,000.

[c]Means followed by the same letter are not significantly different, according to Waller-Duncan's procedure at $P \leq 0.05$.

Table 3. Value of tomato crop harvested from experimental plots, cost of control, and net returns for spring, 1993 field trial, Immokalee, FL.

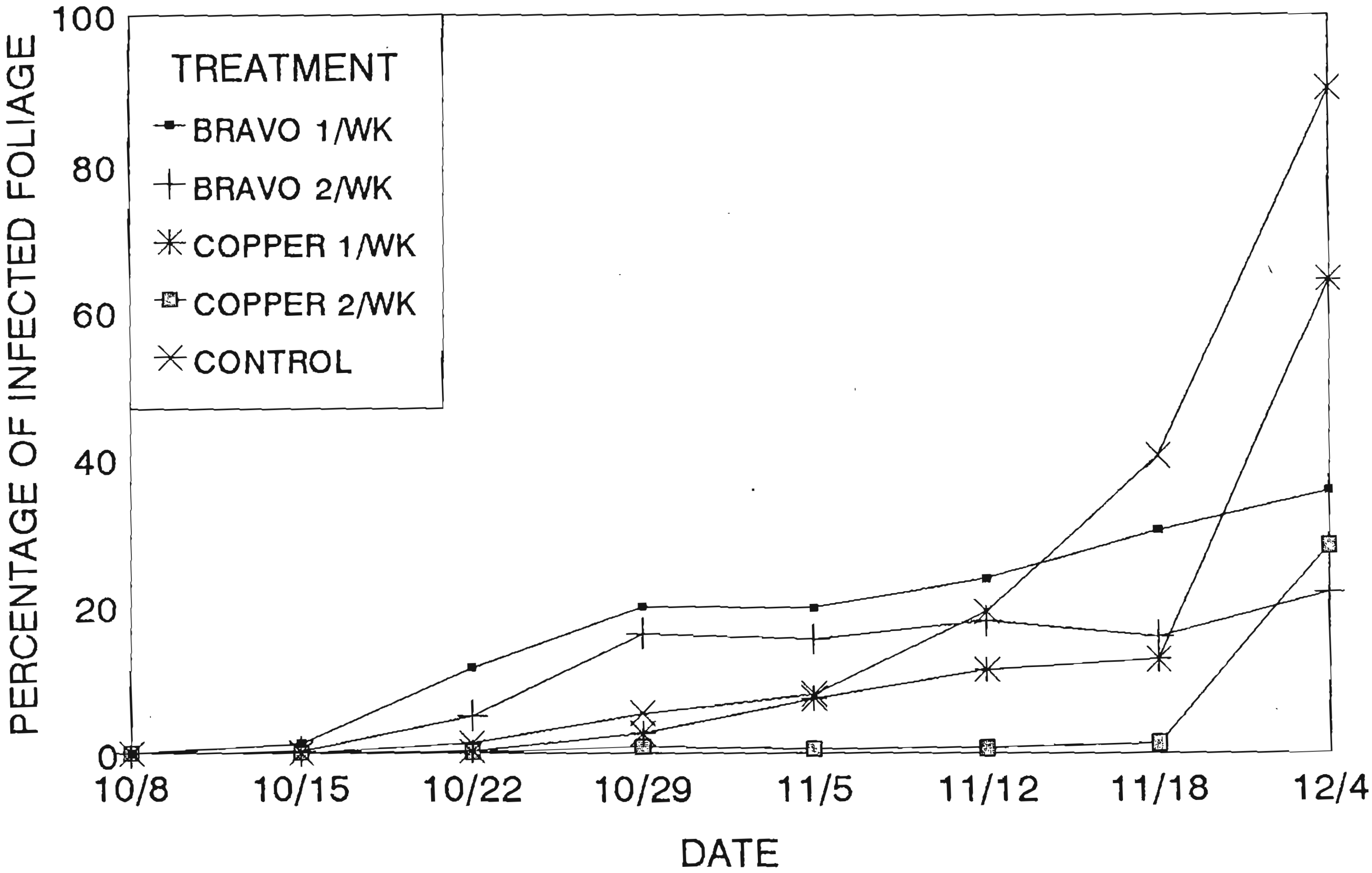
Treatment	Yield of extra-large fruit (tons)[a]	Value of extra-large fruit ($)	Total marketable yield (tons)	Total value of crop ($)	Cost of fungicides ($)	Estimated application costs ($)	Total costs ($)	Net return($)[b]
Chlorothalonil 1x/wk	20.6 a[c]	9,064	30.2 b	11,896	214	21	235	11,661
Chlorothalonil C/M 1x/wk	21.5 a	9,460	31.8 b	12,500	220	21	241	12,259
Copper/maneb 1x/wk	22.2 a	9,768	33.8 b	13,168	92	21	113	13,055
Copper/maneb 2x/wk	26.6 a	11,704	40.4 a	15,768	185	42	227	15,541
Control	20.6 a	9,064	32.4 b	12,480	---	--	0	12,480

[a]All data reported on a per acre basis.

[b]Copper/maneb 2x/wk shows a return on investment (compared to control) of ($15,541 - 12,480) = $3,061/acre. For an 800 acre farm, net return on investment = $2,448,800.

[c]Means followed by the same letter are not significantly different, according to Waller-Duncan's procedure at $P \leq 0.05$.

TOMATO FUNGICIDE STUDY
IMMOKALEE FL FALL 1992



TOMATO FUNGICIDE STUDY
IMMOKALEE, FL FALL 1993

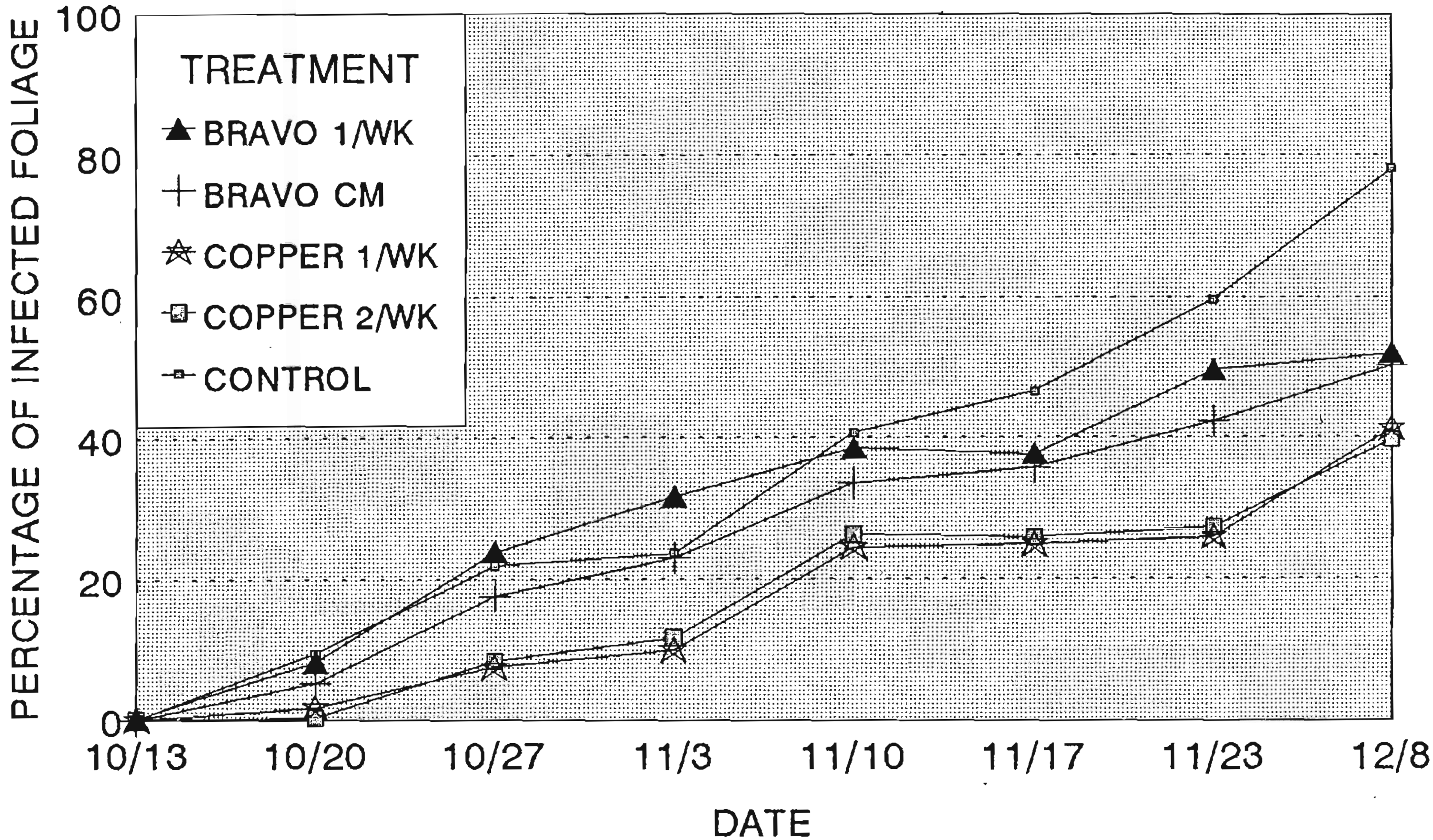
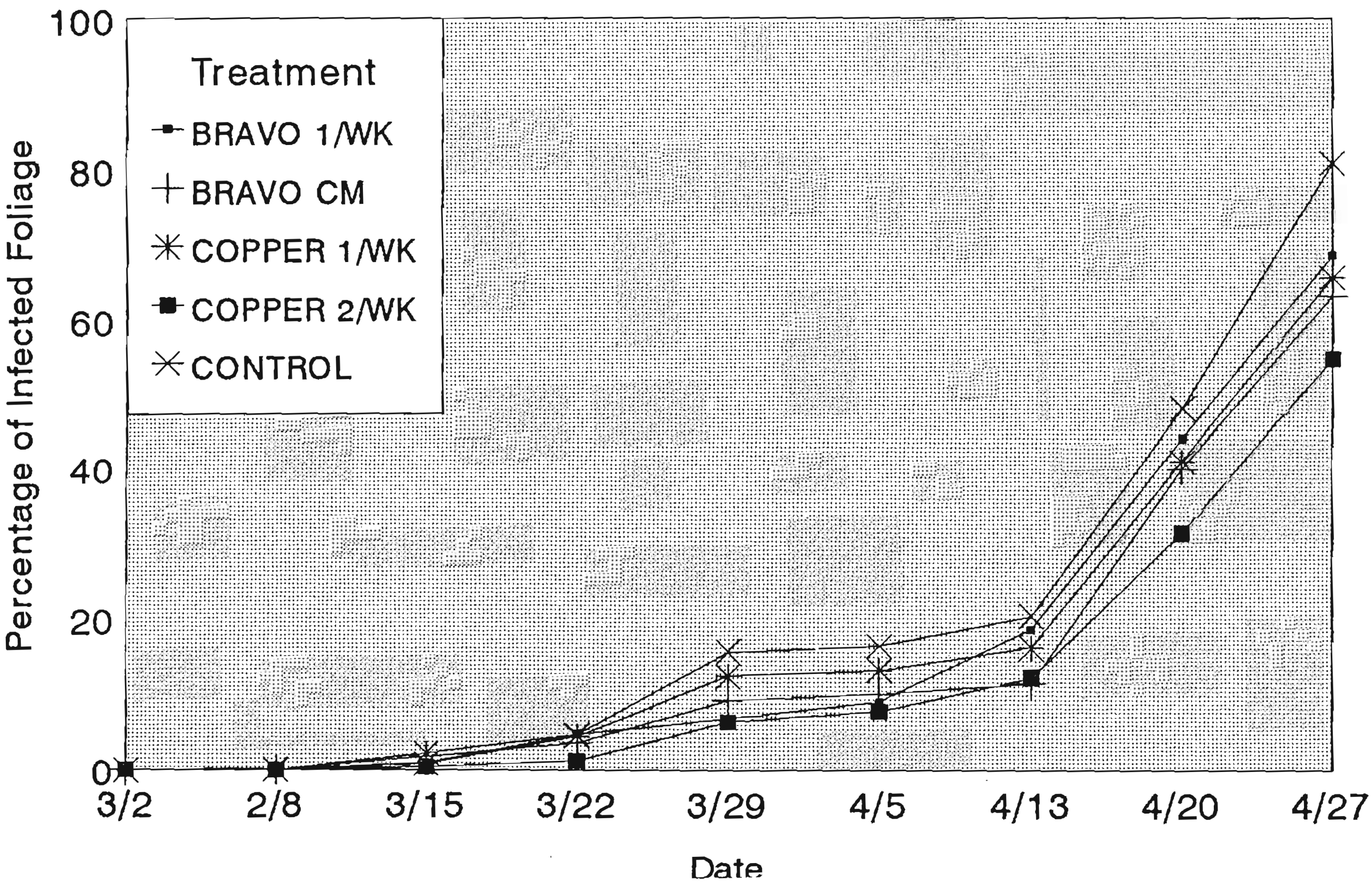


FIGURE 2
Percentage of infected foliage determined by actual estimates of lost and damaged foliage

TOMATO FUNGICIDE STUDY
IMMOKALEE, FL SPRING 1994



Biological Control of Fusarium Crown and Root Rot Using Benefical Fungi

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ABSTRACT

Experiments were conducted to evaluate commercial formulations of two beneficial fungi, *Trichoderma harzianum* and *Glomus intraradices*, for the control of Fusarium crown and root rot of tomato, caused by *Fusarium oxysporum* f. sp. *radicis-lycopersici*. Tomato seeds cv. Sunny were planted into soil non-infested and infested with the biocontrol agents. After 6-7 weeks, plants were transplanted into commercial tomato fields with a previous history of Fusarium crown and root rot. Disease incidence and severity were recorded at harvest maturity. Large fruits (≥6.27 cm) also were harvested, counted and weighed at maturity. In 1991 and 1993, disease incidence in the controls decreased from 48%-57% to 25-32%, 14%-47%, and 18%-20% for *T. harzianum*, *G. intraradices*, and *T. harzianum* + *G. intraradices*, respectively. Yields of large and extra-large fruit increased over the control 4.1%-25.0%, 11.8%-24.5%, 13.2%-16.3% for *G. intraradices*, *T. harzianum* and *T. harzianum* + *G. intraradices*, respectively. Numbers of large and extra-large fruit increased over the controls 3.7%-17.1%, 12.7%-26.1%, 15.1%-15.2% for *G. intraradices*, *T. harzianum* and *T. harzianum* + *G. intraradices*, respectively. These data suggest that commercial biological control agents can be effective for reducing Fusarium crown and root rot and increasing tomato yields.

INTRODUCTION

Fusarium crown and root rot (FCRR), caused by the fungus *Fusarium oxysporum* Schlecht. f. sp. *radicis-lycopersici* Jarvis & Shoemaker (FORL), is a very important disease of greenhouse and field grown tomatoes in several states throughout the US and other countries such as Great Britain, Israel and Japan (Sherf and MacNab, 1986). In Florida, the re-occurrence of FCRR has been increasing over the last years, and yield losses of up to 15 percent have been recorded (Jones et al, 1990).

Several control procedures have been attempted for managing FCRR in the greenhouse and field (McGovern et al, 1993; Rowe and Farley, 1981). Fumigation with methyl bromide/chloropicrin has provided good but not complete control of this disease in the field. However, the classification of methyl bromide as an ozone depleter has prompted the EPA to phase this chemical out of usage by the year 2000 (USDA, 1993). Although fungicides such as benomyl or captafol have been demonstrated to be effective, captafol is no longer labelled for usage, and there is an imminent possibility of fungicide resistance. In addition, commercially resistant tomato cultivars, until most recently (McGovern et al, 1993), were not available or had not been completely subjected to the rigors of field testing.

Research has demonstrated that biological control, through the use of beneficial fungi or bacteria, is a potentially feasible alternative to the use of fumigants or fungicides. Fungal antagonists such as *Trichoderma harzianum* and vesicular-arbuscular mycorrhizal (VAM) fungi such as *Glomus intraradices*, individually, have been demonstrated to be effective beneficial fungi acting as biological agents for controlling FCRR (Caron et al, 1986; Sivan and Chet, 1993; Sivan et al, 1987).

Research also has demonstrated that VAM causes changes in the rhizosphere which favor the increase in the activity of other microorganisms (Meyer and Linderman, 1986). This research suggests that VAM and possibly other biocontrol agents such as beneficial fungi are compatible and perhaps provide a new means of controlling root diseases (Linderman, 1988; Linderman, 1992). Since commercial products of both *T. harzianum* and *G. intraradices* were available for field application, the purpose of this study was to determine if these two biocontrol fungal agents could individually and in combination effectively control FCRR under field conditions in Florida.

MATERIALS AND METHODS

Sogevex potting mix (Sogevex, Inc., Stanford, CT) was amended with an isolate of *G. intraradices* or an isolate of *T. harzianum* either alone or in combination. *G. intraradices* used was a commercial VAM-fungus inoculant (Nutri-Link, Native Plants, Inc., Salt Lake City, UT) that contained about 700-1000 chlamydospores g^{-1} of inoculum. *T. harzianum* Rifai strain KRL-AG2 used was a commercial formulation known as F-Stop (Kodak, NY) containing about 4×10^8 colony forming units (cfu) g^{-1} of inoculum. Amended mixes were dispensed into containerized flats with a cell volume of about 30 ml each as previously described (Datnoff et al, 1991). The final inoculum concentration of VAM was about 500 chlamydospores; whereas, *T. harzianum* was 1×10^6 cfu for each inoculated cell. 'Sunny' tomato seeds were planted and grown in a greenhouse for approximately six to seven weeks. Plants were fertilized with a 20-2-20 N-P-K nutrient solution applied by using a rate dispenser (Dosatron International, Clearwater, FL). Greenhouse temperatures ranged from about 16 to 22C in the evenings and 28 to 34C during the day. Natural lighting in the greenhouse was supplemented with high pressure sodium vapor lamps that provided an average PAR of 46.1 uE s^{-1} m^{-2}. Before or at outplanting, VAM fungus infection was determined to be about 35 to 50%, while root colonization by *T. harzianum* was about 90 to 100%.

Tomatoes non-inoculated and inoculated with the biological control agents were transplanted into fields previously known to have FCRR. Each treatment was arranged in a randomized complete block design that included either 5 or 6 replications. Conventional cultural and pest management practices of tomatoes were used throughout the study. Incidence and severity of FCRR were determined from ten plants per replication. Incidence was based on the number of plants exhibiting symptoms of FCRR. Severity of FCRR was determined using a rating scale of 0 to 3, where 0=no disease and 3 = 50 to 100% internal necrosis of root system 10 to 15 cm up the petiole from the crown. The percent mean severity for each numerical rating was used for estimating difference between treatments. Plants were harvested when approximately 5 to 10% of the fruit were pink, and were primarily graded on USDA standard of large to extra large fruit, diameter $\geq$ 6.27 cm, using a caliber set. The total number and yield of these fruits were recorded from ten plants per replication. Yields were converted to tons/Acre equivalents. Data were subjected to ANOVA and means were tested for significant differences. In addition, arcsin transformations were used when appropriate.

RESULTS AND DISCUSSION

There was good disease development of FCRR at the farm locations in both years (Table 1). The disease incidence and severity of FCRR ranged from 0-60% and 0-47%, respectively, in 1991 at Stuart, FL; while it was 0-80% and 0-27%, respectively, in 1993 at Immokalee, FL.

The commercial formulations of *G. intraradices* and *T. harzianum* used either alone or in combination were very effective in reducing both the incidence and severity of FCRR (Table 1). These results support other researchers findings using either one of these beneficial fungi for controlling FCRR under field conditions (Caron et al, 1986; McGovern et al, 1993; Sivan and Chet, 1993; Sivan et al, 1987).

In 1991, *G. intraradices* alone and the combination of both biologicals significantly reduced (P=0.05) the incidence and severity of FCRR over the control. In 1993, *T. harzianum* alone and the combination of both biologicals significantly reduced (P=0.05) the incidence and severity of FCRR over the control. Although *T. harzianum* alone or *G. intraradices* alone significantly reduced disease, generally, only the combination was consistently effective in both years. This suggests that the combination of these two biologicals are consistently more effective or efficient together than either applied alone. This result may partially support Linderman's hypothesis (Linderman, 1988) that VAM and rhizosphere associates such as *T. harzianum* function in tandem to biologically control root diseases.

The yields and numbers of large to extra large fruit (≥6.25 cm) increased over the control in both years (Tables 2 and 3). Yields of large and extra-large fruit increased over the control 4.1%-25.0%, 11.8%-24.5%, 13.2%-16.3% for *G. intraradices*, *T. harzianum* and *T. harzianum* + *G. intraradices*, respectively. Numbers of large and extra-large fruit increased over the controls 3.7%-17.1%, 12.7%-26.1%, 15.1%-15.2% for *G. intraradices*, *T. harzianum* and *T. harzianum* + *G. intraradices*, respectively. Although significant increases ($P=0.05$) could not be detected for large, extra-large, total marketable fruit size and numbers, this may be partially explained by the fact that only the second and/or third harvest could be obtained in both years because the growers inadvertently took the first.

Although colonization of tomato roots by VAM and *T. harzianum* were known before outplanting to the field, only VAM root colonization was determined at the end of the tests and it was about 1-2%. Further research needs to be conducted to temporally monitor the populations of the biocontrol agents and the pathogen in the field. This information will be very important for better elucidating the mechanism (s) involved in biocontrol of FCRR. Nevertheless, this information is exciting because the potential of using commercially prepared beneficial fungi as biologicals for controlling a root disease such as FCRR appears to available and effective.

SUMMARY

The results of this research to use commercially prepared beneficial fungi as biological agents for controlling FCRR are very encouraging. However, these results need to be extended through further research of these and other biologicals because of site and seasonal variations. In addition, this strategy should be considered only as a part of an integrated management approach that includes sanitation, crop rotation, host plant resistance, etc. for adequately controlling FCRR.

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Table 1. Influence of *Trichoderma harzianum* and *Glomus intraradices* on incidence and severity of Fusarium crown and root rot.

Treatments	1991[1] % Disease Incidence	1991[1] % Disease Severity[2]	1993[1] % Disease Incidence	1993[1] % Disease Severity[2]
Control	48.0 a[3]	18.1 a	56.6 a	16.2 a
Trichoderma harzianum (T)	32.0 ab	12.4 ab	25.0 b	7.5 bc
Glomus intraradices (G)	14.0 b	5.9 b	46.6 a	12.9 ab
T + G	22.0 b	10.6 ab	18.3 b	4.1 c

[1]1991 and 1993 represent field locations in Stuart and Immokalee, FL, respectively.

[2]Analysis of % disease severity was conducted using arcsine-transformed data.

[3]Means followed by the same letter are not significantly different, according to Protected Fisher's Least Significant Difference at $P \leq 0.05$.

Table 2. Influence of *Trichoderma harzianum* and *Glomus intraradices*, alone and in combination, on large, extra-large, and marketable fruit yields in tomato fields naturally infested with *Fusarium oxysporum* f. sp. *radicis-lycopersici*.

Treatments	1991[1] Yield of large + extra-large fruit[2] (Tons/Acre)	1991[1] Total marketable fruit yield[2] (Tons/Acre)	1993[1] Yield of large + extra-large fruit[2] (Tons/Acre)	1993[1] Total marketable fruit yield[2] (Tons/Acre)
Control	6.8 a[3]	18.2 a	4.9 a	12.2 a
Glomus intraradices (G)	8.5 a	18.4 a	5.1 a	11.9 a
Trichoderma harzianum (T)	7.6 a	18.1 a	6.1 a	12.8 a
T + G	7.7 a	19.3 a	5.7 a	12.1 a

[1]1991 and 1993 represent field locations in Stuart and Immokalee, FL, respectively.

[2]Large and extra-large fruit were determined using a caliber set at 6.27 cm. Yields of large, extra-large and total marketable fruit were converted from kg fruit/16 or 24 ft. plots. Only second and/or third harvest could be obtained in both years because growers inadvertently took the first.

[3]Means followed by the same letter are not significantly different, according to Protected Fisher's Least Significant Difference at $P \leq 0.05$.

Table 3. Influence of *Trichoderma harzianum* and *Glomus intraradices*, alone and in combination, on large, extra-large, and total marketable number of fruits in tomato fields naturally infested with *Fusarium oxysporum* f. sp. *radicis-lycopersici*.

	1991[1]		1993[1]	
Treatments	Large, extra-large fruit[2] (Number/Acre)	Total marketable fruit[2] (Number/Acre)	Large, extra-large fruit[2] (Number/Acre)	Total marketable fruit[2] (Number/Acre)
Control	32,488.5 a[3]	89,056.0 a	28,359.0 a	90,840.8 a
Glomus intraradices (G)	38,054.5 a	88,451.0 a	29,403.0 a	88,617.4 a
Trichoderma harzianum (T)	36,602.5 a	87,241.0 a	35,755.5 a	92,701.1 a
T + G	37,389.0 a	98,131.0 a	32,670.0 a	87,800.6 a

[1]1991 and 1993 represent field locations in Stuart and Immokalee, FL, respectively.

[2]Large and extra-large fruit were determined using a caliber set at 6.27 cm. Numbers of large, extra-large and total marketable fruit were converted from number of fruit/16 or 24 ft. plots. Only second and/or third harvest could be obtained in both years because growers inadvertently took the first.

[3]Means followed by the same letter are not significantly different, according to Protected Fisher's Least Significant Difference at $P \leq 0.05$.

Recent Developments in Tomato Geminiviruses: A New Pesticide and a New Virus

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SUMMARY

Two new developments in tomato viruses occurred this past spring, one which has immediate impact and the other potential impact on tomato production in Florida. One was the availablity of Admire for management of whiteflies and tomato mottle virus and the second was the identification of tomato yellow leaf curl virus in the Caribbean. As soon as Admire was made available to tomato growers studies were conducted in grower's fields and at the Gulf Coast Research Center to determine the usefulness of this pesticide for management of tomato mottle virus. Preliminary results of these studies indicate that Admire appeared to be effective in managing TMoV under conditions of the past spring. Further testing will need to be done to extend these initial findings. In addition, significant differences in yield were found between the Admire-trated and conventionally sprayed tomatoes.

In March 1994 tomato yellow leaf curl virus, a whitefly transmitted virus, was confirmed as the cause of a disease devastating tomato production in the Dominican Republic. Two months later this disease was identified in Jamaica. Unpublished reports suggest the virus infects tomatoes in Cuba. The virus has not been found in Florida but the possibility of its movement to Florida is all too possible. A review of the virus is presented which describes symptoms, possible management practices and the differences between this virus and tomato mottle virus.

symptoms. At the end of the season samples were collected from plants where it was difficult to determine infection by symptom expression. These samples were analyzed by nucleic acid spot hybridization. Five yellow sticky cards were evenly distributed in each block to measure whitefly adults. These were examined and changed weekly. In addition, estimates of the whitefly immature and adult population were collected by examining the lower side of twenty leaves in each subplot. Immatures were counted on the underside of leaves that were seventh or nineth from the top of the plant and adults were counted on the underside of leaves that were third to fourth from the top. Twenty plants from the middle of each block were harvested for yield comparisons.

Table 3. Schedule of insecticide applications used in the conventional spray program in a replicated field experiment, spring 1994 season

TIME	First Half of Week	Second Half of Week
First week, and Odd Numbered Weeks	Danitol + Monitor	Thiodan
Second Week, and Even Numbered Weeks	Asana + Lorsban	M-Pede
Weeks During Harvest	M-Pede	Asana

Application rates of insecticides were as follows: Asana (10 oz./A), Danitol (2/3 pts./A), Lorsban (1 lb./A), Monitor (1.5 pts./A), M-Pede (1%), and Thiodan (1.33 qts./A).

Results.

Virus Incidence. Tomato mottle virus incidence was low throughout the season in this field experiment. This was probably due to a late date of transplanting (4 March). There was not a significant difference in virus incidence between the conventionally sprayed tomatoes and the Admire treated tomatoes (Table 4). However, the Admire-treated tomatoes had a consistently lower incidence of virus throughout the season. These results are similar to those observed in the grower fields, where little difference was seen between the two insecticide treatments when virus pressure was low.

Yield. There were some differences in yield seen between the conventional pesticide program and Admire. Total marketable yield (after three harvests) was significantly greater in the conventionally sprayed tomatoes than in the Admire-treated tomatoes (Table 6). This was due to a greater number of fruit harvested from the conventionally sprayed plants, since the average fruit size was actually greater in the Admire-treated tomatoes. There were no significant differences in the harvests of extra-large fruit between the two treatments in either the first pick or the total harvest. In the first harvest there were no significant differences between the marketable yields of Admire and the conventionally-sprayed tomatoes. However the average fruit size was significantly greater in the Admire-treated tomatoes. A greater weight of cull tomatoes were harvested from the Admire-treated tomatoes in the first pick. After three harvests there were no differences in the amount of culls harvested.

TABLE 6. Comparison of a conventional pesticide program and Admire on tomato yield

	FIRST HARVEST				TOTAL OF THREE HARVESTS			
Insecticide	Total Mark. Yield[1] (ca/A)[2]	Extra Large (ca/A)	Avg. Size Fruit (lbs)	Culls (ca/A)	Total Mark. Yield (ca/A)	Total Extra Large (ca/A)	Avg. Fruit Size (lbs)	Culls (ca/A)
Admire	1420a	593a	0.39a	147a	3362a	710a	0.38a	440a
Conv.	1226a	395a	0.31b	101b	3824b	613a	0.29b	415a

[1] Total marketable yield
[2] ca/A = 25 lb cartons per acre. Acre = 8712 linear bed ft. with 5 ft. centers, 2.5 ft. beds, 2 ft. plant spacing
Yield values based on 80 plants (10 plants per row, 10 rows). Plants were staked.
Fertilization: Two surface bands 10 in. to each side of plant row of 15-0-30 at 1917 lbs/A plus 523 lbs./A super phosphate. Field was fumigated with methyl bromide:chloropicrin and covered with black plastic mulch. Seepage irrigation was used.

Summary of Replicated Field Experiment. No significant differences were found between conventionally sprayed and Admire-treated tomatoes with respect to virus incidence, hand counts of whitefly populations and adults trapped on yellow sticky cards. Virus incidence was low in general, due to the planting date of the experiment, while whitefly populations were moderate until the end of the season when the populations were relatively high. Some differences in yield were seen between the two treatments. The conventionally-sprayed tomatoes had a significantly greater yield after three harvests, though the Admire-treated tomatoes had significantly larger fruit.

which matures in August. A high percent (50%) of *C. acutum* plants sampled were infected with TYLCV. It is believed that whiteflies acquire TYLCV from *C. acutum* plants in early summer and then transmit the virus to tomatoes over a several week period. Whitefly populations are very low in the winter and increase to high populations by summer. Viruliferous whiteflies are first detected in June and their numbers increase rapidly thereafter. Tomatoes are planted in the summer at the same time that whitefly populations are high. The combination of a weed reservoir, high populations of the whitefly vector and young tomato plants is a devastating situation for tomato production.

It is possible that if TYLCV were to be introduced into Florida that it could establish in the ditch banks and weedy areas surrounding tomato fields. Besides tomato, at least three of the known hosts of TYLCV occur in Florida tomato production areas - *Datura stramonium, Solanum nigrum* and *Sonchus oleraceae*. This would be a very different situation from that of tomato mottle virus which has no known significant weed hosts.

MANAGEMENT OF TYLCV IN TOMATO

As the disease cycle discussed above might indicate, TYLCV is a very difficult pathogen to manage. In Israel, Turkey, Cyprus and probably many other countries, the virus persists in natural weed reservoirs in the absence of a tomato crop. Whiteflies in many regions readily feed and reproduce on tomato increasing the difficulty of management. A number of different control strategies for TYLCV have been tried with limited success. The most successful strategy to date has been the use of resistant cultivars.

As with other plant viruses which can be transmitted for long periods of time by their vector, suppression of the vector may provide an effective means of reducing spread within a field, and sometimes reducing the number of vectors which land in the field. Biological control, which often works well in the abscence of broad spectrum pesticides to reduce the impact of the whitefly as a pest, offers insufficient control of the vector for the reduction of virus. Insectidical control is difficult and expensive to maintain throughout an entire cropping season, and may be impossible when initial populations are high. In order to avoid invasion of new crops by large numbers of virus-carrying whiteflies, nearby infected crops must be destroyed well in advance of planting. Yiled loss from virus is more severe the earlier the infection begins so invasion of young tomatoes by viruliferous whiteflies must be avoided at all cost.

Cultural Practices. Eradication of overwintering weed hosts in Cyprus significantly reduced the incidence of TYLCV. However, the same practice was not effective in Israel, possibly due to long distance movement of viruliferous whiteflies. In Israel yellow mulches (plastic, straw, sawdust) were found to be effective in decreasing virus spread. (Reflective mulches which disorient the whiteflies have been shown to be more effective than colored mulches in reducing the incidence of tomato mottle virus in Florida). The use of trap crops of cucumber, a more preferred whitefly host, delayed TYLCV spread when planted in alternate rows to, and 30 days before, tomatoes. Fine mesh screens were found to effectively exclude whiteflies and virus from tomato transplant greenhouses. However, this strategy requires extra cooling of the greenhouses due to reduced air flow and may not be economically feasible in Florida. Windbreaks have been tried but resulted in higher whitefly populations and higher numbers of infected plants.

Pesticides. Frequent applications of pesticides help to decrease whitefly populations and suppress the spread of TYLCV. Nevertheless, virus management through whitefly control is impractical in years where whiteflies populations are high. Several foliar applied insecticides are available for killing whitefly adults and immatures. When applying foliar insecticides, special attention should be paid to assuring good coverage on the underside of the leaves where whiteflies reside. Insecticides with differing modes of action should be rotated to retard selection for resistance to any one type. Soil-applied systemic insecticides (such as imidacloprid) have been shown to be effective at reducing spread of TYLCV within tomato fields (secondary spread), but have not been effective at reducing the amount of virus being introduced into fields (primary spread).

Resistant Cultivars. Fresh market tomato hybrid cultivars with tolerance to TYLCV and adapted to the climate of Israel have been released. Plants of the hybrid cultivar TY20 become infected but produce an acceptable yield (22 tons/A compared to 1.6 tons/A for a susceptible cultivar) if plants are protected for four weeks after transplanting using a combination of available control practices. Other hybrid cultivars (TY80, TyKing) have also been developed with tolerance to TYLCV. These cultivars are not adapted to Florida production conditions.

As the timelines began to take shape, it became clear that several of the applications had overlapping REIs. In fact, some overlapped to the point where re-entry would be prohibited for several days at a time. Table 1 summarizes the number of days per week where a Restricted Entry Interval is not in effect for the 3 different spray schedules.

CONCLUSIONS

The authors developed these timelines for the purpose of educating Florida tomato growers about the potentially difficult situation that the new Worker Protection Standard will cause with labor intensive crops such as tomatoes. They are not endorsing any of the spray schedules presented in this report since crop protection needs vary considerably by season, field, and grower. The authors urge growers to use these as samples for a method of comparing different spray options which suit the requirements of their farms, especially when cultural operations require that either workers or handlers perform hand labor tasks in tomato fields.

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GROWER #1

Operation	Date	REI(s)	Chemical(s)
	Oct. 1		
Fumigation - H[1]		N[2] 48+P[3]	Methyl bromide, + Chloropircrin
		N |	
	Oct. 8	N V	
		N 48+P, 12	Gramoxone, Sencor
		N |	
		N V	
	Oct. 15		
	Oct. 22		
	Oct. 29		
Planting - W[4]			
		N 24, 12	Kocide, Manzate
		N V	
	Nov. 5	N 12	Lorsban
		N 12	Asana
Reset - W			
	Nov. 12	N 24	Thiodan
		N V	
Prune - W		N 12	Lorsban
	Nov. 19	N 48+P, 24	Monitor, Danitol
		N | V	
		N V	
		N 48+P	Gramoxone

[1] H = Handler Task
[2] N = No re-entry
[3] +P = + Posting
[4] W = Worker Task

```
Operation Date               REI(s)             Chemical(s)
---                 | N   |    12, 12         Agrimek, Lorsban
Tie - W             | N   V    12             Asana
---                 |
                                                      GROWER #1
          Nov. 26   - N  12                   Asana
                    | N  12                   Lorsban
                    | N  48+P, 24             Monitor, Danitol
                    | N   |     V
                    | N   V     48, 12        Bravo CM, Lorsban
                    | N          |
                    | N  12      V            Soap
          Dec. 3    - N  12                   Lorsban
                    |
                    | N  12                   Asana
                    |
                    | N  48+P, 24             Monitor, Danitol
                    | N   |     V
---                 | N   V     12            Soap
Tie - W   Dec. 10   - N  24                   Ambush
---                 | N   V
                    |
                    | N  24                   Thiodan
                    | N   V    12             Agrimek
                    |
                    | N  12                   Lorsban
          Dec. 17   - N  12                   Asana
                    |
                    |
                    | N  24, 24, 12           Kocide, Thiodan,
                    | N   V   V               + Manzate
                    | N  48+P, 24             Monitor, Danitol
                    | N   |     V
          Dec. 24   - N   V
                    |
                    | N  48, 12     Ridomil-Bravo, Lorsban
                    | N   |  48+P, 24       Gramoxone, Enquik
                    | N   V    | 12 V       Asana
                    | N        V
---                 | N  12                   Oil
Tie - W   Dec. 31   -
---                 |
                    |
                    | N  48, 24               Bravo, Thiodan
                    | N   |   V
                    | N   V
                    |
          Jan. 7    -
                    |
                    |
                    | N  48, 12               Bravo, Agrimek
                    | N   |
                    | N   V
                    | N  48+P, 24, 12         Monitor, Kocide,
          Jan. 14   - N   |     V             + Manzate
```

```
Operation Date              REI(s)            Chemical(s)
          Jan. 14    - N   |      V           + Manzate
                     | N   V
                     |                                    GROWER #1
                     | N-  48, 12             Bravo, Lorsban
                     | N   |
                     | N   V
                     | N   12, 12             Ridomil-Manzate,
          Jan. 21    -                        + Lorsban
                     |
                     |
                     | N   48+P, 24           Monitor, Danitol
                     | N   |      V
                     | N   V
                     |
          Jan. 28    - N   24, 12             Kocide, Manzate
                     | N   V
                     | N   12                 Agrimek
                     | N   48, 48             Bravo, Lannate
                     | N   |   |
                     | N   V   V
                     |
          Feb. 4     - N   24, 12             Kocide, Manzate
                     | N   V
                     |
-------              | N   48                 Bravo
  ^                  | N   |
Harvest - W          | N   V
  |                  | N   24, 12             Kocide, Manzate
  |       Feb. 11    - N   V
  |                  |
  |                  |
  |                  | N   48                 Lannate
  |                  | N   |
  |                  | N   V
Harvest - W          |
  |       Feb. 18    -
  v                  | N   48                 Bravo
-----------          | N   |
Crop                 | N   V    48+P          Gramoxone
Destruction - H      | N        |
-----------          | N        V
                     |
          Feb. 25    -
                     |
                     |
                     |
                     |
                     |
                     |
          Mar. 4     -
```

Figure 1. Spray schedule, Restricted Entry Intervals, and hand labor tasks for Grower #1.

Operation	Date		REI(s)	Chemical(s)
---		N	48, 48, 24	Champ, Bravo,
Tie - W		N	| | V	+ Pounce
---		N	V V	
	Nov. 26			**GROWER #2**
		N	12	Manzate
	Dec. 3	N	12, 12	Manzate, Agrimek
		N	48+P	Gramoxone
		N	|	
		N	V	
		N	48	Bravo
---		N	|	
Tie - W	Dec. 10	N	V	

		N	12	Manzate
	Dec 17	N	48, 48, 12	Champ, Bravo,
		N	| |	+ Asana
		N	V V	
		N	48, 12	Champ, Asana
		N	|	
		N	V	
	Dec. 24			
		N	24, 12, 12	Kocide, Agrimek,
		N	V	+ Asana
---		N	24, 12	Pounce, Manzate
Tie - W	Dec. 31	N	V	

		N	48, 12	Bravo, Asana
		N	|	
		N	V	
	Jan. 7			
		N	48, 24, 24, 12	Bravo, Kocide,
		N	| V V	+ Pounce, Agrimek
		N	V	
	Jan. 14			

GROWER #2

Operation	Date	REI(s)	Chemical(s)
	Jan. 14		
Tie - W		N 48, 24, 12, 12	Bravo, Thiodan, + Manzate, Asana
		N 24, 12	Kocide, Asana
	Jan. 21		
		N 48, 24, 24, 12	Bravo, Kocide, + Pounce, Manzate
		N 24	Pounce
	Jan. 28		
		N 24	Kocide
		N 48, 24, 24, 12	Bravo, Kocide, + Pounce, Manzate
	Feb. 4		
Harvest - W		N 24	Pounce
	Feb. 11		
Harvest - W			
	Feb. 18		
	Feb. 25		
Crop Destruction-H		N 48+P	Gramoxone
	Mar. 4		

(In the original figure, each REI is marked by a downward arrow and "N" entries on the timeline; the harvest period spans from the first to the second harvest marker.)

Figure 2. Spray schedule, Restricted Entry Intervals, and hand labor tasks for Grower #2.

GROWER #3

```
Operation Date                REI(s)          Chemical(s)
             Oct. 1     -
                        |
                        |
                        |
---------               |
Fumigate-H[1]           | N[2] 48+P[3]        Methyl bromide,
---------               | N    |              + Chloropircrin
             Oct. 8     - N    V
                        |
                        |
                        |
                        | N    48+P, 12       Gramoxone, Sencor
                        | N    |
                        | N    V
             Oct. 15    -
                        |
                        |
                        |
                        |
                        |
                        |
             Oct. 22    -             +------------------------
                        |             |[1] H = Handler Task
                        |             |[2] N = No re-entry
                        |             |[3] +P = + Posting
                        |             |[4] W = Worker Task
                        |             |[5] PBO = Pipernyl Butoxide
                        |             +------------------------
             Oct. 29    -
                        |
                        |
---------               |
Planting - W[4]         |
---------               | N    24, 12         Kocide, Manzate
                        | N    V  12, 12           Asana, PBO[5]
             Nov. 5     -
                        | N    48+P, 24,12    Monitor, Ambush,
                        | N    |        V     + BT
                        | N    V
                        | N    48+P           Monitor, Asana
                        | N    |
-----                   | N    V
Reset - W Nov. 12       - N    48, 24         Bravo, Thiodan
-----                   | N    |   V
                        | N    V  12, 12, 12  Lorsban, Asana,
-----                   |                     + BT
Prune - W               | N    12, 12         Ambush, PBO
-----                   |
                        | N    48+P, 24       Monitor, Ambush
             Nov. 19    - N    |      V
                        | N    V    48+P,  24,  12    Gramoxone,
                        | N         |      V      + Thiodan,
                        | N         V             + Agrimek
```

GROWER #3

<table>
<tr><th>Operation</th><th>Date</th><th></th><th></th><th>REI(s)</th><th>Chemical(s)</th></tr>
<tr><td>---</td><td></td><td>|</td><td>N</td><td>12, 12</td><td>Asana, PBO</td></tr>
<tr><td>Tie - W</td><td></td><td>|</td><td>N</td><td>48, 24,12</td><td>Lannate, Kocide,</td></tr>
<tr><td>---</td><td></td><td>|</td><td>N</td><td>| V</td><td>+ Manzate</td></tr>
<tr><td></td><td>Nov. 26</td><td>-</td><td>N</td><td>V</td><td></td></tr>
<tr><td></td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>12, 12</td><td>Lorsban, Asana</td></tr>
<tr><td></td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>24, 12</td><td>Ambush, PBO</td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>V</td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>24, 12</td><td>Thiodan, BT</td></tr>
<tr><td></td><td>Dec. 3</td><td>-</td><td>N</td><td>V</td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>48+P, 24</td><td>Monitor, Ambush</td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>| V</td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>V 48, 12, 12</td><td>Bravo, Asana, PBO</td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>|</td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>48+PV, 12</td><td>Monitor, Asana</td></tr>
<tr><td>---</td><td></td><td>|</td><td>N</td><td>| 48</td><td>Lannate</td></tr>
<tr><td>Tie - W</td><td>Dec. 10</td><td>-</td><td>N</td><td>V | 24, 12</td><td>Thiodan, Agrimek</td></tr>
<tr><td>---</td><td></td><td>|</td><td>N</td><td>V V</td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>24, 24, 12, 12</td><td>Kocide, Ambush,</td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>V V</td><td>+ Manzate, PBO</td></tr>
<tr><td></td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>12, 12</td><td>Lorsban, Asana</td></tr>
<tr><td></td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Dec. 17</td><td>-</td><td>N</td><td>48+P, 12</td><td>Monitor, Asana</td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>|</td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>V</td><td></td></tr>
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<tr><td></td><td></td><td>|</td><td>N</td><td>24, 12</td><td>Thiodan, BT</td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>V</td><td></td></tr>
<tr><td></td><td>Dec. 24</td><td>-</td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td>|</td><td>N</td><td>48+P, 24</td><td>Monitor, Ambush</td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>| V</td><td></td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>V 24, 12</td><td>Ambush, PBO</td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>V</td><td></td></tr>
<tr><td>---</td><td></td><td>|</td><td>N</td><td>48+P, 48, 12</td><td>Monitor, Bravo,</td></tr>
<tr><td>Tie - W</td><td>Dec. 31</td><td>-</td><td>N</td><td>| |</td><td>+ Asana</td></tr>
<tr><td>---</td><td></td><td>|</td><td>N</td><td>V V</td><td></td></tr>
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<tr><td></td><td></td><td>|</td><td>N</td><td>24, 12, 12</td><td>Ambush, PBO, BT</td></tr>
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<tr><td></td><td></td><td>|</td><td>N</td><td>V</td><td></td></tr>
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<tr><td></td><td></td><td>|</td><td>N</td><td>24, 12</td><td>Ambush, Lorsban</td></tr>
<tr><td></td><td></td><td>|</td><td>N</td><td>V</td><td></td></tr>
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<tr><td></td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Jan. 14</td><td>-</td><td>N</td><td>12, 12</td><td>Asana, PBO</td></tr>
</table>

GROWER #3

```
Operation Date                REI(s)           Chemical(s)
          Jan. 14     - N  12, 12              Asana, PBO
                      |
                      |
                      |
                      | N  48+P, 24            Monitor, Ambush
                      | N   |      V
                      | N   V
          Jan. 21     -
                      | N  24, 12              Ambush, Lorsban
                      | N   V
                      |
                      | N  48, 24, 12          Bravo, Ambush,
                      | N   |   V              + PBO
                      | N   V
          Jan. 28     -
                      | N  48+P, 24            Monitor, Ambush
                      | N   |      V
                      | N   V    24, 12        Ambush, Lorsban
                      | N         V
                      | N  24, 12              Asana, PBO
          Feb. 4      - N   V
                      |
                      |
-------               |
   ^                  |
Harvest - W           |
   |                  |
   |      Feb. 11     -
   |                  | N  48+P, 24, 24, 12 Monitor,
   |                  | N   |      V   V     + Ambush, Kocide,
   |                  | N   V                + Manzate
   |                  | N  24, 12            Ambush, PBO
   |                  | N   V
Harvest - W           |
   |      Feb. 18     -
   v                  |
-------               | N  48, 24, 12        Bravo, Ambush,
                      | N   |   V            + Lorsban
                      | N   V
                      |
-----------           |
Crop      Feb. 25     -
Destruction - H       | N  48+P              Gramoxone
-----------           | N   |
                      | N   V
                      |
                      |
                      |
          Mar. 4      -
```

Figure 3. Spray schedule, Restricted Entry Intervals, and hand labor tasks for Grower #3.

Table 1. Effect of 3 Different Spray Schedules on the Total Number of Days/Week without a Restricted Entry Interval

	NUMBER OF DAYS/WEEK WITHOUT AN R.E.I.		
WEEK OF	GROWER #1	GROWER #2	GROWER #3
Oct. 29 - Planting	5	7	5
Nov. 5 - Reset	5	5	1
Nov. 12 - Prune	4	3	3
Nov. 19 - Tie #1	1	3	0
Nov. 26	0	6	2
Dec. 3	2	1	0
Dec. 10 - Tie #2	2	5	2
Dec. 17	2	1	1
Dec. 24	1	4	2
Dec. 31 - Tie #3	4	3	3
Jan. 7	3	4	3
Jan. 14 - Tie #4	1	3	3
Jan. 21	4	2	2
Jan. 28	1	2	1
Feb. 4 - Harvest	1	5	6
Feb. 11 - Harvest	3	7	2
Feb. 18 - Harvest + Crop Destruction (Growers 1 & 3)	3	7	4
Feb. 25 - Crop Destruction (Grower 2)	7	4	4
Total Days for Re-entry	49	72	44

where the existing acreage becomes a nursery and incubator for insects and disease pathogens.

Market influences in 1993-94 appeared to have contributed to the creation of a huge whitefly nursery in Southwest Florida. When prices fell in mid-January, nearly 5000 acres were taken out of production in less than three weeks (Figure 2). This acreage was being abandoned or destroyed just after the peak of the spring plantings (Figure 4). In late December and early January, over 4000 acres of tomatoes had been planted. The large acreage being harvested in mid-January 1994 acted as a breeding ground for the silverleaf whitefly populations, which subsequently moved to the young spring tomato crop when thousands of acres were taken out of production over a short period of time.

Silverleaf Whitefly Populations

Although whitefly populations vary from year to year there is typically a significant population spike after harvest and crop destruction. Figures 6 and 7 illustrate this phenomenon for a specific field over a two year period. After the harvest was complete sticky trap counts of whitefly increased dramatically. Note also that whitefly counts in this field were four times higher last season than in 1992-93.

Admire Efficacy

In December 1993 the Florida Department of Agriculture issued a Section 18 emergency exemption for the use of Admire™ (imidacloprid) for the control of silverleaf whitefly on tomatoes in Florida. Admire, a soil applied systemic insecticide, was tested in replicated trials at the Southwest Florida Research and Education Center in the spring of 1994. The Section 18 emergency exemption also provided an opportunity to monitor its efficacy in large scale farm demonstrations.

Replicated Trial, Materials and Methods

Chemical control plots 48 feet long and 2 rows wide on 6 foot centers were located within a 2.4 acre tomato planting on drip irrigation. Experimental design was randomized complete block with 4 replications and 5 treatments, 3 of which are included here. Tomato variety Sunbeam seedlings were transplanted on 28 February 1994 at 18 inch spacing and received weekly fungicide sprays. Admire (imidacloprid) was applied to one of the plots in each replication, at the rate of 1 pint of product per acre, by drenching 4 ounces of diluted material around the root ball of each plant on 4 March. Admire plots were not treated again until 6 May 1994, when they were sprayed with Sunspray Oil at the rate of 1.5% v/v. Conventional chemical treatment plots were sprayed weekly according to a rotating schedule of Thiodan (endosulfan) or Danitol (fenpropathrin) plus Monitor (methamidophos) delivered through Albuz @ ATR yellow nozzles at 200 PSI from a tractor-mounted plot sprayer using two drops per row. Two nozzles per drop (4/row) were used initially, increasing to 3 (6/row) and finally 4 per drop (8/row) on 6 May. Control plots were not sprayed with insecticide. Adult whiteflies were evaluated weekly using a beatpan method. Immature populations were estimated from a sample of 3 trifoliates per plot taken from the 5th, 6th, or 7th node from the top, the highest position pupal exuviae were observed. Nymphs and pupae were counted under a stereoscopic microscope within a 1 cm^2 area designated by a paper template placed twice on either side of the midrib for a total of 4 cm^2 per leaflet = 12 cm^2/trifoliate. Plants exhibiting symptoms of TMoV were flagged and counted weekly beginning 7 April. Only unmarked symptomatic plants were counted in subsequent weeks. Tissue samples were submitted to the SWFREC diagnostic laboratory to verify the presence of TMoV.

Replicated Trials, Results

The Admire treatment produced a significant reduction in numbers of both immature and adult whiteflies when tested against an untreated control and a conventional spray program (Figure 8 & 9). The similarity in efficacy between conventional and untreated control in this trial should also be noted. Also, the conventional spray treatment exhibited less virus than the control, but by the end of the season differences were negligible (Figure 10). The apparent failure of conventional sprays to control whitefly could be attributed to small plot size and high populations resulting in a great deal of migration between plots. However, the incidence of TMoV infection was drastically reduced by the Admire treatment when compared to either the conventional or the untreated control.

Farm Demonstration, Materials and Methods

Two locations consisting of 13.3 acres (plot 1) and 10.4 acres (plot 2) were selected for the trials. Every other 6-row block in the two fields was treated with Admire after planting by soil application with a hand wand sprayer calibrated to deliver 1 pint of product per acre. Plot 1 was planted on 12/30/93 and treated on 1/10/94. Plot 2 was planted on 12/21/93 and treated on 1/11/94. All of the blocks in both plots were treated with a conventional spray program for the first three weeks after the application of Admire. This was done in order to protect the tomatoes until the Admire could be translocated throughout the plant. The conventional spray program consisted of various tank mixes applied three times per week, and included combinations of synthetic pyrethroids, Bt's, organo-phosphates, chlorinated hydrocarbons, and carbamates. The schedule was subsequently reduced in both treatments to just one application of an organo-phosphate plus a Bt each week. Beginning the week of February 8, 1994, plots were sampled for whitefly adults, pupae and nymphs on a weekly basis. Six samples were taken in both the treated and untreated blocks of each plot. Beatpan counts (5 plants per sample) were used to estimate adult whiteflies populations. Pupal and nymphal counts were taken from three trifoliate leaves removed from the fifth node of three plants per sample. The incidence of Tomato Mottle Virus (TMoV) was monitored beginning on 2/19/94. One hundred plants in each of six replications per treatment in both plots were identified and examined on a weekly basis for the expression of viral symptoms.

Farm Demonstration, Results

The population of whitefly adults, pupae and nymphs remained relatively low in both treatments and there was no significant differences between treatments. However, the incidence of TMoV showed a distinct response to the Admire treatment. By the time the crop was ready for harvest the Admire treated blocks in both plot 1 and plot 2 showed roughly half the viral infection observed in the untreated blocks (Figure 11 and 12).

Admire Efficacy, Conclusions

The suppression of all whitefly stages in the replicated trials demonstrated the efficacy of Admire against this pest. Suppression of TMoV spread in Admire plots in spite of heavy pressure from viruliferous whiteflies indicated that Admire acted quickly against adults. The lack of differences between the conventional spray treatment and the untreated control illustrated the potential for loss of whitefly control in Spring of 1994. Low counts of whitefly adults and immatures in the demonstration plots would suggest that although populations in these particular fields were low, there was a high incidence of viruliferous whiteflies. Although no claims have been made by Miles Labs that Admire will reduce the incidence of TMoV, our data supports such an hypothesis. Perhaps Admire reduced TMoV incidence by limiting the feeding time of infected whiteflies in the treated blocks thereby reducing the transmission of the virus.

Summary

The 1993-94 tomato season was a blood letting at the best. High incidence of Tomato Mottle Virus reduced yields and quality and combined with depressed prices to make this one of the worst seasons ever. High prices in the late fall led to large field inventories of tomato, which may have acted as nurseries, spawning high populations of viruliferous whiteflies, which in turn attacked the young spring plantings as the old fields were destroyed. Although total suppression of whitefly and TMoV may not have been achieved with Admire TMoV infection rates would probably have been greater without the availability of this product.

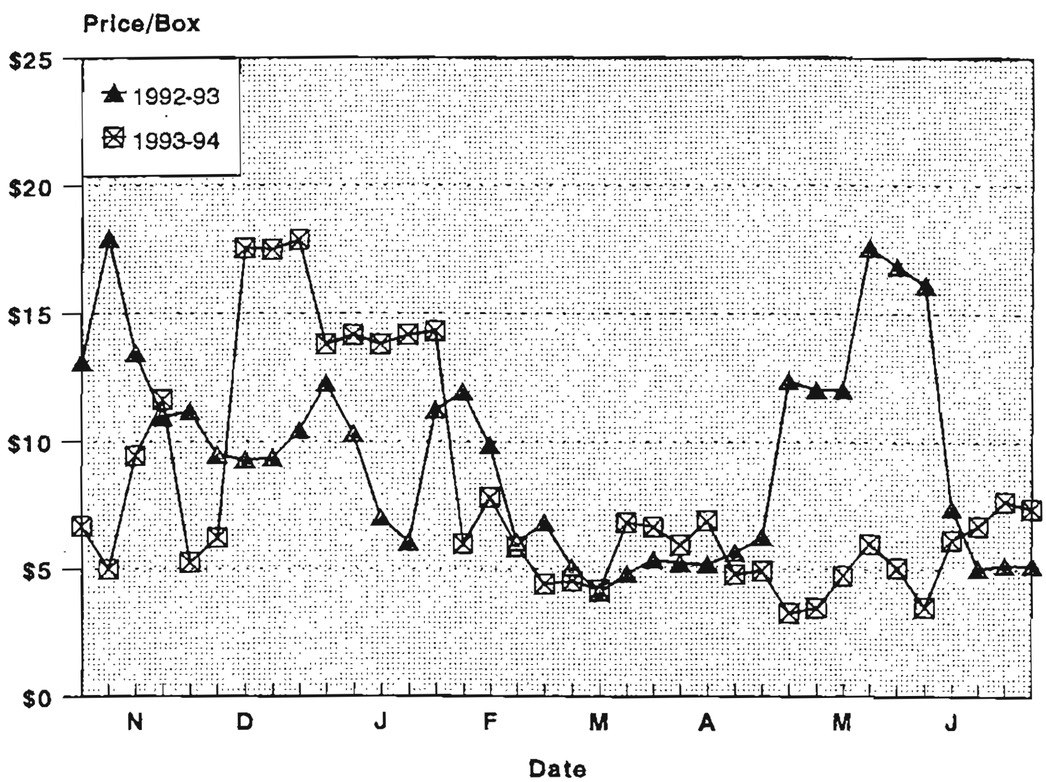

Figure 1: Average Tomato Prices 1992-93 & 1993-94
(Florida Tomato Committee)

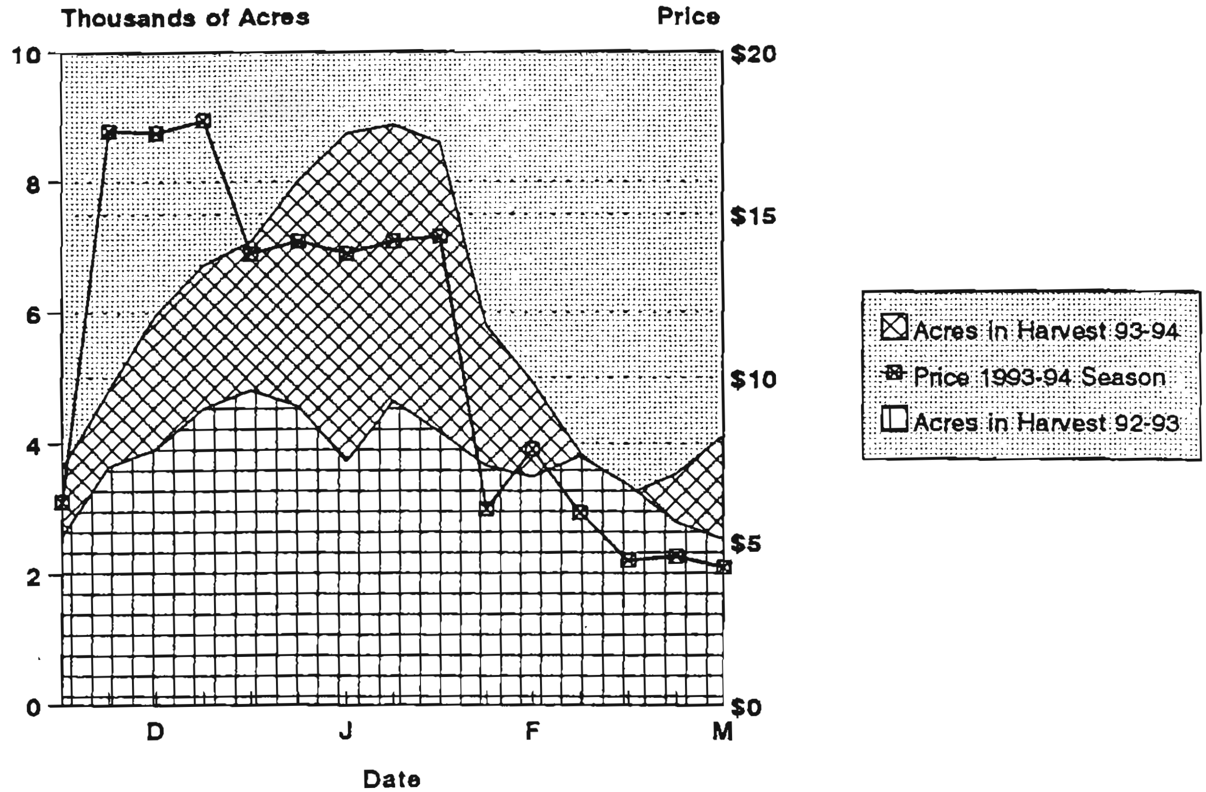

Figure 2: Average Tomato Price vs Total Acres Being Harvested
(Florida Tomato Committee & Florida Agricultural Statistics Service)

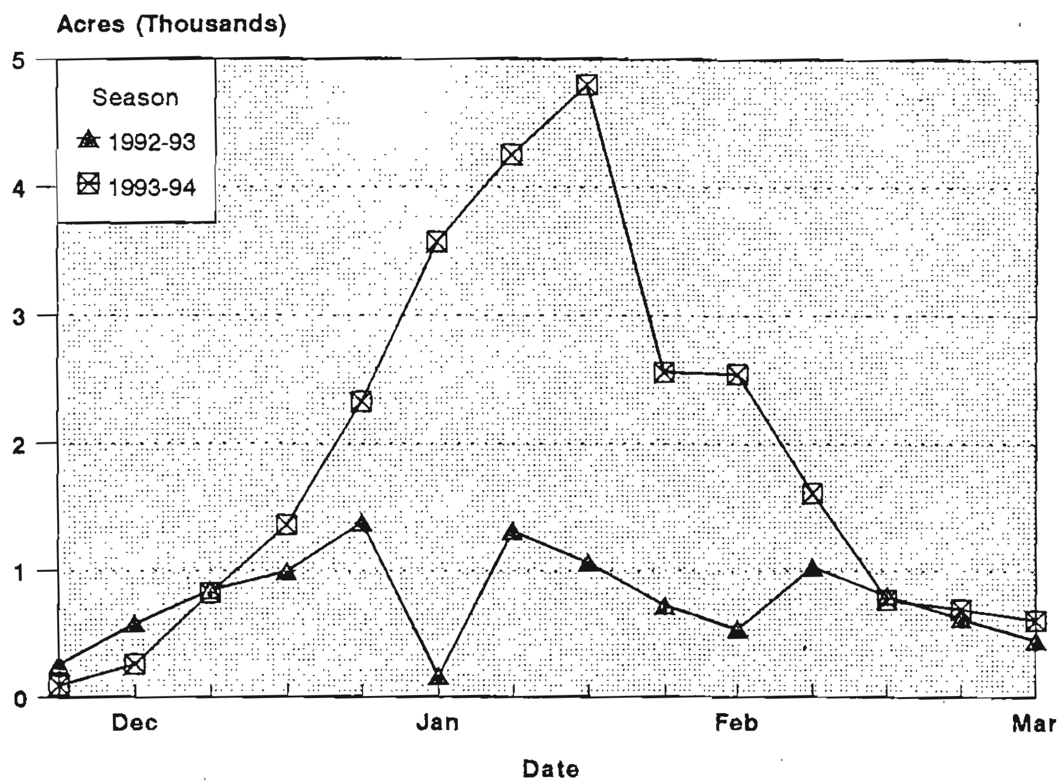

Figure 3: Tomato Harvest Progress; Three or More Harvests
(Florida Agricultural Statistics Service)

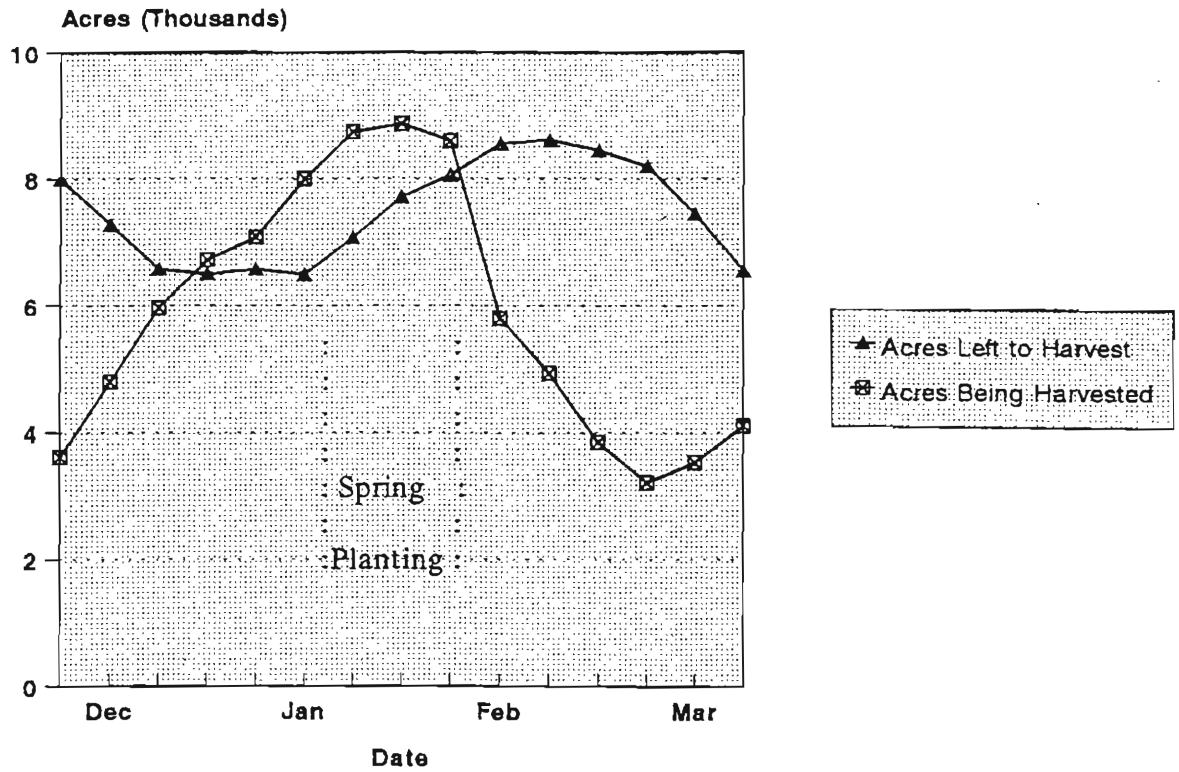

Figure 4: Tomato Harvest vs Un-harvested Acres 1993-94
(Florida Agricultural Statistics Service)

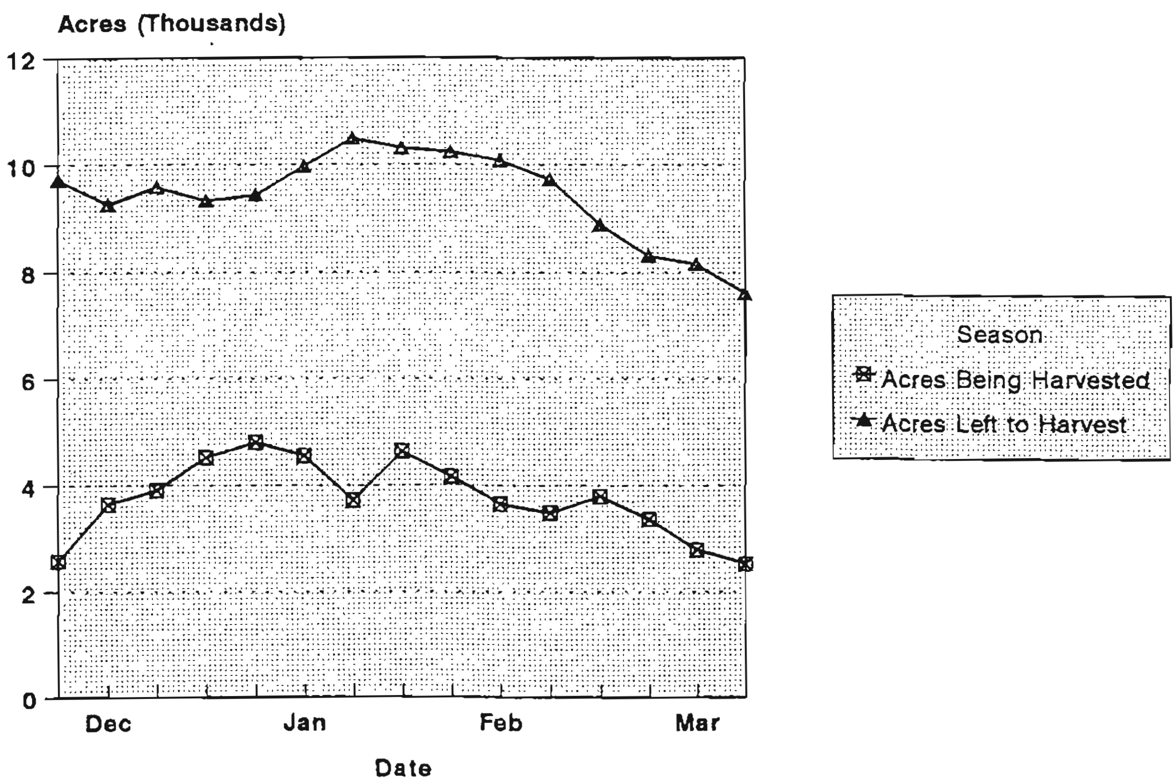

Figure 5: Tomato Harvest vs Un-harvested Acres 1992-93
(Florida Agricultural Statistics Service)

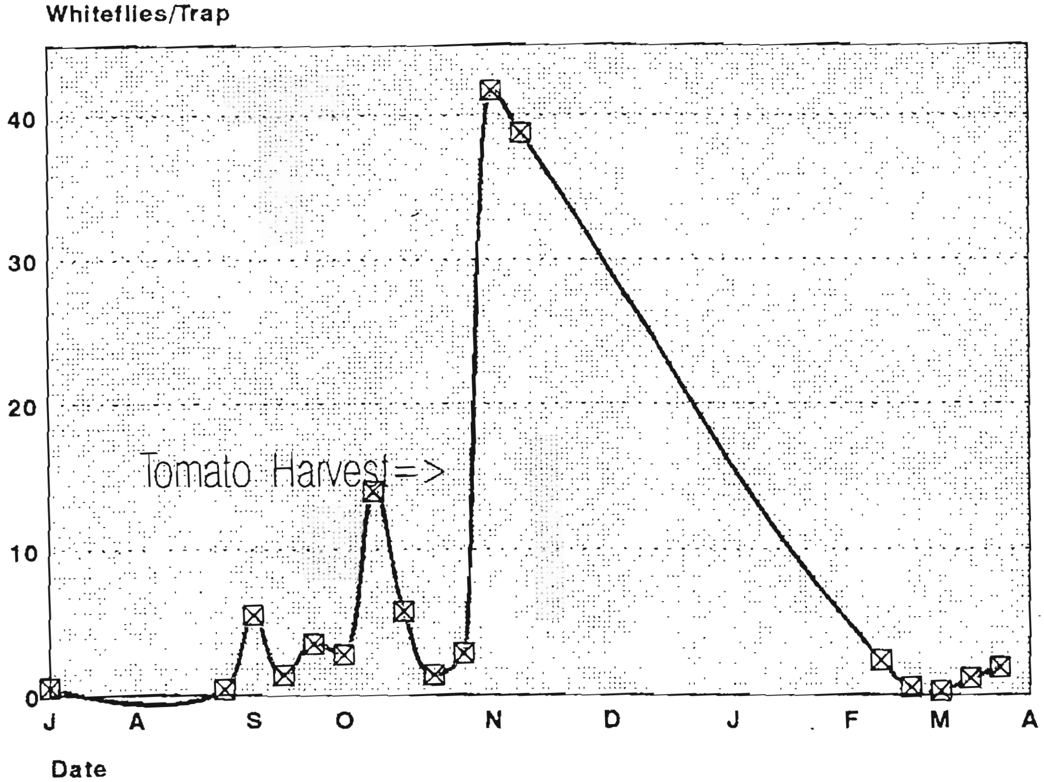

Figure 6: Whiteflies on Sticky Traps - Corkscrew Area 1993-94

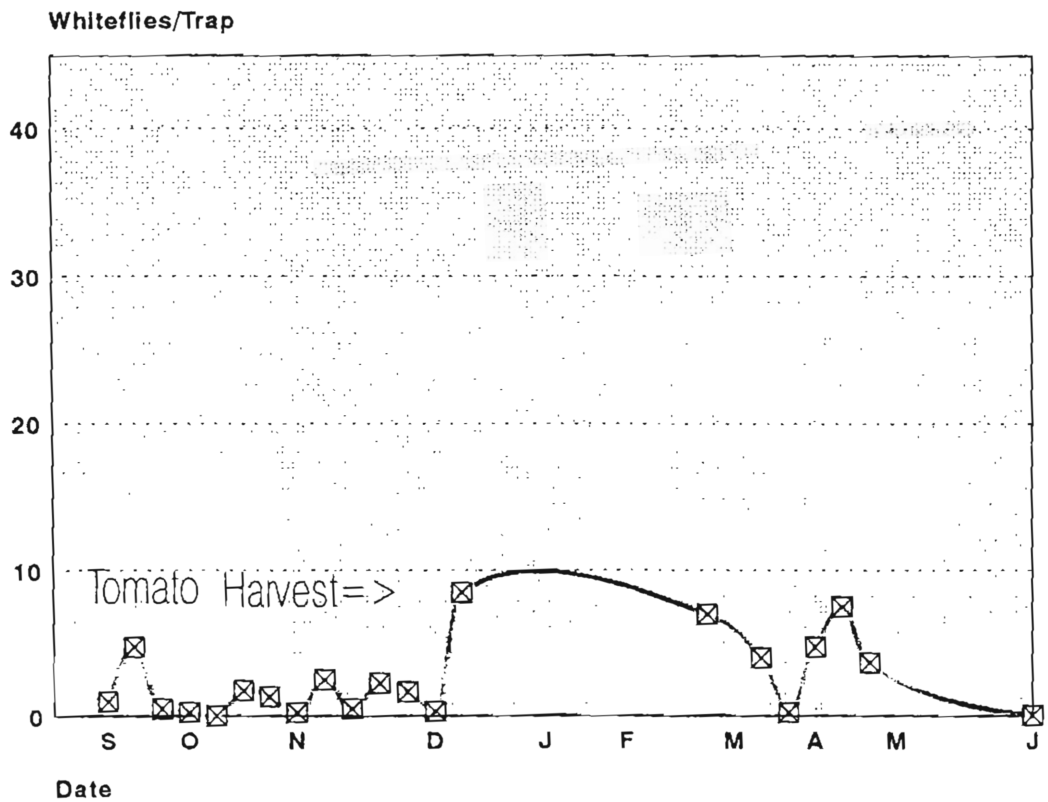

Figure 7: Whiteflies on Sticky Traps - Corkscrew Area 1992-93

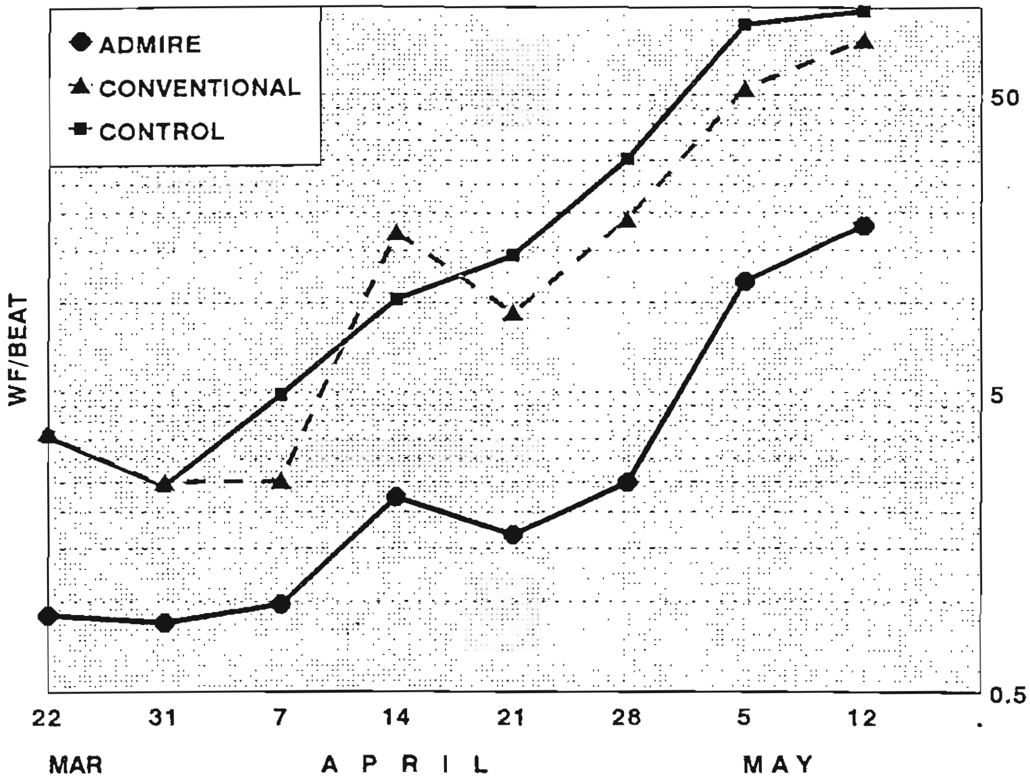

Figure 8: Adult Whiteflies - Replicated Trial

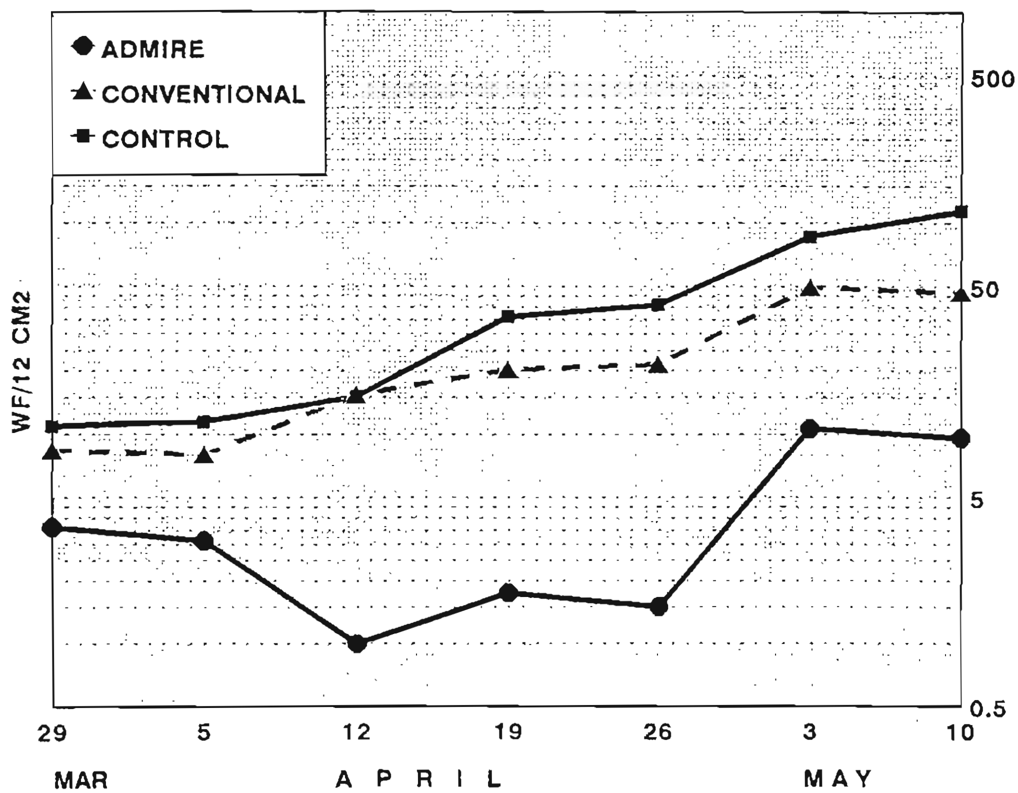

Figure 9: Immature Whiteflies - Replicated Trial

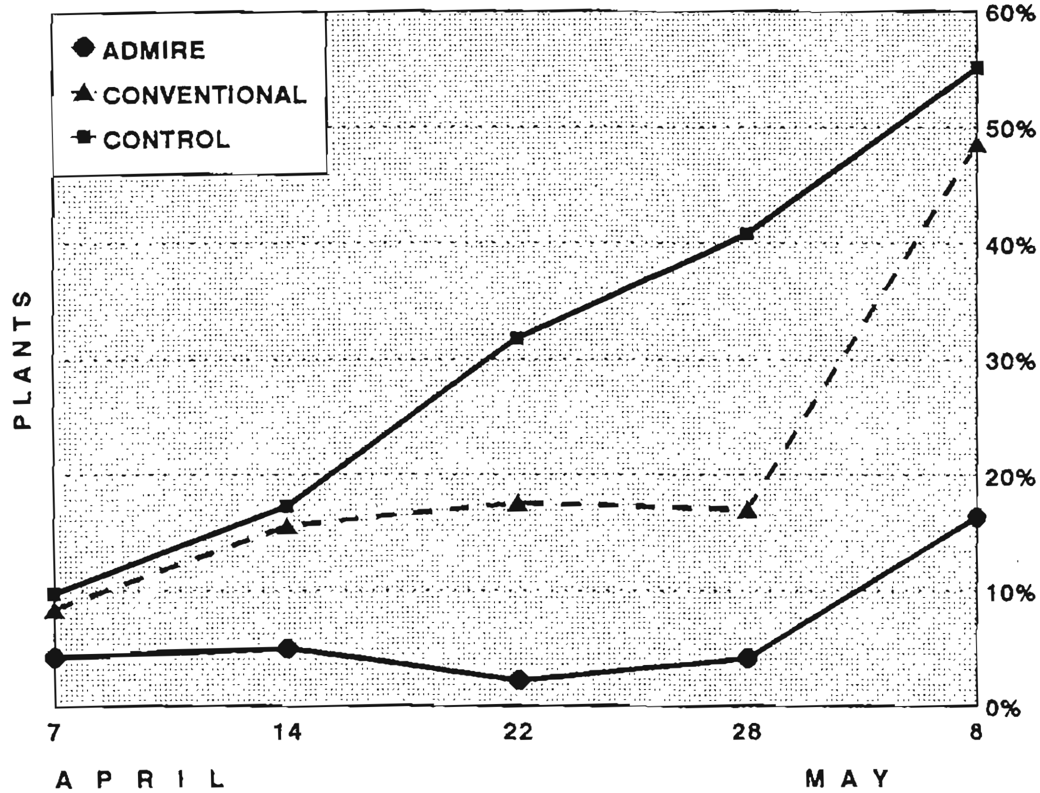

Figure 10: Weekly TMoV Infection Rate - Replicated Trial

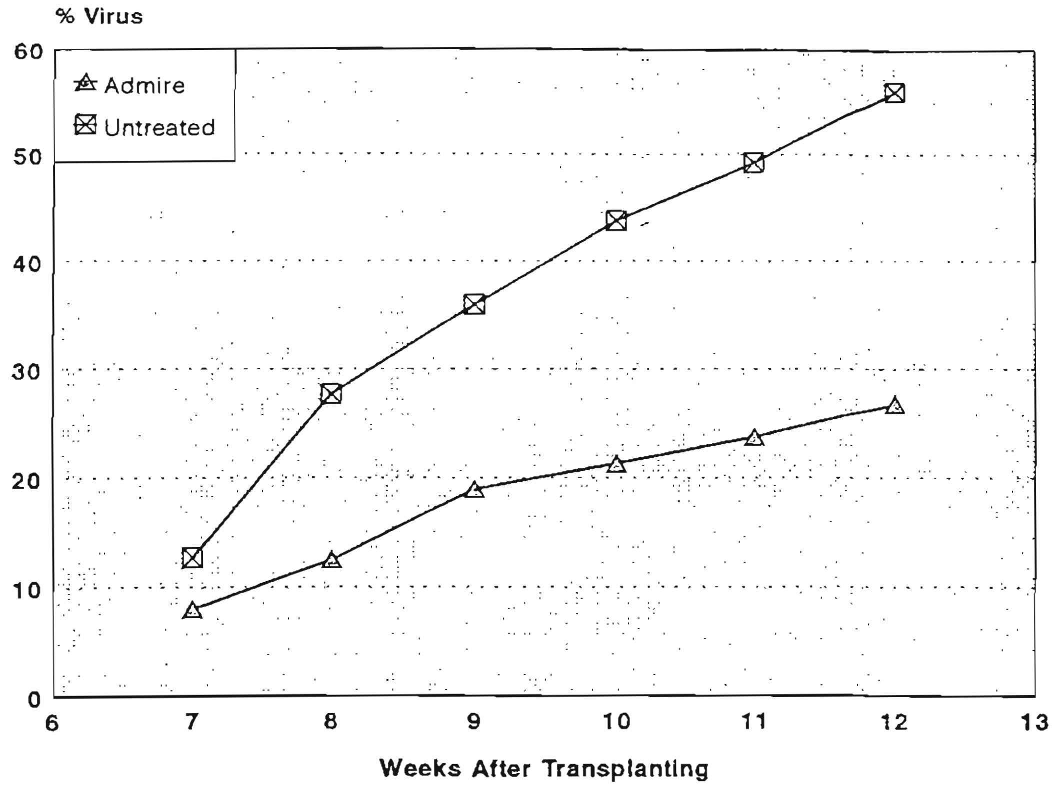

Figure 11: Plot #1 Occurrence of Tomato Mottle Virus

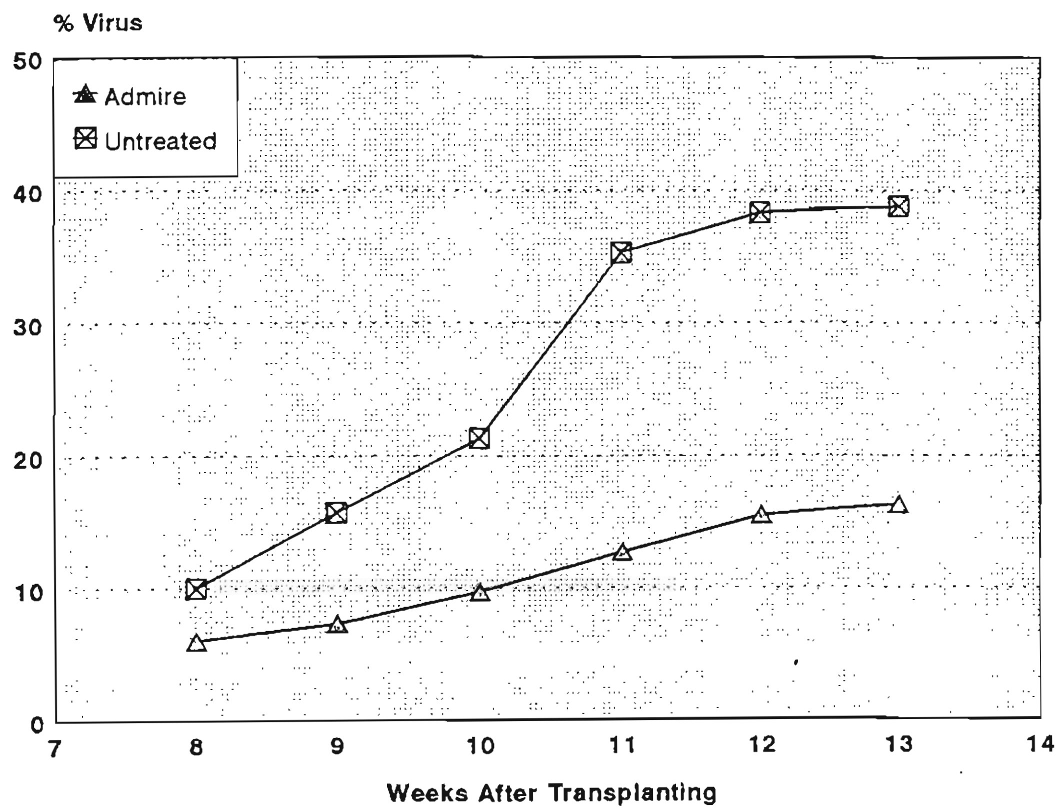

Figure 12: Plot #2 Occurrence of Tomato Mottle Virus

POTASSIUM SOURCE AND RATE FOR POLYETHYLENE-MULCHED TOMATOES

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S.M. Olson, North Fla. REC, Quincy
R.C. Hochmuth, Suwannee Valley AREC, Live Oak
A.A. Csizinszky, Gulf Coast REC, Bradenton
and K.D. Shuler, Palm Beach County Coop. Ext. Serv., West Palm Beach

Tomato is the most valuable vegetable grown in Florida. During 1992-93, the crop was grown on 48,400 acres and had an on-farm value of $626 million. Most tomato production is on sandy soils that are irrigated with subsurface (seepage) irrigation and, more recently, some with drip-irrigation. These soils are typically low in N and K. Current IFAS N and K recommendations for tomato production on soils testing low in K are 160 lb/acre N and 160 lb/acre K_2O. Although these recommendations are based on years of research (Everett, 1976; Persaud, et al., 1976; Csizinszky, 1985 and Hochmuth, et al., 1991), most tomato growers apply larger amounts of N and K fertilizer (200 to 600 lb/acre) in an effort to reduce risks associated with leaching. Grower concern for producing high yields of high quality fruit has often resulted in use of excessive rates of K that many in fact reduce fruit yield.

Little information can be found on the effects of K source on tomato nutrition. In a study by Locascio, et al. (1982), yields of drip irrigated tomato were similar with NH_4NO_3 and KCl as with KNO_3 and $Ca(NO_3)_2$ as N and K sources. However, in areas where soil soluble salts are high, potassium sulfate and potassium nitrate are commonly used for all or part of the K applied as the salt indices of these K sources are lower than for potassium chloride. A recent cost of these K sources in bulk for one pound of K_2O from KCl was 15.4¢, from K_2SO_4 was 28.5¢, and from KNO_3 was 33.8¢ with N calculated at 35¢/lb as NH_4NO_3. Studies were conducted in five locations in Florida to evaluate the effects of K source and rate on tomato production on sandy soils using varying fertilizer placement and irrigation practices.

Materials and Methods

Studies were conducted in Quincy on an Orangeburg fine sandy loam soil during the spring of 1986, 1990, and 1991; in Gainesville on an Arrendondo fine sand (spring 1986); in Live

Oak on a Lakeland fine sand (spring 1990); in Bradenton on an Eau Gallie fine sand during spring 1991, spring 1992, and fall 1992, and on a Mayakka fine sand in Palm Beach in winter 1990-91. 'Sunny' tomatoes were grown in all studies. Treatments in the 1986 studies at Quincy and Gainesville were a 2x2 factorial with 2 K sources, KCl and K_2SO_4, and 2 K_2O rates of 216 and 434 lb/acre. In the later studies, treatments were a 3x5 factorial with 3 K sources and 5 K rates. The K sources were KNO_3, KCl, and K_2SO_4 and the K_2O rates were 80, 160, 240 at Quincy and 96, 190, 290, 380 lb/acre at Live Oak and Bradenton. In addition, a 0 K treatment was included in all studies except at Palm Beach where K_2O rates were 80, 160, 240, 320, and 400 lb/acre and K was supplied as one-half each K_2SO_4 and KNO_3. Treatments were applied in a randomized block design with 4 replications. Preplant soil K data and current IFAS recommendations for K on each soil site are shown in Fig. 2, 4, 6, 8, and 9 for the various locations. Fertilizer was formulated to contain 200 lb/acre N from NH_4NO_3 (remainder for KNO_3 treatments), 40 lb/acre micronutrient mix (F503) and was applied broadcast in the bed with P at all locations except Bradenton and Palm Beach. At Bradenton, P was applied broadcast in the bed and the N and K were applied in 2 bands on the bed shoulders. At Palm Beach, 80 lb/acre K_2O was applied preplant broadcast and the remainder was banded on the bed shoulders. All soils were fumigated with methyl bromide before application of polyethylene mulch. Irrigation was supplied by seepage at Bradenton and in Palm Beach, and by drip at Quincy, Live Oak, and Gainesville. Tomatoes were harvested and graded into marketable sizes of extra large (5x6), large (6x6), and medium (6x7) size fruit.

Results

In the 1986 studies at Gainesville and Quincy, marketable fruit yields were similar with KCl and K_2SO_4 as the K source (Fig. 1). The preplant soil K values were 60 and 50 ppm, respectively, and the K_2O recommendation was 100 lb K_2O/acre. As expected, fruit yields with applications of 216 and 434 lb/acre K_2O were similar at both locations (Fig. 2).

In 1990 and 1991 studies at Quincy, soil test values at the study sites were 37 and 34 ppm K, respectively, and were considered medium. A response for K was predicted for 100 lb and 130 lb/acre K_2O on the two sites, respectively. In both years, marketable fruit yields were not affected by potassium source (Fig. 3) but, yields were significantly increased with K fertilization (Fig. 4). Yields in 1990 were increased from 1890 ctn/acre with 0 K to about 2600 ctn/acre with K application. No significant difference in yield was obtained with K_2O rates from 80 to 320 lb/acre. In 1991, 662 ctn/acre were produced with no K_2O. With an application of K, yield increased with each increase in K_2O from 80 to 160 lb/acre, however, fruit yield was reduced with each increase to 240 and to 320 lb/acre K_2O. These yield responses to 100 to 130 lb/acre K_2O were similar to those predicted by soil test.

Studies conducted at Live Oak during 1990 were conducted on a soil testing medium in K (54 ppm) where the K recommendation was 100 lb K_2O/acre. Fruit yields were similar with the K sources, KNO_3, KCl, and K_2SO_4 (Fig. 5). With no K application, the marketable fruit yield was 1847 ctn/acre and was increased to an average of 2130 ctn/acre with K application (Fig. 6). Most of the yield increase occurred with the application of 190 lb K_2O/acre. Thus, the IFAS recommendation of 100 lb/acre K_2O appeared to be low.

Three studies were conducted at Bradenton on soils testing low in K (Fig. 8). Responses to 130 to 160 lb/acre K_2O were predicted. In two of the three studies, K-source had no effect on marketable yield (Fig. 7) and yields with the three sources varied less than 3% from each other. In the spring 1992 study, however, a significant response to K source was obtained (Fig. 7). Marketable fruit yields were 10% higher with K_2SO_4 than KCl and 9% higher with KNO_3 than K_2SO_4. Differences in yield with KNO_3 and KCl were significant but yield differences between KCl and K_2SO_4 or between K_2SO_4 and KNO_3 were not significant.

In all studies at Bradenton, total marketable yields were significantly increased by the application of K (Fig. 8). With an increase in K rate in 1991, marketable tomato yields increased linearly from 1301 ctn/acre to 1471 ctn/acre with an increase in K_2O rate from 96 to 390 lb/acre. In spring and fall 1992, the yield responses to K rate were also significant but most of the response occurred with the application of 290 lb/acre K_2O.

During the winter of 1990-91, a K rate study with KNO_3 and K_2SO_4 as the K sources was conducted in Palm Beach (Fig. 9) on a soil testing 12 ppm K (very low) where a response to 160 lb/acre K_2O was predicted. Some K_2O along with the N and P fertilizer (80 lb K_2O) was applied preplant broadcast, with the remainder of the K_2O applied in double bands on the bed surface near the bed shoulders. Marketable fruit yields were maximized with K_2O between 240 and 320 lb/acre.

In seven of the eight studies where K source was evaluated, differences in yields were not significant. In one of the eight studies, yields were 10% higher with K_2SO_4 than KCl and 9% higher with KNO_3 than K_2SO_4. Only the 20% difference in yield with KNO_3 and KCl was significant.

In the nine studies where K rate was evaluated, responses were related to K placement and irrigation system used. With all broadcast preplant K fertilization and drip irrigation, maximum yields were produced with 80 to 190 lb/acre K_2O. With the application of K in double bands on the bed shoulder and seep irrigation, maximum yields were obtained between 240 to

320 lb/acre K_2O. These studies indicate that IFAS maximum K_2O recommendation of 160 lb K_2O/acre is slightly low and that K_2O placement might have an effect on K efficiency. With broadcast-incorporated placement, predicted K_2O needs were close to the crop response obtained. With band placement on the bed shoulders, predicted K_2O needs were much lower than the level of response obtained. With shoulder-band placement, much of the K_2O remains on the bed shoulder after the crop is grown, therefore some of this fertilizer should be broadcast to increase use efficiency.

It should be noted, that with a common grower application of 600 lb/acre K_2O from KNO_3, the cost for potassium fertilizer alone would be approximately $200. In contrast, the cost of 200 lb/acre K_2O from KCl would be $30. Thus, the cost of this overfertilization would be $170/acre. If one-half of the acreage were overfertilized in this manner the cost to the tomato industry would be over $4 million per year.

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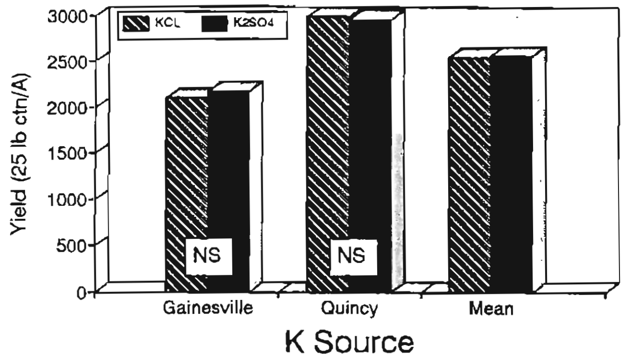

Fig. 1. Effects of K source on tomato yield at Gainesville and Quincy in 1986.

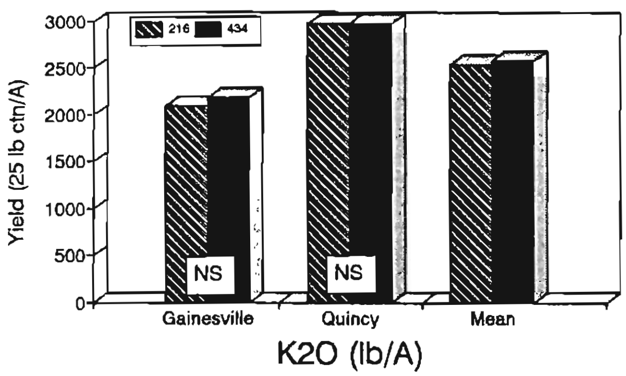

Fig. 2. Effects of K rate on tomato yield at Gainesville and Quincy in 1986 on soils testing 60 ppm and 50 ppm K, respectively IFAS recommendation for K2O was 100 lb/acre.

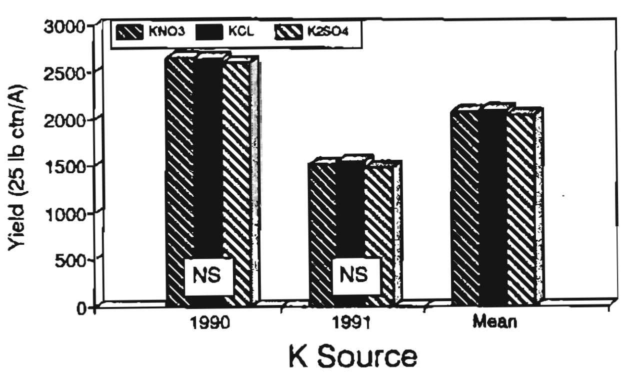

Fig. 3. Effects of K source on tomato yield at Quincy during 1990 and 1991 seasons.

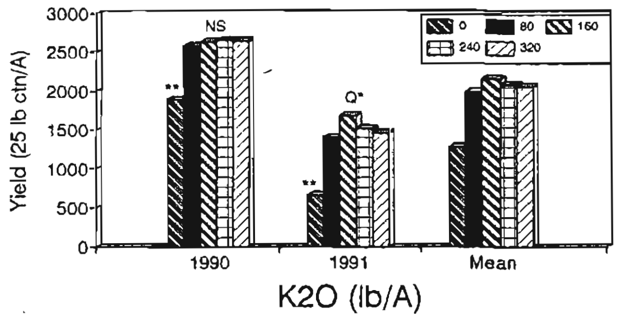

Fig. 4. Effects of K rate on tomato yield at Quincy during 1990 and 1991 on soil testing 37 and 34 ppm K, respectively. IFAS recommendations were 100 and 130 lb/A K2O, respectively

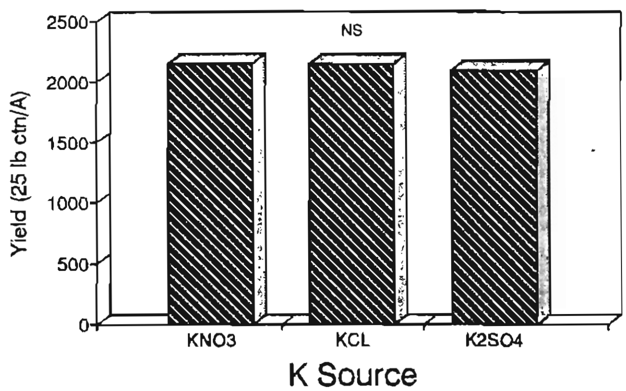

Fig. 5. Effects of K source on tomato yield at Live Oak in 1990..

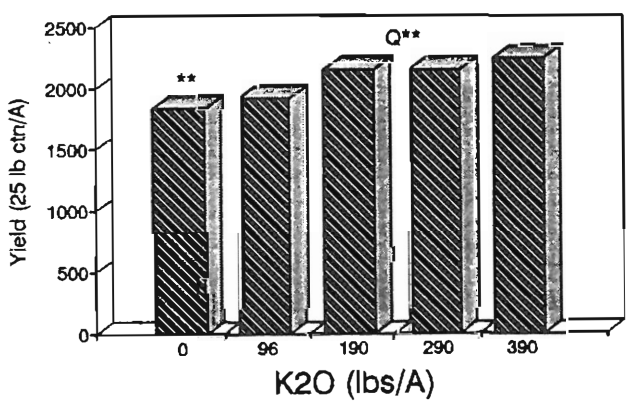

Fig. 6. Effects of K rate on tomato yield at Live Oak in 1990 on a soil testing 54 ppm K. IFAS recommendation for K2O was 100 lb/A.

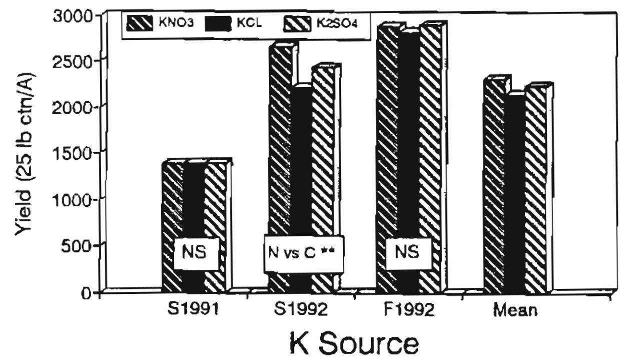

Fig. 7. Effects of K source on tomato yield at Bradenton in Spring 91, Spring and Fall 92.

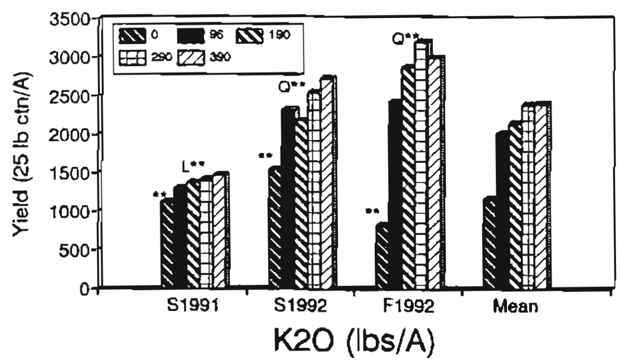

Fig. 8 Effects of K rate on tomato yield at Bradenton in Spring 91, Spring and Fall 92 on soil testing 25, 26 and 15 ppm, respectively. IFAS recommendations for K2O were 130, 130 and 160 lb/A, respectively.

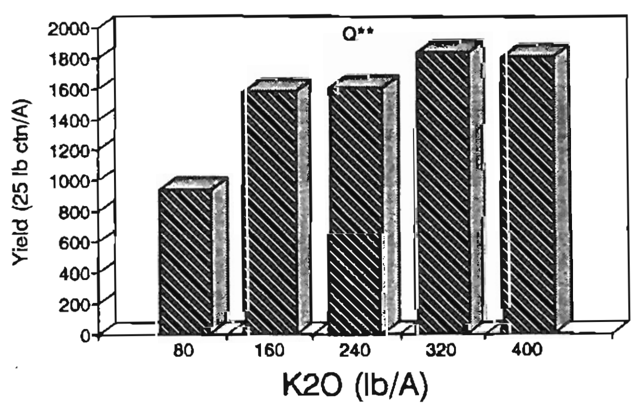

Fig. 9. Effects of K rate on tomato yield at Palm Beach, Winter 1990-91 on a soil testing 12 ppm K. IFAS recommendation was 160 lb/A K2O.

Automatic Transplanting of Florida Tomatoes

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ABSTRACT

There is research and development work going on around the world directed toward the ultimate objective of making the transplanting of plant seedlings fully automatic so that no manual handling is required during the field operation. Modular seedlings are used in all of these systems, and this technology may soon be available to Florida tomato growers.

Several systems will be discussed, including those used for vegetables in California, and in Europe. The performance of these systems in commercial production will be included, along with some observations on what will be required in plant production, handling systems, and engineering.

INTRODUCTION

A person might ask the question of tomato growers, why transplant? I am sure this group knows the various reasons for plant establishment through the setting of seedling plants and I will just briefly review them again for the record.

First of all, we can usually get better germination and emergence of seeds in a greenhouse environment than we can in the field. Consequently, we get a more uniform crop and more plants for the amount of seed used. For crop plants the field season is shorter; subsequently, less irrigation is required and this is important with the competition for water that we are seeing. Plant diseases can be better controlled because seeds are planted in sterile growing media and they can germinate and emerge without suffering from soil born organisms.

Another question that might be asked is what is a transplant? For this discussion we are talking about small seedling plants that are produced in cells in a growing tray or in a plant bed and are later transferred to a field. Most of our discussion is going to be about the modular transplants which are used to start tomatoes. These are seedlings with root balls growing in a media made up of peat, vermiculite or other materials. Traditionally, transplants are thought of as the small seedling plants that are pulled from plant production beds and these are now commonly referred to as bare-root seedlings. The bare root seedlings are for most crops being replaced by the more expensive but better quality modular transplants. The modular transplants are gaining in popularity because there is less transplanting shock and cr(uniformity is frequently better than with the bare-ro(transplants. Modular transplants lend themselves t mechanized or automatic transplanting where no manual handlir of the plants is necessary except for loading trays of plant into transplanting machines.

A question that I have been asked is, "Why do you want t work on automatic transplanting machines, surely there must b many in use now?" The fact is that there have not been man developed and few that will work for our Florida tomat growers. It is surprising to some people to realize tha transplant seedlings are set in the ground one at a time b hand in the same way that they were set 40 or even 60 year: ago.

I feel we should be looking at ways of automating plan setting because it is a very tedious job and one that we migh not always have the available labor to do. It is estimatec that there are over five billion vegetable seedlings transplanted annually in North America and well over a billior seedlings set annually in Florida.

AUTOMATIC TRANSPLANTING SYSTEMS TODAY

Many different plant setting concepts have been tried but at the present time, there are only 2 or 3 fully automatic transplanting systems in use around the world. There are several systems that can be considered semiautomatic that do require some hand feeding or other manual assistance in their operation. Probably the first work on automatic transplanting started in the Netherlands (6) where some researchers developed a peat block transplanter that cut squares of compressed peat containing seedling plants and transferred them to the ground. Unfortunately, the system was not successful because the peat blocks were not dimensionally stable and the separated blocks frequently did not contain seedling plants.

Several automatic transplanters for planting bare-root rice plants are available in the Orient (1). These utilize mechanical fingers that grab plants from a growing mat of seedlings and set them into puddled soil. One or several plants are planted in each bunch. This type of transplanting system probably could not be easily adapted to vegetable production since it is difficult to handle single plants.

A fully automatic transplanting machine has been in use in lettuce and celery in California (2) which utilizes a bottomless plant cell tray that makes possible automatic setting of the plants by pushing them through the bottom of the tray into the soil. The seeds are placed off-center in each cell so that the seedlings develop off-center and are not damaged by the plungers that remove them from the cells. The capacity of an 8-row version of this transplanting machine is reported to be 33,000 plants per hour. This machine cannot plant through plastic so it is not suitable for establishing tomatoes in Florida.

Another fully automatic transplanter that employs mechanical fingers to carry celery and cauliflower seedlings from a tray down to a furrow is being used in California (4) but this machine is also not adaptable for use with plastic mulch.

Two recently developed automatic transplanters handle individual seedlings on pins that penetrate the root ball. The first of these receives horizontal plants as they are pushed from a vertical tray (7) and individually turns them upright before dropping them into a furrow. The second machine that is similar in design has the pins on a belt that carry the seedlings to a mechanical gripper (5) that pulls the plants from the belt before dropping them into a mechanical dibbler. This second machine can be equipped with a hole burner so it is suitable for use on plastic mulch. Development of this latter machine is continuing.

Several other automatic transplanting machines are under development including one that utilizes individual plant cells (3). This machine uses a bucket wheel plant setting mechanism so it should be suitable for plastic mulch culture. Another machine called the "spatial transplanter" because of its unique plant setting mechanism (10) is under development. This machine has transplanted tomato seedlings of over two per second and is capable of transplanting through plastic mulch.

REQUIREMENTS OF AN AUTOMATIC TRANSPLANTER FOR FLORIDA

Not all of the automatic transplanters now available will work on plastic mulch covered growing beds so they are really unsuitable for Florida tomato production. The wide use of plastic mulch probably will require the use of some type of bucket wheel or Ferris wheel type plant placement mechanism that will set the seedlings through the mulch. Holes in the plastic mulch probably need to be made with a hole burner.

The difficult problem of removing plants from a seedling tray or from a belt has not been completely solved. Studies at the University of Florida have shown that there are problems with the techniques of pushing (8) or blowing (9) modular seedlings out of growing trays. Frequently plant root balls become impaled on the pushing pins and plants fly random distances when they are blown from the cells. Tray cells will have to have large drain holes if mechanical plungers are used to push the seedlings out. Florida growers may have to use trays with very smooth and hard surfaces so that the seedlings can be easily removed from the cells. Some minor dimensional changes may have to be made to the trays to make mechanical handling easier. Probably only trays with rectangular arrangements can be easily automated.

Trays must be inspected for missing plants and replacements made in the greenhouse. This task must be done before the plants leave the greenhouse because there isn't as much time and it is more difficult to accomplish this task on a moving machine. It is anticipated that plants will have to be handled at a rate of about 3 per second in an automatic transplanting machine to be practical. Replacing blanks in the trays can be carried on in the greenhouse over an extended period of time and very possibly automatically with a robot. Greenhouse inspection and handling of plants is a good candidate for the utilization of robots in agriculture.

DISCUSSION

There is considerable interest in automatic transplanting around the world and Florida growers need to be aware of this activity. If economical systems can be developed, the benefits of this method of plant establishment may be extended to tomato production.

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Evaluating the Impact of Transplanting Depth on Tomato Yield

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Abstract. 'All Star' tomato transplants planted to the cotyledon leaves, or to the first true leaf showed greater yields than transplants planted to the top of the rootball. Average fruit weight and extra-large grade fruit were also increased by deeper planting. These data suggest that planting tomato transplants deeper is commercially beneficial in Florida.

Introduction

Information on the effects of planting depth on growth is readily available for fruit trees (Lyons et al., 1983; Rogers and Parry, 1968), seed (Mack et al., 1984; Wilson et al., 1990; Redman and Qi, 1992), and various plant organs (Lindgren, 1990; Han et al., 1991); however, little information exists on vegetable transplant planting depth. Watson (1865) indicated "it is the general rule to set the plants of cabbages (*Brassica oleracea*), peppers, and other plants that form a stem one to two inches deeper than they have previously stood." Planting bare rooted tomato transplants "slightly deeper" than their plant bed depth was a tradition in the early 1900s (Tracy, 1908; Work, 1945). More recently, research on cabbage transplant depth was conducted by Miller et al. (1969) who found larger yields with deeper transplanting, but inconsistent head size. Kwapata (1991) noted that in tomato (*Lycopersicon esculentum*) yields could be increased by plastic mulch, but mulch depths exceeding 10 cm did not further increase yields over shallower mulch depths. Vavrina et al. (1994) have shown bell pepper (*Capsicum annuum)* yields can be increased by deeper transplanting in Florida. Whether planting depths are intentional or a result of soil tillage, more information on the consequences of different planting depths is needed. This study was designed to analyze the effect of transplanting depth on tomato yield under subsurface seepage irrigation and polyethylene mulch culture in SW Florida.

Materials and Methods

'All Star' (Petoseed, Saticoy, CA) tomato transplants were grown in Vegetable Plug Mix (Terra/Asgrow, Montgomery, AL) in 26-cm^3 inverted pyramid containerized cells (Todd™, Plant City, FL) under natural light and temperature regimes for fall production.

Plants were transplanted on 30 Sept. 1993 in Immokalee, FL either to the top of the rootball, to the cotyledon leaves, or to the first true leaf. Anatomical designations were used as a planting depth determinant rather than measured distances above the rootball.

Plants in Immokalee (Immokalee fine sand - sandy, silicaceous, hyperthermic, Arenic Haplaquod) were transplanted into raised beds on 1.8 m centers, one row to the bed, with 18 inches between plants. The Immokalee crop received (lbs/A): 200 N, 250 K, and 75 P and micronutrients by soil test. Sixty lbs/A of N and K, and all the P plus micronutrients were broadcast, then bedded over to a depth of 4 to 6 inches. The remaining N and K were applied in two narrow bands on top of the bed, 8 inches to either side of the bed crown, while simultaneously fumigating with 350 lbs/A 98% methyl bromide: 2% chloropicrin and shaping the final bed. The beds were then covered with 1 mil white polyethylene mulch.

Yield by harvest included weight and number of fruit. Average individual fruit weight and size grades were also determined at each harvest. Harvest dates were 20, 28 Dec. 1993, and 11, Jan. 1994. Planting depths were replicated six times and ANOVA analysis was performed to test for yield differences among the depths. All mean comparisons were identified by Fisher's LSD.

Results and Discussion

Tomato yield (mature green) increased with increasing planting depth at first and third harvest, and in combined harvest total yield (Table 1). A 26% increase in 25 lb boxes of fruit was realized at first harvest by planting transplants to the first true leaf when compared to just covering the rootball. With all harvests combined, plants transplanted to the first true leaf showed an 18% increase in total yield. Tomato transplants planted to the cotyledon leaf produced yields intermediate to the rootball and true leaf plantings.

When breaker and red fruit were included in the yield totals a similar pattern emerged (Table 2). Planting tomato transplants to the first true leaf resulted in significantly more 25 lb boxes of fruit at first harvest and in combined harvest total yield when compared to the transplant technique of just covering the rootball. Planting transplants to the cotyledon leaves also resulted in larger yields than rootball depth planting but only in total yield. The number of boxes of extra-large fruit was increased at first harvest by deeper planting (Table 3). Extra-large fruit production was greater for deeper plantings at third harvest and in combined harvest total yield but was not sufficiently great to result in significant yield increases. The volume of extra-large fruit when expressed as a percentage of the total yield of fruit at either first or combined harvest was similar across all treatments (79 - 81% at first harvest, 72 - 75% from combined harvests).

Average fruit weight, was not affected by planting depth at any particular harvest, however proved to be significantly greater when considered over all harvests (Table 4). Practically speaking however, an increase in 0.2 of an ounce per fruit may not be of commercial value.

Greater yields from deeper transplant depth seen in the fall in SW Florida may be the result of improved temperature conditions for root growth. Deeper plantings may place tomato roots in a cooler environment with fewer radical temperature swings. White (1937) showed the optimum temperature for good root growth is 68-91F. Root growth slows in temperatures of 95-104F and practically ceases at temperatures greater than 104F. This factor could be of considerable importance in late summer and early fall plantings grown under plastic mulch where soil temperatures often exceed 100F (Vavrina, 1994). Other explanations for increased yields with deeper planting may include earlier fertilizer and water acquisition, and reduced transplant shock from wind displacement. Additional roots sprouted along the main stem of the tomato may be of some importance.

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Table 1. Tomato Planting Depth Effect on Mature Green Fruit.

Depth	Harvest First	Second	Third	Total
		---------------- 25 lb boxes/A ----------------		
First True Leaf	679 a	336 a	888 a	1903 a
Cotyledon	603 ab	350 a	779 ab	1731 ab
Rootball	503 b	358 a	701 b	1562 b

Table 2. Tomato Planting Depth Effect on Breaker, Red Fruit and Mature Green Fruit Combined.

Depth	Harvest First	Second	Third	Total
		---------------- 25 lb boxes/A ----------------		
First True Leaf	679 a	342 a	1041 a	2062 a
Cotyledon	611 ab	361 a	996 a	1969 a
Rootball	510 b	358 a	873 a	1741 b

Table 3. Tomato Planting Depth Effect on Extra-Large Fruit.

Depth	Harvest First	Second	Third	Total
		---------------- 25 lb boxes/A ----------------		
First True Leaf	534 a	214 a	630 a	1378 a
Cotyledon	483 ab	237 a	559 a	1279 a
Rootball	408 b	247 a	511 a	1166 a

Table 4. Tomato Planting Depth Effect on Average Fruit Weight.

Depth	Harvest First	Second	Third	Total
		----------------oz./fruit----------------		
First True Leaf	6.94 a	6.16 a	5.78 a	6.16 ab
Cotyledon	6.97 a	6.86 a	5.82 a	6.30 a
Rootball	6.96 a	6.12 a	5.71 a	6.11 b

The Early History of the Tomato in Florida

by Andrew F. Smith

The cherry-fruited tomato plant originated in the coastal highlands of what is today northern Chile, Peru, Ecuador and Columbia. Mayan and other Mesoamerican peoples domesticated the plant and used its fruit in their cookery. They also nurtured a large, lumpy mutation of the fruit.[1] The Aztecs readily adopted the plant and called it the *xitomatl*, because of its perceived similarity to the *tomatl* (Physalis ixocarpa, or husk tomato), a plant thought to have originated in Mexico.[2]

The Spanish first came into contact with the *xitomatl* after their conquest of Mexico in 1519. They confused the *tomatl* and the *xitomatl*, although the two plants are only remotely related botanically. In Spanish, the *xitomatl* eventually became the main referent of the Spanish term *tomate*. As a general practice, the Spanish distributed desirable fruits and vegetables throughout their empire. The Spanish introduced the *tomate* into the Caribbean, Philippines and Europe, where they grew easily in the Mediterranean climate of Spain and Italy. They were used for culinary purposes in Italy as early as the 1540s, where they were called *pomidoro*, or golden apples, and later *pomo amoris*, or love apples.[3] When the tomato arrived in what is today the United States has been a topic of discussion since the early nineteenth century.

American pop-historians frequently report that our forebears eschewed tomatoes, considering them simultaneously poisonous and aphrodisiacs. Historical gardeners claim that tomatoes were not grown in their region until the 1840s or even later. Agricultural historians proclaim that they did not become a field crop until decades after the Civil War. Culinary historians profess that Americans did not devour them until the mid-nineteenth century. They also report that tomato growing in Florida did not begin until the end of the nineteenth century.

In 1987, a study was launched to explore these myths and examine the tomato's history in America. To date, over thirty thousand references to the tomato have been uncovered that were published or written in America prior to the twentieth century. Of these references many relate to the history of the tomato in Florida. The preliminary findings based upon this data contradict widely held assumptions about the tomato's early history in America and in Florida. For instance, the tomato was introduced into America before the end of the seventeenth century. By the end of the eighteenth century Americans ate tomatoes in every region of the nation, although the it was a relatively unimportant garden product. There is no evidence that anyone in America ever considered the tomato an aphrodisiac. With regard to the tomato in Florida, almost all of the widely held assumptions are also contradicted, but its real history is even more bizarre and inherently interesting that the frequently repeated myths.

First, the tomato has been grown in Florida since the mid eighteenth century, and was probably introduced at a much earlier date. The archaeobotanist Dr. C. Margaret Scarry from the Kentucky Anthropological Research Facility in Lexington reported in 1991 that tomato seeds had been recovered at an excavation of the Spanish Fort Matanzas near St. Augustine, Florida. The level at which the seeds were found corresponded to the construction period of the fort (1740-2), indicating that laborers ate tomatoes while working on the fort. When John Bartram, the preeminent natural scientist in colonial America, visited English-controlled St. Augustine in 1765 he found the "tomatis" plant growing.[4] Along Florida's Gulf coast, tomatoes were used for culinary purposes during the 1780s and 1790s, and were the most common vegetable grown in gardens by the 1820s.[5] It is probable that tomato cultivation began in Florida in and around Spanish settlements shortly after their establishment. Despite its success in Florida, and other southern states, the tomato was but a very minor garden vegetable in northern and mid-western states during the early nineteenth century.

Second, a dramatic shift in tomato usage occurred during the late 1830s and early 1840s in America, and to a lesser *extent in Florida, mainly as a result of activities of the medical profession*. On August 20, 1835, St. Augustine's *Florida Herald* declared that tomatoes were the most healthy vegetable, and ingesting them successfully treated diarrhoea, violent bilious attacks, dyspepsia and cholera, a disease which ravaged many American cities during this time. These claims were published for decades across America. In Florida, they were reprinted by the *Florida Agriculturist* as late as 1874.[6] The immediate effect of these claims was the introduction of "tomato pills." In Pensacola J. O. Smith reported that these pills were a new and invaluable medicine for all diseases arising from impurities of the blood, morbid secretions of the liver and stomach, fevers, bilious affections and almost every other disease known to mankind.[7] These claims for the healthful qualities of tomatoes and the subsequent claims of tomato pill manufacturers were particularly influential in the northern and midwestern states where tomato consumption was limited. By the late 1840s tomatoes were cultivated and consumed from Maine to California, and from Oregon to Florida. In Florida truck farming of tomatoes for local use began as early as the 1840s. In 1845, the *Florida Herald* proclaimed that "He that does not love tomatoes [was] an object of pity."[8] During the 1840s and 1850s, truck farming began in southern states to meet this growing northern need. Prior to the Civil War, tomatoes were grown in Norfolk, Virginia, and in Charleston, South Carolina, and were shipped to northern cities as far north as Boston.

Third, increased consumption and demand for tomatoes in northern states resulted from the Civil War, and was a major factor for initiating tomato truck farming in Florida. Wars tend to produced unintended consequences. One unintended consequence of the Civil War was the dramatic increase in tomato cultivation and consumption. To feed the large Union armies, large numbers of contracts were let to canning factories, which mainly employed female workers. Tomatoes had been first canned commercially during the 1840s. However, the canning industry was still in its infancy when the Civil War broke out. These contracts greatly improved the canning industry in New Jersey, Pennsylvania, Ohio and Maryland. Costs for canning tomato products decreased appreciably, just as technological advancements improved the industry, and canned goods became affordable to all but the very poor. Union soldiers became fond of tomatoes during the war, and demand for them soared when the war ended. Obviously, fresh tomatoes were even better than canned tomatoes, but the growing season in the north was limited to a few months during the summer. As Florida was comparatively less affected by the ravages of the war than other southern states, shortly after the end of the war, fresh tomatoes were grown for shipment northward. For instance, on June 12, 1867, the *Farmer's Register* announced that tomatoes had been shipped northward from Florida about a month previously.[9] By 1870, C. P. Perry and P. F. Wilson, who cultivated small gardens and truck crops in the Arredondo section of Alachua County, also grew tomatoes for export. Two years later, S. J. Crown, Sr. came to Florida with Mr. Burr and located at Palmer, where they grew 20 acres of tomatoes. According to George Weber, Arredondo was first commercial tomato-growing section of the state. Within twelve years Florida tomatoes were sold on the Chicago market for about $4.25 per bushel crate. By 1883, tomatoes were grown as far south as the Florida Keys and were transhipped from Key West weeks before local tomatoes ripened in northern states. By 1885, Florida tomatoes were quoted in New York and Philadelphia markets.[10]

Fourth, in order for the tomato industry in Florida to grow, foreign competition needed to be eliminated. While Florida growers could produce tomatoes weeks earlier than growers in other southern states due to better climatic conditions, they could not easily compete with growers in Bermuda, the Bahamas and the Caribbean. Export of tomatoes from these islands to northern cities had begun during the Civil War when southern tomato areas had become inaccessible due to the blockade. This trade thrived during the 1860s and 1870s. In 1874 alone, 85,000 crates were shipped from Bermuda to New York city.[11] This trade was so lucrative that it paid the exporter to incur the costs of production plus transportation costs and an extremely high rate of spoilage due to the fact that steamers came once a week, and often stopped in other cities before their arrival at their final destination. Tomatoes grown in these islands were priced from $.75 to $1 less per bushel crate than similar produce from Florida. The Tariff Act of 1883, which levied a ten percent duty on imported vegetables, effectively eliminated all foreign competition for Florida tomato growers. The consequences of this were felt immediately. Two years after its passage, J. N. Whitner, author of *Gardening in Florida*, announced that tomatoes occupied "the front rank of early vegetables grown in Florida for Northern and Western Markets." Early shipments brought "fancy prices," and growers frequently realized $6 to $10 per bushel. This more than compensated for the initial capital needed to grow tomatoes.[12]

Fifth, Florida growers needed to overcome numerous problems related to seed selection, insect infestation, diseases and cultivation procedures. In the main Florida growers initially used seeds imported from northern seedsmen. Obviously, northern seeds were not the best for the climatic and soil conditions in Florida. Florida's growers dependence upon tomato seeds developed in northern states did not change until the creation of the Agricultural Experiment Station at the University of Florida, where various tomato seeds were tested systematically and improvements encouraged beginning in the 1890s. New varieties were developed for conditions in Florida greatly increased the yield of tomato harvests. Florida growers also confronted serious problems with soil conditions and with infestations of insects and diseases that were not as common in other tomato growing areas in America. The solution to these problems also awaited the efforts of the Florida Agricultural Experiment Station during the 1890s.[13]

Fifth, climatic conditions contributed to the expansion of the shift of tomato industry in Florida. By far the greatest agricultural product exported from Florida was citrus. However, it takes several years for the trees to bear fruit commercially. While most citrus growers were well funded mainly by northern interests, others needed to survive during the time that it took the citrus trees to bear fruit. Many grew tomatoes and other vegetables as supplementary crops. Likewise, when freezes destroyed citrus trees, growers often had to rely upon tomato and other vegetables to make ends meet while their orchards grew back. As freezes were regular occurrences in central and northern parts of Florida from 1880 to 1900, tomato production expanded in citrus areas during this time.[14] In addition, it meant that as soon as growers could move south of the "frost" line they did so.

Seventh, the construction of the railroads accelerated the shift of the tomato growing areas from the north-central *part of the state to the southern part*. Tomatoes were shipped north from Arredondo by 1880, and probably well before.[15] Other growers shipped tomatoes by wagon to ports on rivers or on the coast, and then steamers transshipped them to rail heads.[16] Despite this complicated system of transportation growers still made a good return on their investment. The down side was that tomato growing could only occur relatively close to railroads, navigable rivers or other accessible water ways. As the railroads expanded southward, so did tomato growing.[17] Before the railroad was completed to Miami, a relative small tomato cultivation occurred on Key Biscayne and a few other coastal areas. After the railroad was completed in 1896, Dade County became the major producer of tomatoes in Florida. By the beginning of the twentieth century the tomato had been crowned "King" in Dade County.[18]

IMPLICATIONS

Today, Florida tomato growers are confronted with a series of potential difficulties. The North American Free Trade Association (NAFTA) will likely mean stiffer competition from growers in Mexico, who have easy access to cheaper labor, and who do not have the same regulations confronting growers in Florida. Likewise, on the horizon are potential competition from tomato growers in other states who might use some of the genetically engineered tomatoes to grow fresh tomatoes later and earlier than they are currently able to do. In the past, tomato growers in Florida faced enormous difficulties before their dramatic successes during the twentieth century. Growers overcame these challenges with creativity and hard work. If the early history of the tomato in Florida is a guide to its future, it is likely that Florida tomato growers will confront and overcome new problems as well.

End Notes

1. Today's smooth skinned varieties are crosses between the smooth skinned cherry tomato and the large lumpy mutation.

2. Robert L. Dressler, *Botanical Museum Leaflets, Harvard University No. 6*, 16 (December 1953): 137; J. N. Rose, "Notes of Useful Plants of Mexico," *Contributions to the U.S. National Herbarium* (Washington, DC: 1899), vol. 5, p. 210; J. A. Jenkins, "The Origin of the Cultivated Tomato," *Economic Botany*, 2 (October-December 1948): 379-92.

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4. C. Margaret Scarry, "Plant Remains from Fort Matanzas," unpublished paper, dated February 1991; John Bartram, "Diary of the Journey through the Carolinas, Georgia and Florida from July 1765 to April 10, 1766," annotated by Francis Harper, *Transactions of the American Philosophical Society*, NS, Part 1, 33 (1942): 53.

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6. *Florida Herald*, August 20, 1835; *Florida Agriculturist*, 1 (May 9, 1874): 151.

7. *Pensacola Gazette*, December 1, 1838-February 16, 1839; *Pensacola Gazette*, August 1, 1839-March 28, 1840; *Pensacola Gazette*, April 4, 1840-March 27, 1841.

8. *Florida Herald*, September 2, 1845.

9. *Farmer's Register*, June 12, 1867, as in the *Rural New Yorker*, 18 (August 8, 1867): 247.

10. George F. Weber, "A Brief History of Tomato Production in Florida," *Proceedings of the Florida Academy of Sciences*, 4 (1940): 167-74; *Florida Agriculturist*, NS8 (June 24, 1885): 52; *Florida Agriculturist*, NS5 (January 31, 1883): 332.

11. *Florida Agriculturist*, 1 (June 6, 1874): 183.

12. J. N. Whitner, *Gardening in Florida, A Treatise on the Vegetables and Tropical Products* (Jacksonville, Florida: C. W. DaCosta, 1885), 125.

13. Some of their publications about tomatoes include: P. H. Rolfs, "Grasses, Forage Plants, Tomato Blight," *Florida Agricultural Experiment Station Bulletin*, 18 (1892): 10; P. H. Rolfs, "The Tomato and Some of its Diseases," *Florida Agricultural Experiment Station Bulletin*, 21 (1893): 1-38; P. H. Rolfs, "Some Market Vegetables for Florida," *Florida Agricultural Experiment Station Bulletin*, 31 (1898): 188-99; P. H. Rolfs, "Diseases of the Tomato," *Florida Agricultural Experiment Station Bulletin*, 47 (1898): 115-52.

14. See the *Report of the Commissioner of Agriculture of the State of Florida* from 1889 to 1901.

15. *Florida Agriculturist*, NS2 (April 28, 1880): 396.

16. George F. Weber, "A Brief History of Tomato Production in Florida," *Proceedings of the Florida Academy of Sciences*, 4 (1940): 167.

17. *Florida Agriculturist*, 18 (December 16, 1891): 689; Sara Crim, "The Story of Lauderdale," *Ft. Lauderdale Daily News*, October 20, 1940.

18. *Florida East Coast Homeseeker*, 7 (August 1905): 6-8.

THE CALIFORNIA PERSPECTIVE ON THE ESL TOMATO

FRED L. WILLIAMSON (PRESIDENT - ANDREW & WILLIAMSON SALES CO., INC.)

EXTENDED SHELF LIFE V.R. TOMATOES FROM A GROWER/SHIPPER POINT OF VIEW

GROWERS' POINTS

1. WARM WEATHER A MUST
2. SOME ARE VERY SENSITIVE TO DISEASES
3. YIELDS ARE LOWER
   - a) Fruit load
   - b) X-fancy pack reduces yield
   - c) Smaller size on top
4. SLOWER TO RIPEN
5. MUST HARVEST 2 COLOR OR HIGHER
6. SAME PROBLEMS AS ANY TOMATO
   - a.) Cracks
   - b) Sunburn
   - c) Cold set, etc.
7. NOT UTOPIAN TOMATO

SHIPPERS' / RECEIVERS' POINTS

1. 5 - COLOR ON ARRIVAL A PROBLEM WITH SOME RECEIVERS
2. EXPECTIONS OF QUALITY IS HIGHER
3. SLOW TO TURN COLOR AT DESTINATION
4. SOME STANDARD VARIETIES AS GOOD (LAW SUIT EXAMPLE)
5. WANT 4X4 - 4X5, FEW 5X5's NO 5X6's

Q & A's

POTATO LATE BLIGHT EPIDEMICS OF 1993 AND 1994...SHORT TERM PROBLEM OR LONG TERM CONSTRAINT ON PRODUCTION

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In September, 1995, a major conference is being held in Ireland to commemorate the 150th anniversary of the great Irish Potato Famine. The Irish Potato Famine followed devastation of the Irish potato crop by *Phytophthora infestans*, the cause of potato late blight. The science of plant pathology as we know it today, evolved from early studies of this important disease. It is ironic that the 150th anniversary of late blight in Ireland coincides with changes in the world and north American populations of *P. infestans* which may be second in importance only to the initial introduction of late blight into north America and Europe in the 1840's. The present changes involve migration of new "strains" of *P. infestans* from Mexico into European, North American, and other potato and tomato production systems (2,3). In this report I will briefly discuss these changes and summarize the status of late blight in Florida potatoes and tomatoes and conclude with a prognosis of future constraints for managing late blight in these crops.

Background

Mating types. The fungus *P. infestans* belongs to a group of fungi called oomycetes and which includes the downy mildew pathogens. Many oomycetes typically have both sexual and asexual stages within their life cycles. Although many can complete their life cycle by mating with themselves (i.e. homothallic types), others including *P. infestans*, require two different mating types (i.e. heterothallic types). The two mating types of *P. infestans* are designated A1 and A2. Sexual reproduction of durable oospores can occur only if the A1 and A2 mating types come in contact. The oospores of *P. infestans* are believed to be the overseasoning or survival propagules of the fungus. Until the early 1980's the only region known to have both the A1 and A2 mating types was the central highlands of Mexico where the late blight fungus is believed to have originated. (2).

During the early 1980's the A2 mating type was discovered in Europe, thus opening the possibility for sexual reproduction of *P. infestans* outside of Mexico. Canadian and U.S. interest in late blight was accelerated with the report in 1991 of A2's in North America (1,2).

There are two important aspects of sexual reproduction and production of oospores relative to managing late blight. First, sexual reproduction of the fungus could result in rapid development of new strains which may place constraints on breeding for resistance and/or in creation of more aggressive strains. Secondly, persistence of the late blight pathogen from season to season has here to fore been dependent upon survival in infected host tissues such as potato tubers. The production of oospores could enable *P. infestans* to overseason thus eliminating the need for survival in infected plant tissues. During the past four years both A1 and A2 mating types have been found in north American populations of *P. infestans*. Both were found in Florida in 1993.

Metalaxyl insensitivity -- Metalaxyl (Ridomil®) is an oomycete specific, systemic fungicide which has been highly effective in controlling late blight. Extensive use of metalaxyl coupled with generally unfavorable weather conditions for late blight development in most north American potato producing regions helped to reduce late blight to negligible levels during the late 1980's and early 1990's. Even when late blight occurred in Florida potatoes during this period, timely applications of metalaxyl quickly eliminated the problem. Unfortunately, introduction of the A2 mating type into N. America has been coincident with development of metalaxyl insensitivity in populations of the pathogen. It is important to note, however, that mating type and insensitivity to metalaxyl are not coupled. Both mating types can be either sensitive or insensitive to the fungicide. It is coincidental that most of the A2 mating types introduced into North america are also insensitive to metalaxyl.

Genotypes -- Modern biochemical methods such as DNA fingerprinting and isozyme analysis provide useful tools to further characterize "strains" or genotypes of *P. infestans*. Using such methods, Goodwin et al (3) have identified a number of genotypes which they have named US-1, US-2, etc. Genotype identification is essential to reliably trace movement of *P. infestans* strains. It is also useful in devising management strategies for controlling late blight. The traditional strain or genotype of *P. infestans* in N. America was classified as US-1 by Goodwin, Fry et al (3). The US-1 genotype is typically sensitive to metalaxyl and is the A1 mating type. As of July, 1994 it is still the predominant mating type in Wisconsin, Minnesota, and North Dakota.

Pathogenicity -- The relative aggressiveness of *P. infestans* strains most likely varies both on the same host (i.e. potato or tomato) as well as between hosts (potato vs tomato). For example US-7, the predominate genotype in Florida during 1993 is more aggressive on tomato than potato. Conversely, US-8, apparently the most common genotype in Florida during 1994, produces severe losses on potato and is a minor pathogen of tomato. Both US-7 and US-8 are A2 mating type and are metalaxyl insensitive. It is also important to note that physiologic races of *P. infestans* exist within the new genotypes, although there seems to be more and a greater complexity of races.

In summary, because of the existence of new "strains" of *P. infestans* it is essential to know genotype, mating type, and status of metalaxyl insensitivity to adequately evaluate the mechanics of late blight epidemics in potato and tomato. In the case of potato, it is also useful to know pathogen races when developing resistant cultivars. The make up and mix of *P. infestans* populations is not stable and can change rapidly both in space and in time. this is especially true when metalaxyl is used in field situations having mixed populations of sensitive and insensitive strains.

Late blight in Florida during 1993 and 1994

Sources of inoculum. *Phytophthora infestans* is not known to oversummer in Florida and primary inoculum for potato late blight is believed to be reintroduced each year in infected seed tubers imported from seed producing states. Late blight was severe in many seed producing states during 1992 and 1993. Introduction of late blight into Florida coupled with highly favorable weather conditions during the 1993 and 1994 growing seasons resulted in widespread epidemics during both seasons. Although only limited genotype data were obtained in 1993, isolates of *P. infestans* from early season outbreaks in most Florida locations, generally were the same as the genotypes detected in the states which produced the seed. Data form 1994 are still incomplete. Significant levels of late blight in seed tubers can be expected again in 1994 because the disease is presently severe in several seed producing states/provinces.

Genotype/mating type/metalaxyl insensitivity. The genotypes, mating types, and reaction to metalaxyl of *P. infestans* found in Florida during the past several years are summarized in Table 1. There was a greater diversity of genotypes observed in 1993 relative to 1994, however, this could be due to a larger number of samples being analyzed in 1993.

As indicated earlier, the most prevalent genotype during 1993 was US-7. This genotype is more aggressive on tomato than it is on potato. Since it is insensitive to metalaxyl, it is not clear whether it was initially the most widespread, or rather, that it was selected for by use of metalaxyl during the season. Since most potato samples collected early in the season in the Hastings area were sensitive to metalaxyl, it is likely that it was selected.

It is also important to note that there were two farms in the Manatee/Hillsborough area which had both A1 and A2 mating types identified. There was no evidence for sexual reproduction in the field samples.

In 1994 the only genotype identified so far has been US-8 which is aggressive on potato but a weak pathogen of tomato. It is metalaxyl insensitive and the A2 mating type. Although genotype data for the Hastings area are incomplete, all isolates examined in 1994 were the A2 mating type and insensitive to metalaxyl...including isolates made early during the epidemic.

Control. Extensive fungicide tests were performed on potato in the Hastings area during 1994. All isolates of *P. infestans* made from the test plots were A2 mating type and insensitive to metalaxyl. Genotypes analyses being performed by Steve Goodwin are at this writing incomplete.

All contact fungicides tested (Metiram (Polyram®), mancozeb (Dithane® M-45, Manzate® 200), chlorothalonil (Bravo® 720), and maneb (Manex®) effectively controlled late blight relative to the unsprayed controls. Timing of fungicide applications and coverage of plants was judged to be critical in controlling the strains of late blight in these tests. Unless stems, petioles, and leaf axils were thoroughly covered, numerous stem lesions were observed. Sporulation was profuse on stem lesions and many girdled and killed entire stems. The importance of fungicide timing is illustrated in Figure 1. Even though less than 1% late blight occurred in the test plots at the time of first application, delaying application by five days nearly negated use of fungicides after that time.

Conclusions/Prognosis. There are many unanswered questions regarding management of these new "strains" of late blight in potatoes and tomatoes. The relative impact of late blight in potato during a given season will be dependent on weather conditions/blight severity in potato seed producing states, mix of genotypes introduced in seed tubers, weather conditions in Florida, and diligence of commercial growers relative to good management practices. Weather permitting, late blight can be expected in 1995 because it is already widespread in some seed producing states. Some of the new "strains" appear to be more aggressive than US-1 and therefore will be more difficult to control. There will be less room for error in fungicide applications and greater potential for crop losses during blight favorable years.

A prognosis for tomato is more difficult because we do not have as much data. Although infected seed tubers may be important as an inoculum source for late blight in potatoes, this may not always be the case for tomatoes, especially if US-8 is the predominant genotype. Given an aggressive genotype such as US-7, however, and late blight will be a major constraint in tomato production. The disease was devastating in sections of California during the past several seasons.

In conclusion, good management practices are more crucial than ever. Plant only certified seed or transplants, destroy all cull piles, and volunteer tomato and potato plants. Adhere to a recommended fungicide program using a contact fungicide or a contact fungicide combined with a metalaxyl program. Start sprays early, as suggested by Blitecast or when plants are 4-6 in. tall, whichever comes first. Avoid long durations of wetness during irrigation.

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gltA_rev_seq	gtl_Fwd_seq	gapA_fwd-amp	pex147r	avr3b_r	p4_rev
gapA_rev_ampseq	syrB1	DC6	PiAvr4seqF	EF1-986R	
gapA_Fwd_seq	syrB2	Avr2_f2	Avr2_R1e	Avr3b_F	
glta_fwd_amp	O8-1	Avr2_r2e	Avr2_f1	avr3a_F	
gyrB_rev_amp_seq	O8-2	ITS4	GDF1	BOX_A1	
gltA_rev_amp	tabA2	inf_FWD2	FM35	Avr3a_R	
gyrB_fwd_amp_seq	tabA1	PiAvr4seqR	FMPhy_10b	ACT-783R	
rpoD_fwd_seq	tagtox-10_rev	O8-4	GDR1	p2_rev	
rpoD_rev_amp_seq	tagtox-10_fwd	pex147f	ACT-512F	p2_fwd	
rpoD_fwd_amp	inf_rev	o8-3	ITS4	p4_fwd	

gltA_rev_seq	gtl_Fwd_seq	gapA_fwd-amp	pex147r	avr3b_r	p4_rev
gapA_rev_ampseq	syrB1	DC6	PiAvr4seqF	EF1-986R	
gapA_Fwd_seq	syrB2	Avr2_f2	Avr2_R1e	Avr3b_F	
glta_fwd_amp	O8-1	Avr2_r2e	Avr2_f1	avr3a_F	
gyrB_rev_amp_seq	O8-2	ITS4	GDF1	BOX_A1	
gltA_rev_amp	tabA2	inf_FWD2	FM35	Avr3a_R	
gyrB_fwd_amp_seq	tabA1	PiAvr4seqR	FMPhy_10b	ACT-783R	
rpoD_fwd_seq	tagtox-10_rev	O8-4	GDR1	p2_rev	
rpoD_rev_amp_seq	tagtox-10_fwd	pex147f	ACT-512F	p2_fwd	
rpoD_fwd_amp	inf_rev	o8-3	ITS4	p4_fwd	

Table 1. Summary of genotypes, metalaxyl (Ridomil) sensitivity, and *Phytophthora infestans* mating types observed in Florida.

Genotype	Metalaxyl sensitivity	Mating type	Counties
US-1	+	A1	Collier, Lee, Putnam(?), Manatee, St. Johns(?)
US-6	0	A1	Lee*, Manatee, St. Johns
US-7	0	A2	Manatee, St. Johns
US-8	0	A2	Dade**, Other(?)**, Collier**

* and ** indicates 1991 and 1994 identifications, respectfully. All others determined in 1993.

Data are summarized from samples analyzed by S. B. Goodwin and Ludwick Sujkowski, Cornell University; K. L. Deahl, S. P. Demuth, and R. W. Goth, USDA Vegetable Laboratory, Beltsville, MD; and T. Young, Ciba Laboratories, Vero Beach, FL.

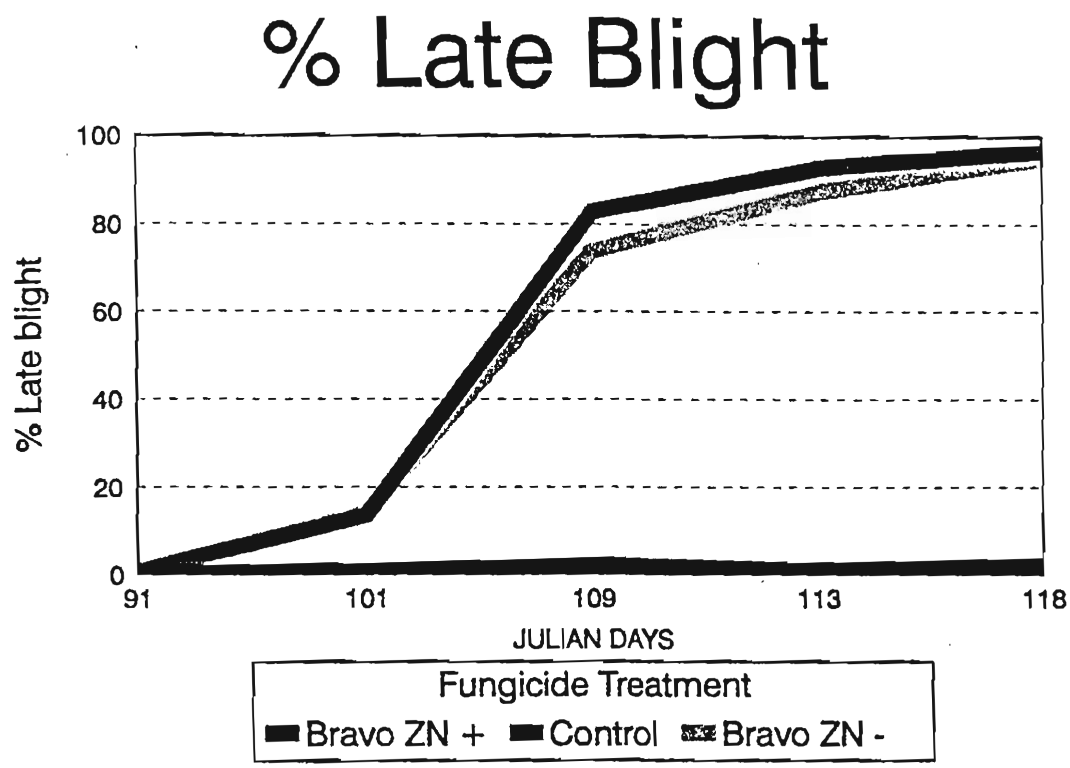

Figure 1. Comparison of late blight disease progress in nonsprayed and Bravo Zn plots. The Bravo Zn+ plots were sprayed 1, 6, 13, 20, 27 April and 4 May. The initial application in Bravo Zn- was delayed until 6 April.

APPENDIX A

TOMATO VARIETIES FOR FLORIDA

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Variety selection, often made several months before planting, is one of the most important management decisions made by the grower. Failure to select the most suitable variety or varieties may lead to loss of yield or market acceptability.

The following characteristics should be considered in selection of tomato varieties for use in Florida:

*Yield - The variety selected should have the potential to produce crops at least equivalent to varieties already grown. The average yield in Florida is currently about 1200 25-pound cartons per acre. The potential yield of varieties in use should be much higher than average.

*Disease Resistance - Varieties selected for use in Florida must have resistance to Fusarium wilt, race 1 and race 2; Verticillium wilt (race 1); gray leaf spot; and some tolerance to bacterial soft rot. Available resistance to other diseases may be important in certain situations.

*Horticultural Quality - Plant habit, stem type and fruit size, shape, color, smoothness and resistance to defects should all be considered in variety selection.

*Adaptability - Successful tomato varieties must perform well under the range of environmental conditions usually encountered in the district or on the individual farm.

*Market Acceptability - The tomato produced must have characteristics acceptable to the packer, shipper, wholesaler, retailer and consumer. Included among these qualities are pack out, fruit shape, ripening ability, firmness and flavor.

CURRENT VARIETY SITUATION

Many tomato varieties are grown commercially in Florida but only a few represent most of the acreages.

'Agriset 761' was grown on 41% of the acreage in Florida in the 1993-94 season - a dramatic increase from about 29% in the previous season. 'Agriset 761' was grown on about 62% of the acreage in southwest, about 40% of the acreage in west central Florida, and was the predominant variety in north Florida.

The acreage planted with 'Sunny' declined to about 18% of the total after having been the leading variety in the state for many years, often with about 80% of the acreage. However, 'Sunny' was still grown on almost 80% of the acreage on the east coast.

'Solar Set' continued as the third most important Florida-grown variety with about 9% of the acreage. 'Solar Set' was most popular in west central Florida, but was grown in all production areas - the only variety with that distinction. 'Solar Set' continued to be an important factor in the north Florida fall crop.

'Bonita' was grown on about 7% of the statewide acreage, however, virtually all of the plantings were in Dade County where it represented more than 50% of the acreage there.

'Sunbeam' was planted on about 5% of the statewide acreage with the greatest concentration - about 10% of the acreage - in west central Florida.

'BHN 26' was grown on about 4% of the Florida acreage representing about 9% of the southwest Florida acreage.

'Merced' with about 3% of the state's acreage and 7% of the southwest Florida acreage and 'Cobia' with about 2% of the state's acreage and 20% of the Dade County acreage are the only other varieties of importance in the 1993-94 season. However, many other varieties were grown on limited or experimental acreages.

TOMATO VARIETY TRIAL RESULTS

Summary results listing the five highest yielding and five largest fruited varieties from trials at the Gulf Coast Research and Education Center, Bradenton; a commercial farm in Delray Beach; Ft. Pierce Agricultural Research & Education Center; and North Florida Research & Education Center, Quincy, for the Spring 1993 season are shown in Table 1. High total yields and large fruit size were produced by 'Passion' at Bradenton; 'Merced', XPH 10005, PSX 853389, and 'Olympic' at Delray Beach; 'Olympic', 'Merced', Fla. 7430, and 'Agriset 761' at Ft. Pierce; and 'Mountain Spring' at Quincy. 'Bonita' produced high yields at three and 'Merced' at two locations. Large fruit size was produced by 'Merced' in four locations and by 'Agriset 761', 'Olympic', 'Passion', and XPH 10005 in two locations.

It is important to note that the same entries were not included in all of the trials.

Table 1. Summary of University of Florida tomato variety trial results. Spring 1993.

Location	Total Yield (ctn/acre)		Large Fruit Size (oz)	
Bradenton (1)	Fla. 7375	2628	HMX 2822	7.2
	Fla. 7249B	2612	Olympic	6.8
	Passion	2594	Passion	6.8
	Bonita	2591	Merced	6.7
	Fla. 7430	2558[1]	FMX 171	6.7[2]
Delray Beach[3] (3)	Merced	2247	PSX 853389	7.8
	XPH 10005	2177	Merced	6.8
	PSX 853389	2136	Tango	6.6
	Cobia	2053	Olympic	6.5
	Olympic	2030	XPH 10005	6.4
Ft. Pierce (3)	Olympic	2077	Olympic	8.6
	Merced	1947	Merced	8.5
	Bonita	1925	Agriset 761	7.7
	Fla. 7430	1900	Fla. 7430	7.6
	Agriset 761	1864[4]	Solar Set	7.5[5]
Quincy (3)	Monte Verde	2664	Passion	8.8
	Bonita	2605	Mountain Spring	8.5
	PSX 877491	2600	Merced	8.1
	Mountain Spring	2562	Agriset 761	8.1
	Sunbeam	2528[6]	XPH 10005	8.0[7]

[1] 14 additional entries had yields similar to those of Fla. 2558.
[2] 8 additional entries had fruit weight similar to that of FMX 171.
[3] Statistical interpretation of data not available.
[4] Five additional entries had yields similar to those of 'Agriset 761'.
[5] Seven additional entries had fruit weight similar to 'Solar Set'.
[6] 18 additional entries had yields similar to those of 'Sunbeam'.
[7] Ten additional entries had fruit weight similar to that of XPH 10005.

Seed Sources:

Agrisales: Agriset 761
Asgrow: Solar Set, Sunbeam, XPH 10005
Ferry-Morse: FM 171, Monte Verde

Harris Moran: HMX 2822
Petoseed: Olympic, Passion, PSX 877491
Rogers NK: Bonita, Cobia, Merced, Mountain Spring, Tango
University of Florida: Fla. 7249B, Fla. 7375, Fla. 7430

Summary results listing outstanding entries in order from trials at the Gulf Coast Research & Education Center, Bradenton and North Florida Research & Education Center, Quincy for the Fall 1993 season are shown in Table 2. High yields and large fruit size were produced by 'Merced' at Quincy. The highest yields were produced by 'Agriset 761' at both locations. 'Passion' produced the largest fruit size at both locations.

Table 2. Summary of University of Florida tomato variety trial results. Fall 1993.

Location	Total Yield (ctn/acre)		Large Fruit Size (oz)	
Bradenton (2)	Agriset 761	1513	Passion	5.6
	Solar Set	1459	HMX 2822	5.5
	Sunmaster	1445	XPH 10005	5.4
	XPH 10005	1404	Mountain Fresh	5.2
	Solimar	1373[1]	FMX 174	5.1[2]
Quincy (3)	Agriset 761	1485	Passion	6.3
	Fla. 7375	1424	Tango	6.2
	Colonial	1394	PSR 810790	6.1
	Fla. 7249B	1323	Merced	6.0
	Merced	1320[3]	Mountain Spring	5.9[4]

[1] 14 additional entries had yields similar to those of 'Solimar'.
[2] Ten additional entries had fruit weight similar to that of FMX 174.
[3] 12 additional entries had yields similar to those of 'Merced'.
[4] Nine additional entries had fruit weight similar to that of 'Mountain Spring'.

Seed Sources:

Agrisales: Agriset 761
Asgrow: Solar Set, Solimar, XPH 10005
Ferry-Morse: FMX 174, Mountain Fresh
Harris Moran: HMX 2822
Petoseed: Colonial, Passion, Sunmaster, PSR 810790
Rogers NK: Merced, Mountain Spring, Tango
University of Florida: Fla. 7249B, Fla. 7375

For spring and fall 1993 combined, high yields and/or large fruit size were achieved by 'Merced' eight times, 'Agriset 761' and 'Passion' five times, 'Olympic' and XPH 10005 four times, and 'Bonita', Fla. 7430, and 'Mountain Spring' three times each.

It should be noted that in some of these trials, there were little or no significant differences among the entries. This indicates that there are a large number of varieties that produce large yields and have large fruit size which are available to growers. In some instances, other factors may dictate the selection process.

TOMATO VARIETIES FOR COMMERCIAL PRODUCTION

The varieties listed have performed well in University of Florida trials conducted in various locations. Those varieties designated as **FOR TRIAL** should be evaluated in trial plantings before large-scale production is attempted.

Agriset 761 (Agrisales). An early midseason, determinate, jointed hybrid. Fruit are deep globe and green shouldered. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, gray leaf spot.

Bonita (Rogers NK). A midseason, jointless hybrid. Fruit are globe-shaped and green-shouldered. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), gray leaf spot.

Heatwave (Petoseed). An early, large, jointed, uniform-green fruited hybrid. Determinate. Fruit is set under high temperatures (90-96°F day/74-78° night). For late summer or fall plantings. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, gray leaf spot.

Merced (Rogers NK). Early, deep-globe shaped, green-shouldered fruit are produced on determinate vines. Jointed hybrid. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), gray leaf spot, tobacco mosaic virus. **FOR TRIAL**.

Olympic (Petoseed). A mid-season determinate, jointed hybrid. Fruit are deep oblate with green shoulders. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, and gray leaf spot.

Solar Set (Asgrow). An early, green-shouldered, large-fruited, jointed hybrid. Determinate. Fruit set under high temperatures (92°F day/72° night) is superior to most other commercial cultivars. Resistant: Fusarium wilt (race 1 and 2), Verticillium wilt (race 1) and gray leaf spot.

Sunbeam (Asgrow). Early mid-season, deep-globe shaped fruit are produced on determinate vines. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and race 2), gray leaf spot, Alternaria. **FOR TRIAL**.

Sunny (Asgrow). A midseason, jointed, determinate, hybrid. Fruit are large, flat-globular in shape, and are green-shouldered. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, gray leaf spot.

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APPENDIX B

TOMATO FERTILIZER MANAGEMENT

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Prior to each cropping season, soil tests should be conducted to determine fertilizer needs. Obtain an IFAS soil sample kit from the local agricultural Extension agent for this purpose. Commercial soil testing laboratories also are available, however, be sure the commercial lab uses methodologies calibrated for Florida soils. Routine soil testing will help reduce overfertilization which reduces farming efficiency and increases the risk of groundwater pollution.

The crop nutrient requirements of nitrogen, phosphorus, and potassium (designated in fertilizers as $N-P_2O_5-K_2O$)in Tables 1 and 2 represent the optimum amounts of these nutrients needed for maximum production (7).

A portion of this required nutrition will be supplied by the native soil and by previous crop residue. The remainder of the nutrient requirements will be supplied by fertilizer, and this amount must be determined by soil testing. Therefore, nutrient amounts in these tables are applied as fertilizers only to soils testing very low in the specific plant nutrients. Automatic use of the amounts of nutrients in the tables without a soil test may result in wasted fertilizer, crop damage from salt injury, reduced yields and quality, and a risk to the environment if fertilizer runs off or leaches to the watertable.

Liming

The optimum pH range for tomatoes is between 6.0 and 6.5. Fusarium wilt problems are reduced by liming within this range, but it is not advisable to raise the pH higher than 6.5 because of reduced micronutrient availability.

Calcium and magnesium levels should be corrected according to the soil test. If both elements are low, broadcast and incorporate dolomitic limestone. Where calcium alone is deficient, lime with "hi-cal" limestone. Adequate calcium is important for reducing the severity of blossom-end rot. Research shows that a Mehlich-I (double-acid) index of 300 to 350 ppm would be indicative of adequate soil-Ca. On limestone soils, add 30-40 pounds per acre of magnesium in the basic fertilizer mix. It is best to apply lime several months prior to planting. However, if time is short, it is better to apply lime any time before planting than not to apply it at all. Where the pH does not need modification, but magnesium is low, apply magnesium sulfate or potassium-magnesium sulfate with the fertilizer.

Blossom-end rot. At certain times, growers have problems wit blossom-end-rot, especially on the first one or two frui clusters. Blossom-end rot (BER) is basically a Ca deficienc but is often more related to water stress than to C concentrations in the soil. This is because Ca movement in th plant is with the water stream. Anything that impairs th ability of the plant to obtain water will increase the risk c BER. These factors include damaged roots from flooding c mechanical damage, clogged drip emitters, inadequate wate applications, and alternating dry-wet periods. Other cause include high fertilizer rates, especially potassium an nitrogen. High fertilizer increases the salt content an osmotic potential in the soil reducing the ability of roots t obtain water.

There should be adequate Ca in the soil if the double-aci index is 300 to 350 ppm, or above. In these cases, added gypsu (calcium sulfate) is unlikely to reduce BER. Foliar sprays o Ca are unlikely to reduce BER because Ca does not move out o the leaves to the fruit. Foliar-applied Ca stays on the lea from where it more likely will wash during a rain.

BER is most effectively controlled by attention t irrigation. Maintaining adequate and uniform amounts of wate are keys to reducing BER potential. Growers who keep N and rates at soil-test-predicted levels are at least risk from BER

Table 1. Fertility recommendations for non-mulched tomatoes grown on irrigated soils testing very low in phosphorus and potassium.

	Nutrient requirements	Supplemental application	
Soil	lbs/A $N-P_2O_5-K_2O$	lbs/A $N-P_2O_5-K_2O$	Number of Applications
Irrigated Mineral	160-160-160	30-0-20	0-4
Marl	120-160-160	30-0-20	0-3
Rockdale[1]	120-200-180	30-0-20	0-3

[1]A portion of the phosphorus (25 pounds per acre) in the supe or triple super form should be placed in the drill or under th plug-mix to supply an adequate amount for germinating seedling or transplants.

Micronutrients

For virgin, sandy soils, or sandy soils where a proven nee exists, a general guide for fertilization is the addition o micronutrients (in pounds per acre) manganese -3, copper -2 iron -5, zinc-2, boron-2, and molybdenum-.02. Micronutrient may be supplied from oxides or sulfates. Growers usin micronutrient-containing fungicides need to consider these sources when calculating fertilizer micronutrient needs. More information on micronutrient use is available (2,4,8).

Table 2. Fertility recommendations for mulched tomatoes on irrigated soils testing very low in phosphorus and potassium.

		Nutrient requirements	Supplemental Applications[1]	
Soil	Number of expected harvests	lbs/A[2] $N-P_2O_5-K_2O$	lbs/A $N-P_2-O_5-K_2O$	Number of Applications
Mineral	2-3	160-160-160	30-0-20	0-2
Rockdale	2-3	120-200-180	30-0-20	0-2

[1]Sidedressing to replenish nitrogen and potassium can be accomplished by the use of a liquid fertilizer injection wheel.

[2]Approximately 7200 linear bed feet of crop per acre (43,560 square feet).

Properly diagnosed micronutrient deficiencies can often be corrected by foliar applications of the specific nutrient. For most micronutrients, a very fine line exists between sufficiency and toxicity. Foliar application of major nutrients (nitrogen, phosphorus, or potassium) has not been shown to be beneficial where proper soil fertility is present. For more information on foliar micronutrient fertilization of tomatoes, consult the Commercial Vegetable Fertilization Guide, Circular 225-C (2).

Fertilizer application

Nonmulched Crops. Apply all phosphorus and micronutrients, and no more than one-half of the nitrogen and potassium prior to planting and incorporate by disking or rototilling. Increased fertilizer efficiency can be realized by a "modified broadcast" method where the needed fertilizer is broadcast in the bed area only, rather than over the entire field. For rates, see Table 1. Incorporation will place some fertilizer near the transplant root or germinating seed. The remaining nitrogen and potassium fertilizer can be banded in an area on both sides of the row just ahead of developing root tips through the early part of the growing season.

Several supplemental sidedress band applications of nitrogen and potassium may be needed after leaching rainfall. These are applied on the bed shoulders just ahead of the expanding root system, until 2 to 4 weeks before the end c harvest period. A shallow cultivator sweep will cover th fertilizer and help correct bed erosion. Liquid fertilizer ca be used by knifing it into the soil, using caution to avoid roc damage.

Strip mulch. The strip mulch system uses a narrow 10- t 12-inch strip of polyethylene mulch laid over a fertilizer ban to help reduce fertilizer leaching. With the strip mulc system, broadcast and incorporate all of the phosphorus an micronutrients with 20 percent of the nitrogen and potassium The remaining nitrogen and potassium should be applied in a ban 2 to 3 inches deep and covered with the mulch strip in a inverted "U" fashion so that the highest point is directly ove the fertilizer band. Tomatoes can then be planted in a singl row to one side of the strip. No additional fertilizer i usually required although sidedressings may be needed afte leaching rains. This system is less costly than the full-be mulch system, but does not have all the advantages such a fumigant and fertilizer efficiency, weed control, and growt enhancement.

Full-Bed Mulch with Seep Irrigation. Under this system, the crop may be supplied with all of its soil requirements before the mulch is applied (Table 2). It is difficult to correct a deficiency after mulch application, although new fertilizing equipment, such as a liquid fertilizer injection wheel, can facilitate sidedressing through the mulch. The injection wheel will also be useful for replacing fertilizer under the used plastic mulch for double-cropping systems.

A general sequence of operations for the full-bed plastic mulch system is:

1. Land preparation, including development of irrigation and drainage systems, and liming of the soil.

2. Application of "starter" fertilizer or "in-bed" mix. This should comprise only 10 to 20 percent of the total nitrogen and potassium seasonal requirement and all of the phosphorus and micronutrients. Starter fertilizer can be broadcast over the entire area prior to bedding and then incorporated. During bedding, the fertilizer will be gathered into the bed area. An alternative is to use a "modified broadcast" technique for systems with wide bed spacings. Use of modified broadcast or banding techniques can increase phosphorus and micronutrient efficiencies, especially on alkaline soils.

3. Formation of beds, incorporation of herbicide, and application of mole cricket bait.

4. Application of remaining fertilizer. The remaining 80 to 90 percent of the nitrogen and potassium is placed in narrow bands 9 to 10 inches to each side of the plant row in furrows. The fertilizer should be placed deep enough in the grooves for it to be in contact with moist bed soil. Bed presses are modified to provide the groove. Only water-soluble nutrient sources should be used for the banded fertilizer. A mixture of potassium nitrate (or potassium sulfate or potassium chloride), calcium nitrate, and ammonium nitrate has proven successful.

5. Fumigation, pressing of beds, and mulching. This should be done in one operation, if possible. Be sure that the mulching machine seals the edges of the mulch adequately with soil to prevent fumigant escape.

There is equipment that will do most of the operations in steps 4 and 5 above in one pass over the field. More information on fertilization of mulched crops is available (1, 9).

Water management with the seep irrigation system is critical to successful crops. Use water-table monitoring devices and tensiometers in the root zone to help provide an adequate water table but no higher than required for optimum moisture. Do not fluctuate the water table since this can lead to increased leaching losses of plant nutrients.

Mulched Culture with Overhead Irrigation. For the sandy soils, maximum production has been attained by broadcasting 100 percent of the fertilizer in a swath 3 to 4 feet wide and incorporating prior to bedding and mulching. Be sure fertilizer is placed deep enough to be in moist soil. Where soluble salt injury has been a problem, a combination of broadcast and banding should be used. Incorporate 30 percent to 40 percent of the nitrogen and potassium and 100 percent of the phosphorus and micronutrients into the bed by rototilling. The remaining nitrogen and potassium is applied in bands 6 to 8 inches to the sides of the seed or transplant and 2 to 4 inches deep to place it in contact with moist soil. Perforation of the plastic is needed on soils such as coarse sands and Rockdale where lateral movement of water through the soil is negligible. On Rockdale soil, a small amount of superphosphate (25 pounds phosphorus per acre) should be applied in the drill area to support germinating seedlings or transplants.

Mulched Production with Drip Irrigation. Where drip irrigation is used, drip tape or tubes should be laid 2 to 3 inches below the bed soil surface prior to mulching. This placement helps protect tubes from mice and cricket damage. The drip system is an excellent tool with which to fertilize the crop. Where drip irrigation is used, before planting apply all phosphorus and micronutrients, and 20 percent to 40 percent of total nitrogen and potassium prior to mulching. Use the lower percentage (20 percent) on seep-irrigated tomatoes. Apply tl remaining nitrogen and potassium through the drip system : increments as the crop develops.

Successful crops have resulted where the total amounts (N and K_2O were applied through the drip system. Some growe1 find this method helpful where they have had problems wi1 soluble-salt burn. However, it is important to begin wi1 rather high rates of N and K_2O to ensure young transplants a1 established quickly.

Suggested schedules for fall and spring crop nutrie1 injections are presented in Table 3. These schedules have be(successful in both research and commercial situations, but migl need slight modifications based on potassium soil-test indic(and grower experience.

Additional nutrients can be supplied through dr: irrigation if deficiencies occur during the growing season.] careful not to apply excessive amounts of water with tl fertilizer because severe leaching can occur. Tensiometers c: be used to help monitor soil moisture and guide the applicati(of water. More detail on drip-irrigation management f(fertilization is available (5).

Sources of N-P_2O_5-K_2O. About 30 to 50 percent of the tot: applied nitrogen should be in the nitrate form for soil treat(with multi-purpose fumigants and for plantings in cool so. temperature.

Slow-release nitrogen sources may be used to supply portion of the nitrogen requirement. On a trial basis, f(overhead irrigated tomatoes, apply one-third of the tot: required nitrogen as sulfur-coated urea (SCU) or isobutylide1 diurea (IBDU) incorporated in the bed. Nitrogen from natur: organics and most slow-release materials should be consider(ammoniacal nitrogen when calculating the amount of ammoniac: nitrogen.

Normal superphosphate and triple superphosphate a: recommended for phosphorus needs. Both contribute calcium a1 normal superphosphate contributes sulfur.

Recent research has shown that all sources of potassium c: be used for tomatoes. Potassium sulfate, sodium-potassi nitrate, potassium nitrate, potassium chloride, and potassiu magnesium sulfate are all good K sources. If the soil te predicted amounts of K_2O are applied, then there should be : concern for the K source or its associated salt index.

Tissue analyses. Analysis of tomato leaves for miner nutrient content can help guide a fertilizer management progr or assist in diagnosis of a suspected nutrient deficienc Tissue nutrient norms are presented in Table 4.

Growers with drip irrigation can obtain faster analyses for N by using a plant sap quick test. Several kits have been calibrated for Florida tomatoes (3). Interpretation of these kits is provided in Table 5. More information is available on plant analysis (6).

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Table 3. Schedules for N and K_2O injections for mulched tomatoes on soils testing low in K for situations where zero or 30 lb N and K_2O per acre are applied dry in the bed.

Season	Dry fert.[y] (lb/A)	Week 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Season total (lb/A)
		lb per acre per week[z]														
Fall	0	10.5	10.5	10.5	14	14	17.5	17.5	17.5	14	14	10.5	10.5	-	-	161
	30	0	7	10.5	10.5	14	14	14	14	14	14	10.5	10.5	-	-	162
Spring	0	7	7	10.5	10.5	10.5	14	14	14	14	14	14	14	10.5	7	161
	30	0	7	7	7	10.5	10.5	10.5	14	14	14	10.5	10.5	10.5	7	163

[y]Dry fertilizer is the amount of N and K_2O incorporated in the bed. These schedules assume no banded fertilizer.

[z]Pounds per acre per week at 7, 10.5, 14, and 17.5 are 1, 1.5, 2, and 2.5 lb. per acre per day. Acre is based on 6-ft. spacing or 7260 linear bed foot of bed per acre (43,560 sq. ft.).

Table 4. Deficient, adequate, and excessive nutrient concentrations for tomatoes [most-recently-matured (MRM) leaf (blade plus petiole)].

				N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu	Mo
				%						ppm					
Tomato	MRM leaf	5-leaf stage	Deficient	<3.0	0.3	3.0	1.0	0.3	0.3	40	30	25	20	5	0.2
			Adequate range	3.0 5.0	0.3 0.6	3.0 5.0	1.0 2.0	0.3 0.5	0.3 0.8	40 100	30 100	25 40	20 40	5 15	0.2 0.6
			High	>5.0	0.6	5.0	2.0	0.5	0.8	100	100	40	40	15	0.6
	MRM leaf	First flower	Deficient	<2.8	0.2	2.5	1.0	0.3	0.3	40	30	25	20	5	0.2
			Adequate range	2.8 4.0	0.2 0.4	2.5 4.0	1.0 2.0	0.3 0.5	0.3 0.8	40 100	30 100	25 40	20 40	5 15	0.2 0.6
			High	>4.0	0.4	4.0	2.0	0.5	0.8	100	100	40	40	15	0.2
			Toxic (>)								1500	300	250		
	MRM leaf	Early fruit set	Deficient	<2.5	0.2	2.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate range	2.5 4.0	0.2 0.4	2.5 4.0	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
			High	>4.0	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
			Toxic (>)											250	
	MRM leaf	First ripe fruit	Deficient	<2.0	0.2	2.0	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate range	2.0 3.5	0.2 0.4	2.0 4.0	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
			High	>3.5	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6

Continued

Table 4. Deficient, adequate, and excessive nutrient concentrations for tomatoes [most-recently-matured (MRM) leaf (blade plus petiole)].

				N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu	Mo
				%						ppm					
Tomato	MRM leaf	During harvest period	Deficient	<2.0	0.2	1.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate range	2.0	0.2	1.5	1.0	0.25	0.3	40	30	20	20	5	0.2
				3.0	0.4	2.5	2.0	0.5	0.6	100	100	40	40	10	0.6
			High	> 3.0	0.4	2.5	2.0	0.5	0.6	100	100	40	40	10	0.6

Table 5. Suggested nitrate-N concentrations in fresh petiole sap for tomatoes.

Stage of growth	NO_3-N conc. (ppm)
Transplant to 1-inch fruits	600-800
One-inch fruits to first harvest	400-600
Main harvest	300-400

APPENDIX C

Weed Control in Tomatoes[1]

William M. Stall and J. P. Gilreath[2]

Although weed control has always been an important component of tomato production, its importance has increased with the introduction of the sweet potato whitefly and development of the associated irregular ripening problem. Increased incidence of several viral disorders of tomatoes also reinforces the need for good weed control. Common weeds, such as the difficult to control nightshade, and volunteer tomatoes (considered a weed in this context) are hosts to many tomato pests, including sweet potato whitefly, bacterial spot, and viruses. Control of these pests is often tied, at least in part, to control of weed hosts. Most growers concentrate on weed control in row middles; however, peripheral areas of the farm may be neglected. Weed hosts and pests may flourish in these areas and serve as reservoirs for re-infestation of tomatoes by various pests. Thus, it is important for growers to think in terms of weed management on all of the farm, not just the actual crop area.

Total farm weed management is more complex than row middle weed control because several different sites, and possible herbicide label restrictions are involved. Often weed species in row middles differ from those on the rest of the farm, and this might dictate different approaches. Sites other than row middles include roadways, fallow fields, equipment parking areas, well and pump areas, fence rows and associated perimeter areas, and ditches.

Disking is probably the least expensive weed control procedure for fallow fields. Where weed growth is mostly grasses, clean cultivation is not as important as in fields infested with nightshade and other disease and insect hosts. In the latter situation, weed growth should be kept to a minimum throughout the year. If cover crops are planted, they should be plants which do not serve as hosts for tomato diseases and insects. Some perimeter areas are easily disked, but berms and field ditches are not and some form of chemical weed control may have to be used on these areas. We are not advocating bare ground on the farm as this can lead to other serious problems, such as soil erosion and sand blasting of plants; however, where undesirable plants exist, some control should be practiced, if practical, and replacement of undesirable species with less troublesome ones, such as bahiagrass, might be worthwhile.

Certainly fence rows and areas around buildings and pumps should be kept weed-free, if for no other reason than safety. Herbicides can be applied in these situations, provided care is exercised to keep it from drifting onto the tomato crop.

Field ditches as well as canals are a special consideration because many herbicides are not labeled for use on aquatic sites. Where herbicidal spray may contact water and be in close proximity to tomato plants, for all practical purposes, growers probably would be wise to use Diquat only. On canals where drift onto the crop is not a problem and weeds are more woody, Rodeo, a systemic herbicide, could be used. Other herbicide possibilities exist. Growers are cautioned against using Arsenal on tomato farms as tomatoes are very sensitive to this herbicide. Particular caution should be exercised if Arsenal is

1. This document, Fact Sheet HS-200, was reviewed November 1992, by the Florida Cooperative Extension Service. For more information, contact your county Cooperative Extension Service office.

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Trade names, where used, are given for the purpose of providing specific information. They do not constitute an endorsement or guarantee of products named, nor does it imply criticism of products not named.

used on seepage irrigated farms as it has been observed to move in some situations.

Use of rye as a windbreak has become a common practice in the spring; however, in some cases, adverse effects have resulted. If undesirable insects such as thrips buildup on the rye, contact herbicide can be applied to kill it and eliminate it as a host, yet the remaining stubble could continue serving as a windbreak.

The greatest row middle weed control problem confronting the tomato industry today is control of nightshade. Nightshade has developed varying levels of resistance to some post-emergent herbicides in different areas of the state. Best control with post-emergence (directed) contact herbicides are obtained when the nightshade is 4-6 inches tall, rapidly growing and not stressed. Two applications in about 50 gallons per acre using a good surfactant is usually necessary.

With post-directed contact herbicides, several studies have shown that gallonage above 60 gallons per acre will actually dilute the herbicides and therefore reduce efficacy. Good leaf coverage can be obtained with volumes of 50 gallons or less per acre. A good surfactant can do more to improve the wetting capability of a spray than can increasing the water volume. Many adjuvants are available commercially. Some adjuvants contain more ingredient then others and herbicide label specify a minimum active ingredient rate f adjuvant in the spray mix. Before selecti adjuvant, refer to the herbicide label to determ adjuvant specifications.

Additionally important is good field san with regard to crop residue. Rapid and thc destruction of tomato vines at the end of the s always has been promoted; however, this pı takes on new importance with the sweet whitefly. Good canopy penetration of pesı sprays is difficult with conventional hydraulic spı once the tomato plant develops a vigorous bus to foliar interception of spray droplets. The potato whitefly population on commercial farm observed to begin a dramatic, rapid increase abo time of first harvest in the spring of 1989. increase appears to continue until tomato vine killed. It is believed this increase is due, in pa coverage and penetration. Thus, it would be wis growers to continue spraying for whiteflies until crop is destroyed and to destroy the crop as soo possible with the fastest means available.

The importance of rapid vine destruction can be overstressed. Merely turning off the irrigation allowing the crop to die will not do; application desiccant followed by burning is the prudent cou

Table 1. Chemical Weed Controls: Tomatoes

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. AI./Acre) Mineral	Muck
DCPA (Dacthal W-75)	Established Tomatoes	Posttransplanting after crop establishment (non-mulched)	6.0 - 8.0	---
		Mulched row middles after crop establishment	6.0 - 8.0	---
Remarks: Controls germinating annuals. Apply to weed-free soil 6-8 weeks after crop is established and growing rapidly or to moist soil in row middles after crop establishment. Note label precautions o replanting non registered crops within 8 months.				
Diquat (Diquat H/A)	Tomato Vine Burndown	After final harvest	0.375	---
Remarks: Special Local Needs (24c) label for use for burndown of tomato vines after final harvest. Applications of 1.5 pts. material per acre in 60-120 gals. of water is labelled. Add 16-32 ozs. of Valent X-77 spreader per 100 gals. of spray mix. Thorough coverage of vines is required to insure maximum burndown.				

Weed Control in Tomatoes

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. AI./Acre) Mineral	Muck
MCDS (Enquik)	Tomatoes	Postemergence directed/ shielded in row middle	5 - 8 gals.	---
Remarks: Controls many emerged broadleaf weeds. Weak on grasses. Apply 5-8 gallons of Enquik in 20-50 gallons of total spray volume per treated acre. A non-ionic surfactant should be added at 1-2 pints per 100 gallons. Enquik is severely corrosive to nylon. Non-nylon plastic and 316-L stainless steel are recommended for application equipment. Read the precautionary statements before use. Follow all restrictions on the label.				
Metribuzin (Sencor DF) (Sencor 4) (Lexone DF)	Tomatoes	Postemergence Posttransplanting after establishment	0.25 - 0.5	---
Remarks: Controls small emerged weeds after transplants are established direct-seeded plants reach 5-6 true leaf stage. Apply in single or multiple applications with a minimum of 14 days between treatments and a maximum of 1.0 lb ai/acre within a crop season. Avoid applications for 3 days following cool, wet or cloudy weather to reduce possible crop injury.				
Metribuzin (Sencor DF) (Sencor 4) (Lexone DF)	Tomatoes	Directed spray in row middles	0.25 - 1.0	---
Remarks: Apply in single or multiple applications with a minimum of 14 days between treatments and maxiumum of 1.0 lb ai/acre within crop season. Avoid applications for 3 days following cool, wet or cloudy weather to reduce possible crop injury. Label states control of many annual grasses and broadleaf weeds including, lambsquarter, fall panicum, *amaranthus* sp., Florida pusley, common ragweed, sicklepod, and spotted spurge.				
Napropamid (Devrinol 50WP) (Devrinol 50DF) (Devrinol 2E)	Tomatoes	Preplant incorporated	1.0 - 2.0	---
Remarks: Apply to well worked soil that is dry enough to permit thorough incorporation to a depth of 1-2 inches. Incorporate same day as applied. For direct-seeded or transplanted tomatoes.				
Napropamid (Devrinol 2E) (Devrinol 50WP)	Tomatoes	Surface treatment	2.0	---
Remarks: Controls germinating annuals. Apply to bed tops after bedding but before plastic application. Rainfall or overhead-irrigate sufficient to wet soil 1 inch in depth should follow treatment within 24 hours. May be applied to row middles between mulched beds. A special Local Needs 24(c) Label for Florida. Label states control of weeds including Texas panicum, pigweed, purslane, Florida pusley, and signalgrass.				
Paraquat (Gramoxone Extra)	Tomatoes	Premergence; Pretransplant	0.62 - 0.94	---
Remarks: Controls emerged weeds. Use a non-ionic spreader and thoroughly wet weed foliage.				
Paraquat (Gramoxone Extra)	Tomatoes	Post directed spray in row middle	0.47	---
Remarks: Controls emerged weeds. Direct spray over emerged weeds 1-6 inches tall in row middles between mulched beds. Use a non-ionic spreader. Use low pressure and shields to control drift. Do not apply more than 3 times per season.				

Weed Control in Tomatoes

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. AI./A(Mineral	Muck
Sethoxydim (Poast)	Tomatoes	Postemergence	0.188 - 0.28	---
Remarks: Controls actively growing grass weeds. A total of 4 1/2 pts. product per acre may be ap in one season. Do not apply within 20 days of harvest. Apply in 5-20 gallons of water adding 2 pts oil concentrate per acre. Unsatisfactory results may occur if applied to grasses under stress. Use lb ai (1 pt.) to seedling grasses and up to 0.28 lb ai (1 1/2 pts.) to perennial grasses emerging fror rhizomes etc. Consult label for grass species and growth stage for best control.				
Trifluralin (Treflan EC) (Treflan MTF) (Treflan 5) (Treflan TR-10) (Tri-4) (Trilin)	Tomatoes (except Dade County)	Pretransplant incorporated	0.75 - 1.0	---
Remarks: Controls germinating annuals. Incorporate 4 inches or less within 8 hours of application. F in Florida are erratic on soils with low organic matter and clay contents. Note label precautions of pl non-registered crops within 5 months. Do not apply after transplanting.				
Trifluralin (Treflan EC) (Treflan MTF) (Treflan 5) (Treflan TR-10) (Tri-4) (Trilin)	Direct-Seeded tomatoes (except Dade County)	Post directed	0.75 - 1.0	---
Remarks: For direct-seeded tomatoes, apply at blocking or thinning as a directed spray to the so between the rows and incorporate.				

APPENDIX D

Insect Control in Tomatoes[1]

Freddie Johnson[2]

Table 1. Chemical Insect Control in Tomatoes

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
ANTS			
carbaryl (Sevin)	5 B	20 - 40 lb	0
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
APHIDS			
aliphatic petroleum (JMS Stylet Oil)	97.6% EC	see label	see label
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest
diazinon AG500	4 EC	1/2 pt	1
dimethoate (Cygon)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston 8)	8 EC	1.2-10.5 oz/1000 ft	30 (see label for further instructions)
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qt	2
esfenvalerate (Asana XL) (potato aphid)	0.66 EC	5.8 - 9.6 fl oz	1
malathion	8 EC	1 1/2 pt	1
methamidophos (Monitor)	4 EC	1/2 - 1 1/2 pt	7
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pt	1
methyl parathion (Setre)	4 EC	1/2 - 2 pt	15
oil (Sun Spray)	98.8%	1-2 gal/100 gal H_2O	**warning-read label**
Note: Sun Spray oil can cause phytotoxic (plant) burns if used during periods of prolonged high temperature and high relative humidity. Do not spray plants under moisture stress. Do not use in combination with or immediately before or after spraying with dimethoate (Cygon) or fungicides such as Captan, Folpet, Dyrene, Karathane, Morestan, sulfur, or any product containing sulfur. Use with Bravo is not recommended.			
pyrethrins + piperonyl butoxide (Pyrenone) (green peach aphid)	66% L (EC)	2 - 12 oz per 100 gal	0
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0

1. This document is Fact Sheet ENY-444, a series of the Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Revised: June 1994.
2. Extension Entomologist, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville FL 32611.

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
		APHIDS (continued)	
rotenone (Rotacide)	EC	1 gal	0
soap, insecticidal (M-Pede)	49% EC	1-2 gal/100 gal H_2O	0
		ARMYWORMS **(See also: Beet, Fall, Southern, and Yellow-striped Armyworm)**	
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_2O 150 - 300 gal/A	1
Bacillus thuringiensis	See individual brand labels		---
carbaryl (Sevin)	5 B	20 - 40 lb	0
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lb	14
diazinon AG500 (fall and southern armyworm)	4 EC	3/4 - 1 pt	1
esfenvalerate (Asana XL) (beet, Southern, Western yellow-striped)	0.66 EC	5.8 - 9.6 fl oz	1
methomyl (Lannate LV)	2.4 L	3/4 - 1 1/2 pt	1
methyl parathion (Setre)	4 EC	1/2 - 2 pt	15
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz per 100 gal	0
rotenone (Rotacide)	EC	1 gal	0
		BEET ARMYWORMS **(See also: Armyworms)**	
esfenvalerate (Asana XL) (aids in control)	0.66 EC	5.8 - 9.6 fl oz	1
methomyl (Lannate LV)	2.4 L	1/2 - 3 pt	1
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on c tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lb. active ingredient per acre season which is equivalent to 76.8 oz of Ambush 2 EC or 48 oz of Pounce 3.2 EC.			
		BANDED CUCUMBER BEETLES	
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	0
diazinon AG500	4 EC	3/4 - 1 pt	1
		BLISTER BEETLES	
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qt	2
methoxychlor	2 L	100 oz/100 gal H_2O	7
		CABBAGE LOOPERS **(See also: Loopers)**	
azadirachtin (Neemix)	25%	2 1/2 pt 100 gal H_2O 150 - 300 gal/A	1
Bacillus thuringiensis	See individual brand labels.		0
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
endosulfan (Phaser, Thiodan)	3 EC	1 - 1 1/3 qt	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
	CABBAGE LOOPERS (continued)		
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pt	1
methyl parathion (Setre)	4 EC	2 - 3 pt	15
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lb. active ingredient per acre per season which is equivalent to 76.8 oz of Ambush 2 EC or 48 oz of Pounce 3.2 EC.			
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
rotenone (Rotacide)	EC	1 gal	0
	COLORADO POTATO BEETLES		
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_20 150 - 300 gal/A	1
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 pt	up to day of harvest
carbaryl (Sevin)	80S	2/3 - 1 1/4 lb	0
disulfoton (Di-Syston 8)	8 EC	1.2 - 10.5 oz/1000 ft	30 (see label for further instructions)
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qt	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
methoxychlor	2 L	75 - 100 oz/100 gal H_20	7
methyl parathion (Penncap M)	2 EC	4 pt	15
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lb. active ingredient per acre per season which is equivalent to 76.8 oz of Ambush 2 EC or 48 oz of Pounce 3.2 EC.			
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz per 100 gal	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pt	0
rotenone (Rotenox) (Rotacide)	5% L EC	2/3 gal 1 gal	0 0
	CORN EARWORMS **(See also: Tomato Fruitworms)**		
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_20 150 - 300 gal/A	1
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pt	up to day of harvest for 3 pt or less; 14 for 3+ pt
Bacillus thuringiensis	See individual brand labels		0
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pt	1
methoxychlor	2 L	75-100 oz/100 gal H_20	7
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
	CRICKETS		
carbaryl (Sevin)	5 B	20 - 40 lb	0
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
rotenone (Rotacide)	EC	1 gal	0

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
CUCUMBER BEETLE (See also: Banded Cucumber Beetle)			
azinphosmethyl (Guthion) (banded cucumber beetle)	2 S, 2 L (EC)	1 1/2 - 2 pt	up to day of harvest
methoxychlor	2 L	75-100 oz/100 gal H_2O	7
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pt	0
rotenone (Rotacide)	EC	1 gal	0
CUTWORMS			
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_2O 150 - 300 gal/A	1
Bacillus thuringiensis	See individual brand labels		0
carbaryl (Sevin)	80S (WP)	2 1/2 lb	0
	5 B	20 - 40 lb	0
diazinon AG500	14 G	14 - 28 lb	preplant
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
malathion	5 EC	1 1/2 - 2 pt	1
methomyl (Lannate LV (variegated cutworm)	2.4 L	1 1/2 pt	1
permethrin (granulate cutworm)			
(Ambush)	2 EC	3.2 - 12.8 oz	up to day of harvest
(Pounce)	3.2 EC	2 - 8 oz	
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on che tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lb. active ingredient per acre p season which is equivalent to 76.8 oz of Ambush 2 EC or 48 oz of Pounce 3.2 EC.			
rotenone (Rotacide)	EC	1 gal	0
DARKLING BEETLES			
carbaryl (Sevin)	5 B	20 - 40 lb	0
DROSOPHILAS (FRUIT FLIES, VINEGAR FLIES)			
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	0
diazinon AG500 (vinegar fly)	4 EC	1/2 - 1 1/2 pt	1
malathion	8 EC	1 1/2 pt	1
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
rotenone (Rotacide) (fruit fly)	EC	1 gal	0
EUROPEAN CORN BORERS			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pt	0
FALL ARMYWORMS (See also: Armyworms)			
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
diazinon AG500	4 EC	3/4 - 1 pt	1
methomyl (Lannate LV)	2.4 L	1 1/2 pt	1
methoxychlor	2 L	75-100 oz/100 gal H_2O	7
FLEA BEETLES			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
		FLEA BEETLES (continued)	
carbaryl (Sevin)	80S (WP)	2/3 - 1 1/4 lb	0
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
disulfoton (Di-Syston 8)	8 EC	1.2 - 10.5 oz/100 ft	30 (see label for further instructions)
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qt	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
methyl parathion (Penncap M)	2 EC	2 - 4 pt	15
methoxychlor	4 L	1 - 3 qt	1 - 1 3/4 qt; 7 - 1 3/4+ qt
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz per 100 gal	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pt	0
rotenone (Rotacide)	EC	1 gal	0
		FLEAHOPPERS	
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0
		GARDEN SYMPHYLANS (SYMPHYLANS)	
fonofos (Dyfonate)	10 G	20 lb	preplant, broadcast
diazinon AG500	4 EC	10 qt	preplant, broadcast
		GRASSHOPPERS	
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest
carbaryl (Sevin)	5 B 80 S	20 - 40 lb 2/3 - 1 7/8 lb	0 0
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
rotenone (Rotacide)	EC	1 gal	0
		HORNWORMS (TOMATO HORNWORM, TOBACCO HORNWORM)	
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_2O 150 - 300 gal/A	1
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pt	up to day of harvest for 3 pt or less; 14 for 3+ pt
Bacillus thuringiensis	See individual brand labels.		0
carbaryl (Sevin) (tomato hornworm)	80S (WP)	1 1/2 - 2 1/2 lb	0
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qt	2
esfenvalerate (Asana XL) (tomato hornworm, tobacco hornworm)	0.66 EC	2.9 - 5.8 fl oz	1
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pt	1
methyl parathion (Penncap M)	2 EC	4 pt	15
methoxychlor	2 L	75 - 100 oz/100 gal H_2O	7
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lb. active ingredient per acre per season which is equivalent to 76.8 oz of Ambush 2 EC or 48 oz of Pounce 3.2 EC.			
		LACE BUGS	
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
LEAFHOPPERS			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest
carbaryl (Sevin)	80 S	2/3 - 1 1/4 lb	0
disulfoton (Di-Syston 8)	8 EC	1.2 - 10.5 oz/1000 ft	30 (see label for further instructions)
dimethoate (Cygon)	4 EC	1/2 - 1 pt	7
methoxychlor	2 L	75 - 100 oz/100 gal H_2O	7
methyl parathion (Setre)	4 EC	1 - 2 pt	15
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pt	0
rotenone (Rotacide)	EC	1 gal	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H_2O	0
LEAFMINERS			
azadiractin (Neemix)	25%	2 1/2 pt/100 gal H_2O 150 - 300 gal/A	1
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	up to day of harvest
diazinon AG500 (dipterous leafminer)	4 EC 50 WP	1/2 pt 1/2 lb	1 1
dimethoate (Cygon)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston 8)	8 EC	1.2 - 10.5 oz/1000 ft	30 (see label for further instructions)
methamidophos (Monitor) adults (fresh fruit only)	4 EC	1/2 - 1 1/2 pt	7
methyl parathion (Penncap M)	2 EC	2 - 4 pt	15
oxamyl (Vydate L) (serpentine leafminers except *Liriomyza trifolii*)	2 EC	2 - 4 pt	1
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherr tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lb. active ingredient per acre per season which is equivalent to 76.8 oz of Ambush 2 EC or 48 oz of Pounce 3.2 EC.			
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0
rotenone (Rotacide)	EC	1 gal	0
LOOPERS (See also: Cabbage Looper)			
azadiractin (Neemix)	25%	2 1/2 pt/100 gal H_2O 150 - 300 gal/A	1
Bacillus thuringiensis	See individual brand labels		—
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pt	1
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0
MEALY BUGS			
malathion (Cythion)	5 EC	1 1/2 - 2 pt	1
MITES			
MITES (GENERAL):			
dicofol (Kelthane) (Pacific, tropical, two-spotted, tomato russet)	MF (4 EC)	3/4 - 1 1/2 pt	2

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
		MITES (continued)	
disulfoton (Di-Syston 8)	8 EC	1.2 - 10.5 oz/1000 ft	30 (see label for further instructions)
malathion (Cythion)	8 EC	1 1/2 pt	1
methyl parathion	4 EC	1 - 2 pt	15
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0
TOMATO RUSSET MITE:			
dicofol (Kelthane)	MF- 4 EC	3/4 - 1 1/2 pt	2
endosulfan (Phaser, Thiodan)	3 EC	1 1/3 qt	2
methyl parathion (Setre)	4 EC	1/4 - 1 pt	15
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H_2O	0
sulfur	see individual brand labels		---
SPIDER MITE:			
dicofol (Kelthane)	MF- 4 EC	3/4 - 1 1/2 pt	2
malathion	5 EC	1 1/2 pt per 100 gal	1
		MOLE CRICKETS	
diazinon	14 G	7 lb	preplant
	AG500	1 qt	preplant, broadcast
		PINWORMS (TOMATO PINWORM)	
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_2) 150 - 300 gal/A	1
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pt	up to day of harvest for 3 pt or less; 14 for 3+ pt
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lb	14
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
methamidophos (Monitor) (fresh fruit only)	4 EC	1/2 - 1 1/2 pt	7
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pt	1
methyl parathion (Penncap M)	2 EC	4 pt	15
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
Pheromones (NoMate TPW Spiral) (NoMate TPW Fiber) (Checkmate TPW)	The product funtions by disrupting mating communications of adult moths. Read label carefully.		See label
		PLANT BUGS	
carbaryl (Sevin) (tarnished plant bug)	80S (WP)	1 1/2 - 2 1/2 lb	0
methyl parathion (Setre)	4 EC	2 pt	15
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H_2O	0
		PSYLLIDS	
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_20 150 - 300 gal/A	1
methyl parathion	4 EC	1 - 3 pt	15

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
		PSYLLIDS (continued)	
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
rotenone (Rotacide)	EC	1 gal	0
		SALTMARSH CATERPILLARS	
Bacillus thuringiensis	See individual brand labels		0
		SOUTHERN ARMYWORMS (See also: Armyworms)	
diazinon AG500	4 EC	3/4 - 1 pt	1
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
methomyl (Lannate LV	2.4 L	1 1/2 - 3 pt	1
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lb. active ingredient per acre per season which is equivalent to 76.8 oz of Ambush 2 EC or 48 oz of Pounce 3.2 EC.			
		SOWBUGS	
carbaryl (Sevin)	5 B	20 - 40 lb	0
		STINKBUGS	
azinphosmethyl (Guthion) (green stinkbugs)	2S, 2L (EC)	1 1/2 - 2 pt	up to day of harvest
carbaryl (Sevin) (suppression)	80S (WP)	1 1/2 - 2 1/2 lb	0
endosulfan (Phaser, Thiodan)	3 EC	1 - 1 1/3 qt	2
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0
		THRIPS	
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H_2O	0
		TOMATO FRUITWORMS (CORN EARWORM)	
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_20 150 - 300 gal/A	1
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pt	up to day of harvest for 3 pt or less; 14 for 3+ pt
Bacillus thuringiensis	See individual brand labels		0
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lb	14
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
endosulfan (Phaser, Thiodan)	3 EC	1 1/3 qt	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
methamidophos (Monitor)	4 EC	1/2 - 1 1/2 pt	7
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pt	1
methyl parathion (Penncap M)	2 EC	4 pt	15
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
TOMATO FRUITWORMS (CORN EARWORM) continued			
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lb. active ingredient per acre per season which is equivalent to 76.8 oz of Ambush 2 EC or 48 oz of Pounce 3.2 EC.			
TOMATO PINWORM			
Chlorpyrifos (Lorsban) (except cherry tomatoes)	50W	2 lb	14
TUBERWORMS			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 1/4 - 3 pt	0
VEGETABLE WEEVIL			
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_20 150 - 300 gal/A	1
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pt	0
WHITEFLIES			
azadirachtin (Neemix)	25%	2 1/2 pt/100 gal H_20 150 - 300 gal/A	1
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	up to day of harvest
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lb	14
endosulfan (Phaser, Thiodan)	3 EC	2/3 qt/100 gal H_2O- use 100 - 200 gal/A	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
methamidophos (Monitor) (apply in tank mix with pyrethroids)	4 EC	1 1/2 - 2 pt	7
permethrin (ambush)	25W	3.2 - 12.8 oz	0-Ambush 7-Monitor Apply as a tank miz with Monitor 4, ground spray only.
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 oz	0
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pt	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H_2O	0
WIREWORMS			
diazinon	14 G AG 500	21 - 28 lb 3 - 4 qt	preplant preplant, broadcast
dichloropropene (Telone)	II, C-17	see labels	—
YELLOW-STRIPED ARMYWORMS (See also: Armyworms)			
azinphosmethyl (Guthion)	2L, 2S (EC)	3 - 6 pt	up to day of harvest for 3 pt; 14 - 3+ pt
endosulfan (Phaser, Thiodan)	3 EC	1 1/3 qt	2
esfenvalerate (Asana XL) (Western Yellow Striped)	0.66 EC	5.8 - 9.12 oz	1

TABLE 2. Limitations and Restrictions

Chemical	Restricted Entry Interval in Hours	Post signs
carbaryl (Sevin)	12	No
pyrethrins + piperonyl butoxide (Pyrenone)	12	No
aliphatic petroleum (JMS Stylet Oil)	12	No
*azinphosmethyl (Guthion)	48	No
diazinon	12	No
dimethoate (Cygon)	12	No
endosulfan (Thiodan, Phaser)	24	No
*esfenvalerate (Asana XL)	12	No
malathion	12	No
*methamidophos (Monitor)	48	Yes
*methomyl (Lannate)	48	No
*methyl parathion	48	Yes
oil (Sun Spray)	12	No
pyrethrins + rotenone (Pyrellin)	12	No
*disulfoton (Di-Syston)	48	Yes
rotenone (Rotacide)	12	No
soap, insecticidal (M-Pede)	12	No
azadirachtin (Neemix)	12	No
Bacillus thuringiensis	12	No
chlorpyrifos (Lorsban)	12	No
*permethrin (Ambush, Pounce)	24	No
cryolite (Kryocide)	12	No
methoxychlor	12	No
*fonofos (Dyfonate)	48	Yes
*oxamyl (Vydate)	24	No
docofol (Kelthane)	12	No
sulfur	12	No
*dichloropropene (Telone)	72	Yes

*Restricted Use Chemical

APPENDIX E

NEMATICIDES REGISTERED FOR USE ON FLORIDA TOMATO

Row Application (6' row spacing - 36" bed)[4]					
Product	Broadcast (Rate)	Recommended Chisel Spacing	Chisels (per Row)	Rate/Acre	Rate/1000 Ft/Chisel
FUMIGANT NEMATICIDES					
Methy Bromide[3]					
98-2	240-400 lb	12"	2	120-200 lbs	8.2-13.7 lb
80-20	225-350 lb	12"	2	112-175 lbs	7.7-12.0 lb
75-25	240-375 lb	12"	2	120-187 lbs	8.2-12.9 lb
7-30	300-350 lb	12"	2	150-175 lbs	10.3-12.0 lb
67-33	225-375 lb	12"	2	112-187 lbs	7.7-12.9 lb
57-43	350-375 lb	12"	2	175-187 lbs	10.3-12.9 lb
50-50	340-400 lb	12"	2	175-250 lbs	10.3-17.2 lb
Chloropicrin[1]	300-500 lb	12"	2	150-250 lbs	10.3-17.2
Telone II[2]	12-15 gal	12"	2	6-7.5 gal	39.7-66.1 fl oz
Vapam	50-100 gal	5"	3	25-50 gal	1.1-2.2 gal
NON-FUMIGANT NEMATICIDES					
Vydate L - treat soil before or at planting with any other appropriate nematicide or a Vydate transplant water drench followed by Vydate foliar sprays at 7-14 day intervals through the season; do not apply within 7 days of harvest; refer to directions in appropriate "state labels", which must be in the hand of the user when applying pesticides under state registrations.					

1. If treated area is tarped, dosage may be reduced by 33%.

2. The manufacturer of Telone II and Telone C-17 has suspended their sale and distribution in all of Florida south of and including Dixie, Gilchrist, Marion, Volusia, and Flager Counties.

3. Use of methyl bromide for agricultural soil fumigation is scheduled for phaseout Jan 1, 2001.

4. Rate/acre estimated for row treatments to help determine the approximate amounts of chemical needed per acre of field. If rows are closer, more chemical will be needed per acre; if wider, less.

Rates are believed to be correct for products listed when applied to mineral soils. Higher rates may be required for muck (organic) soils. Growers have the final responsibility to guarantee that each product is used in a manner consistent with the label. The information was compiled by the author as of July 28, 1994 as a reference for the commercial Florida tomato grower. The mentioning of a chemical or propietary product in this publication does not constitute a written recommendation or an endorsement for its use by the University of Florida, Institute of Food and Agricultural Sciences, and does not imply its approval to the exclusion of other products that may be suitable. Products mentioned in this publication are subject to changing Environmental Protection Agency (EPA) rules, regulations, and restrictions. Additional products may become available or approved for use.

Prepared by: J. W. Noling, Extension Nematology, CREC, Lake Alfred, FL

APPENDIX F

Tomato Plant Disease Control Guide

Thomas A. Kucharek

Crop	Chemical	Maximum Rate/Acre/ Appl.	Maximum Rate/Acre/ Crop	Min. Days To harvest	Pertinent Diseases	Select Remarks
Tomato	For best possible chemical control of bacterial spot, a copper fungicide must be tank-mixed with a maneb or mancozeb fungicide.					
	Ridomil 2E	8 pts. per treated acre	12 pts.	-	Pythium diseases	See label for use at and after planting
	Kocide 101, Blue Shield, or Champion WP'S	4 lbs.	-	NTL[1]	Bacterial spot	
	Kocide 606, Cuproxat, Champion or Champ FL'S	5 1/3 pts.	-	NTL[1]	Bacterial spot	
	Basic copper sulfate (CP or Tri-Basic) WP'S	4 lbs.	-	NTL[1]	Bacterial spot	
	Copper count N	3/4 gal.	-	NTL[1]	Bacterial spot	
	Maneb 80WP	3 lbs.	21 lbs.	5	Early blight Late blight Grey leaf spot Bacterial spot[2]	

[1]Not within 5 days when tank mixed with maneb or mancozeb fungicides.
[2]When tank-mixed with a copper fungicide.

Crop	Chemical	Maximum Rate/Acre/ Appl.	Crop	Min. Days To harvest	Pertinent Diseases	Select Remarks
Tomato (Cont'd)	Manex or Manex Plus Zinc F4 FL's	2.4 qts	16.8 qts.	5	Early blight Late blight Gray leaf spot Bacterial spot[1]	
	Dithane DF, Penncozeb or Manzate 200 DF'S	3 lbs.	21 lbs.	5	Early blight Late blight Gray leaf spot Bacterial spot[1]	
	Penncozeb or Dithane M-45 WP'S	3 lbs.	21 lbs.	5	Early blight Late Blight Gray leaf spot Bacterial spot[1]	
	Dithane F-45 or Manex II FL'S	2.4 qts.	16.8 qts.	5	Early blight Late blight Gray leaf spot Bacterial spot[1]	
	Bravo 720, Terranil 6L, or Echo 720	3 pts.	-	1	Early blight Late blight Gray leaf spot Target spot	Use higher rates at fruit set and lower rates before fruit set.

[1]When tank-mixed with a copper fungicide

Crop	Chemical	Maximum Rate/Acre/ Appl.	Crop	Min. Days To harvest	Pertinent Diseases	Select Remarks
Tomato (Cont'd)	Bravo 90DG or Terranil 90DF Echo 90 DF	2 1/4 lbs. 2.3 lbs. 2.3 lbs	-	1	Early blight Late blight Gray leaf spot Target spot	Use higher rates at fruit set and lower rates before fruit set.
	Bravo W-75	3 lbs.	-	1	Early blight Late blight Gray leaf spot Target spot	
	Bravo 500, Chloronil 500, Terranil 4L, Evade, Supanil, or Echo 500	4 pts.	-	1	Early blight Late blight Gray leaf spot Target spot	Use higher rates at fruit set and lower rates before fruit set.
	Ridomil Bravo 81W	3 lbs.	-	1	Late blight Early blight Gray leaf spot Target spot	Limit is 4 appl/crop
	Ridomil MZ58 WP	2 lbs.	-	5	Late blight	Limit is 4 appl/crop
	Benlate 50WP	1 lb.	-	1	Leaf mold Botrytis Sclerotinia	

[1]Do not exceed limits of mancozeb active ingredient as indicated for Dithane, Penncozeb, Manex II or Manzate 200 (e.g. 16.1 lbs. a.i. for Dithane M45 80WP equals 21 lbs. of formulation for Dithane M-45 or 33.5 lbs formulation of Ridomil MZ-58.

Crop	Chemical	Maximum Rate/Acre/ Appl.	Maximum Rate/Acre/ Crop	Min. Days To harvest	Pertinent Diseases	Select Remarks
Tomato (Cont'd)	JMS Stylet Oil	3 qts.	-	NTL	Potato Virus Y Tobacco Etch Virus	See label for specific info on appl. technique (e.g. use of 400 psi spray pressure)
	Ridomil/Copper 70W		2.5 lbs.[1]		7	Late blight

[1]Maximum/crop is 3.0 lbs. a.i. of metalaxyl from Ridomil/copper, Ridomil MZ58, & Ridomil Bravo 81W