Vegetable Crops
Special Series
SS-VEC-01

Proceedings
Florida Tomato Institute
1991

Vegetable Crops Department
Institute of Food and Agricultural Sciences
University of Florida, Gainesville, FL 32611

C.S. Vavrina
Editor

TABLE OF CONTENTS

APPENDICES

INSECT-TRANSMITTED VIRUSES OF TOMATO IN FLORIDA

JANE E. POLSTON
DAVID J. SCHUSTER
Departments of Plant Pathology and Entomology
Gulf Coast Research and Education Center
Bradenton, FL

and

ERNEST HIEBERT
Department of Plant Pathology
Gainesville, FL

Introduction

Diseases caused by viruses have at various times interfered with tomato production in the state of Florida. Though there are a large number of viruses which can infect tomato, only nine viruses have been identified in Florida which cause disease in tomato. Two of these viruses, tobacco mosaic virus and tomato mosaic virus, are transmitted mechanically. The other seven, all insect-transmitted, are the Florida tomato geminivirus, potato virus Y, pseudo curly top virus, tobacco etch virus, tomato spotted wilt virus, tomato yellow top virus, and a newly discovered closterovirus.

Tomato Viruses - the Worldwide Picture

Tomato production around the world is plagued by viruses. Approximately 30 different viruses have been identified which cause a naturally occurring disease in tomato. Many more viruses have been identified which can infect tomato experimentally but for various reasons (the lack of the vector, the lack of an overseasoning source, etc...) are not found inciting disease in tomato fields. Many of these viruses have several recognizable strains which vary in symptom type and severity, host range and transmissibility.

These 30 or so viruses are transmitted by a wide range of vectors. The majority are transmitted by aphids. The next largest group of viruses is transmitted by whiteflies. This is followed by thrips, beetles, leafhoppers, treehoppers and nematodes. In the temperate zone, aphid- and leafhopper-transmitted viruses predominate while in the warmer climates aphid- and whitefly-transmitted viruses are the main problem.

Tobacco mosaic and tomato mosaic virus when present can be impediments to production. The use of resistant cultivars has reduced the impact of these two mechanically-transmitted viruses.

Recently, the whitefly-transmitted geminiviruses have been of particular concern in Florida. Though there is an absence of hard data in many cases, it appears that there are geminiviruses infecting tomato plants throughout the tropics and sub-tropics. Reports of these viruses have come from Brazil (Matryis et al., 1975), Costa Rica (Rosset et al., 1990), Egypt (Nour El-Din et al., 1969), Japan (Osaki et al., 1979), India (Verma et al., 1975) Israel (Cohen and Nitzany, 1966), Mexico (Brown and Nelson, 1988), Thailand (Thanapase et al., 1983), and Venezuela (Lastra and Gil, 1981). There are probably undocumented infections in many other countries. Because these viruses are geographically separated and are not seed transmitted it is likely that a number of different viruses are causing these diseases. Symptoms in tomato generally fall into one or more of three catagories: leaf curl, mosaic or bright yellow mosaic. Early infections often result in stunted plants with no yield. No symptoms on the fruits have been described. Infected tomatoes in general have reduced yields. In most cases these viruses are a major hindrance to tomato production.

Tomato Viruses in Florida

To date, seven insect-transmitted viruses have been identified as the cause of disease in tomato plants in Florida. Two other viruses, tobacco mosaic virus and tomato mosaic virus, are mechanically transmitted. Four viruses have been known for many years and three have been recognized only recently. Of the seven viruses, three are transmitted by aphids, either non-persistently or persistently, one is transmitted by whiteflies, one by thrips, one by treehoppers, and one has an undetermined vector. Only three of the seven viruses, Florida tomato geminivirus, tomato spotted wilt virus and potato virus Y, are believed to have an economic impact on Florida tomato production.

Potato Virus Y

Potato virus Y (PVY) is the type member of the Potyvirus group, the largest group of plant viruses. PVY is distributed around the world and has a large number of characterized strains. PVY was first reported from Florida in 1946 (Felix, 1946). In general PVY causes a mild mottle with some rugosity and leaf distortion in tomato. In older infections leaflets and petioles may roll downward giving the plant a droopy appearance (Conover and Fulton, 1953). There are usually no symptoms on the fruit. A more severe strain of PVY has been found in Florida which causes an interveinal necrosis in addition to the symptoms described above (Conover and Fulton, 1953). Infections in young

plants can significantly reduce yields.

PVY can be transmitted by over 25 species of aphids (de Bokx and Huttinga, 1981). Aphids acquire and transmit PVY in a matter of minutes, but do not retain the virus for more than about one hour (non-persistent transmission). Myzus persicae, the green peach aphid, is one of the most common aphids in Florida and can readily transmit PVY (Adlerz, 1981). It is possible that it is the most important vector of PVY in tomato in this state. PVY is readily detected in tomato by ELISA (enzyme-linked immunosorbent assay) or virus inclusion body analysis (Christie and Edwardson, 1977).

The host range of PVY is mainly in the family Solanaceae. In Florida, PVY can easily be found in tobacco, potato and pepper as well as tomato. The major weed hosts of PVY in Florida are the solanaceous plants black nightshade (Solanum nigrum) and Solanum gracile (Zitter, 1971). These two plants grow as perennials in southern Florida and have been identified as virus sources for peppers (Zitter, 1971).

Tobacco Etch Virus

Tobacco etch virus (TEV) also belongs to the Potyvirus group and is distantly related to PVY. TEV causes rugosity, puckering and mottling in tomato leaves and mottled and undersized fruit. These symtoms are generally more severe than those caused by PVY. Several biologically distinct strains of TEV have been identified though all cause similar symptoms in tomato (Zitter, 1973).

TEV infects other solanaceous plants and can easily be found in tobacco, tomato and pepper plants in Florida. It also has been found in Florida naturally infecting the solanaceous weeds Solanum aculeatissimum Jacq., black nightshade (Solanum nigrum L.), Physalis arenicola Kearney, Physalis angulata L. and the non-solanaceous weeds Cassia tora L. and Linaria canadensis (L). Dum. Black nightshade, a symptomless host, is suspected of being the most important source of TEV for pepper fields (Anderson, 1959). This also may hold true for tomatoes.

TEV is non-persistently transmitted by at least 10 species of aphids, including the green peach aphid, Myzus persicae, which is a common aphid in Florida (Adlerz, 1981, Purcifull and Hiebert, 1982). TEV is readily detected in tomato by ELISA and by virus inclusion body analysis (Christie and Edwardson, 1977).

Though undocumented in tomato, TEV infection of pepper in Palm Beach county TEV first appears two weeks before peak aphid flights. The same may be true in tomato. Aphid populations begin to build in the latter half of the fall tomato crop and continue to increase throughout the spring tomato crop peaking in April (Adlerz, 1981). The appearance and frequency of TEV in tomato is probably correlated with aphid populations, so that as aphid

populations increase, TEV infections also increase.

Florida Tomato Geminivirus

The Florida tomato geminivirus (FTGV) is a relatively new virus problem in tomatoes in Florida. The virus was first seen in tomato fields in the fall of 1989 and has been found in tomato every season since then. FTGV appears to cause a chlorotic mottle in younger leaves and chlorosis and drooping of older leaves. As with other viruses, symptoms are influenced by temperature and cultivar. FTGV is best detected using a nucleic acid hybridization assay, though virus inclusion body analysis can also be used.

FTGV belongs to the Geminivirus group of plant viruses. It is transmitted persistently by a single species of whitefly, Bemisia tabaci Genn., the sweet potato whitefly. The whitefly-transmitted geminiviruses can be acquired in as little as 30 minutes. After a period of a few hours the virus can be transmitted in as little as 30 minutes. Once the whitefly has acquired the virus, it can transmit for the remainder of its life. FTGV has been associated with reductions in yield in Florida. The virus appears to reduce yield in tomato by reducing the size of fruit.

At this time the virus appears to have a very narrow host range. In the field the virus has been found only in tomato. Experimentally, the virus has been shown to infect beans (Phaseolus vulgaris L.), and two species of tobacco, Nicotiana x edwardsonii and N. benthamiana. Potato and pepper, two solanaceous crops grown near and at the same time as tomato, are not hosts of this virus.

FTGV is genetically similar to two other Caribbean geminiviruses, abutilon mosaic geminivirus and rhynchosia mosaic geminivirus. However there appear to be significant differences in the host range among the three viruses.

Very little is known about the ecology of this virus. Many weed species have been eliminated as potential sources of the FTGV and no species have been found yet which could serve as reservoirs of the virus. Virus incidence is roughly correlated with whitefly populations; the greater the whitefly populations the higher the incidence of virus.

Tomato Spotted Wilt Virus

Tomato spotted wilt virus (TSWV) is another recent virus problem in Florida. TSWV is found in the temperate and subtropical regions around the world, and infects a wide range of plants (Ie, 1970). TSWV was first identified in tomato in north Florida in 1986 and has been moving southward and increasing in frequency each year since. TSWV can cause a

variety of symptoms in tomato. The characteristic symptoms are bronzing, chlorosis and wilting, but TSWV can be present without these classic symptoms. TSWV can cause the development of ringspots on fruit and deformed fruit.

Until this year TSWV was considered a plant virus though not placed in any taxonomic group. But within the last year TSWV has been placed in the insect virus family, Bunyaviridae. TSWV is considered both an insect and a plant virus since it replicates within both types of organisms. Two strains of TSWV, known as L (for lettuce) and I (for impatiens) recently have been designated as two distinct viruses. The L strain, which is the strain that infects tomatoes and other vegetables, is still known as TSWV. The I strain, which infects many ornamentals, now is called impatiens necrotic spot virus. There appears to be a lot of variability among different isolates of TSWV and within the next few years some of those isolates possibly will be classified as separate viruses.

TSWV is most likely transmitted in Florida tomato fields by two species of thrips, western flower thrips (Frankliniella occidentalis), the onion thrips (Thrips tabaci), and the tobacco thrips (F. fusca). The transmission ability has not yet been established for the flower thrips, F. bispinosa, the most common thrips on west central Florida tomatoes. The eastern flower thrips (F. tritici), also common on tomatoes, is unable to transmit TSWV. TSWV is persistently transmitted by these thrips vectors. Immature thrips acquire TSWV and adult thrips transmit. Acquisition can occur in as little as 15 minutes. There is an incubation period of 4 to 10 days before the thrips can transmit. Adults can transmit virus for 22 to 30 days after acquisition but sometimes retain the virus for life.

Weed hosts and plant reservoirs of the virus in Florida are not yet known, however TSWV has an extremely broad host range among cultivated plants. TSWV can be detected in tomato by ELISA or virus inclusion body analysis.

Tomato Yellow Top Virus

Tomato yellow top virus (TYTV) was first described from Florida in 1977 (Zitter and Tsai, 1981). TYTV is probably a Luteovirus, and occurs in several other tomato production areas around the world. TYTV causes interveinal and marginal chlorosis and downward leaf rolling on young leaves and chlorosis, rugosity, leaf rolling and purpling in older leaves. TYTV reduces flower formation and fruit set. Symptom expression is influenced by temperature and symptoms are best seen in the spring.

TYTV is transmitted in a persistent manner by several species of aphids, including Myzus persicae (Sulzer). The aphid can acquire the virus after a minimum of one hour, there is a time lag of several hours before the virus can be transmitted, and the aphid can then transmit the virus for many days after.

TYTV is only a problem in Florida in areas where potatoes have been grown before tomato. In Florida the TYTV weed host, black nightshade, (Solanum nigrum L.) is suspected of acting as an intermediate host between the potato and tomato crop.

TYTV can be detected using ELISA.

Pseudo Curly Top Virus

Pseudo curly top geminivirus (PCTV) is a geminivirus which was first described from Florida in 1950 (McDaniel and Tsai, 1990). Fortunately this virus occurs at low frequencies and outbreaks of higher frequencies are sporadic. The symptoms caused by this virus are severe; leaf rolling, enlarged veins, purpling and stunting (Simons, 1962). Infected plants are most often seen in the fall tomato crop.

PCTV is transmitted in a persistent manner by the treehopper, Micrutalis malleifera Fowler (Simons, 1958). Apparently the vector prefers Solanum gracile Link to tomato and only infrequently feeds on tomato. This virus does not usually cause any concern in tomato production though sporadic outbreaks have been recorded.

PCTV can be detected in tomato using a nucleic acid spot hybridization assay and virus inclusion body analysis.

Closterovirus

A new virus has been found in tomato in southwest Florida. Tentatively named the tomato closterovirus (TCV), the virus was first found in Collier County in 1990 (McGovern et al., 1991). It appears to belong to the Closterovirus group, based on the size and shape of the virus particles and virus inclusion bodies, and the size and type of nucleic acid. Closteroviruses can be transmitted either by aphids or whiteflies, but not by both. The vector for this virus is not yet known, but is currently being investigated.

The symptoms associated with this virus are unclear at this time. The importance and distribution of this virus have yet to be determined. Closteroviruses cause a number of serious diseases in other crops. Currently this virus can be detected using a nucleic acid spot hybridization assay.

Survey of Spring Tomatoes in West Central Florida

Tomato samples from plants showing a variety of virus-like symptoms were collected in April, 1991 from five locations in Manatee County, four farms and the Gulf Coast Research and Education Center. Many of the samples were selected because they displayed symptoms beyond the typical mosaic associated with FTGV. These samples were analyzed for five different viruses using ELISA for all but the Florida tomato geminivirus, which was detected using a nucleic acid dot hybridization assay. The results are shown in Table 1.

FTGV was the most frequently detected virus and was detected in almost half of the samples. PVY was detected in about a third of the samples. TSWV was found in 7% of the samples. TEV was detected in only 2% of the samples. Alfalfa mosaic virus (AMV) and cucumber mosaic virus (CMV) were not detected in any of the samples. These two viruses have been reported in tomato from other states but neither have been reported infecting tomato in Florida. More than one virus was detected in 43% of the samples. Approximately one third of the samples either were not infected with a virus, though they showed virus-like symptoms, or were infected with a virus or viruses for which assays were not conducted.

Timing of Virus Infections

Insect vectored tomato viruses are limited in their distribution and spread by the biology and life cycle of their vectors. The aphid-transmitted viruses are only present when their vector(s) are present (unless they're seed-borne or propagule-borne). Often the more vectors the higher the incidence of virus.

The results of one and a half years of water pan trap catches of aphids from west central Florida, is presented in Figure 1. Trap catches of aphids were low throughout the summer and remained low until later in the fall when they showed a large peak in November. Their numbers remain high until early January when they began to taper off. This suggests that the aphid-transmitted viruses would be most common in the crop following the population peaks, the spring crop, and would be less of a concern in the fall crop. Two aphid-transmitted viruses were detected in the samples collected during the spring season, one, PVY, at fairly high rates (38%).

The whitefly populations in west central Florida show a very different distribution from the aphid populations (Figure 2). The numbers of whiteflies caught in traps were the highest in June, reflecting the movement of whiteflies out of declining tomato fields. Trap catches declined somewhat from that peak but remained relatively high throughout the summer and fall with a

second peak in late December, again reflecting movement out of declining tomatoes. The trap catches in August and September suggest a fair amount of movement of whiteflies. Numbers of whiteflies trapped were lowest in January, February and March. These fluctuations in trap catches suggest that the whitefly-transmitted viruses will probably be more of a concern in the fall crop than in the spring crop. Since FTGV was detected in 50% of the samples collected in the spring, this does not present a bright outlook for fall tomato crops.

Literature cited

Adlerz, W. C. 1981. Weed hosts of aphid-borne viruses of vegetable crops in Florida. pp. 467-478 in Pests, Pathogens and Vegetation. J. M. Thresh, ed. Pitman Publishing Inc., Marshfield, Mass.

Anderson, C. W. 1959. A study of field sources and spread of five viruses of peppers in central Florida. Phytopathology 49:97-101.

de Bokx, J. A. and H. Huttinga. 1981. Potato virus Y. No. 242 in: Descriptions of Plant Viruses. Commonw. Mycol. Inst., Assoc. Appl. Biologists, Kew, Surrey, England.

Brown, J. K. and M. R. Nelson. 1990. Transmission, host range, and virus-vector relationships of chino del tomate virus, a whitefly-transmitted geminivirus from Sinaloa, Mexico. Plant Disease 72:866-869.

Cohen,S. and F. E. Nitzany. 1966. Transmission and host range of tomato yellow leaf curl virus. Phytopathology 56:1127-1131.

Conover, R. W. and R. W. Fulton. 1953. Occurrence of potato virus Y on tomatoes in Florida. Plant Dis. Reptr. 37:460-462.

Christie, R. G. and J. R. Edwardson. 1977. Light and electron microscopy of plant virus inclusions. Fla. Agric. Exp. Stn. Monogr. 9, 155 p.

Felix, E. L. 1946. Virus diseases of vegetables. Florida Agricultural Expt. Sta. Ann. Rept. for 1946. p. 191.

Ie, T. S. 1970. Tomato spotted wilt virus. No. 39 in: Descriptions of Plant Viruses. Commonw. Mycol. Inst., Assoc. Appl. Biologists, Kew, Surrey, England.

Lastra, R. and F. Gil. 1981. Ultrastructural host cell changes associated with tomato yellow mosaic. Phytopathology 71:524-528.

Matyis, J. C., D. M. Silav, A. R. Oliveira, and A. S. Costa. 1975. Purificacao e morfologia do virus do mosaico dourado do tomateiro. Summa Phytopathologica I:267-274.

McDaniel, L. L. and J. H. Tsai. 1990. Partial characterization and serological analysis of pseudo-curly top virus. Plant Dis. 74:17-21.

McGovern, R. J., C. L. Davis, R. M. Harveson, R. F. Lee, H. R. Pappu, C. L. Niblett, and R. H. Brlansky. 1991. Report of a clostero-like virus from tomatoes in Florida. Phytopathology (in press).

Nour El-Din, F., H. M. Mazyad, and M. F. Hassan. 1969. Tomato yellow leaf curl virus disease. Agricultural Research Review (Cairo) 47:49.

Osaki, T. and T. Inouye. 1978. Resemblance in morphology and intranuclear appearance of viruses isolated from yellow dwarf diseased tomato and leaf curl diseased tobacco. Annals Phytopath. Soc. Japan 44:167-178.

Purcifull, D. E. and E. Hiebert. 1982. Tobacco etch virus. No. 258 in: Descriptions of Plant Viruses. Commonw. Mycol. Inst., Assoc. Appl. Biologists, Kew, Surrey, England.

Rosset, P., R. Meneses, R. Lastra and W. Gonzalez. 1990. Estimacion de perdidas e identificacion del geminivirus transmitido al tomate por la mosca blanca Bemisia tabaci Genn. (Homoptera: Aleyrodidae) en Costa Rica. Manejo Integrado de Plagas, No. 15, p.24-34.

Simons, J. N. 1962. The pseudo-curly top disease in south Florida. J. of Econ. Entomol. 55:358-363.

Simons, J. N. and D. M. Coe. 1958. Transmission of pseudo-curly top virus in Florida by a treehopper. Virology 6:43-48.

Thanapase, W. P. Poolpol,, T. Sutabutra, S. Attathom. 1983. Causal agent and some important characteristics of tomato leaf curl disease. Kasetsart J. Nat. Sci. 17:90-99.

Verma, H. N., K. M. Srivastava and A. K. Mathur. 1975. A whitefly transmitted yellow mosaic virus disease of tomato from India. Plant Dis. Reptr. 59:494-498.

Zitter, T. A. 1971. Virus diseases of pepper in South Florida. Plant Dis. Reptr. 56:991-994.

Zitter, T. 1973. Further pepper virus identification and distribution studies in Florida. Plant Dis. Reptr. 57:991-994.

Zitter, T. and J. H. Tsai. 1981. Viruses infecting tomato in southern Florida. Plant Dis. 65:787-791.

Table 1. Frequency of Six Viruses Detected in Tomato Plants Showing Virus-Like Symptoms

Location	No. Samples[1]	Viruses Detected						
		AMV[2]	CMV[2]	FTGV[3]	PVY[2]	TEV[2]	TSWV[2]	ø
A_1	8	0	0	7	7	0	1	0
A_2	23	0	0	8	1	0	0	14
B	17	0	0	6	9	0	2	5
C	5	0	0	0	3	2	1	2
D	14	0	0	13	7	0	2	0
E	15	0	0	6	4	0	1	6
Total	82	0	0	40	31	2	7	27
Frequency		0%	0%	48%	38%	2%	9%	33%

[1]Samples were collected April, 1991 in Manatee County, FL.
[2]Detected using ELISA (enzyme linked-immunosorbent assay).
[3]Detected using nucleic acid spot hybridization assay.

AMV = Alfalfa mosaic virus, CMV = Cucumber mosaic cucumovirus, FTGV = Florida tomato geminivirus, PVY = Potato virus Y, TEV = Tobacco etch potyvirus, TSWV = Tomato spotted wilt bunyavirus, ø = no virus detected.

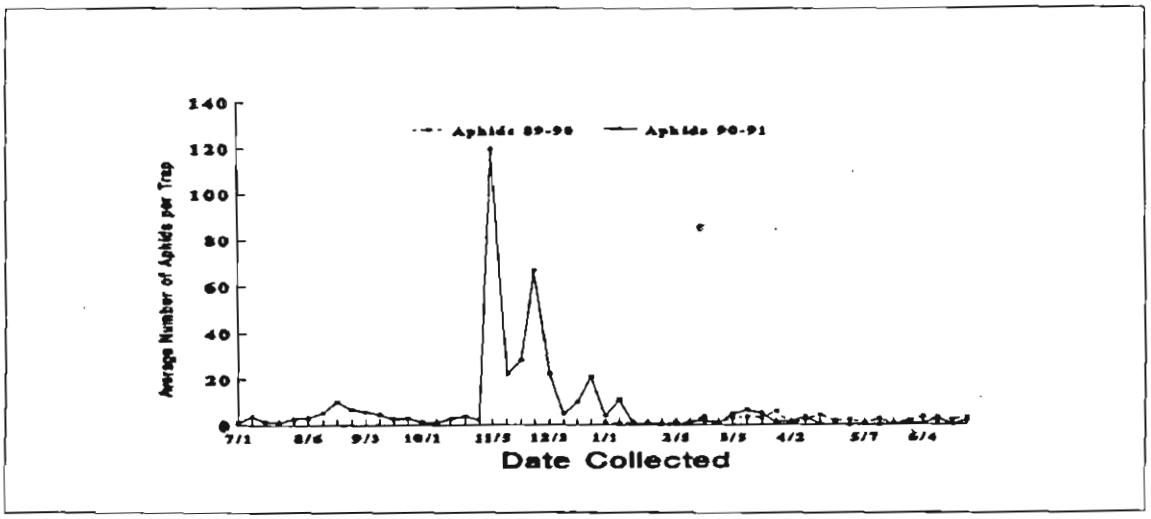


Figure 1. Frequency of aphids trapped in water pan traps at the Gulf Coast Research and Education Center from December 1989 through July 1991. Values represent averages of all aphid species collected twice weekly from 4 x 4 in. yellow pan traps, at four locations.

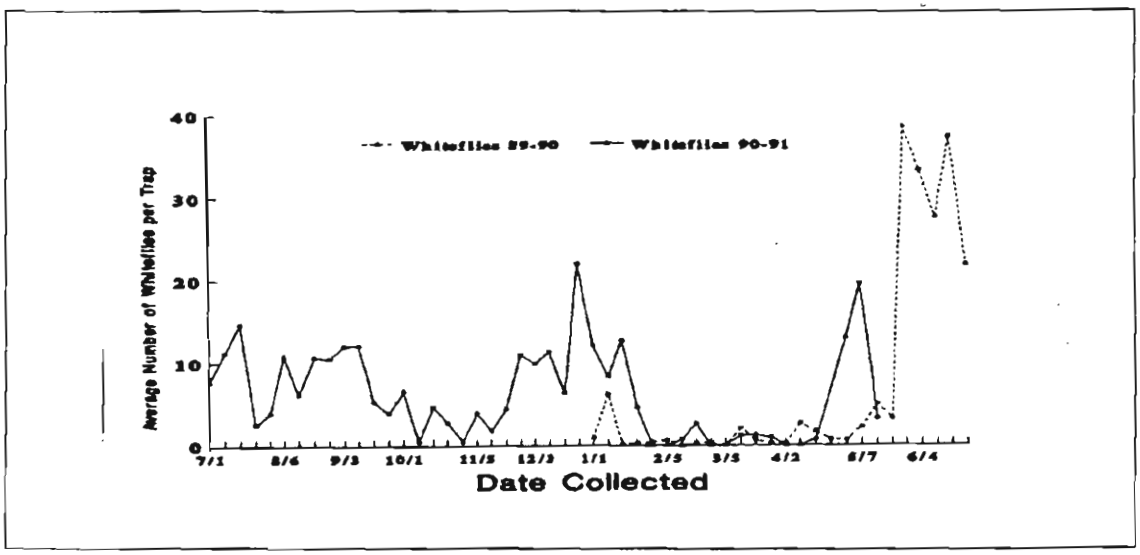


Figure 2. Frequency of whiteflies trapped in water pan traps at the Gulf Coast Research and Education Center from December 1989 through July 1991. Values represent averages of all whitefly species collected twice weekly from 4 x 4 in. yellow pan traps, at four locations.

ALTERNATE HOSTS OF THE FLORIDA TOMATO GEMINIVIRUS

R. J. McGovern
P. A. Stansly
Southwest Florida Research
and Education Center
Immokalee, FL 33934

J. E. Polston
D. J. Schuster
Gulf Coast Research
and Education Center
Bradenton, FL 34203

E. Hiebert
Plant Pathology Dept.
University of Florida
Gainesville, FL 32511

Introduction

Since its first appearance in the fall of 1989, a new disease of tomato caused by the Florida tomato geminivirus (FTGV) has become an important limiting factor for tomato production in the southern half of the state. Common symptoms of FTGV in tomato includes mosaic, stunting, distortion of shoots and leaves and reduced yields. The virus is vectored (spread) by *Bemisia tabaci*, the sweetpotato whitefly (SPWF) (3).

Alternate hosts including both weeds and cultivated plants often play key roles in the epidemiology of plant viruses by providing reservoirs for the virus itself and/or its vectors. A number of important weed hosts have been identified for aphid-vectored viruses in Florida (1). Our goal is to gain fundamental knowledge concerning the host range of FTGV so that effective management strategies may be developed.

Methods

Field Surveys - Samples of symptomatic and nonsymptomatic weeds were collected, for the most part, from within and around tomato fields in southwest Florida exhibiting a high incidence of geminivirus. Weed surveys were conducted both during and after the spring, 1991 cropping season. Over 590 samples representing 39 species in 14 families (Caprifoliaceae, Commelinaceae, Compositae, Convolvulaceae, Cruciferae, Cucurbitaceae, Euphorbiaceae, Leguminosae, Malvaceae, Myrtaceae, Onagraceae, Rubiaceae, Solanaceae, Urticaceae) were tested for the presence of FTGV. Virus detection was accomplished by means of nucleic acid hybridization assays (dot-blots) which utilized nucleic acid probes complementary to FTGV. Two probes were used; one (A-probe) is general in scope and detects SPWF-transmitted geminiviruses, while the other (B-probe) is highly specific for FTGV. Sweetpotato whiteflies collected from certain weeds in the field were also assayed in the same manner.

Transmission Studies - Virus inoculum was originally obtained from cuttings of an infected, field-grown tomato plant (*Lycopersicum esculentum* (L). Karst. ex Farw. 'Sunny') which exhibited typical FTGV symptoms. Two different methods were utilized for virus acquisition by SPWF. In one method infected tomato plants were used to rear colonies of viruliferous SPWF while nonviruliferous colonies of SPWF were maintained on tomatoes free of FTGV. Alternatively, SPWF from an

nonviruliferous colony were allowed an acquisition time of 48-72 hours on FTGV-infected tomatoes before being transferred to test plants.

Three controls were used for each experiment: (1) test plant species exposed to nonviruliferous SPWF, (2) tomatoes exposed to nonviruliferous SPWF, and (3) tomatoes exposed to viruliferous SPWF. The fourth treatment consisted of the weeds and cultivated plants exposed to viruliferous SPWF. Each treatment consisted of 4-12 seedlings which were maintained in screened cages in transfer rooms under fluorescent lights at 23-25C/73-77C or in a greenhouse at 21-37C/70-100F. Approximately 250 SPWF (~20 SPWF/plant) were introduced into the cages and allowed to feed for 48-72 before being killed with insecticide. In a number of cases transmission to 'Sunny' tomatoes from certain field collected weeds exhibiting geminivirus-like symptoms was also attempted via SPWF and mechanical means. Approximately 250 SPWF were introduced into cages containing symptomatic weed plants and allowed to feed for 24 hours. Eight tomato plants were then placed in the cages. Whiteflies were augmented on a weekly basis for 3-4 weeks.

Attempts to mechanically transmit virus to tomato from symptomatic weeds used pulverized tissue (1:10, W/V) in a buffer containing 0.1 M KH_2PO_4 containing 0.2% mercaptoethanol at a Ph of 7.4. Virus inoculum was rubbed on the leaves of test plants coated with carborundum (320 grit) using cotton tip applicators. Positive controls were inoculated with either macerates from FTGV-infected tomatoes and negative controls received buffer alone. Mechanically inoculated plants were maintained as above.

Over 240 plants representing 23 species in 8 families (Compositae, Cruciferae, Cucurbitaceae, Euphorbiaceae, Leguminosae, Malvaceae, Onagraceae, Solanaceae) were inoculated via SPWF or mechanical means. All experimental plants were monitored for virus symptom expression for 3-4 weeks. In the case of the mechanical transmission attempts test plants were cut back and symptom expression was monitored for an additional 3-4 weeks. Detection of FTGV in test plants also utilized dot-blot assays. Individual SPWF from positive and negative colonies were probed for FTGV in the same manner.

Results and Discussion

Whitefly transmission of FTGV from tomato to tomato (positive controls), based on expression of typical symptoms and dot-blot assays averaged above 75%. Mechanical transmission from tomato to tomato ranged from 25-30%. Three of 8 SPWF from the FTGV-infected colony gave a strong positive reaction, 5 gave a weak positive and all of the whiteflies from the FTGV-free colony tested negative by means of dot-blots. None of the test plants exposed to SPWF from the FTGV-free colony developed symptoms or tested positive for FTGV.

Three symptomatic field-collected weed species, *Sida acuta* Burm. f. (Teaweed), *Sida*

hombifolia (Indian Hemp) and *Macroptilium lathyroides* (Benth.) Urban (Phasibean) and one symptomatic cultivated species, *Euphorbia millii* Desmoul. (Crown of Thorns) tested positive only with the A-probe indicating infection with a geminivirus distinct from FTGV. Five nonsymptomatic weed species, *Ludwigia erecta* (L.) Hara., *L. decurrens* Walt., (Water primrose) *Chamaesyce hypericifolia* (L.) (Spurge), *C. hirta* (L.) Millsp. (Hairy Spurge) and *Sesbania* sp. (Sesban) tested positive with both A and B probes indicating probable infection with FTGV. It is interesting to note that individual SPWF collected from weeds (*Ludwigia bonariensis*, *M. lathyroides*) during the summer fallow season in a field near Immokalee also tested positive in dot blot assays with both probes. The results of field surveys are listed in Table 1.

Thus far transmission attempts from FTGV-infected tomatoes to two species of *Ludwigia* (*L. bonariensis* and *L. octovalvis*) and to a great number of other weeds and cultivated plants have been unsuccessful (Table 2). We have likewise failed to transmit virus from symptomatic *Sida* spp. and *M. lathyroides* to tomato either mechanically or via SPWF providing confirmation of their distinctness from FTGV. On the other hand FTGV was transmitted via whitefly to the weed *Solanum viarum* Dun. (Tropical Soda Apple) and to *Physalis ixocarpa* (tomatillo) and *Phaseolus vulgaris* L. (bean Top Crop'). Transmission was based on symptom expression (stunting, mosaic and leaf curl in Tropical Soda Apple and tomatillo and very mild mosaic in bean) and positive dot-blot assays with both A and B probes. Back-transmission experiments using SPWF to infect tomato are currently underway. Mechanical transmission of FTGV to two species of tobacco, *Nicotiana edwardsonii* and *N. benthamiana* was previously demonstrated (D. Purcifull, personnel communication).

Unlike those geminiviruses spread by leafhoppers, it is not unusual for whitefly-vectored geminiviruses to have very narrow host ranges (2). At present the role played, if any, by *S. viarum* and *P. vulgaris* in FTGV epidemiology is not known. Thus far no samples of *S. viarum* from the field have tested postive. However, *S. viarum* is an extremely thorny and noxious weed in its own right and is rapidly becoming a problem in southwest Florida. While of great interest, the results with field-collected weeds and whiteflies are preliminary. The potential of certain weeds to serve as reservoirs for FTGV must be confirmed through further surveys involving large numbers of samples and transmission experiments consisting of whitefly transmission to and from tomato.

References

1. Adlerz, W.C. 1981. Weed Hosts of Aphid-borne Viruses of Vegetable Crops in Florida. Pages 467-478 In J. M. Thresh Ed. Pests,Pathogens and Vegetation. Pittman Publishing Inc., Marshfield, Massachusetts.

2. Bock, K.R. 1982. Gemini Diseases of Tropical Crops. Plant Disease. 66:266-270.

3. Kring, J.B., Schuster, D.J., Price, J.F. and Simone, G.W. 1990. Sweetpotato Whitefly Transmission Studies of Florida Tomato Disorders. Florida Experiment Station Journal Series No. A-00073. 5 pp.

TABLE 1. TOMATO GEMINIVIRUS FIELD SURVEY

PLANT	COMMON NAME	VIRUS SYMPTOMS	# SAMPLED	# POSITIVE (DOT-BLOT ASSAY)
CAPRIFOLIACEAE				
Lonicera japonica	Japanese Honeysuckle	Yellow netting	4	0
COMMELINACEAE				
Commelina sp.	Spiderwort	-	7	0
COMPOSITAE				
Ambrosia artemisiifolia L.	Common Ragweed	+/- Mosaic, Distortion, Stunting	23	0
Bidens sp.	Spanish Needles	+/- Mosaic	24	0
Eclipta alba L.	Eclipta	-	7	0
Sonchus oleraceus L.	Common Sow Thistle	-	5	0
CONVOLVULACEAE				
Ipomea sp.	Morning Glory	Leaf curl	2	0
CRUCIFERAE				
Brassica oleracea var. *capitata* L.	Cabbage	Mosaic	1	0
B. oleracea var. *Tronchuda* L.	Kale	Mosaic, Distortion	1	0
CUCURBITACEAE				
Cucurbita pepo L.	Zucchini	Silver Leaf	1	0
Momordica pendula L.	Wild Balsam Apple	-	4	0
EUPHORBIACEAE				
Chamaesyce hirta (L.) Millsp.	Hairy Spurge	-	4	1/1*
C. hypericifolia (L.) Millsp.	Spurge	-	10	3/3

TABLE 1 (con.)

PLANT	COMMON NAME	VIRUS SYMPTOMS	# SAMPLED	# POSITIVE (DOT-BLOT ASSAY)
EUPHORBIACEAE (con.)				
Euphorbia millii (L.) Millsp. Desmoul.	Crown of Thorns	Mosaic, Distortion, Yellow-netting	29	8/0**
Euphorbia cyathophora (Murr.) Kl. & Gke.	Painted Leaf, Wild Poinsettia	-	5	0
LEGUMINOSAE				
Crotalaria rotundifolia L.	Rabbit Bells	-	5	0
Crotalaria sp.	-	-	20	0
Desmodium sp.	Beggar's Lice	Mosaic	2	0
Galactia sp.	Milk Pea	-	2	0
Indigofera hirsuta Harv.	Hairy Indigo	-	9	0
Macroptilium lathyroides (Benth.) Urb.	Phasibean	Bright mosaic	48	10/0
Sesbania sp.	Sesban	-	12	2/2
MALVACEAE				
Sida spp.	Broomweed, Teaweed	Bright mosaic	66	20/0
S. acuta Burm. f.	Teaweed	"	3	3/0
S. rhombifolia L.	Indian Hemp	"	2	1/0
Urena lobata L.	Caesarweed	-	29	0
Hibiscus rosa-sinensis L.	Hibiscus	Mosaic	47	0
MYRTACEAE				
Myrica cerifera L.	Southern Wax Myrtle	Leaf distortion	3	0
ONAGRACEAE				
Ludwigia bonariensis (Micheli) Hara.	Water primrose	-	34	12/0

TABLE 1. (con.)

PLANT	COMMON NAME	VIRUS SYMPTOMS	# SAMPLED	# POSITIVE (DOT-BLOT ASSAY)
ONAGRACEA (con.)				
L. erecta (L.) Hara.	*	-	20	5/5
L. octovalvis (Jacq.) Raven	*	-	33	0
L. decurrens Walt.	*	-	9	3/3
RUBIACEAE				
Diodia teres Walt.	Poor Joe	-	6	0
D. virginiana L.	Buttonweed	Vein-clearing	1	0
SOLANACEAE				
Capsicum annuum L.	Bell Pepper	Chlorosis, Mosaic	10	0
Physalis angustifolia Nutt.	Narrow Leaf Ground Cherry	-	4	0
Physalis sp.	Ground Cherry	-	13	0
Solanum viarum	Tropical Soda Apple	Chlorosis	22	0
Solanum sp.	Nightshade	+/- Mosaic, Distortion	58	0
URTICACEAE				
Boehmeria cylidrica Jacq.	False Nettle	Mosaic	1	* 0

INSECT	HOST PLANT	VIRUS SYMPTOMS	# SAMPLED	POSITIVE (DOT-BLOT ASSAY)
Bemisia tabaci (Sweet potato whitefly)	*Ludwigia* sp.	-	7	2/2
*	*Macroptilium lathyroides* (Benth.) Urb.	Bright Mosaic	2	1/1

*Positive with both A and B probes
**Positive with A-probe only

TABLE 2. TOMATO GEMINIVIRUS - EXPERIMENTAL TRANSMISSION VIA SWEETPOTATO WHITEFLY

PLANT	COMMON NAME	NO. INOCULATED	SYMPTOMS	# POSITIVE (DOT-BLOT ASSAY)
COMPOSITAE				
Bidens bipinnata L.	Spanish Needles	12	-	0
Carthamus tinctorius (L.)	Safflower	4	-	0
Helianthus annuus L.	Sunflower 'Teddy Bear'	6	-	0
CRUCIFERAE				
Brassica oleracea var. *capitata* L.	Cabbage	8	Vein-clearing	0
CUCURBITACEAE				
Cucurbita pepo L.	Acorn Squash 'Table Ace'	6	-	0
Melothria pendula L.	Creeping Cucumber	8	-	0
EUPHORBIACEAE				
Poinsettia cyathophora (Murr.) Kl. & Gke.	Fiddler's Spurge	12	-	0
LEGUMINOSAE				
Macroptilium lathyroides (Benth.) Urb.	Phasibean	14	-	0
Phaseolus vulgaris L.	Bean 'Top Crop'	15	Mild Mosaic	5/5
	'Blue Lake'	12	-	N.D.
Phaseolus limensis Macfady	Lima Bean	4	-	0
Rhyncosia minima (L.) DC.	-	13	-	0
MALVACEAE				
Abelmoshus esculentus (L.) Moench	Okra 'Annie Oakley'	4	-	0
Gossypium hirsutum L.	Cotton	4	-	0
Sida acuta Burm. f.	Teaweed	18	-	0

TABLE 2. (Con.)

PLANT	COMMON NAME	NO. INOCULATED	SYMPTOMS	# POSITIVE (DOT-BLOT ASSAY)
ONAGRACEAE				
Ludwigia bonariensis (Micheli) Hara.	Water primrose	26	-	0
L. octovalvis (Jacq.) Raven	*	12	-	0
SOLANACEAE				
Capsicum annuum L.	Bell Pepper	12	-	0
Physalis angustifolia Nutt.	Narrow Leaf Ground Cherry	12	Chlorosis	0
P. ixocarpa Brot.	Tomatillo	8	Stunting, Leaf curl	3/3
S. americanum L.	Common Nightshade	10	-	0
S. tuberosum L.	Potato	4	-	0
S. melongena var. *esculentum* Nees.	Eggplant	9	-	0
Solanum viarum	Tropical Soda Apple	8	Stunting, Mosaic	1/1

*Positive with both A and B probes

MANAGEMENT STRATEGIES FOR THE SWEETPOTATO WHITEFLY

P. A. Stansly[1], D. J. Schuster[2] and G. L. Leibee[3]

The sweetpotato whitefly Bemisia tabaci Gennadius (SPWF) has been the primary pest of tomato in south Florida since causing serious economic losses in spring 1988. That year an irregular ripening condition of fruit went undetected until post-harvest ethylene treatment (Maynard & Cantliffe 1988). The following fall, a tomato geminivirus (TGV) transmitted by SPWF appeared simultaneously in the Immokalee/Naples and Palmetto/Ruskin production areas (Hiebert 1990, Kring et al. 1990). TGV seriously impacts yield with reductions of up to 75% if plants are symptomatic 4 weeks post-planting (Stansly & Schuster 1990). High numbers of SPWF are not necessary to initiate and maintain a potentially catastrophic disease cycle, especially when the cycle is prolonged by overlapping plantings. This occurred in the Immokalee area during the 1990/91 season following a warm winter which allowed harvested fields to serve as a source of both inoculum and whiteflies for the spring crop. Insecticides were of little help in stemming the tide of viruliferous whiteflies into newly planted fields with disastrous results.

Clearly, more effective management strategies are required to deal with SPWF and TGV. In addition to more economical and effective insecticides to control whitefly within the crop, it is also necessary to manage the entire cropping system to avoid build-up and movement of SPWF and TGV from crop to crop. Fields heavily infected during spring 1991 had been relatively clean the previous spring after the Christmas freeze eliminated SPWF and TGV along with the fall crop. We can learn from that painful experience how to better manage these twin treats to tomato production.

Carryover between crops. Standard post-harvest practice is desiccation with a herbicide or simply curtailing irrigation, driving whiteflies out of the field in search of greener "pastures". The crop may be left standing "in limbo" while managers watch the market, causing a slower but larger exodus.

---

[1]Southwest Florida Research and Education Center, P. O. Drawer 5127, Immokalee FL 33935

[2]Gulf Coast Research and Education Center, 5007 60th St. E., Bradenton FL 34203

[3]Agricultural Research and Education Center, 2700 Celery Ave., Sanford FL 32771

The effect on newly planted fields nearby can be devastating as seen last spring in Immokalee. Although fall and spring tomato crops do not generally overlap in the Palmetto/Ruskin area, winter crops such as cabbage may provide a bridge between seasons, at least for SPWF (Table 1).

Ideally, old and new crops should be widely separated in time and/or space, but unfortunately, this is not always practical. An alternative would be a practical method of killing both plants and whiteflies. We are still working on this problem and carrying out field tests to compare the effectiveness of herbicides either alone or in combination with insecticides and propane flamers to kill vines and whiteflies, especially adult whiteflies.

Insecticide Resistance. Faced with the threat of serious economic losses, growers are forced to rely on a limited arsenal of insecticides, each application of which increases selection pressure for resistant strains of SPWF. Reduced susceptibility is now detectable in both the Immokalee and Palmetto/Ruskin productions areas, especially to endosulfan (Thiodan) and fenvalerate (Pydrin) (Table 2). These levels of apparent resistance signal the need for careful management i.e, rotation and reduced usage of particular classes of insecticide.

Spray materials. During the 1990/91 season there was widespread interest in the use of household liquid detergents for control of SPWF. The initial inspiration may have been articles appearing in national and local newspaper reporting results obtained by USDA researchers at the Western Cotton Insects Laboratory in Tempe, Arizona (Butler & Henneberry 1990). The experiments were done in the greenhouse by individually spraying leaves heavily infested with SPWF nymphs and pupae. The leaves were picked 24 hours later, and placed in a petri dish, their undersides in close contact to water-sensitive paper. Live nymphs secrete honeydew which will leave a visible spot on the paper. After 15 minutes mortality is evaluated by comparing the number of spots on papers from treated leaves to an unsprayed control. Many detergents and oils were tested in this way, and most caused greater than 90% mortality to SPWF immatures at concentrations of 1% (Butler et al. 1991).

In this same paper we report similar results from a field trial on cucumber at SWFREC and the effect on adults in a commercial cucumber field near GCREC using a hand-held motorized "Solo" sprayer to obtain underleaf coverage of mature vines. The plots were sampled before and after spraying by shaking 5 leaves over a black aluminum baking pan coated with an oil/detergent mixture to trap adult whiteflies. Significant reductions in SPWF populations were obtained with 0.5% solutions of detergent, M-Pede insecticidal soap, soybean oil and Saf-T-Side oil, with no significant differences between treatments

although the lowest counts were obtained from the detergent plots.

Another field experiment at SWFREC in spring 1991 tested the efficacy of one detergent (Liquid Tide) sprayed either twice a week, or once a week alternated with a crop oil (JMS Stylet Oil) to three chemical insecticide regimes: Asana XL tankmixed with Lorsban alternated with Thiodan every 7 days, Danitol tankmixed with Monitor alternated with Thiodan every 10 days, and Danitol alternated with Monitor alternated with Thiodan ever 7 days. The overall rates per acre of Danitol and Monitor were the same in both treatments employing these materials. Plots were 2 rows wide and 25 feet long, and there were 8 replications of each material.

Plots were planted 15 March and two TGV-infected plants per plot were set out on 21 March to provide an inoculum source. Treatments began on 26 March and ended on 9 May. Whitefly immatures were counted on the terminal trifoliate of the 6th leaf from the top of 3 randomly selected plants per plot at 2-week intervals (N=4). Adult whitefly were counted on 4 alternate weeks by carefully inverting the 3rd leaf from the top of 3 randomly chosen plants per plot. All plants were inspected weekly for geminivirus symptoms. Fruit was not suitable for normal grading due to a heavy infestation of tomato pinworm, and only total fruit number and weight was obtained (harvest 25 May).

Only in plots treated with 0.25% Tide Liquid Detergent twice a week were there significantly fewer SPWF (small and large sessile nymphs) than either the unsprayed check or some other treatment (Table 3a). Three treatments had significantly lower geminivirus incidence through 47 days post-planting than the unsprayed check: Tide Liquid Detergent twice a week, Tide Liquid once a week alternated with JMS Stylet Oil and Monitor + Danitol alternated with Thiodan once a week (Table 3d). There were no significant differences in yield.

Although it appears that detergents may be useful in augmenting the arsenal against SPWF, it must be stressed that the results reported here are still preliminary. Of even greater concern are the possible phytotoxic effects of detergents reported by Vavrina & Stansly at this meeting.

Additional results from field tests with chemical insecticides and petroleum oils carried out by DJS at GCREC in Bradenton are given in Tables 4 through 7.

Applications methods. All lifestages of SPWF normally occur on the underside of the leaf where adequate spray coverage is most difficult. The excellent control of SPWF with oils and detergents reported by Butler et al. (1991) were obtained by hand spraying the leaf underside to runoff or nearly so.

Growers apply less material and the coverage obtained in commercial applications is inferior. It is clear that many materials are effective in killing SPWF if adequate coverage can be obtained.

The spring 1991 field trial at SWFREC described above compared two types of sprayers, one using high pressure technology, and the other ("Berthoud") employing a high-speed ,fan-generated airstream to atomize and propel the spray material and also to agitate the plant canopy. Four of the 8 replications for each treatment were randomly chosen to be sprayed with a tractor-drawn boom sprayer using a diaphragm pump and drop nozzles fitted with Albuz ceramic hollow cone tips (ATR lilac delivering ca. 0.223 gal/min @ 400 lbs/in^2) calibrated at 103 gal/acre at the maximum of 8 nozzles per row. The other 4 replications were sprayed with "Berthoud" airboom sprayer, which when employing all 4 nozzles per row (bottom "fan" and top "cannon") was calibrated at 104 gal/acre. However, 163 gal/acre were inadvertently put out with the airboom sprayer when only 2 nozzles per row were used for the first 2 applications.

Differences between the two kinds of sprayers were not significant for any particular lifestage of SPWF. However, the airboom sprayer gave consistently better control over all lifestages including adults (Table 8), and over all observation dates, including later ones when the two sprayers were calibrated at the same rate. In contrast, there were no differences between sprayers in counts of leafminer and tomato pinworm, whose control on the outside, sampled leaves probably did not depend on underleaf coverage.

In another field test, water sensitive paper was used to compare coverage obtained with the two sprayers. One inch squares of the paper were stapled to the underside of leaves in 4 locations on the plant. The paper sections where then separated into 5 coverage categories and the results tabulated (Table 9). They showed that significantly better coverage was obtained with the airboom sprayer, especially of the inside portions of the plant.

Biological Control. Anyone searching for SPWF in relatively undisturbed habitat, even where host plants are abundant, will probably be struck by its scarcity compared to cultivated fields. The reasons for this scarcity is uncertain, although it is likely that mortality from naturally occurring predators, parasites, and pathogens is a significant factor. Recent surveys have shown that hymenopteran (wasp) parasites are a significant component in the natural enemy complex attacking SPWF in Florida, with the relative importance of specific parasite species showing seasonal and host-plant variations (Fig 1.)

Table 1. Sticky trap catches of sweetpotato whitefly in the Palmetto/Ruskin production area (DJS, unpublished data).

Number of Sweetpotato Whitefly Adults/Trap						
	Week of Sampling					
Commodity	2/18	3/5	3/18	4/1	4/15	4/29
Cabbage	143	35	86	28	46	8
Potatoes	2	5	24	33	36	29
Tomato	<1	<1	<1	6	7	11
Cherry Tomato	0	1	1	4	22	27
Pepper	0	1	0	2	2	2
Squash	<1	<1	2	<1	92	0
Cucumber	0	<1	1	0	8	6

Table 2. Mortality of field-collected SPWF in 1991 compared to a laboratory-reared susceptibile colony as determined by bioassay at a dose equal to the LC 50 for the reference colony (G. L. Leibee & C. E. Mantilla, unpublished data).

		Insecticide		
Location	Date	Endosulfan	Fenvalerate	Chlorpyrifos
Immokalee_1	7 Feb.	26%	57%	79%
Immokalee_1	18 Apr.	88%	45%	180%
Immokalee_2	2 May	20%	57%	23%
Immokalee_3	2 May	45%	69%	20%
Ruskin	16 May	35%	86%	49%
Parrish	16 May	10%	83%	42%

Table 3a. Mean number of SPWF per sample and tomato geminivirus incidence over 4 sampling periods.

Treatment	Rate (ai/100Gal.)	Frequency	Whitefly Stage						
			Eggs	Crawlers	Sm. Nymphs	Lg. Nymphs	Pupae	Adults	Virus
1. Tide Liq.	0.25gal.	2 x per week	5.1a[1]	0.3a	19.9b	0.5b	0.5a	2.0a	41.9c
2. JMS Stylet Oil Tide Liquid	0.75gal.	1 x per week	6.7a	0.0a	34.5a	5.5a	1.0a	2.2a	40.5c
3. Monitor+ Danitol or Thiodan	0.75lbs. 0.2lbs. 0.5lbs.	Sequentially, every 10 days.	10.6a	0.1a	23.6a	2.4ab	0.8a	1.8a	47.3c
4. Monitor or Danitol or Thiodan	0.75lbs. 0.2lbs. 0.5lbs.	Sequentially, every 7 days.	6.0a	0.0a	22.9a	3.8ab	0.3a	2.2a	59.9bc
5. Asana+ Lorsban or Thiodan	0.05lbs. 1.0lbs. 0.5lbs.	Sequentially, every 10 days.	10.7a	0.1a	32.5a	4.9ab	2.0a	2.8a	65.3ab
6. Unsprayed Check			7.1a	0.0a	38.2a	5.2a	1.4a	3.1a	73.3a

[1]Means in the same column followed by the same letter are not significantly different ($P < 0.05$; LSD test).

Table 3b. Mean number of tomato pinworms per 3 trifoliate sample and mean yield per plot.

Treatment	Rate (a.i./100gal)	Frequency	Pinworms		Fruit	
			Live	Dead	Number	Weight
Monitor w/ Danitol or Thiodan	0.75lbs. 0.2lbs. 0.5lbs.	Sequentially, every 7 days.	0.2c	33.1ab	277 a	37.9a
Asana & Lorsban or Thiodan	0.05lbs. 1.0lbs. 0.5lbs	Sequentially, every 10 days.	1.1a	49.7a	345 a	44.3a
Unsprayed Check			0.9ab	48.4a	281 a	33.7a
Stylet Oil	0.75gal.	2 x per week	0.6abc	33.8ab	283 a	35.5a
Tide Liquid	0.25gal.	2 x per week	0.4bc	25.0b	357 a	41.8a
Monitor & Danitol or Thiodan	0.75lbs. 0.2lbs. 0.5lbs.	Sequentially, every 10 days.	0.5bc	27.3b	290 a	39.3a

Table 4. Management of SPWF and FTGV with insecticides, GCREC Bradenton, Fall 1990 - a. SPWF, b. yield, c.,d. FTGV incidence.

Treatment and lb (AI)/acre		No. sweetpotato whitefly immatures/10 leaflets							
		Eggs		Crawlers		Sessile nymphs		Pupae	
		25 Oct	27 Nov	25 Oct	27 Nov	25 Oct	27 Nov	25 Oct	27 Nov
Brigade 10 WP	0.1	1.7a*	0.5a	2.3ab	0.5a	0.0a	0.2a	0.3a	0.0a
Brigade 10 WP	0.05	2.2a	0.5a	1.8ab	1.5a	1.8ab	0.0a	0.8a	0.0a
Asana XL 0.66 EC + Monitor 4 EC**	0.05 0.75	3.2abc	0.5a	3.5ab	0.5a	2.8abc	0.2a	1.0ab	0.2a
Asana XL 0.66 EC + Lorsban 50 WP	0.05 0.75	2.0a	0.0a	2.0ab	0.8a	0.5a	0.0a	0.2a	0.2a
CME 13411 100Gm/L***	0.06	2.8ab	0.2a	3.2ab	1.2a	4.2abc	0.0a	2.0b	0.0a
Danitol 2.4 EC	0.2	3.5abc	0.5a	1.5ab	1.8a	2.2abc	0.2a	0.0a	0.2a
Danitol 2.4 EC + Monitor 4 EC	0.2 0.75	2.0a	0.8a	1.0a	1.2a	0.5a	0.0a	0.0a	0.2a
Danitol 2.4 EC + Monitor 4 EC**	0.2 0.75	4.0abc	1.2a	0.8a	1.0a	3.0abc	2.2a	0.0a	0.8a
FCI 1555B		9.8c	0.8a	4.0ab	1.2a	5.8bc	0.2a	0.8a	0.2a
Lorsban 50 WP	1.0	4.0abc	0.2a	3.0ab	0.5a	2.0abc	0.0a	0.2a	0.0a
SN 85292 400 Gm/L SC	0.375	5.0abc	1.0a	6.2ab	0.8a	2.0abc	1.5a	0.0a	0.0a
Check (water)	---	9.2bc	0.5a	6.8ab	2.2a	6.8c	0.8a	0.8a	0.2a

*Means within a column followed by the same letter are not significantly different at P<0.05 level, Duncan's multiple range test.
**Applied every two weeks.
***Applied weekly until 13 Nov., then every two weeks thereafter.

Three row (5 ft centers) by 20 ft plots, 4 replications, planted 5 Sep., 13 applications from 14 Sep. to 3 Dec., using "highboy sprayer @ 200 psi 3.4 mph with #3 disks & 25° cores, 4 nozzles per row minimum (50 gpa) 8 nozzles maximum (100 gpa). Seventh or 8th terminal leaflet sampled for immature SPWF, all plants examined for FTGV, all fruit harvested three times beginning 14 Nov., 50 fruit samples ripened in paper bags and graded 1 to 4 for irregular ripening.

Table 4b.

Treatment and lb (AI)/acre		Fruit yield/10 plants			Irregular ripening	
		No.	Wt(lb)	Wt/fruit	Rating	% Unmarketable
Brigade 10 WP	0.1	348.0a	87.9a	0.254abc	2.0a	1.0a
Brigade 10 WP	0.05	342.8a	77.3a	0.226bc	2.0a	0.7a
Asana XL 0.66 EC + Monitor 4 EC**	0.05 0.75	344.5a	80.7a	0.235abc	2.0a	0.0a
Asana XL 0.66 EC + Lorsban 50 WP	0.05 0.75	340.8a	74.5a	0.217bc	2.0a	0.6a
CME 13411 100Gm/L***	0.06	294.3a	80.5a	0.289a	2.0a	0.0a
Danitol 2.4 EC	0.2	336.5a	78.2a	0.232abc	2.0a	0.7a
Danitol 2.4 EC + Monitor 4 EC	0.2 0.75	370.5a	92.0a	0.247abc	2.0a	0.5a
Danitol 2.4 EC + Monitor 4 EC**	0.2 0.75	344.5a	85.7a	0.243abc	2.0a	0.4a
FCI 1555B		341.0a	95.8a	0.278ab	2.0a	0.0a
Lorsban 50 WP	1.0	321.0a	80.2a	0.252abc	2.0a	0.4a
SN 85292 400 Gm/L SC	0.375	373.8a	78.0a	0.211c	2.0a	0.2a
Check (water)	---	352.5a	71.1a	0.202c	2.0a	0.8a

*Means within a column followed by the same letter are not significantly different

Table 4c.

Treatment and lb (AI)/acre		% virus infected plants					
		19 Sept	27 Sept	4 Oct	12 Oct	18 Oct	24 Oct
Brigade 10 WP	0.1	0.0a*	9.7ab	20.0a	30.9a	54.1a	63.8a
Brigade 10 WP	0.05	0.0a	11.0ab	22.6a	34.1a	62.9a	79.6abc
Asana XL 0.66 EC	0.05						
+ Monitor 4 EC**	0.75	0.0a	9.0ab	23.1a	33.3a	69.3a	86.5abc
Asana XL 0.66 EC	0.05						
+ Lorsban 50 WP	0.75	0.0a	7.1a	19.4a	26.4a	58.0a	72.2abc
CME 13411 100Gm/L***	0.06	0.0a	14.8ab	33.3a	47.5a	77.6a	87.8bc
Danitol 2.4 EC	0.2	0.0a	12.3ab	26.4a	32.9a	63.9a	85.2abc
Danitol 2.4 EC	0.2						
+ Monitor 4 EC	0.75	0.0a	9.7ab	16.8a	26.5a	51.6a	66.5ab
Danitol 2.4 EC	0.2						
+ Monitor 4 EC**	0.75	0.0a	10.3ab	21.2a	30.2a	59.2a	77.8abc
FCI 1555B		0.0a	14.8ab	33.9a	43.0a	76.9a	90.4a
Lorsban 50 WP	1.0	0.0a	21.2b	30.2a	42.4a	68.2a	82.5abc
SN 85292 400Gm/L SC	0.375	0.0a	16.0ab	28.9a	43.0a	77.6a	91.0c
Check (water)	---	0.0a	15.4ab	25.6a	39.8a	74.4a	85.9abc

Table 4d.

Treatment and lb (AI)/acre		% virus infected plants			
		1 Nov	7 Nov	16 Nov	23 Nov
Brigade 10 WP	0.1	80.0ab	87.1ab	87.1a	87.1a
Brigade 10 WP	0.05	90.5abc	96.2abc	96.8abc	96.8abc
Asana XL 0.66 EC + Monitor 4 EC**	0.05 0.75	95.5ab	99.4c	100.0c	100.0c
Asana XL 0.66 EC + Lorsban 50 WP	0.05 0.75	85.7abc	87.6abc	88.2ab	88.2ab
CME 13411 100Gm/L***	0.06	95.5ab	96.8abc	98.1bc	98.1bc
Danitol 2.4 EC	0.2	98.1b	98.7bc	98.7bc	98.7c
Danitol 2.4 EC + Monitor 4 EC	0.2 0.75	78.7a	86.4a	89.0ab	90.3abc
Danitol 2.4 EC + Monitor 4 EC**	0.2 0.75	88.9abc	92.2abc	93.4abc	94.1abc
FCI 1555B		94.9ab	97.4abc	97.4abc	98.1bc
Lorsban 50 WP	1.0	94.8ab	98.7bc	98.7bc	98.7c
SN 85292 400Gm/L SC	0.375	96.2b	98.1abc	98.1bc	98.7c
Check (water)	---	94.9ab	96.2abc	96.8abc	97.5bc

Table 5. Management of SPWF and FTGV with insecticides, GCREC Bradenton, Spring 1991, a. SPWF, b. leafmines and yield, c.,d. FTGV incidence.

Treatment and lb (AI)/acre		No. sweetpotato whitefly immatures/10 leaflets				
		Eggs	Crawlers	Sessile nymphs	Pupae	Pupae exuviae
Agri-Mek 0.15 EC	0.01	46.5b*	244.5a-c	115.5a-c	10.8b-d	18.8a-d
Agri-Mek 0.15 EC + Saf-T-Side Oil	0.01 1% v/v	54.8b	249.0a-c	106.8a-d	4.8c-e	8.3cd
Asana XL 0.66 EC + Lorsban 50 WP	0.05 1.0	33.5b	64.7d	29.8c-f	1.0de	2.0d
Asana XL 0.66 EC & Lorsban 50 WP**	0.05 1.0	41.3b	83.0cd	25.8c-f	0.5de	1.3d
Danitol 2.4 EC + Monitor 4 EC	0.2 0.75	21.3b	127.2b-d	11.3f	0.8de	1.0d
Foil OF	3qt***	56.5b	454.0a	102.0b-e	23.3ab	9.5cd
Lorsban 50 WP + crop oil****	1.0 1% v/v	52.3b	263.8ab	83.5b-f	5.3c-e	8.3cd
Margosan-O 3%	20 ppm	31.5b	305.5ab	229.8a	48.0a	78.8a
MK-936 MPF 0.15 EC	0.01	42.8b	232.5a-c	165.5ab	28.8ab	51.0ab
RH-9999 20 WP*****	0.1	35.0b	209.3a-c	63.5b-f	8.5b-e	15.8b-d
RH-9999 20 WP	0.05	41.8b	269.5a-c	208.0ab	14.0a-c	19.3a-d
RH-9999 20 WP	0.025	58.5b	280.3ab	152.0ab	23.5ab	29.5a-c
SN 85292 40SC	0.38	48.3b	267.0a-c	25.0d-f	0.3e	3.0cd
Trophy 1EC + Lorsban 50 WP	0.03 1.0	24.3b	168.5b-d	18.5ef	1.0de	1.8d
Check (water)	---	150.5a	288.8ab	104.5a-d	16.0a-c	42.0ab

Methods as in Table 4. Planting date 14 Mar., 10 applications between 10 Mar. and 29 May, 2 harvests 28 May and 3 June.

Table 5b.

Treatment and lb (AI)/acre		No. leafmines/ min search	Fruit yield/10 plants No.	Wt(lb)	Wt/fruit
Agri-Mek 0.15 EC	0.01	28.0b	281.0a-c	78.0a	0.28a
Agri-Mek 0.15 EC + Saf-T-Side Oil	0.01 1% v/v	11.3b	242.0a-e	65.0a-d	0.27a
Asana XL 0.66 EC + Lorsban 50 WP	0.05 1.0	110.3a	264.8a-d	68.5a-d	0.26a
Asana XL 0.66 EC & Lorsban 50 WP**	0.05 1.0	66.5a	239.5a-e	58.0a-e	0.24a-c
Danitol 2.4 EC + Monitor 4 EC	0.2 0.75	100.8a	251.5a-e	60.1a-d	0.24a-c
Foil OF	3qt***	68.0a	199.5de	49.0df	0.24a-c
Lorsban 50 WP + crop oil****	1.0 1% v/v	91.5a	216.0c-e	50.2c-f	0.23a-c
Margosan-O 3%	20 ppm	118.0a	190.0e	40.1ef	0.19bc
MK-936 MPF 0.15 EC	0.01	21.0b	200.0de	37.8f	0.18c
RH-9999 20 WP*****	0.1	115.0a	271.0a-c	75.9ab	0.28a
RH-9999 20 WP	0.05	92.3a	217.8c-e	52.8b-f	0.24a-c
RH-9999 20 WP	0.025	65.8a	218.8b-e	51.5c-f	0.23a-c
SN 85292 40SC	0.38	96.8a	288.5ab	73.5a-c	0.25ab
Trophy 1EC + Lorsban 50 WP	0.03 1.0	105.3a	236.3a-e	60.0a-d	0.26a
Check (water)	---	117.8a	296.5a	80.4a	0.27a

*Data were transformed square root of X+0.5 prior to analyses but are presented in the original scale. Means within a column followed by the same letter are not significantly different at P<0.05 level, Duncan's multiple range test.
**Alternated every three to four days.
***Amount of product.
****Lorsban was combined with Saf-T-Side Oil for the first 8 applications and with Sunspray Ultrafine Oil for the last two applications.
*****Combined with Triton B-1956 at 0.06% v/v.

Table 5c.

Treatment and lb (AI)/acre		virus infected plants				
		10 Apr	17 Apr	24 Apr	3 May	8 May
Agri-Mek 0.15 EC	0.01	0.0b*	3.3ab	3.3ab	6.4a	10.9a
Agri-Mek 0.15 EC + Saf-T-Side Oil	0.01 1% v/v	0.6ab	1.3a-c	2.6ab	5.1ab	7.0a-c
Asana XL 0.66 EC + Lorsban 50 WP	0.05 1.0	0.0b	1.3a-c	2.5ab	3.8ab	5.8a-c
Asana XL 0.66 EC & Lorsban 50 WP**	0.05 1.0	0.6ab	0.6bc	0.6ab	1.9ab	3.2a-c
Danitol 2.4 EC + Monitor 4 EC	0.2 0.75	0.0b	0.0c	0.0b	0.0b	0.6c
Foil OF	3qt***	0.0b	0.0c	1.3ab	2.5ab	2.5a-c
Lorsban 50 WP + crop oil****	1.0 1% v/v	0.0b	0.0c	0.6ab	3.2ab	5.8a-c
Margosan-O 3%	20 ppm	0.6ab	1.3a-c	1.3ab	2.6ab	3.8a-c
MK-936 MPF 0.15 EC	0.01	0.0b	0.6bc	2.6ab	5.1ab	5.8a-c
RH-9999 20 WP*****	0.1	0.0b	1.3a-c	2.6ab	5.1ab	8.3ab
RH-9999 20 WP	0.05	1.3a	3.2a	3.8a	7.0a	9.0a
RH-9999 20 WP	0.025	0.0b	0.0c	1.3ab	2.6ab	3.8a-c
SN 85292 40SC	0.38	0.0b	0.6bc	1.3ab	6.4a	10.3a
Trophy 1EC + Lorsban 50 WP	0.03 1.0	0.0b	0.0c	0.0b	1.3ab	1.3bc
Check (water)	---	0.0b	0.6bc	1.3ab	2.5ab	7.1a-c

Table 5d.

Treatment and lb (AI)/acre		virus infected plants		
		17 May	23 May	30 May
Agri-Mek 0.15 EC	0.01	12.2ab	21.1a-c	27.6a
Agri-Mek 0.15 EC + Saf-T-Side Oil	0.01 1% v/v	7.7a-c	17.3a-d	17.3a-c
Asana XL 0.66 EC + Lorsban 50 WP	0.05 1.0	5.8bc	14.7a-d	14.7a-c
Asana XL 0.66 EC & Lorsban 50 WP**	0.05 1.0	4.5bc	7.7b-d	7.7bc
Danitol 2.4 EC + Monitor 4 EC	0.2 0.75	4.5bc	7.0d	7.1c
Foil OF	3qt***	10.3a-c	17.9a-d	17.9a-c
Lorsban 50 WP + crop oil****	1.0 1% v/v	9.6a-c	18.0a-d	20.5ab
Margosan-O 3%	20 ppm	10.9a-c	21.7a-c	21.7ab
MK-936 MPF 0.15 EC	0.01	10.3a-c	14.1a-d	16.0a-c
RH-9999 20 WP*****	0.1	10.9ab	25.0ab	25.0ab
RH-9999 20 WP	0.05	21.8a	29.5a	29.5a
RH-9999 20 WP	0.025	8.3a-c	12.8a-d	13.5a-c
SN 85292 40SC	0.38	10.9a-c	21.8a-c	21.8ab
Trophy 1EC	0.03	1.3c	7.1c-d	7.7bc
Check (water)	---	8.4a-c	19.9a-c	19.9ab

Table 6. Management of SPWF and FTGV with pyrethroid/organophosphate combinations, GCREC Bradenton, Spring 1991, a.,b. SPWF adults, c.,d. SPWF immatures, e. FTGV incidence, f. yield.

		No. adults/trap							
		20	27	3	11	17	24	3	15
Treatment and lb (AI)/acre		Mar	Mar	Apr	Apr	Apr	Apr	May	May
Asana XL 0.66 EC	0.05								
+ Monitor 4 EC	0.75	0.0a*	1.5a	0.5a	27.0a	7.0a	3.0a	3.5a	2.0b
Danitol 2.4 EC	0.2								
+ Monitor 4 EC	0.75	0.0a	0.0a	0.0a	28.0a	8.5a	21.0a	2.0a	0.5b
Check (water)	---	0.0a	1.0a	1.5a	19.5a	13.5a	29.0a	21.5a	21.5a

Table 6b.

		No. adults/30 leaves							
		28	4	10	17	23	2	8	23
Treatment and lb (AI)/acre		Mar	Apr	Apr	Apr	Apr	May	May	May
Asana XL 0.66 EC	0.05								
+ Monitor 4 EC	0.75	1.5a	4.0a	1.5a	0.5a	1.5a	9.0a	2.5a*	19.0b
Danitol 2.4 EC	0.2								
+ Monitor 4 EC	0.75	0.0a	0.5a	2.0a	0.5a	1.0a	8.5a	0.5a	4.5b
Check (water)	---	6.0a	6.0a	4.5a	1.0a	13.5a	4.0a	2.0a	228.5a

Methods as in Table 4 and 5 except that plots were 50 ft long and separated by 50 ft. Adult SPWF sampled each plot for 24 hr with a 4 in^2 yellow water pan trap and counted on an upper, middle and lower leaf of 10 plants/plot. Planting date: 8 Mar., 11 applications from 15 Mar. to 29 May, harvests: 24 May, 3 June.

Table 6c.

Treatment and lb (AI)/acre		No. sweetpotato whitefly immatures/10 leaflets											
		Eggs				Crawlers				Sessile nymphs			
		23 Apr	9 May	23 May	7 June	23 Apr	9 May	23 May	7 June	23 Apr	9 May	23 May	7 June
Asana XL 0.66 EC + Monitor 4 EC	0.05 0.75	0.5a*	0.0b	9.5b	15.0a	1.5a	1.5b	8.0b	71.5b	0.0b	1.5b	1.5b	29.5b
Danitol 2.4 EC + Monitor 4 EC	0.2 0.75	0.5a	0.0b	4.5b	4.0a	0.5a	1.0b	2.0b	56.5b	0.0b	1.5b	0.0b	4.0c
Check (water)	---	11.5a	53.0a	335.0a	24.0a	13.0a	45.5a	158.5a	325.5a	16.5a	105.0a	121.5a	260.5a

Table 6d.

Treatment and lb (AI)/acre		No. sweetpotato whitefly immatures/10 leaflets							
		Pupae				Pupae exuviae			
		23 Apr	9 May	23 May	7 June	23 Apr	9 May	23 May	7 June
Asana XL 0.66 EC + Monitor 4 EC	0.05 0.75	0.0a	0.0a	0.0b	11.0b	0.0a	0.0a	0.0b	18.5b
Danitol 2.4 EC + Monitor 4 EC	0.2 0.75	0.0a	0.0a	0.0b	1.5b	0.0a	0.0a	0.0b	2.5b
Check (water)	---	0.0a	1.0a	19.0a	49.0a	2.0a	0.0a	56.0a	90.0a

*Data were transformed $\log_{10}$ (X+1) prior to analyses but are presented in the original scale. Means within a column followed by the same letter are not significantly different at $F \leq 0.05$ level, orthogonal contrasts in analyses of variance.

Table 6e.

Treatment and lb (AI)/acre		% virus infected plants								
		27 Mar	3 Apr	10 Apr	17 Apr	24 Apr	8 May	17 May	23 May	30 May
Asana XL 0.66 EC	0.05									
+ Monitor 4 EC	0.75	1.0a*	1.0a	1.5a	2.0a	4.0a	4.0a	4.5a	6.5a	6.5a
Danitol 2.4 EC	0.2									
+ Monitor 4 EC	0.75	0.5a	0.5a	0.5a	2.5a	4.0a	4.0a	5.5a	6.0a	6.0a
Check (water)	---	5.5a	5.5a	12.0a	15.0a	19.0a	19.0a	37.5a	46.0a	50.0a

Table 6f.

Treatment and lb (AI)/acre		Fruit yield/20 plants								Irregular ripening rating	
		Extra large		Large		Medium		Cull			
		No.	Wt (lb)	No.	Wt (lb)	No.	Wt (lb)	No.	Wt (lb)	Internal	External
Asana XL 0.66 EC	0.05										
+ Monitor 4 EC	0.75	115.5a**	48.1a	158.0a	49.7a	277.0a	65.4a	174.5a	33.1a	2.0a	3.6a
Danitol 2.4 EC	0.2										
+ Monitor 4 EC	0.75	103.5a	42.9a	178.0a	59.2a	259.0a	64.3a	110.0a	24.1a	2.0a	3.3a
Check (water)	---	147.5a	62.2a	177.5a	55.0a	172.0a	42.3a	87.5a	26.3a	2.3a	4.1a

Table 7. Management of SPWF and FTGV with petroleum oils, GCREC Bradenton, Fall 1990: a. adults, b. SPWF immatures, c. FTGV incidence, d. yield.

Treatment	Gal/ 100 gal	Application pressure	No. sweetpotato whitefly adults/30 leaves					
			21 Sept	2 Oct	17 Oct	2 Nov	9 Nov	20 Nov
JMS Stylet Oil	0.5-0.75*	400	10.0a**	28.5ab	1.5a	13.5ab	21.5a	58.5a
JMS Stylet Oil	0.5-0.75	200	8.0a	17.5b	5.5a	12.0ab	10.5a	52.5a
Saf-T-Side Oil	2	200	7.5a	16.5b	13.0a	8.5b	14.0a	38.0a
Sunspray Ultrafine	2	400	7.0a	16.5b	6.5a	11.5ab	6.0a	48.5a
Sunspray Ultrafine	2	200	9.0a	17.5b	9.0a	11.5ab	12.5a	53.0a
Super Savol	2	200	6.0a	20.5ab	5.0a	8.0b	13.0a	55.5a
Check (water)	-	200	9.0a	40.5a	9.0a	10.0ab	64.0a	68.5a

*The 0.5 gal rate was applied the first three applications and the 0.75 rate the remaining applications.
**Means within a column followed by the same letter are not significantly different at the $P<0.05$ level, Duncan's multiple range test.

Plots 3-25 ft rows, 2 replications planted 10 Sep. Twelve applications from 12 Sep. - 26 Nov. using tracter drawn boom sprayer @ 200 psi D3 disks & 25^{o} cores, 4 nozzles per row (80 gpa with 1 ft extensions (4 times) or 50 gpa without extensions (once), 6 nozzles 75 gpa (twice), 8 nozzles 100 gpa (5 times) or @ 400 psi with TX5-SS hollow core nozzles (6 per row with 2 overhead delivering 85 gpa 4 times, 4 per row, 35 gpa once, 6 per row 50 gpa twice, and 8 nozzles per row, 70 gpa 5 times). Harvest 15 Nov., 5, and 18 Dec.

Table 7b.

Treatment	Gal/ 100 gal	Application pressure(psi)	No. sweetpotato whitefly immatures/10 leaflets							
			Eggs		Crawlers		Sessile nymphs		Pupae	
			23 Oct	20 Nov	23 Oct	20 Nov	23 Oct	20 Nov	23 Oct	20 Nov
JMS Stylet Oil	0.5-0.75*	400	38.0a**	83.5a	11.0a	110.5ab	69.5a	105.5a	3.0a	17.0a
JMS Stylet Oil	0.5-0.75	200	31.5a	28.0a	7.0a	76.5ab	40.5a	37.0a	2.0ab	13.0a
Saf-T-Side Oil	2	200	27.0a	132.5a	13.0a	170.0a	24.0a	106.0a	0.0b	6.5a
Sunspray Ultrafine	2	400	31.5a	9.0a	8.0a	26.0b	32.0a	32.0a	0.5ab	2.5a
Sunspray Ultrafine	2	200	48.0a	39.0a	33.5a	43.5b	39.5a	52.0a	1.5ab	3.0a
Super Savol	2	200	41.0a	38.0a	24.5a	78.5ab	29.0a	49.0a	0.5ab	3.0a
Check (water)	-	200	39.5a	37.0a	29.5a	78.5ab	40.5a	58.5a	2.5ab	10.0a

Table 7c.

Treatment	Gal/ 100 gal	Application pressure(psi)	% virus infected plants							
			20 Sept	27 Sept	4 Oct	12 Oct	18 Oct	24 Oct	1 Nov	7 Nov
JMS Stylet Oil	0.5-0.75*	400	0.0b**	0.0a	5.9cd	17.7ab	69.6ab	87.3a	98.0ab	100.0a
JMS Stylet Oil	0.5-0.75	200	0.0b	1.0a	8.8bcd	22.6ab	74.5ab	91.2a	98.0ab	100.0a
Saf-T-Side Oil	2	200	0.0b	0.0a	3.0d	10.9b	48.9c	70.8b	94.9ab	100.0a
Sunspray Ultrafine	2	400	0.0b	2.0a	15.7ab	24.5ab	57.8bc	85.3ab	96.1ab	99.0a
Sunspray Ultrafine	2	200	0.0b	1.0a	12.7abc	26.5ab	64.7abc	88.2a	96.1ab	100.0a
Super Savol	2	200	0.0b	2.0a	4.9cd	16.6b	63.6abc	77.7ab	92.3b	100.0a
Check (water)	-	200	2.0a	6.9a	20.6a	35.3a	79.4a	91.2a	100.0a	100.0a

Table 7d.

Treatment	Gal/ 100 gal	Application pressure(psi)	Yield/10 plants No.	Yield/10 plants Wt (lb)	Yield/10 plants Wt/fruit	Irregular ripening Rating	Irregular ripening % unmarketable
JMS Stylet Oil	0.5-0.75*	400	224.5a**	60.1bc	0.27a	2.2a	16.1a
JMS Stylet Oil	0.5-0.75	200	227.0a	67.8ab	0.30a	2.2a	11.7a
Saf-T-Side Oil	2	200	316.0a	83.1a	0.26a	2.1a	8.8a
Sunspray Ultrafine	2	400	290.5a	46.8c	0.16b	2.1a	5.4a
Sunspray Ultrafine	2	200	285.0a	66.8ab	0.24ab	2.2a	15.1a
Super Savol	2	200	226.5a	59.4bc	0.26a	2.1a	9.5a
Check (water)	-	200	292.5a	72.5ab	0.25a	2.3a	19.2a

*The 0.5 gal rate was applied the first three applications and the 0.75 rate the remaining applications.
**Means within a column followed by the same letter are not significantly different at the P<0.05 level, Duncan's multiple range test.

Table 8. Average numbers of SPWF, leafminers and tomato pinworm per sample by sprayer type.

Treatment	WF Eggs	Crawlers	Sm. Nymphs	Lg. Nymphs	Pupae	Total Immatures
Berthoud	5.20a	0.20a	22.75b	2.06a	0.38a	30.59
None	7.06a	0.00a	38.22a	5.19a	1.44a	51.91
Pressure	10.43a	0.03a	30.61ab	4.79a	1.49a	47.34

Treatment	Leafminer Live	Leafminer Dead	Leafminer Total	Leafminer Emerged	Live Stings	Dead Pinworm	Pinworm	SPWF Adults	%Virus
Berthoud	3.65a	0.25a	7.47	2.29a	4.42a	0.50a	30.09b	3.06b	50.58b
None	3.72a	0.25a	6.56	2.37a	6.91a	0.88a	48.41a	3.01a	73.33a
Pressure	3.34a	0.17a	7.01	2.09a	5.17a	0.59a	37.40ab	2.44ab	49.02b

Table 9. Number of water-sensitive paper cards per coverage category by sprayer type. Ratings from 5 = VERY GOOD to 1 = VERY POOR.

	Rating					
Sprayer	1	2	3	4	5	Average
Airboom	0	16	23	13	12	3.3
Pressure	16	23	16	5	4	2.3

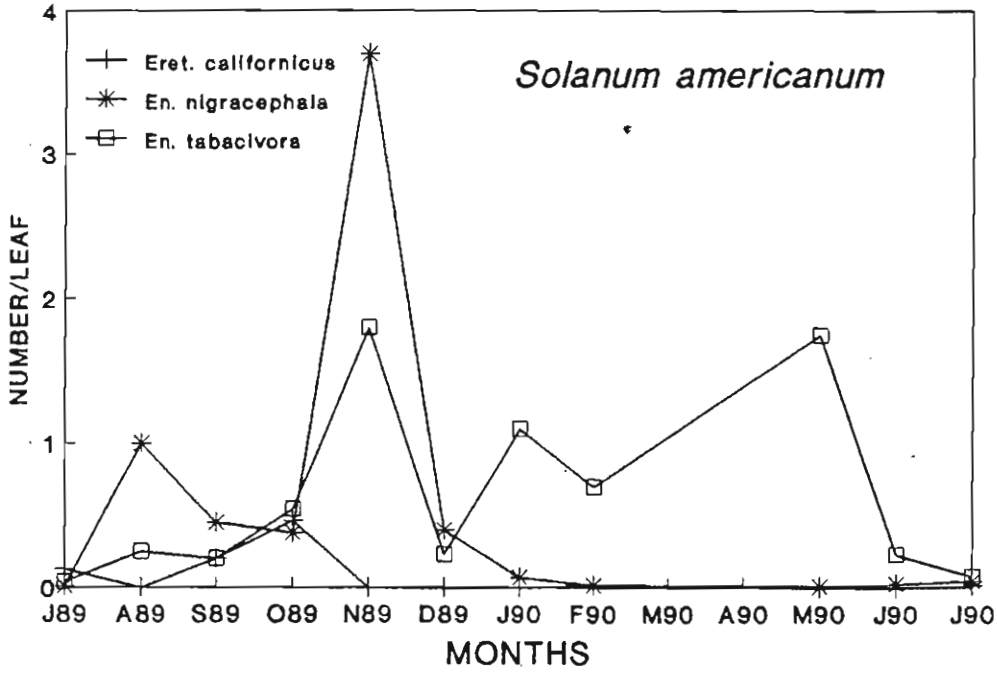


Figure 1. Emergence of hymenopteran parasites from SPWF pupae on nightshade.

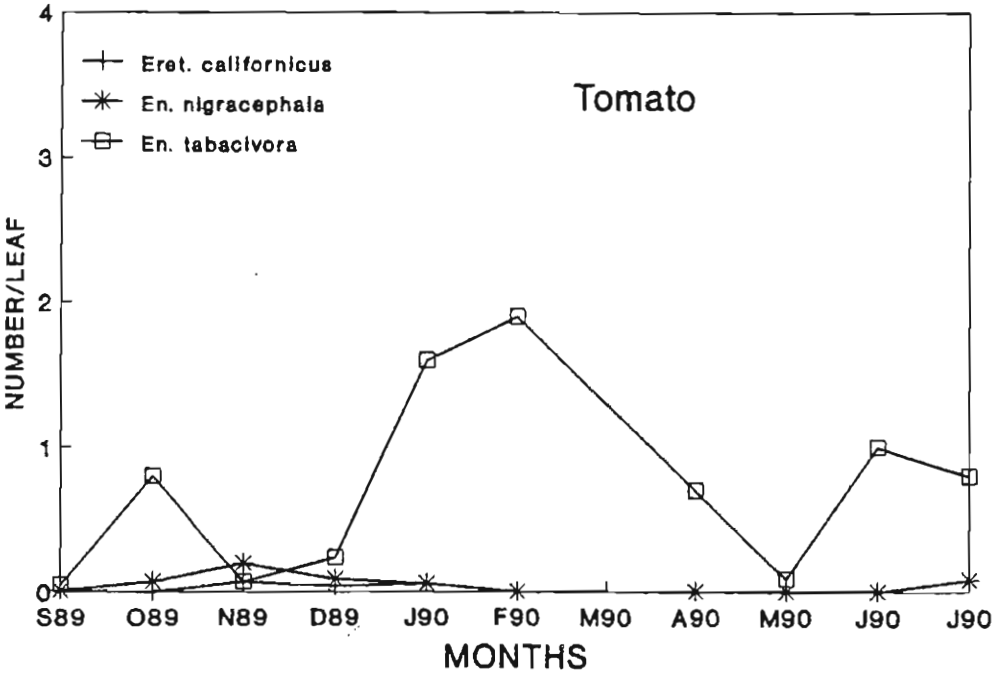


Figure 2. Emergence of hymenopteran parasites from SPWF pupae on tomato.

DETERGENTS AND OILS: RATES, MIXTURES, AND PHYTOTOXICITY

Charles S. Vavrina, Extension Vegetable Specialist
and
Philip Stansly, Extension Entomologist

Southwest Florida Research and Education Center
P.O. Drawer 5127
Immokalee, FL 33934

The onset of the Florida Tomato Geminivirus (FTGV) left growers searching for new spray technology and materials for the control of sweet potato whitefly. Among the materials found to be efficacious by the growers in the spring of 1991 were common laundry and dish detergents (soaps). With methodology founded in organic farming literature, growers were largely "experimenting" with these materials.

Horticultural oil technology had been promoted in the fall of 1990, and by spring 1991 tank mixes of detergents and oils were common on some farms. With little university research to back this methodology and application technology, growers took it upon themselves to develop their own application rates, mixtures, and schedules.

The myriad of products on the market combined with numerous tank mix possibilities made research in this arena difficult to address. However, in an effort to develop some guidelines, a study was undertaken at the Southwest Florida Research and Education Center in June of 1991 on double- cropped old tomato beds. The study was designed to identify detergent, oil, and detergent/oil tank mix phytotoxicity on fresh market tomatoes. The intensity of heat and solar radiation during June provided ideal conditions for phytotoxicity. The treatments were applied at approximately 11 AM to further encourage foliar injury. A backpack sprayer calibrated to deliver 50 gpa at 40 psi was used to apply the treatments.

The detergent used in these studies was Tide Liquid (Proctor & Gamble, Cincinnati, OH), and the oil was Ultra-Fine Oil (Mycogen, San Diego, CA). The following treatments were applied:

Control (Water application)

Detergent at 1%, 2%. 4%, 8% by volume

Oil at 0.5%, 1%, 2%, 4% by volume

Tank mixes of:

- 0.67% detergent to 0.33% oil
- 1.33% detergent to 0.67% oil
- 2.67% detergent to 1.33% oil
- 5.33% detergent to 2.67% oil
- 10.67% detergent to 5.33% oil

Plants were established for 1 week, and 12 plants per plot were designated to receive the treatments. They were applied twice weekly for a period of three weeks resulting in six applications. Percent phytotoxicity ratings were taken 24 hrs after each treatment application by visual assessment of the injured foliage of the entire plant. Following termination of the treatments, five "typical" plants from each treatment were removed (above-ground portion only) and assessed for dry matter accumulation. Treatments were replicated four times and the data was analyzed by ANOVA with mean separation by LSD.

DETERGENT Foliar injury that occurred from the detergent treatments appeared as a "burn", resulting in necrotic lesions or to a lesser extent a bronzing on the leaf surface. All stages of foliage development were susceptible.

The only acceptable detergent treatment was a 1% solution (Fig. 1). One application of 1% detergent resulted in a foliar injury level of less than 5%. This level of injury rose to 35% after four consecutive sprays. The injury appeared to lessen with further sprays.

Concentrations of detergent application higher than 1% were considered unacceptable due to the excessive levels of foliar injury that occurred. Foliar damage continued to accrue with the application of 2% detergent; this treatment was discontinued after three applications. The 4% and 8% concentrations resulted in complete foliage loss with the first application, therefore further treatment was discontinued. Plant loss occurred with all detergent rates applied (Table 1).
The 1% rate was four times greater than the rate commonly used by growers (0.25%). Dr. George Butler, visiting entomologist from Arizona, successfully used 0.5% detergent in his studies without mention of phytotoxicity (personal communication). Whereas growers might feel the level of injury observed with a 1% solution was excessive, the rate may prove effective under circumstances of heavy whitefly infestation.

All detergent application concentrations significantly reduced dry matter accumulation of young tomato plants (Table 1). Tomatoes treated with 1% detergent weighed 1/4 to 1/3 of control fruit. Dry matter accumulation with the 4% detergent concentration reflected regrowth following the single application. Dry matter accumulation at the 8% detergent concentration indicated no regrowth occurred following this single application treatment.

OIL Plants receiving all levels of oil application were free from foliar injury in the form of "burn", and no oil application resulted in plant loss. However, the 2% and 4% oil concentrations treatment levels resulted in severe malformation of young foliage. This effect was greatest in the 4% oil

treatment. Further applications would be likely to result in reduced yield or unmarketable fruit.

Both the 0.5% and 1% oil applications were acceptable without the resultant leaf malformation. These rates are within the labeled rate guidelines for most oils.

Tomato dry matter accumulation for oil-treated plants approximated control plant growth at concentrations of 1 and 2% (Table 1). The 4% oil application resulted in plant weights 1/3 of that of the control. The 0.5% oil application resulted in about the same weight reduction as the 4% treatment when compared to the control. This phenomenon is difficult to explain considering the dry matter accumulation of the 1% and 2% oil treatments.

DETERGENT/OIL TANK MIXES Most of the 2:1 detergent to oil tank mix combinations resulted in foliar injury (Figure 2). Significant plant loss occurred with the 5.33% detergent/2.67% oil and 10.67% detergent/5.33% oil treatments after one application, therefore these treatments were discontinued. The 0.67% detergent/0.33% oil mix resulted in 25% injury after three applications, but injury subsided with further growth of the plant. This application mix might be efficacious under heavy whitefly pressure.

All detergent/oil tank mixes resulted in a reduction of tomato dry matter accumulation when compared to the control (Table 1). The 0.67% detergent/0.33% oil mix showed the least overall weight reduction resulting in 55% of the control weight.

It should be emphasized that these applications were applied on a twice-weekly schedule to young, newly-established plants, applied with a backpack sprayer at 40 psi. Plant response to these treatments under spray pressures greater than 100 psi is subject to debate. These preliminary results need further corroboration to ascertain if such dramatic weight loss by detergent treated plants was truly an effect of the treatment. The study will be repeated in a fall '91 trial at SWFREC.

Carson, Julie A

From: Mendez Martinez,Joel A
Sent: Monday, August 20, 2012 9:03 AM
To: Carson, Julie A
Subject: BIOCHEMIST BOOK

Hi Julie,

I'm wondering if you please can get the book **Lehninger's PRINCIPLES OF BIOCHEMISTRY fifth edition** by David L. Nelson and Michael M. Cox and the book titled Ecology and behavior of the ladybird beetles (Coccinellidae) by I. Hodek[3], H. F. van Emden[4], A. Honěk[5] J. P. Michaud[1] and James D. Harwood[2] from the library.

By the way, my biochemist class will be offered on line, so I won't have to use the polycom for this purpose.

Thank you very much.

Have a nice day. ☺

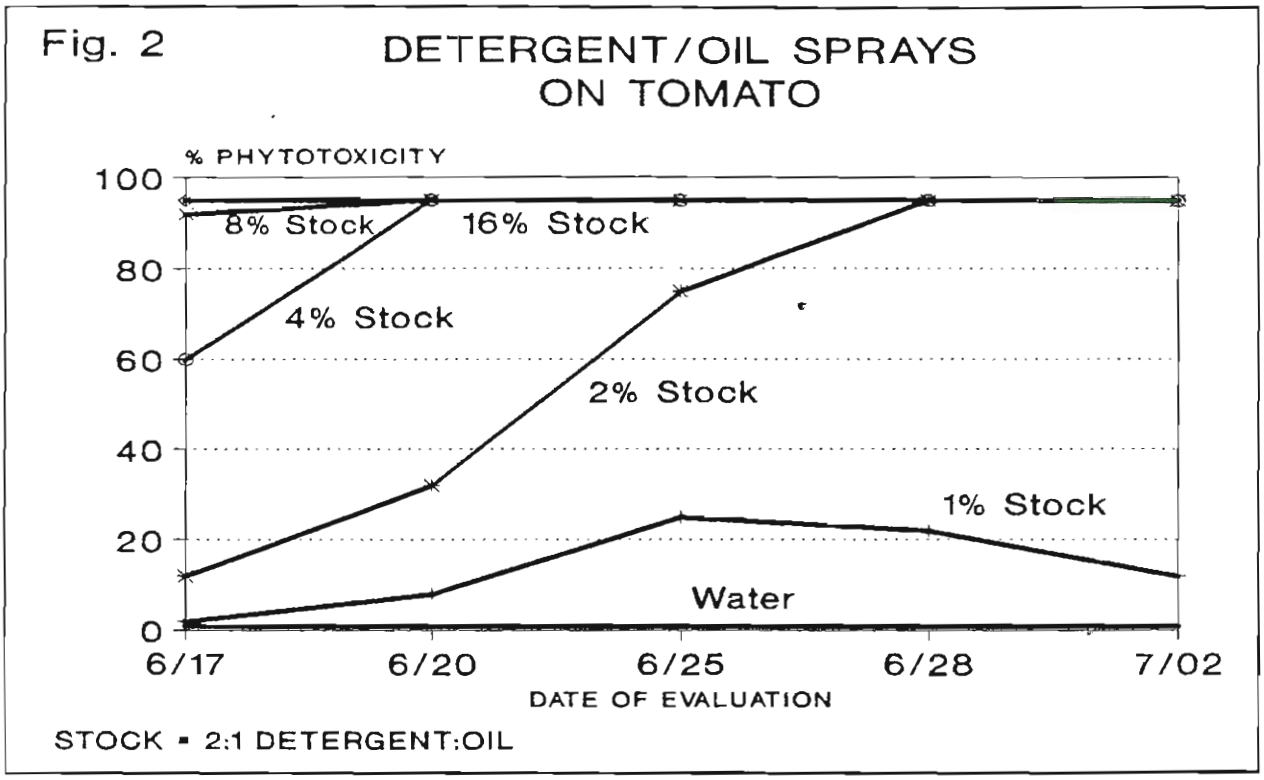
Joel.

Table 1. Tomato seedling dry weights, 1 month after planting and after receiving detergent, oil, or detergent/oil sprays twice weekly.

Treatment	Rate	Dry Weight Per Plant[a]	Sample Size
		--(grams)--	(no.)
Water	Check[e]	6.377	5
Detergent	1 %[e]	1.779	4
	2 %[d]	0.640	4
	4 %[c]	2.003	4
	8 %[c]	0.669	1
Oil	0.5 %[e]	1.740	5
	1 %[e]	5.158	5
	2 %[e]	5.507	5
	4 %[e]	2.277	5
Detergent/Oil[b]			
	0.67%/0.33%[e]	3.563	5
	1.33%/0.67%[d]	1.574	5
	2.67%/1.33%[c]	1.231	5
	5.33%/2.67%[c]	0.0	0
	10.67%/5.33%[c]	0.0	0
LSD 5%		2.96	1

[a] Averaged from a 5 plant sample when available
[b] Stock solution = 2:1 detergent:oil
[c] Plants received one spray
[d] Plants received three sprays
[e] Plants received six sprays

Fig. 2


DETERGENT/OIL SPRAYS
ON TOMATO
% PHYTOTOXICITY
100
80
60
40
20
0
8% Stock
16% Stock
4% Stock
2% Stock
1% Stock
Water
6/17
6/20
6/25
6/28
7/02
DATE OF EVALUATION
STOCK = 2:1 DETERGENT:OIL

PROSPECTS FOR BIOLOGICAL CONTROL OF *BEMISIA TABACI*

Lance S. Osborne
University of Florida
CFREC-Apopka
2807 Binion Rd.
Apopka, FL 32703
(407) 889-4161

Kim Hoelmer
USDA-ARS
Horticultural Research Laboratory
2120 Camden Rd.
Orlando, FL
(407) 889-4161

Dan Gerling
George Wise Faculty of Life Sciences
Department of Zoology
Tel Aviv University
Tel Aviv 69978 ISRAEL

Summary

The prospects for biological control of *Bemisia tabaci* in the southeastern United States and elsewhere using natural enemies from Florida are discussed. An overview of research in progress on managing this whitefly with *Encarsia formosa*, *E. transvena*, *Eretmocerus californicus*, *Delphastus pusillus*, and *Paecilomyces fumosoroseus* is presented.

INTRODUCTION

The sweetpotato or cotton whitefly, *Bemisia tabaci*, is a major pest worldwide of economically important crops, including cotton, cucurbits, lettuce, soybeans, and tomatoes. This pest attacks over 500 different plants, many of which are widely distributed weeds and garden plants. Until late 1986 this whitefly was not considered a pest of plants grown under protected culture. In the past several years it has become one of the most important and economically damaging pests in North American greenhouses in addition to its increasing importance as a pest of field crops. The whitefly severely impacts important vegetable and ornamental crops by reducing host plant vigor, yield, and promoting growth of sooty mold. Transmission of viral diseases is a major problem in many parts of the whitefly's range and is now becoming a problem in the southeastern United States. Resistance to insecticides has been reported in many parts of *Bemisia*'s range. While attempting to control this pest growers are also under pressure to reduce

applications of chemical pesticides as public awareness of pesticide usage increases. Crops grown in protected culture receive the greatest amount of pesticide applications per acre; groundwater contamination from this industry is now a major concern.

Numerous natural enemies of Bemisia tabaci have been recorded (Cock 1986) from many parts of the world, but little is known about the resident natural enemy complex in the southeastern U. S. A. and other humid subtropical and tropical regions. It is expected that once these regions are surveyed, potentially valuable natural enemies of B. tabaci will be discovered. Many candidate species from other areas are also available for possible importation but biological information about many of these species is lacking and resources for exploration, collection and quarantine rearing are inadequate. A concerted effort is being made to manage Bemisia in many parts of the world where is has become a problem including North America and recent interest in biological control has been high. In the southeast U.S.A. the efforts of many scientists are being coordinated through a regional project entitled "Biological Control of Selected Arthropod Pests and Weeds Through Introduction of Natural Enemies".

2. General Approach to Control of B. tabaci

We agree with the views expressed by van Lenteren & Woets (1988) that natural enemies should ideally be used in protected cultures at low host levels. However, since 1) B. tabaci develops quickly, 2) occurs naturally in hot climates where control of temperature is limited (in cold countries there is more control of glasshouse temperature), and 3) there often is constant migration of whiteflies from the outside, growers are often faced with high localized populations even if we introduce natural enemies initially at low levels. Therefore, it may not be possible to rely on a single natural enemy species. Instead we may have to utilize several species to provide control under different host conditions (low and high density-efficient species).

Citrus blackfly is an example of effective biological control where several parasitoid species were initially introduced; one multiplied rapidly and quickly reduced blackfly numbers but another eventually became dominant while remaining effective at low and high blackfly densities (Summy et al. 1983, Thompson et al. 1987).

3. Natural enemies

3.1 Parasitoids

As most workers in this field are aware, many whitefly parasitoids belong to taxonomically unsettled groups. Species identifications are very difficult to obtain and often controversial for species in the genera Encarsia and Eretmocerus. Taxonomists urgently need financial support in order to provide the needed support services required for progress in research on parasitoids that attack B. tabaci. Additional funding is needed for surveys of the parasitoid fauna in many areas of the world, and for continued maintenance of parasitoid cultures that show promise in order to make them available when the need arises.

Encarsia formosa is the only species commercially available at this time. Reports on its ability to reduce B. tabaci populations have been mixed. There are many possible reasons for this; most probably relate to Bemisia's occurrence over a wide range of host plants, cropping and environmental conditions. Studies are currently being conducted to compare this species with those found in Florida. It has been suggested that Encarsia formosa may provide acceptable control only under conditions where SPWF is limited by sub-optimal temperatures such as occur at the northern limits of its distribution in the field and in northern glasshouse culture or on plants which are marginally suitable for the development of whitefly populations.

Considerations of host finding efficiency and of rearing expense are very important in evaluating candidates. Eretmocerus species are generally more efficient in host finding and possess a desirable functional response; and being arrhenotokous unlike most Encarsia species, may be easier and cheaper to rear. Some species have longer developmental periods from oviposition, but this may be offset by higher searching and oviposition rates.

Five species of parasitoids (Hymenoptera: Aphelinidae) are found parasitizing Bemisia tabaci in substantial numbers in Florida. Four have been tentatively identified as Encarsia transvena (or near transvena), Encarsia nigricephala, Encarsia tabacivora, and Eretmocerus californicus. Still unidentified is a species of Encarsia near formosa. We are currently rearing Encarsia transvena, E. formosa and Eretmocerus californicus.

Encarsia transvena is found in central Florida in populations of papaya whitefly, Trialeurodes variabilis, as well as in SPWF populations. This species has been reported from Africa, the Far East, and Hawaii. It has a highly female-biased sex ratio. There is some evidence for both unisexual and

bisexual populations. Current laboratory cultures are bisexual. Males develop as hyperparasites of females, and have also been reared from parasitized aphids. Females prefer to oviposit in third and fourth instar Bemisia (fig. 1). This species has a relatively short development time for females of 12 to 14 days at 25° C (fig. 2), considerably less than the whitefly's development time of 24 to 25 days. Male E. transvena development is completed in as few as 9 days. Substantial host-feeding occurs, increasing its impact on whitefly populations. Female longevity (under glasshouse conditions in Florida) is greater than that of E. formosa (fig.3) but its general level of activity as evidenced by parasitism in paired comparisons appears to be lower. The species is behaviorally difficult to experiment upon.

Encarsia formosa has not established in field populations of Bemisia in Florida but reproduces well in greenhouse populations. The species is thelytokous on B. tabaci, as it is on greenhouse whitefly, although males are produced in low numbers. Oviposition and host-feeding behavior is similar to that of E. transvena (fig. 1), but development requires three more days at 25 °C (fig. 2). Low relative humidity appears to be especially detrimental to adult survival in this species (fig. 3). Survival is increased under higher humidity conditions but does not approach that of E. transvena.

Eretmocerus californicus occurs across the southern United States and into South America as far as Brazil. It adapts well to greenhouse rearing conditions. Females deposit eggs on the leaf surface underneath whitefly nymphs; they will accept all nymphal instars but prefer the second and third (fig. 1). After hatching, the larva eventually penetrates the host and completes development as an endoparasite. Development requires 18 to 24 days at 25 °C (fig. 2). Adult survival is similar to E. transvena (fig.3). Females are very active relative to the species of Encarsia we have investigated. Fecundity studies in progress indicate that individual females lay five to six eggs per day during the first week following emergence, after which daily oviposition decreases. E. californicus also host-feeds, causing additional mortality. Both females and males develop as primary parasitoids. In contrast, males of most Encarsia species develop as hyperparasites of females.

The potential of the other species remains to be investigated. Each has been recovered in abundance from field collections. Field populations of B.tabaci are sometimes heavily parasitized even at low densities.

In Florida, a modified banker-plant system is being evaluated as a method for distributing parasitoids. Papaya plants (Carica papaya) are infested with papaya whitefly and then exposed to parasitoids. These plants can be placed into or

alongside crops without releasing additional B. tabaci, and could be helpful in overcoming the reluctance of growers to place natural enemies with pests into their crops. The suitability of this whitefly as a host for the above species of parasitoids is being studied. The predatory beetle Delphastus pusillus will also feed and reproduce on papaya whitefly.

3.2 Predators

There are many predators that will attack whiteflies. These include various Hemiptera (especially Anthocoridae, and predatory Miridae), Coleoptera (Coccinellidae), Neuroptera (Chrysopidae, Hemerobiidae, Coniopterygidae), Diptera (Dolichopodidae, Syrphidae, Anthomyiidae), Hymenoptera (Formicidae), Araneida and Acarina (Phytoseiidae, Stigmaeidae). Some of these are opportunistic predators of adult whitefly, others are general predators of leaf-feeding Homoptera, still others are specific predators of whiteflies. Very little information is available on the biology and impact of most predators of sweetpotato whitefly, especially in field crops.

The most promising predator to date for use in greenhouses is the coccinellid, Delphastus pusillus Casey. This species is distributed across most of the southern and eastern U. S. and throughout the Caribbean, Central and northeastern South America. Larval and adult beetles feed voraciously on eggs, immatures, and adult whiteflies. They feed specifically upon whiteflies, but will accept spider mites as alternate prey if whiteflies are not available. Eggs are typically laid on leaves with high densities of whitefly eggs. Eggs are deposited on the leaf surface; females also frequently place eggs inside SPWF exuviae. Beetles prefer eggs to older whiteflies and can consume several hundred per day. Older larvae gradually cease feeding and move down the plant in search of protected places for pupation. Development time under greenhouse conditions (mean of 26-27 °C) is 21 to 22 days. Adult females live an average of 50 days, males about 40. Well-fed females lay 3 to 4 eggs per day. Initial results suggest that D. pusillus is best adapted to feeding and reproducing at high whitefly densities. Prospects for mass rearing appear promising.

Another coccinellid, Clitostethus arcuatus (Rossi), has been implicated in dramatic reductions of whiteflies in small research greenhouses in Israel but biological data is sparse. This species appeared on its own inside two greenhouses containing cotton plants and lantana. C. arcuatus was first detected in mid June. By the 3rd week of July both greenhouses were completely clean of SPWF and stayed clean until mid August. The beetles then disappeared and did not reappear when SPWF reappeared in September. This species was recently imported into California for evaluation against the recently introduced ash whitefly, Siphoninus phillyreae (Halliday).

A coniopterygid obtained from Kenya was released in Israel but disappeared after one generation in the field before significant data were obtained. Substantial mortality due to predation by coniopterygids has been observed on greenhouse whitefly in California in some tree crops.

3.3 Fungal Pathogens

The use of insect pathogens for the control of whiteflies dates back to the early part of this century when Florida citrus growers used Aschersonia. This fungus was encouraged to grow on whiteflies infesting citrus trees. Branches were then harvested from these trees and the infected whiteflies moved throughout the state to facilitate the spread and control of citrus whiteflies by Aschersonia. Problems with the control of greenhouse whitefly in greenhouses resulted in the development of a commercial products which contain strains of the fungus Verticillium (Cephalosporium) lecanii.

Studies have been conducted at the Central Florida Research and Education Center, Apopka to determine the potential for using Paecilomyces fumosoroseus to control Bemisia tabaci. This pathogen has been responsible for very dramatic epizootics in greenhouses and on raised benches and in relatively open structures that were covered with shade cloth. Paecilomyces fumosoroseus possesses many desirable attributes; quick knockdown (fig.4), infects all stages (fig.5.) tolerance to pesticides, ease of production, and a broad spectrum of activity. The University of Florida and W.R. Grace have entered a cooperative agreement to pursue the development and commercialization of this pathogen. Therefore, many aspects of our current research with this pathogen can not be disclosed in print at this time.

4. Conservation of Natural Enemy Populations

Many species of whitefly parasitoids and predators will attack other species of whitefly when they are sympatric with Bemisia. Research is needed to determine the importance of wild populations of whitefly and enemy reservoirs in the vicinity of field crops and the influence of weedy and native plant hosts on the movement of whiteflies and natural enemies into adjacent areas. Existing opinions on the size and importance of wild populations of Bemisia are somewhat contradictory. Whitefly species in general do not reach damaging levels in undisrupted habitats, an indication of the impact of their natural enemies (DeBach and Rose 1977, Rose and Wooley 1984) and of environmental mortality factors (Horowitz et al. 1984). Further improvements in the specificity of new pesticides such as growth regulators are likely to create new opportunities for conservation of natural enemies.

5. Opportunities for Integration with Chemical Pesticides

Integration of natural enemy releases with existing pesticides used against B. tabaci will continue to be an important goal. Many currently registered pesticides are very detrimental to natural enemies. Insecticidal soaps and oils, and pesticides containing neem are a few compounds that allow some parasitoid and predator activity. Results of tests with predators and parasitoids of cotton aphid and sweetpotato whitefly show that neem extracts were relatively non-toxic and did not greatly reduce predation and parasitism. Parasitism by Eretmocerus and Encarsia transvena was recorded in several greenhouse trials in which Margosan-O was applied up to four times. In each case, plants treated with Margosan-O had levels of parasitism comparable to unsprayed controls or significantly higher than when other pesticides were used.

Development of new growth regulators for whitefly control such as buprofezin and those compounds that belong to the benzoyl urea group (teflubenzuron, CGA-184699, andalin) offer additional hope for the future compatibility of selective insecticides and parasitoids. These materials have significant activity against specific whitefly stages: eggs and early instars. Since parasitoids will attack older nymphs and prepupae, we may be able to integrate the two. Selective compounds could be used to reduce the whitefly populations to manageable levels that parasitoids would be able to keep in check.

Initial results with potentially selective compounds from trials in Florida demonstrated that parasitoids persisted in trials using kinoprene, CGA-184699, teflubenzuron and fenoxycarb. Some IGRs (buprofezin) were so effective against SPWF that no nymphs remained for parasitoids to attack, so their immediate effect on the parasitoids could not be assessed.

Buprofezin was evaluated under field conditions in Israel for two years. The effect of this compound on individual species varied: Eretmocerus mundus was negatively affected, perhaps because it selects younger whitefly nymphs to parasitize than Encarsia species, and parasitism due to it alone declined slightly in IGR treated plots. Parasitism by Encarsia lutea increased slightly in the treated plots.

By combining an effective IPM scouting program with judicious selection of biological, cultural and selective chemical controls, we are hopeful that this whitefly can be managed effectively using the variety of available agents. Figure 6 indicates the significant mortality factors and the corresponding whitefly stages most affected by various factors.

To obtain biological control of Bemisia, we suggest that the sequence of events should be:

1. Introduce density-efficient natural enemies when whitefly populations are low.

2. If Bemisia populations increase due to inadequacy of the original natural enemies, use an IGR, adulticide or mass-released predator effective at high host densities. This will:

A) Quickly reduce the whitefly populations,
B) Conserve the emerging parasitoids which will remain active,
C) Allow continued activity of IGRs: because of their stability over time, they will continue to limit the growth of whiteflies on treated leaves. Parasitoids will have a more important role on newer foliage.

ACKNOWLEDGEMENTS: This research was supported in part by grants from the Bedding Plants Foundation, Inc., Florida Foliage Association, Florida Tomato Exchange, and U.S.D.A.

Literature Cited:

DeBach, P. and M. Rose. 1977. Environmental upsets caused by chemical eradication. Calif. Agric. 31(7): 8-10.

Horowitz, A. R., Podoler, H. and D. Gerling. 1984. Life table analysis of the tobacco whitefly Bemisia tabaci (Gennadius) in cotton fields in Israel. Acta Oecologica: Oecologia Applicata 5(3): 221-233.

van Lenteren, J. C. and J. Woets. 1988. Biological and integrated pest control in greenhouses. Ann. Rev. Entomol. 33:239-269.

Rose, M. and J. Wooley. 1984. Previously imported parasite may control invading whitefly. Calif. Agric. 38(2): 24-25.

Summy, K. R., F. E. Gilstrap, W. G. Hart, J. M. Caballero and I. Saenz. 1983. Biological control of citrus blackfly (Homoptera: Aleyrodidae) in Texas. Environ. Entomol. 12: 782-786.

Thompson, C. R., J. A. Cornell and R. I. Sailer. 1987. Interactions of parasites and a hyperparasite in biological control of citrus blackfly, Aleurocanthus woglumi (Homoptera: Aleyrodidae), in Florida. Environ. Entomol. 16: 140-144.

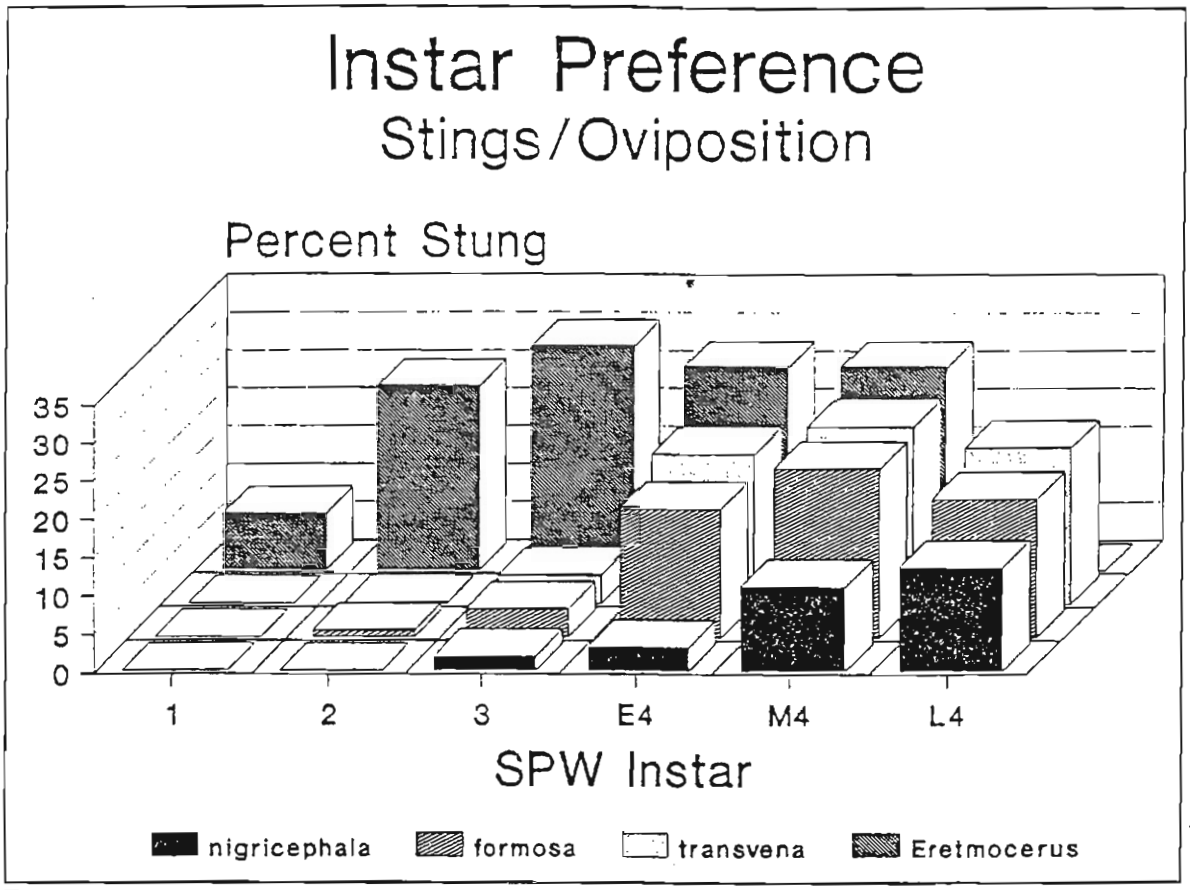


Figure 1: Instar preference for oviposition by 4 parasitoids of B. tabaci in Florida.

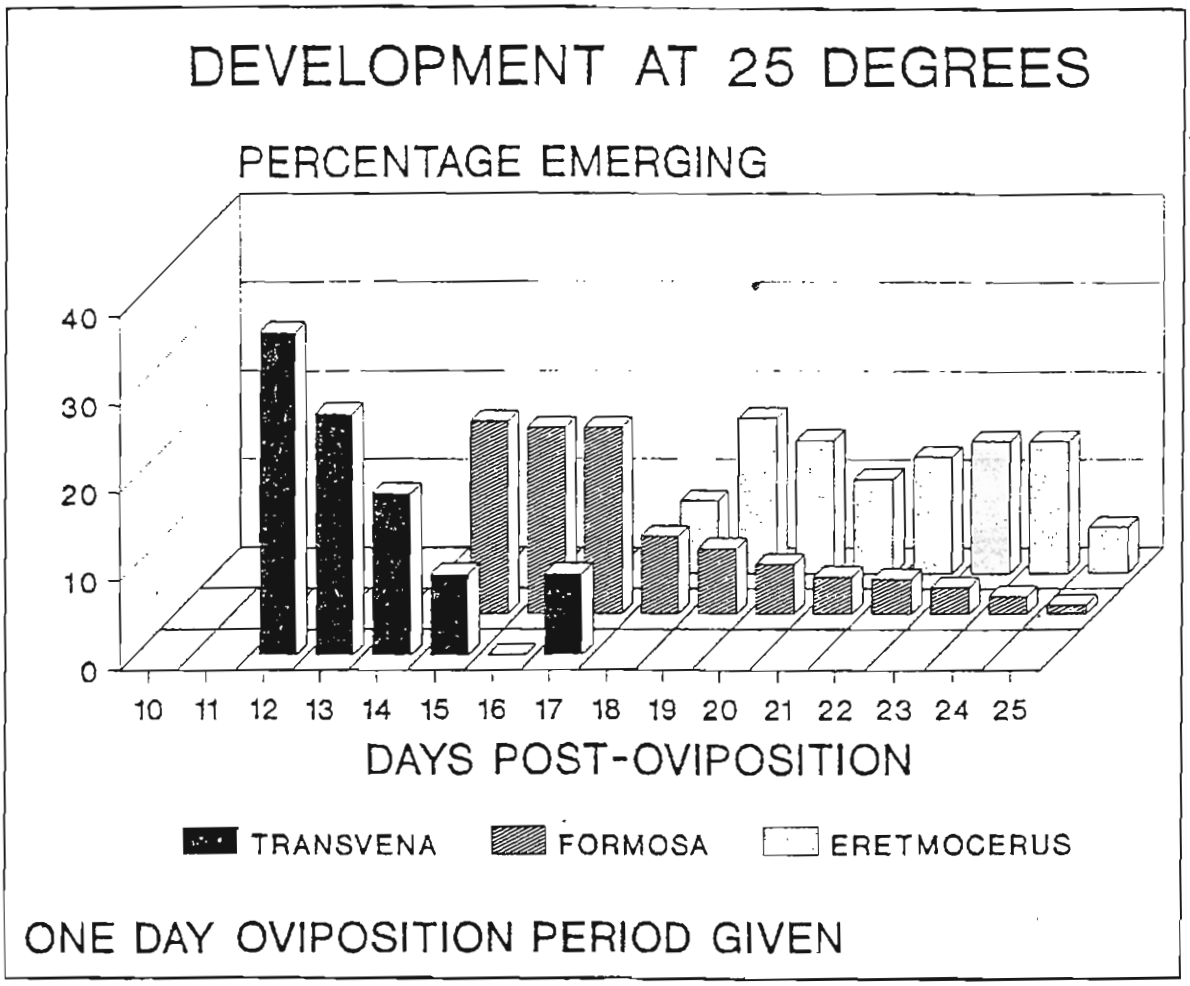


Figure 2: Development of 3 parasitoids of B. tabaci at 25 degrees.

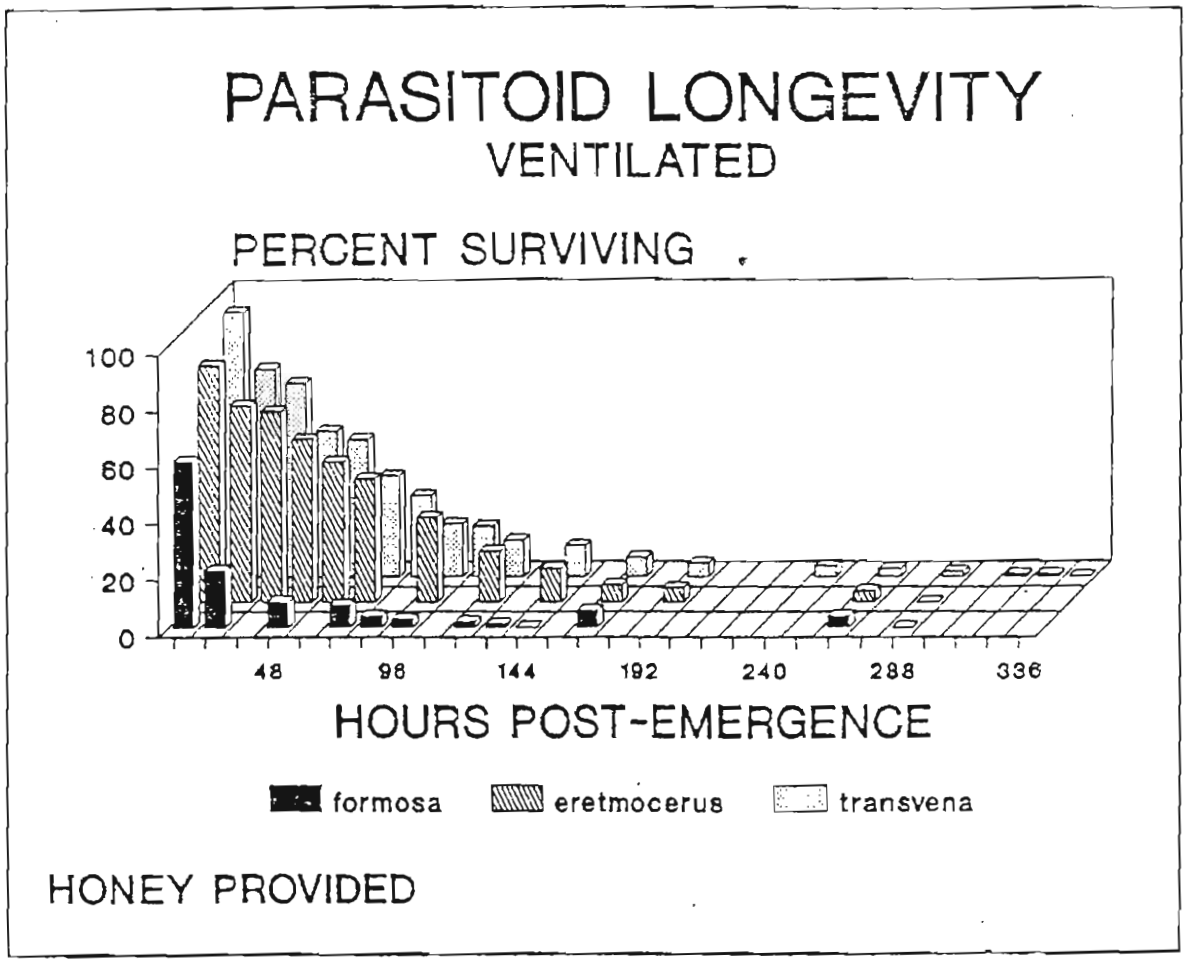


Figure 3: Longevity of 3 parasitoids of B. tabaci in ventilated cages (60-70% RH).

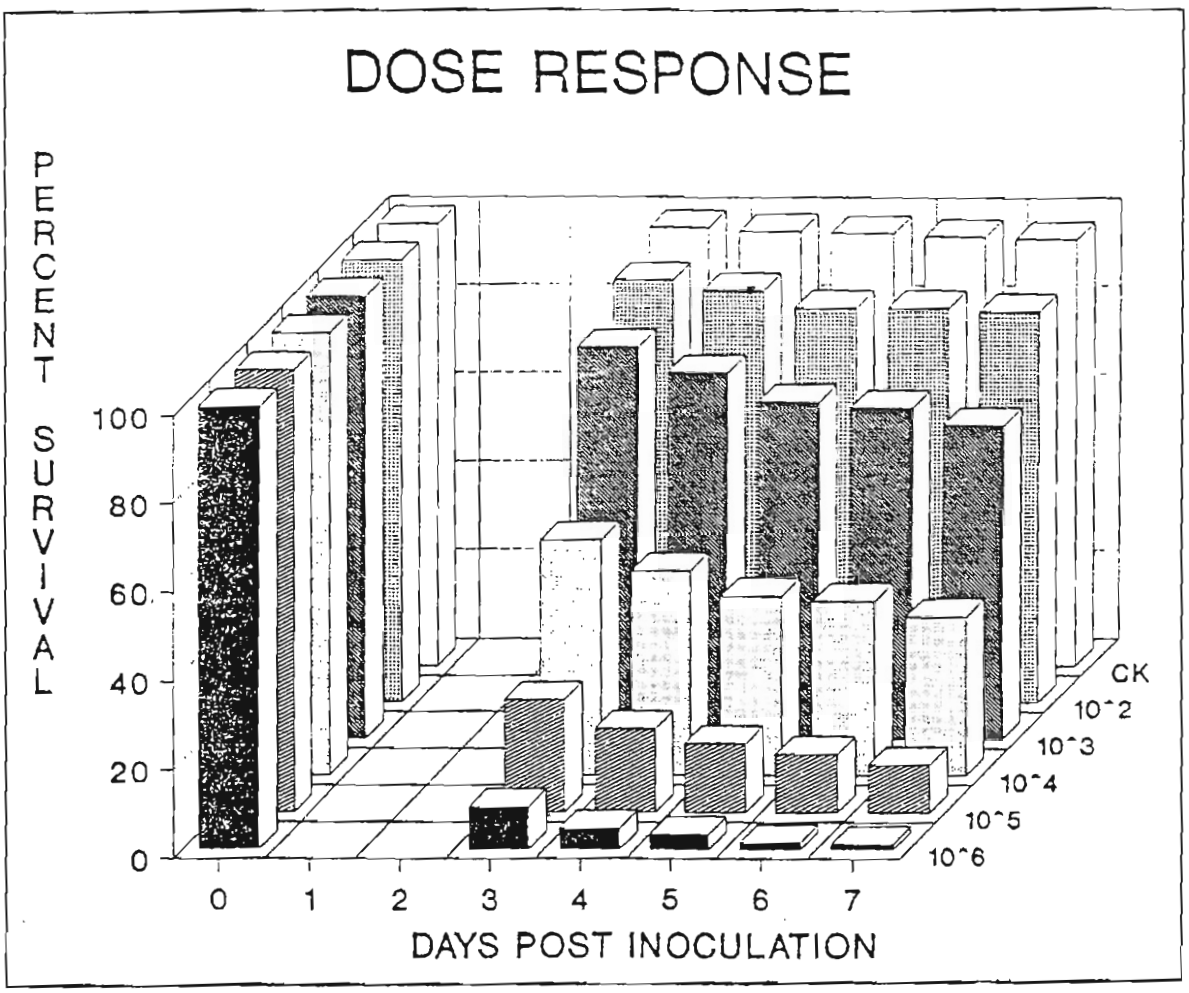


Figure 4: Dose response of early fourth instar nymphs exposed to P. fumosoroseus at 100% RH.

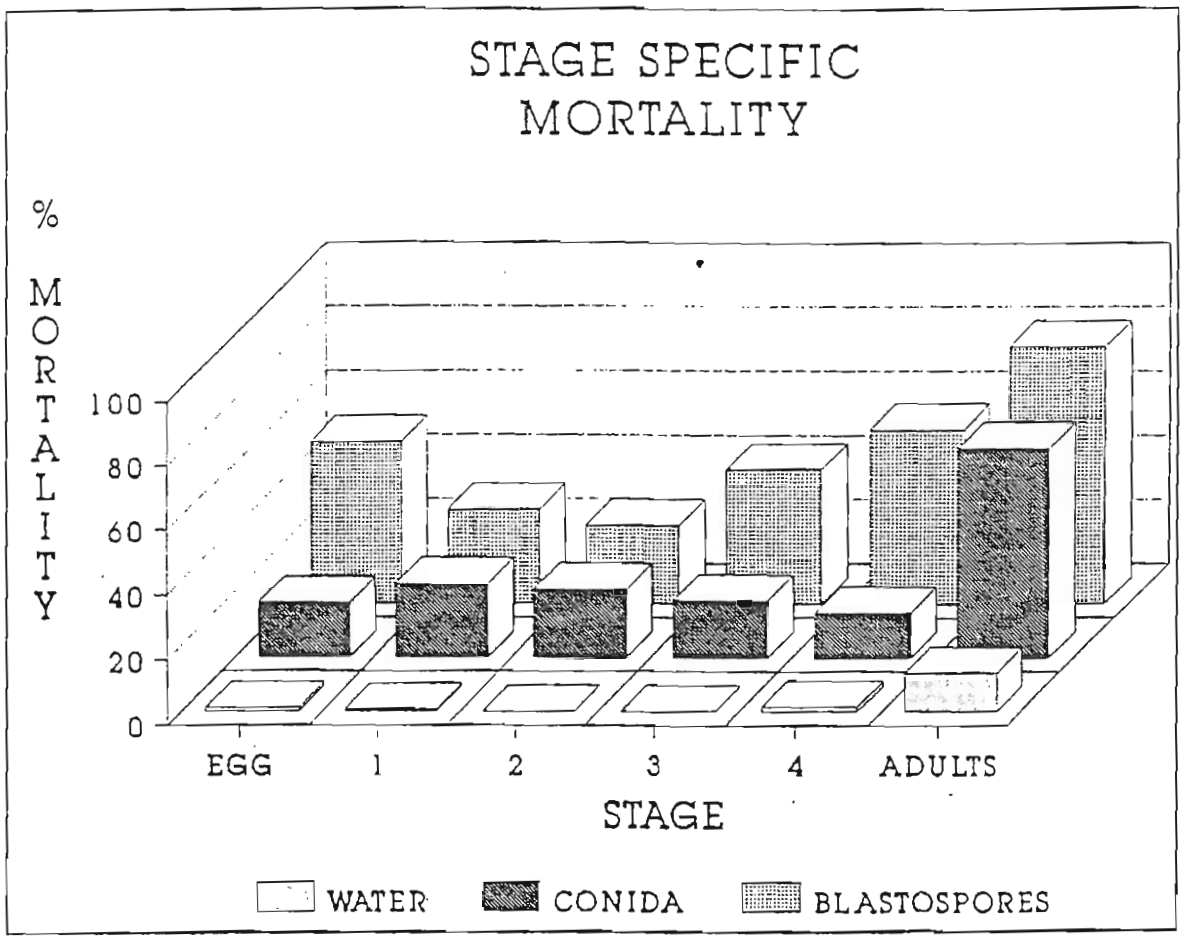


Figure 5: Stage specific mortality when exposed to 1x10^6 conidia or blastospores.

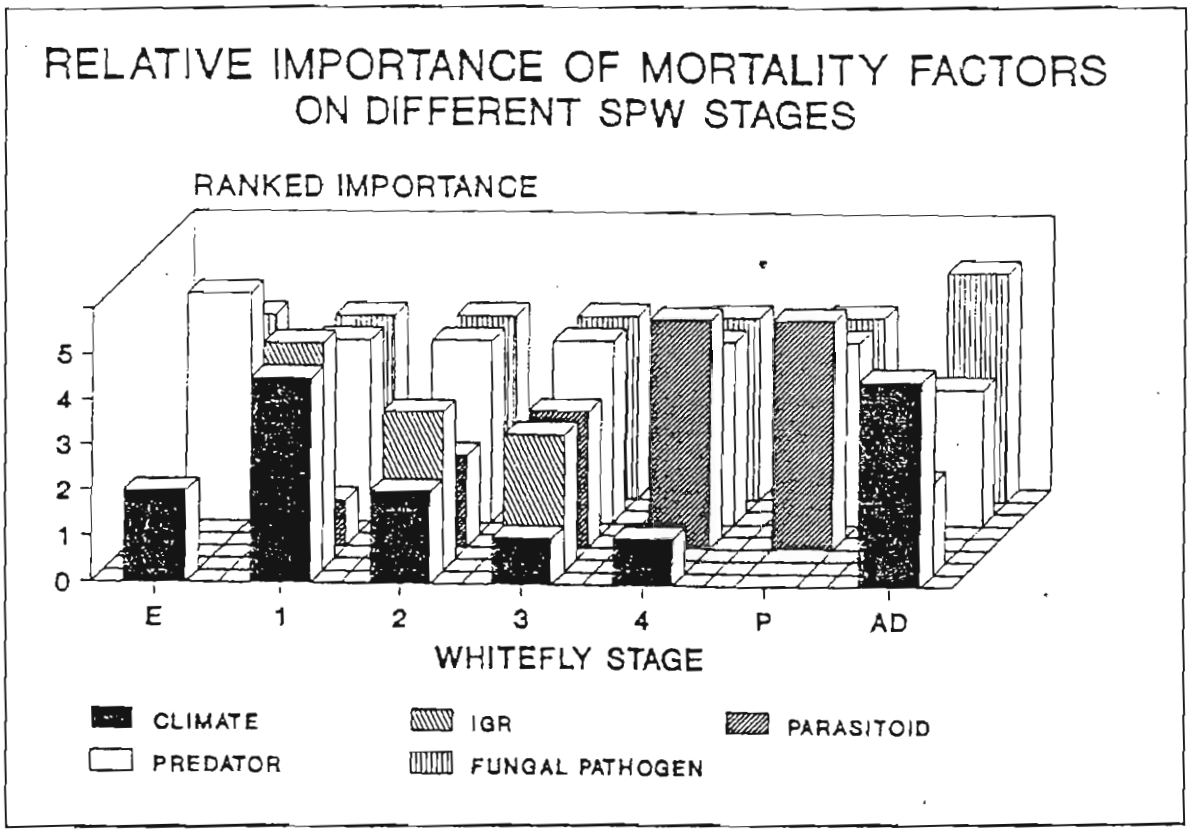


Figure 6: Relative importance of various mortality factors on different stages of B. tabaci.

A NEW DECADE FOR THE IFAS TOMATO BREEDING PROGRAM

J. W. Scott
Gulf Coast Research & Education Center
Bradenton, FL

The Florida tomato industry has entered the last decade of the 20th century A.D. and I have entered my second decade as the IFAS tomato breeder. Sweetpotato whitefly related problems, especially the Florida geminivirus, now pose one of the most serious threats the tomato industry has ever faced. A tight state budget poses a serious threat to the IFAS tomato breeding program as well as other IFAS programs and cutbacks have been implemented. It is difficult to be optimistic about either situation, but strategies to cope with these problems will be presented herein. A presentation of breeding projects nearing the variety testing stage will also be made. This includes lines with bacterial spot resistance combined with heat tolerance and lines resistant to Fusarium wilt race 3.

Florida Geminivirus Crop Control

There will be no quick answer to the geminivirus problem. Over the next several years, growers will have to make decisions based in part on what affect they will have on whitefly and thus virus control. There is much yet to be learned about control of this virus. However, it does appear that the chances of virus infection are reduced as the time between crops is increased. In the Manatee-Hillsborough district, some fall crop fields have been planted in early August or even up in mid July. Formerly the major threats to the early crop yields were heat and bacterial spot epidemics. Now the early crops also shorten the time whiteflies have to survive between tomato crops. Virus infestations in early plantings may threaten not only the individual grower's later crops but also his neighbors' crops. To minimize the virus problem, the tomato industry as a whole may have to consider a ban on early fall planting dates. The delay of planting may not have a great impact on yields from early harvests. For instance, early yields from heat tolerant varieties planted in late August will probably be comparable to early yields of heat sensitive varieties planted a month earlier. The risk of bacterial spot epidemics will also be reduced by the later planting dates. Furthermore, spray costs up to the first harvest would be substantially reduced with less time to the first harvest and less rainy weather in which to spray.

Until geminivirus resistant or tolerant varieties might be developed, growers will have to cope with susceptible varieties. Generally, varieties with larger vines show less severe symptoms than varieties with smaller vines. However, judgements as to varietal differences should be based on packout information. Sometimes varieties with greater viral symptoms on foliage yield more marketable fruit than varieties with fewer symptoms.

Geminivirus Resistance

Accessions were tested in Fall 1990 for resistance in cooperation with Dr. David Schuster. Several accessions with reported tolerance to tomato yellow leaf curl virus or chino del tomate were also tolerant to the Florida geminivirus. Most notable from the testing were several accessions of a wild species, Lycopersicon chilense, which had no symptoms. Crosses were made between 12 L. chilense accessions and tomato and F_1 plants were obtained from eight of these, 15 plants total. Backcrosses of these F_1's to tomato were made this spring and several hundred plants have been obtained although only a few backcross plants were obtained from some of the eight L. chilense F_1 sources. The backcross plants, the L. chilense parents and the hybrids are presently being tested for virus replication and symptoms in cooperation with Dave Schuster and Dr. Jane Polston. It is hoped that one or more of these L. chilense accessions provide a good source of resistance which can be incorporated into Florida tomato varieties. Even if one or more do provide good resistance, a commercially acceptable resistant variety will not be possible for at least five years.

Variety Release Possibilities

Fusarium wilt race 3 resistant hybrids have been tested in advanced trial for the past two years. Although some have had acceptable yields, each one has traits I have not liked. Since this disease has not been widespread in Florida, the decision has been made not to rush with a release but to wait for more improved hybrids.

It has been eight years since we discovered resistance to bacterial spot. Intensive breeding work has been done, but a variety has yet to be released since the genetics is complex and field screening for resistance is often only effective in the summer and early fall. Observations in the last year indicate that several resistant breeding lines now have some parental potential. It is anticipated that bacterial spot tolerant hybrids will enter the advanced trial stage in 1992. Most of these should be heat tolerant as well. An open-pollinated, bacterial spot resistant cherry tomato line, Fla. 7333, is being trialed this fall for possible release. Any growers interested in trial plantings of Fla. 7333 should contact me for seed.

The Next Decade

It is a time of change. There are now six tomato breeders working in Florida for private firms. It will be logical to shift the IFAS program more toward breeding line releases to these companies allowing them to develop most of the finished varieties. In past years, genetics and breeding studies have been conducted to assist in breeding efficiency. A greater emphasis is most likely will be placed on such studies in the future. As mentioned, budget problems have forced some recent cutbacks in the program. Several projects have been shelved for the time being. Hopefully this is a temporary situation. The breeding program will still be quite active but will not cover as wide a range of projects.

The next decade promises a number of new developments in the variety area. Within five years, varieties with resistance to Fusarium wilt race 3 and bacterial spot should be available. Towards the latter half of the decade varieties with resistance to the Florida geminivirus may be available as well, although it is difficult to accurately predict. It is predictable that new maladies for the tomato industry will occur in the next decade. With hard work and good fortune perhaps the Florida geminivirus, bacterial spot, and Fusarium wilt race 3 will be primarily of historical interest.

THE CONDITION OF THE TRANSPLANT AFFECTS TOMATO GROWTH AND DEVELOPMENT

D.I. Leskovar and D.J. Cantliffe
Vegetable Crops Department, IFAS, University of Florida
Gainesville, FL 32611

In Florida, fresh market tomatoes are established in the field by direct seeding or by using containerized transplants. Transplants are generally shipped directly to growers in the trays used for growing the transplants. Field establishment normally occurs between 1 to 3 days, and in some cases up to 7 days, after plant arrival. Transplants shipped out of Florida are hand-pulled from the tray, packed in boxes, and transported at approximately 14C in refrigerated trucks. Field establishment may be delayed from 1 to 7 days depending on weather conditions at planting site and distance to market.

Transplant age at shipping depends on the grower's preference. Growers in the northern U.S. prefer tomato transplants that are at least six-weeks old and 12 to 15 cm in height. Growers in Florida prefer transplants that are 5 or 6-weeks old and 10 cm in height.

Studies on shipping containers, storage time and temperature, and plant age have been reported for bareroot and containerized tomato transplants (Nicklow and Minges 1962; Risse and Moffit 1984; Risse, Kretchman and Jaworski 1985; Risse, Moffit and Bryan 1979; Weston and Zandstra 1989). Storage at 10 to 13C for less than 10 days was recommended for tomato plants (Hardenburg, Watada and Wang 1986). Fruit yield was reduced when bareroot tomato transplants were packed at 1250 plants/crate compared to 1000 plants/crate (Risse, Kretchman and Jaworski 1985).

Plant performance after initial transplanting, depends also on the physiological age of the transplants. Enhanced yield was reported using 3- to 5-week-old bareroot transplants as compared to 7- and 9-week-old transplants, respectively (Nicklow and Minges 1962). Transplant size expressed as height, leaf area or shoot weight, when measured in the greenhouse, generally is larger for older than for younger transplants (Weston and Zandstra 1989). In those previous studies (Nicklow and Minges 1962; Weston and Zandstra 1989), however, shoot and root growth changes that occur during transplant storage and subsequent to planting were not considered.

In these studies, the effects of (a) transplant handling on shoot and root growth changes during extended-low temperature storage, (b) transplant handling on early growth and yield after reduced-ambient storage, and (c) transplant

age on plant growth and yield of tomato transplants were investigated.

Pulled transplants stored at 5C had a longer stem length, more stem dry weight, higher specific leaf area, higher shoot:root ratio and smaller root dry weight than Not Pulled transplants. Shoot growth promotion in Pulled transplants was possibly a response to a higher air temperature in the shoot and root environment caused by the respiration heat generated by the high packing density (Risse, Kretchman and Jaworski 1985). Root growth limitation in Pulled transplants could have been due to excess moisture in the root environment which may have reduced oxygen availability. Specific leaf area increased linearly from 0.213 to 0.250 $cm^2 \cdot mg^{-1}$ as storage time increased from 0 to 8 days, indicating that growth was maintained primarily at the expense of leaves. Similar growth responses were found at 15C, however, leaf and stem growth continued to increase for up to 4 days and decreased thereafter. Lower leaves began to turn yellow after 6 days and leaf deterioration was accentuated after 8 days of storage.

At 5C, leaf area of Pulled transplants increased up to 4 days time at which there was 35% larger leaf area than the Not Pulled transplants. The latter had about the same initial leaf area for the duration of the experiment.

Ethylene evolution was 2.5 ($ml \cdot g^{-1} \cdot hr^{-1}$) at 5C and 2.2 at 15C for Not Pulled plants, and 5.3 at 5C and 2.1 at 15C for Pulled plants. Ethylene stimulation for Pulled plants held at 5C might be attributed to the additive effects of excess of moisture, chilling temperature, and physical stress (1). At 15C, basal roots formed from the hypocotyl, and proliferated in the upper root-media zone, which is a less anaerobic environment than the lower root zone. This new root growth, more evident after 4 days, may have given access to oxygen, reducing ethylene build-up.

Transplants, packed at 2,350 plants$\cdot m^{-2}$, had significantly shorter stem length, and lower leaf area, stem dry weight and root dry weight than Not Pulled transplants that were packed at 658 plants$\cdot m^{-2}$. Under high packing density, and in the presence of high air temperature in the dark, Pulled plants might be expected to deteriorate more than Not Pulled plants. Pulled transplants had higher specific leaf area, lower root dry weight, and higher shoot:root ratio than Not Pulled transplants after 2 days of storage.

In the first and second fruit harvest, Not Pulled transplants had more (3.7 and 3.2 $t \cdot ha^{-1}$) extra large fruits than Pulled transplants (2.2 and 1.9 $t \cdot ha^{-1}$), respectively. Similarly, Not Pulled plants had 70% more total extra large fruits than Pulled plants. Total marketable fruit yield was not affected by handling method. Increased transplant storage

time from 0 to 3 days generally did not lead to a decrease in fruit yield, with the exception of extra large fruits which had a linear decrease in yield from 3.5 to 2.4 $t \cdot ha^{-1}$ when stored from 0 to 3 days.

Stem length and leaf area increased linearly with increasing transplant age, 1 and 2 weeks after transplanting. However, during the first week of growth 3- and 4-week-old transplants had a significantly higher (0.107 $g \cdot g^{-1} \cdot day^{-1}$) relative growth rate (RGR) than older (0.064 $g \cdot g^{-1} \cdot day^{-1}$) transplants. Between 2 and 3 weeks, 4-week plants had a significantly higher plant RGR and root RGR (0.124 $g \cdot g^{-1} \cdot day^{-1}$) than 6 week (0.078) plants. Thus, younger transplants had a greater capacity to resume growth than older transplants. During seedling culture, older (5-week and 6-week) transplants can be exposed to more water and fertilizer stress than younger (3-week and 4-week) transplants (Leskovar, Cantliffe and Stoffella 1990). Nutrient deficiency and dehydration generally decrease the permeability of roots, possibly due to suberization of the cell walls (Passioura 1988).

Early and total fruit yields were similar with all transplant ages. However, 4-week and 5-week transplants had more early large fruit and 4-week transplants more total large fruit yield than 6-week transplants. Therefore, the growth advantages of younger (3-week and 4-week) transplants were translated into similar or higher yields than older transplants.

Four or 5-week-old transplants had significantly longer stems than 2-week and 3-week plants. At transplanting, leaf area increased linearly with increasing transplant age from 2 weeks to 5 weeks; however, in this experiment, these differences were minimal 1 week after transplanting.

Early and total marketable fruit yields were similar among transplant age treatments and 4-week transplants produced a higher early and total extra large fruit yield than did 5-week transplants.

Our studies indicated that transplant maturity and handling affected transplant growth, especially after 4 days of storage at either 5 or 15C. Not Pulled 45-day-old transplants maintained superior shoot and root characteristics than Pulled transplants. Although temperatures between 10 to 13C were suggested to suppress root growth (Hardenburg, Watada and Wang 1986) our data clearly indicated that shoot and root growth continued at even lower temperatures. After 6 days plant separation was difficult due to root binding in Pulled transplants. Storage temperatures should be selected to avoid the possibility of chilling injury or physiological disorders that may be expressed after planting (Wien 1990). Growth and fruit yield of 35-day-old transplants were more affected by transplant handling. Therefore physical stress when pulling

and packing should be minimized. If planting is delayed beyond 2 days, storage at lower than ambient temperatures would be desirable.

The results reported herein suggested that under Florida conditions, no improvement in fruit yields can be expected when using the traditional 5- and 6-week-old transplants compared to younger 4- and 5-week transplants during spring and fall, respectively. Young transplants resume growth faster in the field, and can be produced at low costs, by early removal from the greenhouse.

Literature Cited

Abeles, F.B. 1973. Ethylene in plant biology. Academic Press, U.K.

Hardenburg, R.E., A.E. Watada, and C.Y. Wang. 1986. The commercial storage of fruits, vegetables, and florist and nursery stocks. USDA. Agri. Hdbk. 66.

Leskovar, D.I., D.J. Cantliffe and P.J. Stoffella. 1990. Early transplant growth in relation to fruit yield in tomato. Amer. Soc. Hort. Sci. Ann. Meetings, Tucson, Arizona, Abs. 542.

Nicklow, C.W. and P.A. Minges. 1962. Plant growing factors influencing the field performance of the Fireball tomato variety. Proc. Amer. Soc. Hort. Sci. 81:443-450.

Passioura, J.B. 1988. Water transport in and to roots. Ann. Rev. Plant Physiol. Plant Mol. Biol. 39:245-265.

Risse, L.A. and T. Moffit. 1984. Shipping tomato transplants in returnable shipping containers. Trans. Amer. Soc. Agric. Eng. 27:45-48.

Risse, L.A., D.W. Kretchman and C.A. Jaworski. 1985. Quality and field performance of densely packed tomato transplants during shipment and storage. HortScience 20:438-439.

Risse, L.A., T. Moffit and H.H. Bryan. 1979. Effect of storage temperature and duration on quality, survival and yield of containerized tomato transplants. Proc. Fla. State Hort. Soc. 92:198-200.

Weston, L.A. and B.H. Zandstra. 1989. Transplant age and N and P nutrition effects of growth and yield of tomatoes. HortScience, 24:88-90.

Wien, H.C. 1990. Don't cool tomato transplants. Am. Veg. Grower 38(2):34-36.

DETECTION AND CONTROL OF BACTERIAL SPOT OF TOMATO INCITED BY *XANTHOMONAS CAMPESTRIS* PV. *VESICATORIA*

J. B. Jones, S. S. Woltz and H. Bouzar

Xanthomonas campestris pv. vesicatoria (Xcv), incitant of bacterial spot of tomato, is one of the major concerns in tomato production each year. High temperatures and moisture in the fall contribute significantly to problems, especially in the fall crop. Control by copper compounds or other available bactericides has not been effective enough to consider it the method of choice. Effective control can only be accomplished by using an integrated approach. This involves starting with Xcv-free transplants in the greenhouse, growing in a field situation free of the bacterium, and using a routine (twice weekly) bactericide spray program during the fall crop when rainfall is abundant.

Host resistance to bacterial spot of tomato is a plausible means of control in the future. Only one source with a high degree of field resistance to bacterial spot has been identified on tomato (Hawaii 7998). By incorpo-rating resistance genes from this genotype into genotypes with desired horticultural characteristics, there is potential for reduced losses attributed to Xcv. This resistance has been shown to inhibit development of Florida strains of Xcv. However, South American strains have been shown to be unimpeded by this resistance in Hawaii 7998. Further work has shown that these South American strains are quite different from the Florida strains. It is important to be able to identify these South American strains and prevent establishment of these types in Florida by dissemination via seed or transplants.

This paper will focus attention on two aspects of research on bacterial spot of tomato. First the research on development of monoclonal antibodies will be discussed as it relates to specificity to Florida-type and South American-type strains. Secondly, we will look at recent research on copper chemistry as it relates to control of bacterial spot.

MONOCLONAL ANTIBODIES

Detection of Xcv when present in low populations is hindered by the presence of a diverse microflora on tomato transplants and seed which reduces chances for recovery of the target bacterium. Serodiagnostic assays detect relatively low numbers of the pathogen in environments where contaminants may be present. Monoclonal antibodies (Mabs) as opposed to polyclonal antibodies reduce nonspecific reactions and provide more confidence in the diagnosis. Mabs are highly specific biological reagents generated through a process of immunization of mice, by harvesting mouse spleen cells and fusing these individual cells with tumor (i. e., myeloma) cells to generate hybridomas, which are antibody-producing cell lines (clones). Hybridomas synthesize an unlimited supply of identical antibodies that recognize a specific molecule on the target acterium. Use of selected Mabs provides greater reliability for rapid detection and immunoisolation of the pathogen than conventional methods. We have successfully developed Mabs with distinct reaction profiles to Xcv strains (Table 1). Two Mabs (5D12 and 2H10) were produced using live cells of the Florida (FL) type strain. Because immunization with the South American type strain was unsuccessful, a different protocol was used which consisted of the sequential injection of phenol-treated cells into the mouse. This resulted in the selection of three additional Mabs (4H5, 5F7 and 5E9). Using serological assays, the reaction profiles of 5D12 and 4H5 correlated well with the major division of Xcv into FL and SA strains. However, a few SA strains did not react with any of the developed Mabs.

These antibodies will be used for characterizing strains throughout the Caribbean, South America and many of the areas where Xcv is present to determine the types of strains which exist and attempt to assess their relation-ship to Florida and South American strains both biochemically and pathogenically. This will provide information as to the locales which may show problems in terms of posing a threat to resistance derived from Hawaii 7998.

CHEMICAL CONTROL

Control using copper bactericides is the major means of control but one which may not be sufficient when disease pressure is high. Several years ago we compared a number of copper-organic compounds to determine if copper compounds could be produced which provided control similar to that achieved by the copper-mancozeb combination. One copper-organic compound

mixture (Kocide + the organic compound) was found to be quite effective. The organic compound was designated bactrate. Bactrate effectively reduced disease severity in the greenhouse at concentrations comparable to copper-mancozeb (Table 2). In fact when a one-eighth rate of either of those compounds was applied to tomato foliage, bacterial spot was significantly controlled compared to the control or copper alone.

Bactrate was more seriously considered for further testing in field studies where it was compared with copper-mancozeb and copper alone. In the spring 1991, a randomized block design experiment was set up. With extremely high precipitation that occurred during the season, it was an excellent test for determining bactericide efficacy. In the field test bactrate was not as effective as copper-mancozeb (Table 3) as determined by disease assessment later in the growing season.

Copper residue and ionic copper on the leaf surface were also analyzed to determine whether or not this may have been responsible to some degree for the field results. Copper residue on the leaf surfaces of all treatments was drastically reduced 5 days after application. Of the three copper treatments bactrate + copper had the lowest level of copper residue on the leaf surface (Table 4). Ionic copper was also similarly affected on the bactrate + copper treatment (Table 5). Thus, the potential for copper + bactrate will not be fully understood until it can more effectively withstand weathering. These data also confirm previous studies that in comparison to copper + mancozeb, copper alone does an effective job of reducing bacterial spot severity. The persistence of copper on the leaf surface and the high ionic copper on those leaves may be responsible for the reduced severity on leaves treated with copper alone. This is not a recommendation to use copper without mancozeb, but is only intended to demonstrate the activity copper has when applied alone.

Table 1. Percentage of bacterial strains reacting with mono-clonal antibodies in ELISA.

Bacterial Type	Hybridomas				
	5D12	2H10	4H5	5F7	5E9
Xcv SA group	17	50	50	63	50
Xcv FL group	91	70	0	100	50
Xc Pathovars	ND[a]	ND	14	29	29
Non Xanthomonads	ND	ND	0	25	0

[a]ND=not determined.

Table 2. The effect of various organic compounds when applied with Kocide 101 on bacterial spot severity in the greenhouse.

Treatment	Rate (lbs./100 gal)	Lesions Per G Leaf
Control	-	106.4 a
K101	0.25	86.4 abc
Kocide 101	2.0	40.5 efg
K101 + mancozeb	0.25 + 0.188	48.0 defg
K101 + mancozeb	2.0 + 2.0	21.7 g
K101 + Na_2EDTA	0.25 + 0.25	73.6 bcd
K101 + Na_2EDTA	2.0 + 2.0	Phytotoxicity
K101 + bactrate	0.25 + 0.25	27.7 fg
K101 + bactrate	2.0 + 2.0	30.7 fg

[1]Numbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test.

Table 3. The effect of various copper bactericides on bacterial spot severity on 'Sunny' tomato plants in the Spring 1991.

		Lesions Per G Tissue	
Treatment	Rate	Sampling Date 1	Sampling Date 2
Kocide 101	2	2.1 b	7.4 bc
K101 + dithane M-45	2 + 1.5	2.1 b	5.6 c
K101 + bactrate	2 + 1.5	1.9 b	12.0 b
Control	-	14.2 a	54.2 a

[1]Numbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test.

Table 4. Copper residue on leaf surfaces of field grown tomatoes sprayed with various bactericides.

Treatment	Days After Spray Application 0	5	7
Kocide	0.208[1]a[2]	0.047 a	0.026 a
Kocide + mancozeb	0.187 b	0.037 b	0.021 b
Kocide + bactrate	0.133 c	0.017 c	0.012 c
Control	0.005 d	0.003 d	0.002 d

[1]Value represents mg Cu/g leaf tissue.
[2]Numbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test.

Table 5. Ionic copper on leaf surfaces of field grown tomatoes sprayed with various bactericides.

Treatment	Days After Spray Application 0	5	7
Kocide	685.9[1]a[2]	310.0 a	146.8 a
Kocide + mancozeb	498.3 b	211.4 a	92.0 b
Kocide + bactrate	391.5 b	44.9 c	27.1 c
Control	4.9 c	0.7 c	3.3 c

[1]Value times 10^{-3} ug/ml Cu^{++}
[2]Numbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test.

FUSARIUM CROWN ROT OF TOMATO: SOME FACTORS AFFECTING DISEASE DEVELOPMENT

John Paul Jones, S. S. Woltz, and J. W. Scott
University of Florida, IFAS
Gulf Coast Research and Education Center
5007 60th Street East
Bradenton, Florida 34203

INTRODUCTION

Fusarium crown rot of tomato (Lycopersicon esculentum Mill.) is caused by the soilborne fungus Fusarium oxysporum Schlecht. f. sp. radicis lycopersici Jarvis and Shoemaker. The first occurrence of the disease in Florida most likely was recorded by Cox in 1963 (1). A few years later the disease was found in a tomato field off the Moccasin Wallow Road in the Hillsborough-Manatee area (J. P. Jones, unpublished). Sonoda (3), however, over a decade later was the first in Florida to describe the disease in detail and to identify the pathogen. The disease remained inconsequential in Florida tomato fields until the early 1980's when it became increasingly common. Now arguably it is the most frequently encountered soilborne disease of tomatoes grown in the acid, sandy flatwood soils of southwest Florida and is especially severe in the Immokalee-Naples area. In fact, during the past year, crown rot has caused even greater concern than ever before in the latter area. The 1988 FFVA Committee on Contemporary Control of Vegetable Diseases with Chemicals estimated that yields industry-wide were reduced about 15% by crown rot. Jones, Woltz, and Scott (2) determined that yields of direct-seeded plants and bare-rooted seedling transplants grown in infested soil were reduced 41 and 15%, respectively, compared to similar plants in noninfested soil. Without doubt, crown rot has developed into a serious problem with a potential to devastate individual fields.

This paper primarily is a report of the research advances made in the past year to determine the effect of various environmental and cultural factors on the development of crown rot. Some results also are presented from experiments to determine the mode of action of some cultural practices that have been determined to inhibit disease development. Additionally, some control suggestions are given.

GROWTH ROOM EXPERIMENTS

Wild Host Isolates: Cultures of Fusarium oxysporum were isolated from the roots and crowns of a number of symptomless wild plants and used to inoculate tomato seedlings. Isolates from Scoparia, cudweed, carpet weed, and Brazilian pepper caused

crown rot symptoms on 88, 80, 48, and 95%, respectively, of the inoculated tomato seedlings. These inoculation studies, therefore, demonstrated that the cultures were F. o. f. sp. radicis-lycopersici.

Agar Culture: Tomato seedlings were grown in soft agar containing inorganic nutrients, but without the usual organic amendments, in order to observe the effects of nitrate-ammonium ratios on crown rot with roots and crowns visible. With all-nitrate nitrogen the disease index was 0.38 on a scale of 0 to 6, where 0 = no disease and 6 = dead plants; with 25% ammonium substitution the index was 0.50; with 50% ammonium the index was 1.13; and with 75% the disease index was 4.9. Since a low inoculum level was used and disease developed quickly and extremely severely with increasing ammonium, the culture in agar, or similar media, may be used to obtain direct information on the host-parasite reactions because of the opportunities for isolation of the systems and ease of observation.

Autoclaved vs Nonautoclaved Soil: In an attempt to determine the role of microorganisms in the control of crown rot by lime amendments, the soil mix in a series of three experiments was autoclaved to eliminate the possibility of biological control. In the first experiment, disease incidence decreased in autoclaved soil from 94 to 0% with increasing lime rates. In a second experiment both autoclaved and nonautoclaved mixes were used. Disease incidence was reduced from 15 to 0% in the nonautoclaved mix and from 56 to 0% in the autoclaved mix by increasing the mix pH from 3.8 to 8.0 with lime. In a third experiment, wounded and nonwounded plants were set into autoclaved and nonautoclaved mix. Wounding, as in previous experiments (2), increased disease incidence and severity whether the plants were set into autoclaved or nonautoclaved soil. Liming also decreased the incidence and severity of crown rot regardless of whether the plants were wounded or not or whether the plants were set into autoclaved or nonautoclaved soil. Apparently, inhibition of crown rot by liming is not due to microbial activity.

Inoculum pH Experiment: Five root-dip inocula were prepared in phosphate-buffered solutions adjusted to pH 3.5, 4.5, 5.5, 6.5, or 7.5. Tomato seedlings were inoculated and set into soil mixes adjusted with calcium carbonate to pH 5.0, 5.9, or 7.3. Additionally, a few drops of each buffered inoculum were spread onto water agar plates and the spore germination percentage determined. The percentages of germinated spores after 6 hours of incubation on water agar were 84, 93, 97, 79. and 80% from inoculum buffered at pH 3.5, 4.5, 5.5, 6.5, and 7.5, respectively. Inoculum pH, consequently, did not affect spore germination. Moreover, inoculum pH did not affect disease development regardless of the pH of the soil mix. However, the pH of the mix itself greatly affected crown rot incidence and

severity with the highest pH resulting in the least disease. Apparently, inhibition of crown rot by an increase in mix pH was not due to an inhibition of germination of the spores clinging to the inoculated roots and crowns.

Inoculum Source: Tomato seedlings were root-dip inoculated with F. oxysporum f. sp. radicis-lycopersici isolated from diseased plants obtained from a field near Bonita Springs, Florida. This Gator Hole isolate was compared to isolate 763 obtained from Ohio. The Gator Hole isolate was far more virulent than I-763. Moreover, liming the mix with calcium carbonate to pH 7.8 did not inhibit disease caused by the Gator Hole isolate nearly to the extent that occurred with I-763 (a range of 100 to 66% dead seedling with the Gator Hole isolate compared to a range of 62 to 0% dead for I-763). These results are preliminary and undue alarm should not be taken. Occasionally liming has not resulted in excellent control even with the I- 763 isolate. Dipping roots into an agar-water suspension of 10 to 15 million spores/ml sometimes overwhelms the control exerted by liming the mix. Additional experiments are underway to determine if the lack of pronounced inhibition of the Gator Hole isolate is the rule or the exception.

GREENHOUSE EXPERIMENTS

Micronutrients: Tomato seedlings were grown in containers of Canadian peat-vermiculite in May and inoculated with the crown rot Fusarium. Disease development was limited because of the warm temperatures but one treatment caused severe disease, namely a micronutrient mix appled at higher rates. The disease index for the control plants was 0.10 whereas the micronutrient treatment had an index of 3.89. Thus, it would seem that the micronutrient amendment at high rates had caused the disease to develop at temperatures in the high 80s when the optimum temperature normally is in the low 70s.

Media: Media were compared for crown rot production in pots in the greenhouse at a time when the temperature was low enough for the disease to develop. Two pH levels were used; crown rot was always most severe at the lower pH. In order of increasing severity, the media were: Eau Gallie fine sand (soil), quartz builder's sand, a Gulf Coast Research & Education Center (GCREC)-Florida peat mix, and Canadian peat:vermiculite 1:1. Media were also compared in the constant temperature growth room (72°F) in 7"x10"x2.5" trays with increasing severity found in the following order: quartz builder's sand, GCREC-Florida peat mix, Pro mix, Grace Horticultural mix, vermiculite, Canadian peat, Eau Gallie soil, and Canadian peat:vermiculite 1:1. Experience with various media at different pH's indicates that an acid condition of media is by far the greatest pre-disposing factor for crown rot, although media choice and nutritional variables also contribute to the final degree of severity. Our experience

indicates that adequate acidification of any medium would result in high susceptibility to crown rot when plants are inoculated.

Lime: The relationship of crown rot severity to the amount of lime (powdered $CaCO_3$) per liter of 1:1 Canadian peat:vermiculite was studied in pots in the greenhouse in March. With increasing lime, 0, 0.5, 2, 4, and 8 grams per liter of mix, the incidence of disease was 100, 71, 37, 33, and 8%, respectively. Plant weights (live plants) were 0, 11, 41, 52, and 59 grams per pot, respectively. Media pH values, in order, were 3.9, 4.0, 4.9, 6.9, and 7.2 (averages of the pH values at the beginning and end of the experiment).

Nutrient Solutions: An experiment with tomato grown in pots of 1:1 Canadian peat:vermiculite was carried out in the winter in the greenhouse. Solutions of various nutrient compounds were added to singly supplement the basic fertility program, with twice weekly applications. Points of interest were that ammonium sulfate caused an incidence of 66% severe disease whereas potassium sulfate application was associated with the absence of visible disease. The effects of various fertility factors were studied in the greenhouse in late October-early November with seedlings in trays of Canadian peat:vermiculite. Factorial combinations of lime, nitrogen source, and sodium chloride were used. Crown rot was worsened by added sodium chloride, ammonium sulfate, and low level lime application singly and additively. Crown rot was less in association with sodium chloride omission, calcium nitrate as the nitrogen souce, and higher level lime application. The effects of these factors were singly and additively operational in reducing disease. Another experiment using trays in the greenhouse included high levels of potassium chloride and potassium sulfate in addition to regular fertilization. The high rates of potassium chloride increased disease, whereas high rates of potassium sulfate did not. Sodium chloride and ammonium sulfate again were additively promotive of crown rot.

Chlorides vs. Sulfates: Chloride sources of potassium, sodium, and magnesium were compared with sulfate sources of the elements in greenhouse culture in trays of 1:1 Canadian peat:vermiculite. Magnesium chloride was associated with significantly more crown rot than was magnesium sulfate. A similar difference was found for both sodium and potassium but the difference between chlorides and sulfates was not significant. Fusarium wilt caused by the same species as crown rot was similarly affected by chloride and sulfate sources of the three elements which indicates that the effects of the chloride and sulfate anions may be of general significance for the entire oxysporum species. Chlorides affect soil chemistry differently than sulfates according to our tests. Calcium ion activity was greater in media samples from chloride as compared to sulfate treatments. Salts content (media electrical

conductivity) was greater with chloride than sulfate. Sodium ion activity also was greater with chloride. Soil pH was not affected differentially.

FIELD EXPERIMENT

Soil pH (6.0 vs 7.0), sodium chloride (1,000 lb/acre vs none), and nitrogen source (nitrate vs ammonium) were evaluated in the field during the spring of 1991 for their effects on the occurrence of crown rot of 'Sunny' tomato. Nitrate-nitrogen greatly inhibited the incidence and severity of crown rot compared to ammonium-nitrogen (20% dead roots vs 65%, and 58% incidence vs 93% for nitrate and ammonium, respectively). This very high incidence and severity of diseased roots with ammonium compared to nitrate- nitrogen substantially reduced root weight (32 vs 67 lb), plant volume (height x width) (1355 vs 2351 sq. in.), and fruit weight (1363 vs 3031 lb). Sodium chloride only very slightly increased the occurrence (78 vs 73%) and severity (46 vs 37% dead) of crown-rotted roots compared to no sodium chloride. However, fruit weight (1894 vs 2500 lb), root weight (46.6 vs 52.3 lb), and plant volume (1684 vs 2021 sq. in.) were decreased significantly by the addition of sodium chloride. Soil pH (6.0 vs 7.0) did not affect disease development nor any of the growth parameters presumably because the low pH value ultimately established still was too high to encourage disease. Growth room studies indicate that crown rot is greatly inhibited by an increase in pH from 4.0 to 6.0 and that further increases in pH may not result in further control on a short-term basis.

CONTROL SUGGESTIONS

A. Use healthy, non-wounded transplants.

1. Grow transplants in greenhouses isolated from production fields because the pathogen sporulates on tomato stems in the field and these spores and slime balls blow through the air and can infest the soils and mixes in the greenhouse.

2. Raise the pH of the transplant mix to at least 6.0. This will inhibit colonization following accidental contamination.

3. Quarantine transplant greenhouses and practice sanitation.

a. Keep the greenhouses, benches, and containers clean.

b. Permit only a small crew of workers who have been trained in sanitation procedures to enter the transplant production area.

c. Do not permit personnel who have been in the field production area to enter the transplant production area.

d. Permit only "clean" personnel to haul the transplants to the production field.

e. Ensure that planting crews do not put trays or boxes of transplants on contaminated surfaces (including the ground) or in ditches. Also make sure the transplanters do not wound the transplants.

f. Do not use ditch water to water-in the transplants.

4. Do not pinch stems when dibbling the transplants into the containers. Do not damage transplants with fertilizers, pesticide sprays, or drenches. Do not set plants into salty soil and avoid excessively salty irrigation water.

5. Rotate crops.

6. Raise the pH of the field to at least 6.0 before setting the crop and use nitrate-nitrogen rather than ammonium-nitrogen.

7. Fumigate the production fields and prevent recontamination.

LITERATURE CITED

1. Cox, R. S. 1963. Control of Fusarium wilt, root rot and weeds on trellis-grown tomatoes in south Florida. Proc. Fla. State Hort. Soc. 76:131-134.

2. Jones, J. P., S. S. Woltz, and J. W. Scott. 1990. Factors affecting development of Fusarium crown rot of tomato. Proc. Fla. State Hort. Soc. 103:142-148.

3. Sonoda, R. M. 1976. The occurrence of a Fusarium root rot of tomatoes in South Florida. Plant Disease Reptr. 60:271-274.

NEMATODE MANAGEMENT AND CROP LOSS PREDICTION IN FLORIDA TOMATO PRODUCTION

J.W. Noling
University of Florida, IFAS, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850.

INTRODUCTION

Changes in Florida crop production systems, particularly with respect to irrigation and multiple cropping are mandating reevaluation of nematode management strategies. In Florida, tomatoes are produced on raised beds covered by polyethylene mulch. Broad-spectrum soil fumigants, primarily methyl bromide and chloropicrin (MBC), are then used beneath the polyethylene mulch as a preplant soil borne disease control treatment. Water has been traditionally supplied via seep irrigation, but due to declining water levels and increased urban demand, tomato growers are being forced by water management districts to adopt more water use efficient irrigation practices such as drip irrigation. Increased production costs associated with drip irrigation systems have motivated growers to consider multiple cropping systems in an attempt to amortize these increased irrigation costs over a number of crops.

It should also be recognized that nematode problems may evolve as a result of changing from single to multiple cropping systems. For example, soilborne disease control is seldom complete following preplant fumigation with MBC. Nematode populations often increase during late season causing little or no damage to the primary fumigated crop, but are often at significant level to cause extensive damage to subsequent crops within the multiple crop sequence. Delays in crop destruction following harvest also contributes to greater nematode population buildup by allowing additional cycles of pest population growth. The research challenge for this newly changing production system involves protection and enhancement of vegetable crop yields following the initial fall fumigated primary crop. The objective of this report is therefore to summarize recent field studies evaluating the chemigational use of metham sodium (Vapam, Busan 1020 & other generic forms) for crop destruction purposes, crop yield increase, and control of the southern root-knot nematode, Meloidogyne incognita in Florida drip irrigated, multiple-cropping systems.

Separate studies evaluating metham sodium injection period of 30 to 180 minutes or broadcast equivalent rates of 25 to 100 gallons per acre have been conducted in commercial field and microplot experiments. Differences in crop response and nematode control between the experimental sites were related to

initial soil moisture conditions, drip-irrigation system design, injection period, and application rate. Metham sodium provided significant control of M. incognita at broadcast application rates as low as 25 gallons per acre. In all cases however, highest yields were obtained at broadcast equivalent application rates of 75-100 gallons per acre. Crop response and nematode control increased with length of the metham sodium injection period. Longer injection periods of 1-2 hours allowed greater dispersal and created a wider treated band within the bed. In general, metham sodium treatments were most effective against the root-knot nematode only when at least 50% of the bed was treated.

With regard to metham sodium treated zones, two parallel drip lines per bed provided significantly better nematode control and crop response than did a single drip line per bed. Using two lines per bed and drip emitter spacing of 8 inches, metham sodium was dispersed throughout the entire plant bed. With the single line and drip emitter spacings of 24 inches, the wetted zones were uniform, circular, nonoverlapping areas no greater than 6" in radius from individual emitters. This suggests that if a second crop is planted between emitters, particularly with wide spacings, it may not be possible to provide for adequate dispersal of metham sodium in the irrigation water. A high proportion of plants are likely to be planted within zones which receive no treatment.

CROP DESTRUCTION STUDIES

The results from a series of crop destruction experiments have indicated that plant proximity to drip tube emitters is very important in terms of defining phytotoxic concentrations of metham sodium. In two separate experiments in 1990, it was observed that metham sodium application rates as low as 10-15 gallons per broadcast acre could be effectively used for both tomato and pepper crop destruction purposes if plants were within 1-2 inches of individual drip emitters. When identical studies were performed at commercial field sites where plant distances of 6-8 inches from the drip line were required to avoid damage to the drip tube during transplanting, rates of 20-30 gallon per acre were required to achieve near complete plant mortality. The two-fold increase in application rate was apparently needed to compensate for the additional travel distance required to contact the plant root zone.

CROP LOSS ASSESSMENT AND PREDICTION STUDIES

Root-knot nematode, as the name implies, is known to induce the development of large tumorous galls on the roots of susceptible plants. Modification of the root system after attack by various species of root-knot nematode influences not only the rooting volume of the plant by a reduction in root system size but is also known to reduce the plants ability to efficiently transport water and nutrients through the root

system to plant leaves. Root gall indexes have been developed to visually characterize root gall severity. Studies reported herein have been conducted to consider the potential use of root gall indexes for grower oriented crop loss assessment and prediction purposes.

To investigate the relationship between root gall severity and crop yield response, field microplots were infested with different initial population levels of the southern root-knot nematode, M. incognita. Commercial field sites were also included in which the fields were sampled prior to planting to quantify existing root-knot nematode populations. At crop harvest, individual tomato plants were stripped of fruit, and the fruit sized and weighed for yield determination. At harvest these same plants were also uprooted and the root system evaluated for root gall severity based on a visual rating scale of zero to ten. Gall ratings were then compared with plant yield response to determine possible relationships between the two.

The results from these studies have indicated that root gall severity was very useful and descriptive for estimating yield losses to nematodes even though much of the yield loss attributed to the nematode may have been brought about by secondary organisms causing extensive root decay. Nevertheless, in all studies, crop yields decreased with an observed increase in root galling. Of almost equal importance, final harvest root gall severity values were also very useful in terms of predicting crop losses in a subsequently planted, susceptible crop. The ability of tomato growers to observe and discern small differences in root gall severity of tomato plants remains to be investigated.

SUMMARY

The decision whether to chemigationally use metham sodium should be based on need. Examination of plant root systems following harvest of the primary crop will provide valuable information regarding the distribution and severity of the nematode problem within the field. Once this has been determined, the results from these experiments suggest that strategies which will maximize the outward radial movement of metham sodium will ultimately translate into higher yields because of the increased rooting volume of nematode free soil. Given the sandy nature of our soils, narrower bed widths, drip tubes with closer drip emitter spacing, and planting practices which place plants closer to the drip tube may need to be adopted. Growers must also recognize that acceptable results cannot be obtained with metham sodium if drip tubes are clogged or extensively damaged since uniform field application cannot be achieved.

DEVELOPMENTS IN TOMATO WEED CONTROL

James P. Gilreath
Gulf Coast Research & Education Center
Bradenton, FL

William M. Stall
Vegetable Crops Department
Gainesville, FL

Phyllis R. Gilreath
Florida Cooperative Extension Service
Palmetto, FL

Thomas A. Bewick
Vegetable Crops Department
Gainesville, FL

The importance of weed control and good field sanitation practices has increased greatly in the last few years with the introduction of the sweet potato whitefly and accompanying gemini viruses and irregular ripening. Common weeds, such as nightshade, and volunteer tomatoes are hosts to many tomato pests, including sweet potato whitefly, bacterial spot, and viruses. Control of these pests is often associated with control of weed hosts. Results of nightshade control research were reported previously at the 1989 Tomato Institute. At that time a number of herbicides were being evaluated for control of paraquat-resistant nightshade. Since then herbicide evaluation has continued with both commercial and experimental products for nightshade control in tomato row middles and for crop destruction. As a result of this and related research, several herbicides are now labeled for nightshade control in tomato row middles and at least one very effective herbicide should be labeled in the next few years. The remainder of this paper will focus on these products, both labeled and non-labeled, to provide growers with practical information about each.

LABELED HERBICIDES

Herbicides currently labeled for use in tomato row middles include both pre- and postemergence materials. The most widely used preemergence herbicide, Lexone or Sencor, probably provides the best control of nightshade of the labeled preemergence materials; however, the level of control is seldom commercially acceptable. Control with this herbicide is of short duration and appears as more of a delay in germination and emergence of about 30 days rather than absolute control; eventually, nightshade emerges and grows normally.

Postemergence control of nightshade can be obtained with Gramoxone Extra, Diquat, and Enquik; the level of control depends upon which nightshade species/biotype is involved, plant size at time of application, herbicide rate, adjuvant, application volume, time interval between first and second applications (two close interval applications are usually necessary), and other considerations. Of these three herbicides, Diquat and Enquik are the most effective on what is referred to as "paraquat resistant nightshade". Some success can be achieved with Gramoxone Extra on "paraquat resistant nightshade"; however, the rate required often is higher than the label allows and can be cost prohibitive. Repeat applications appear to have little effect at normal use rates.

Diquat is effective on "paraquat resistant nightshade", but it usually requires two applications to achieve acceptable control. To further cloud the issue, there appears to be some nightshade which is developing tolerance to Diquat. Presently, this problem is very localized and has been reported only in a few small areas in the state, mostly in Dade county. Diquat's registration for use in Florida tomatoes exists as a Section 18 which must be renewed annually. Federal registration of Diquat for use in tomato row middles is pending and until it is granted we will have to rely on Section 18 renewals. Diquat is capable of controlling many grasses provided they are under about 6 inches in height. If grass weeds are much taller than this, addition of Gramoxone Extra to the spray preparation may be required.

Research and grower experience indicate that the best nightshade control is obtained with 2 applications of Diquat at the labeled rate (0.50 lb. a.i./acre) in about 50 gallons of water to the acre using a good surfactant, such as X-77 or Induce. Best control of nightshade plants is achieved when plants are 4 to 6 inches tall, rapidly growing and not stressed; larger plants are much more difficult to control. Application to small seedlings suffers partly from the fact that seedlings emerge over a period of time and not all at once. Although "flushes" occur, they are spread over a period of several days to a few weeks and not one or two days. Application too soon may miss a large percentage of the ultimate population. The two applications should be between 10 and 14 days apart; too short of a time interval is probably worse than waiting past 14 days for the second application as adequate regrowth has not been initiated.

When water volume is increased much beyond 50 gallons per acre, the concentration of Diquat per gallon of spray preparation decreases and a dilution effect occurs, resulting in decreased efficacy. Contrary to popular belief, good leaf coverage can be achieved with volumes of 50 gallons or less per acre. A good surfactant can do more to improve the wetting capability of spray preparations than can increasing the water volume. Remember that most postemergence herbicides are subject

to a dilution effect and increasing the water volume will have more of a deterimental effect than can be overcome by the increased wetting of the foliage.

Many adjuvants are available commercially and a number are very similar in effectiveness. Some adjuvants contain more active ingredient than others and herbicide labels may specify a minimum active ingredient rate for the adjuvant. Before selecting an adjuvant, refer to the herbicide label to determine adjuvant specifications. Generally the rate used is more important than the choice of adjuvant, assuming comparison of the best adjuvants. For example, increasing the rate of X-77 from 0.25% to 0.75% by volume increased Diquat efficacy considerably in research trials. Similar results were observed with Induce. One surfactant manufacturer in particular has publications available which illustrate the concept of water surface tension and its effect on wetting of foliage. It makes interesting reading and could improve your understanding of surfactant chemistry.

In essence, application gallonage is not as important as adjuvant, adjuvant rate, nozzle selection, or application pressure. Many nozzle types and sizes are available; however, not all are designed for postemergence herbicide application. For useful information about nozzle types and operating pressures, consult Spraying Systems Co. Teejet catalog. All nozzles have a recommended operating range for pressure and this range should be observed. Excessive pressure results in production of small droplets which are more likely to drift and will dry more rapidly. Rapid drying is undesirable because, once dry, a herbicide is no longer able to penetrate foliage. Extremely high pressures under conditions of low relative humidity may result in the spray preparation drying before contacting much of the plant foliage. This was observed in one tomato dessication experiment several seasons ago with contact herbicides. Foliage dessication was very poor because the spray preparation dried as soon as or before contact with the tomato plants. The recommended operating pressure range is based on the design and testing of each nozzle type by the manufacturer and should be followed.

Enquik is labeled for use in tomato row middles to control nightshade and other broadleaf weeds. Control of nightshade requires rates of 6 gallons or more per acre. Enquik is usually combined with Gramoxone Extra to improve nightshade control and provide grass control which is not achieved with Enquik alone. There has been no tolerance of nightshade to Enquik reported in Florida. Where tolerance to Diquat has been encountered, tank mixing Diquat with Enquik has enhanced control. Most of the concerns or considerations mentioned for Diquat apply to Enquik: plant size is important, multiple applications are usually required as regrowth from stems occurs, dilution can be a problem, and adjuvant is important as are spray volume and pressure. An additional consideration involves the corrosive

nature of Enquik since it can be hard on pumps, some rubber products, and nylon fittings. Most growers who have used Enquik have purchased pumps with stainless steel components and retrofitted their sprayers to minimize problems with this herbicide. This additional cost should be considered before deciding to use Enquik. Commercial experiences with it are varied. The one thing which impresses most growers is the speed with which Enquik dessicates weeds; visible effects are observed within a few hours of application. Each grower must evaluate his or her own situation when selecting this or any other herbicide.

NON-LABELED HERBICIDES

At the last Tomato Institute results were reported for several non-labeled herbicides which were very effective for nightshade control. Although there are several which are effective and have not produced any phytotoxicity to tomato plants when applied in row middles in experiments, two have special importance because their respective manufacturers have expressed interest in pursuing labels for their use in tomato row middles. You may recall the excitement with which the author spoke about Cobra and Ignite at the 1989 Tomato Institute; well, this enthusiasm has not declined and these are the products which hold promise for the immediate future, although they are probably several years away from registration.

Cobra is a diphenyl ether herbicide similar to Goal; however, it is more effective at lower rates than Goal. It provides excellent preemergence control of nightshade species and many other broadleaf weeds at rates as low as 0.25 lb.a.i./acre. Its leaching potential is minimal as it has very low water solubility. Although it is primarily active on broadleaf weeds, it has provided acceptable grass weed control in some experiments. So far there has been no phytotoxicity observed with Cobra in the numerous experiments conducted both on University of Florida facilities and on grower farms. No damage was observed in a test in the spring of 1991 wherein 5 to 6 inches of water was applied overhead to the field within 24 hours after application of 0.50 lb.a.i./acre of Cobra pretransplant or 6 weeks after transplanting. This experiment was conducted to address concerns of at least one south Florida grower who, several years ago, experienced damage which he believed was the result of application of another diphenyl ether herbicide followed by heavy rains. Little damage was observed from directed applications of Cobra to foliage of tomato plants which were between the second and third string in height. Although results of one test are not definitive, they do suggest that tomato plants at this stage of development would suffer no more injury from careless application of Cobra than from a similar application of Gramoxone Extra or Diquat. Additional experiments are planned for this fall to determine the susceptibility of tomatoes to damage from Cobra at several growth stages. In addition to preemergence activity, Cobra also

is a very effective postemergence herbicide when applied to emerged nightshade growing in tomato row middles. Applications to 4 to 6 inch tall nightshade consistently have provided good to excellent control with the extent of control depending on plant size and Cobra rate. Adjuvant is very important with Cobra. The manufacturer, Valent U.S.A. Corp., has initiated a national registration program on tomato and pepper through IR-4 which will allow for both pre- and postemergence use. Since Cobra is registered on other crops in the U.S.A. it has a chance of getting labeled.

The second promising non-labeled herbicide, Ignite, is a very effective postemergence herbicide which is capable of killing nightshade at all stages of growth with one application at a rate ranging from 0.50 to 1.0 lb.a.i./acre. Ignite is equally effective on many species and biotypes of nightshade, including those with resistance to paraquat and Diquat. It takes several days for Ignite to kill nightshade, but the kill is a complete one and there is no regrowth from stems if coverage was good. Additional adjuvant is not necessary with this product as it already contains one. Improved nightshade control has never been observed with the addition of adjuvant to Ignite. Application volume is important as it is with most other postemergence herbicides; volumes in excess of 75 gallons per acre can decrease efficacy at low rates of Ignite. A recent study suggests that Ignite is no more phytotoxic to tomatoes under normal situations than Gramoxone Extra or Diquat. In this study, damage from sprays directed at the lower leaves of tomato plants and to those hanging into the middles was restricted to the foliage which was contacted by the spray; there was no translocation and damage to remote tissues. The manufacturer, Hoechst-Roussel Agri-Vet Co., is interested in obtaining a postemergence label for Ignite in tomato row middles.

It appears likely that at least one new effective herbicide soon will be labeled for tomato row middle weed control. In the meantime, growers will have to continue relying on the same herbicides they have been using in the immediate past. Maintaining good control of weeds is important for many reasons. Attention to considerations outlined in this paper can help growers achieve good control with existing registered products.

NOTE: The use of trade names and information provided in this article is for informational purposes only and does not constitute an endorsement or recommendation by the authors or the University of Florida.

PLANT ANALYSIS FOR TOMATOES IN FLORIDA

George Hochmuth
Vegetable Crops Department
University of Florida
Gainesville, FL 32611

INTRODUCTION

Plant analysis is a technique for determining the mineral nutrient status of the tomato crop during the season. Usually leaves are analyzed for nutrient content and thus often plant analysis is referred to as leaf tissue analysis. Plant analysis can take basically two forms, analysis of dried leaves and analysis of fresh petiole sap. Both techniques have advantages and disadvantages. This paper describes the use of plant analyses for tomatoes and presents the critical nutrient concentrations at various plant growth stages.

USES OF PLANT ANALYSIS

Plant analysis is often used for two purposes. One purpose is for the diagnosis of suspected nutrient deficiencies. In this situation, plants are analyzed for nutrients to determine if the levels of those nutrients are low enough to be responsible for the symptoms observed and the lack of growth. Plant analysis for diagnostic purposes is not easy and straightforward and should involve investigations of other factors particularly environmental and soil factors that may be indirectly responsible for the nutrient problems observed. For example, root diseases or nematodes could be indirectly responsible for a nutrient deficiency and not a low soil concentration of that nutrient per se. Another use for plant analysis is for refining fertilizer management programs, for example drip irrigation systems. Here, plant analysis through the season can help determine if a particular fertilizer management program is providing optimum nutrition for the crop. Deficiencies or trends towards deficiencies can be detected and corrected if plant analysis is done early enough so that adjustments in fertilizer programs can be made and positive crop responses result.

PLANT ANALYSIS/SOIL ANALYSIS

Plant and soil analysis both have important roles to play in fertilizer management for vegetables. Soil analysis plays its strongest role before the crop is planted by guiding growers in determining optimum amounts of fertilizer to use for the crop. Once the crop has been planted, plant analysis plays a more

important role in determining plant nutrient status and in guiding nutrient additions to the crop during the season.

Sometimes individuals attempt to analyze soil solutions taken during the growing season for nutrient content with the objective of making fertilizer decisions based on those analyses. This system is fraught with potential problems due to sampling errors and interpretation of the analytical results from the soil solution extracts. These problems severely limit the usefulness of this system for vegetables in Florida. Plant analysis during the growing season, while having certain limitations, would be a preferable system for evaluating success of a fertilizer program. This is because the plant represents the end product of nutrient uptake, thus plant analysis lets the plant tell us how well the fertilizer program is performing. Soil samples, on the other hand, represent a snapshot of the nutrient status of the soil at that particular time when the sample was collected. For mobile nutrients such as nitrogen and perhaps potassium, changes in soil concentrations can occur rapidly depending on the irrigation program and the specific location within the bed from where the sample was taken.

Plant analysis does have a disadvantage in that it usually takes somewhat longer to conduct the analysis and receive the results than would a quick-test for nutrients such as nitrogen or potassium conducted on a soil extract. However, there are presently several good methodologies for conducting quick- tests on plant sap. It would seem that these techniques, when time is of the essence, would be superior and preferential to tests conducted on soil solution extracts.

SAMPLING CONSIDERATIONS

Results and recommendations made from plant analysis can only be expected to be as good as the plant sample collected. If sampling is done for diagnostic purposes, then several considerations should be borne in mind. First of all, samplers must keep in mind that published critical nutrient concentrations relate to specific plant parts. Collecting plant parts other than those established as diagnostic plant parts could run the risk of providing false results. In most cases, the general rule-of-thumb is to select most-recently-matured leaves with petioles attached. There are exceptions to this as we will discuss later. The main point to bear in mind is to be sure that one is collecting the correct plant part for laboratory analysis.

For diagnostic purposes, samples from normal healthy plants, if available, should be collected in addition to samples from plants with the suspected nutrient deficiency. Plant diagnostic sampling is often aided by a soil sample collected nearby the symptomatic plants as long as that soil sample is not collected from a fertilizer band. This is one situation where soil sampling during the growing season can assist in determination of the fertilizer program. This is because certain nutrient deficiencies can be related to alkaline soil conditions and having the soil sample can provide additional data useful in the diagnostic procedure. In addition, if it is suspected that certain nutrients were omitted from the fertilizer material, then soil sampling can sometimes assist in determining this fact.

Samples should not be collected from plants exhibiting obvious diseases due to fungi, bacteria, or viruses. In addition, plant samples should not consist of dying or dead parts, or parts that have been severely damaged by insects, wind, or hail. Samplers also should keep in mind the effect that sprays of foliar nutrients from fertilizers or pesticides containing nutrients have on the plant analysis procedure. This is a particular problem with the analysis of micronutrients. These nutrients are difficult to remove from the surface of the plant material and might show up as toxic levels in a plant analysis result when they only were present as a surface contaminant. The value of plant analysis is questionable for samples taken from plants that have received large amounts of foliar nutrients from fertilizers or pesticides.

Prior to collecting samples, the sampler should consult his chosen analytical lab for the proper techniques in handling and shipping the sample. It might be advantageous to partially dry the sample in a warm room or oven prior to shipping. Usually plant samples destined for nutrient analysis should not be shipped in plastic bags because of the potential for decomposition during transit.

DIAGNOSTIC PLANT PART

As mentioned above, the correct plant part must be sampled for meaningful laboratory results and interpretations. For most nutrients the most-recently-matured whole leaf with petiole attached is used for plant analysis. This leaf can be used for all nutrients except for the highly nonmobile elements such as calcium, iron, copper, boron, and zinc. The most-recently-matured leaf for tomatoes is approximately the fifth or sixth expanded leaf from the tip of the plant. This leaf will be the leaf that has nearly reached full diameter and length, and has changed from a light green juvenile color to a mature dark green color. This is an acceptable leaf for nutrient analysis for routine leaf analysis to gather data for evaluating fertilizer

programs. For tomatoes, the leaf is a compound leaf containing a main midrib and petiole with many small leaflets and their associated petioliules. Most-recently-matured whole leaf for a tomato means the large leaf attached to the main stem of the tomato plant including the small leaflets and their petioliules. Most tabulated critical values for nutrients are based on this whole leaf sample and not for other samples such as leaflets or leaf tips.

If certain nonmobile micronutrient deficiencies are suspected, then it would be better to sample young leaves near the tips of the branches of the tomato plant. This is the area of the plant that will be exhibiting deficiency symptoms. These leaves are more appropriate for diagnosing deficiency rather than older leaves that possibly could have accumulated micronutrients earlier in the season and held on to those nutrients during deficiency because those nutrients were not mobilized from those older leaves.

PLANT ANALYTICAL LABORATORIES

There are many commercial and public plant and soil analysis laboratories that can conduct very good analysis of plant tissue for various nutrients. These labs appear below. This listing is not meant to be all-inclusive nor imply recommendation of these laboratories by IFAS over other equivalent laboratories. One point to keep in mind when receiving results and recommendations from commercial plant analysis laboratories has to do with the interpretation of the results. Most commercial laboratories interpret plant analytical results based on observations and results over previous years. Therefore, interpretation of low, medium, or high might simply reflect whether the sample in question is low, medium, or high relative to the average of all other samples analyzed previously.

As a result, interpretations of analytical results and fertilizer recommendations are usually higher than interpretations and fertilizer recommendations made by University laboratories based on actual critical nutrient concentrations.

Table 1. Partial listing of commercial and public laboratories offering agricultural plant analysis services.

A B C Research Corporation 3437 SW 24th Ave. Gainesville, FL 32605 (904) 372-0436	Bionomics Laboratory, Inc. 4310 Anderson Road Orlando, FL 32812 (407) 851-2560
A & L Agricultural Laboratories 1301 W. Copans Rd. Bldg. D, Suite 8 Pompano Beach, FL 33064 (305) 972-3255	Flowers Chemical Laboratory 481 Newberry Port Altamonte Springs, FL 32701 (407) 339-5984
Applied Ag. Research 1305 E. Main St. Lakeland, FL 33801 (813) 686-1017	Technical Services, Inc. 2471 Swan St. Jacksonville, Fl 32204 (904) 353-5761
Aqua Terra Laboratory 1203 Rowayton W. Palm Beach, FL 33401 (407) 793-4056	Thornton Laboratories 1145 E. Cass St. Tampa, FL 33602 (813) 223-9702
Agro Serv. Intn'l., Inc. 215 E. Michigan Ave. Orange City, FL 32763 (904) 775-6601	Extension Soil Testing Laboratory Wallace Building Mowry Road University of Florida Gainesville, FL 32611

PLANT SAP ANALYSIS

Two of the disadvantages in conducting plant analysis has to do with turnaround time and cost. Turnaround time has been improved by most laboratories so that today samples can be analyzed and results returned to the grower in as short a period as 24 hours. There is another technique for growers for determining nutrient status of plants quickly and inexpensively. These procedures involve some type of plant sap analysis and determination of nutrient content of the sap by a quick-test procedure. These procedures have been most developed for nitrate and potassium. Studies conducted at the University of Florida and in many commercial tomato fields have determined critical plant sap nitrate levels and are currently investigating critical potassium sap levels. Plant sap testing offers the potential for conducting a quick test in the field on the plant nitrate or potassium status. Results, if interpretated correctly, can be used to make adjustments in

fertilizer additions particularly for growers using drip irrigation or contemplating sidedressing a crop. As with whole leaf plant analysis, plant sap analysis requires that the correct diagnostic plant part be used and that sampling procedures reflect the existing crop. Plant sap testing currently involves analyzing the sap from chopped petioles of tomato leaves using the most-recently-matured leaf on the plant. Several testing kits are available for analyzing the plant sap. Two kits that rely on colorimetric analyses are the Hach colorimeter and the Merckoquant test strips. The sources for these kits are presented in Table 2. In addition to the colorimeter test kits, there is available a small handheld ion selective electrode (see Table 2). All three test kits have been evaluated for plant sap nitrate testing and the electrode is currently being evaluated for potassium analyses. All kits are easy to use and result in rapid evaluation of plant sap for nitrate (and for potassium with the electrode). Calibration data have been developed for nitrate for tomatoes for all three systems. That data appears in Table 3.

Table 2. Nitrate-nitrogen quick-test kits for use in petiole sap nitrate-N determinations.

---

1. Hach colorimeter - HACH Company, PO Box 389, Loveland, CO, 80539. Kit determines nitrate-N directly from a small hand-held "comparator" or colorimeter. There is a range in test-kit sophistication available from HACH and test kits for several other plant nutrients are available.

2. Merckoquant test strips - EM Science, 111 Woodcrest Rd. PO Box 5018, Cherry Hill, NJ, 08034-0395. Kit tests for total nitrates in test solution by comparison of color developed on test strip with a color chart. Kit is slightly quicker than Hach colorimeter but slightly less quantitative. Available also is "reflectometer" to assist in more quantitative reading of the color developed on the strips.

3. Cardy ion selective electrode - Spectrum Technologies, Inc. 12010 South Aero Drive, Plainfield, Illinois 60544. Ion selective electrodes for total nitrates and potassium. One advantage of the electrodes over the colorimeter techniques is that sap can be read directly on the electrode without the need for dilution as is required in the colorimetric procedures.

SAP ANALYSIS PROCEDURES

All test kits are easy to use and result in rapid evaluations of plant sap for nitrate-N. Calibration data have been developed for the Quant strips, for the HACH system (using the hand-held colorimeter), and for the electrode.

For all systems, petioles collected from most-recently-matured leaves are used for analyses. Most-recently matured leaves are leaves that have essentially ceased to expand and have turned from a juvenile light-green color to a darker color. A random sample of a minimum of 25 petioles should be collected from each "management unit" or "irrigation zone". Management units larger than 20 acres should be subdivided into 20-acre blocks. Leaves with obvious defects or with diseases should be avoided. Sampling should be done on a uniform basis for time of day (best between 10 AM and 2 PM), and for interval after rainfall or fertilization.

For tomatoes, the sample is usually the fifth or sixth leaf from the tip. Whole leaves are collected from the plant and the leaf blade tissue and leaflets are then stripped from the petiole. For tomatoes, a petiole of six to eight inches in length remains. Petioles are chopped into about one-half-inch segments. If analysis is not to be conducted immediately in the field, then whole petioles should be packed with ice and analyzed within a few hours of collecting.

Chopped petiole pieces are mixed and a random subsample (about 1/4 cup) is crushed in a garlic press, lemon press, or hydraulic press (obtainable from HACH Co.). Expressed sap is collected in small beaker or juice glass and stirred.

Early in the season, when sap nitrate-N concentrations are high, the sap will need to be diluted. Dilution makes it possible to read the nitrate-N levels within the scales of the test kits. Dilution also will minimize the interference of the green chlorophyll color of the sap on the reading. Some users have reported success with charcoal-filtered sap. This procedure is particularly good for dark sap that does not need to be diluted. Slightly different results will be obtained with filtered and unfiltered sap and users should standardize procedures with one method. With tomatoes, a dilution of 50 or 60 parts deionized or distilled water to one part sap is needed. Later in the season, a dilution of 20 to 1 will usually suffice. Diluting can be accomplished by using a laboratory pipette and graduated cylinder or less precisely, with an eyedropper. The pipette method is recommended for highest accuracy. Diluted sap is stirred completely prior to use in the test kits.

For the Quant strip test, a test strip is removed from the container (keep strips cool when not in use) and dipped for a second into the diluted sap. Following 60 seconds, the pink or purple color developed on the test pad on the end of the strip is compared to the calibrated color chart provided with the kit. Interpolation will be needed for readings between any two color blocks on the chart. An alternative is to use a newly developed strip color reader. This reflectometer provides for more quantitative evaluation of the color on the strip. Readings are made in parts per million (ppm) nitrates which can be converted into ppm nitrate-N by dividing by 4.45.

For the HACH colorimeter, two viewing tubes are filled with diluted sap. One tube is placed in its slot in the "comparator." Contents of one powder reagent pillow are emptied into the second diluted sap sample and the tube mixed for one minute. After mixing, the tube is placed in its slot in the "comparator" and left for one minute. After one minute, the colors in the viewing slots are matched by rotating the color wheel, and the resulting ppm of nitrate-N read from the dial.

For the ion specific electrodes, plant sap is obtained as above and can be expressed or applied by drops directly onto the calibrated electrode. Electrodes must be carefully calibrated using standard solutions prior to analysis with plant sap. Directions for calibration and use of electrodes accompany the electrode. Plant sap for electrodes can be used directly as it is expressed from the chopped petioles requiring no prior dilution. Readings from the electrodes are in parts per million nitrates which can be converted into ppm nitrate-N by dividing by 4.45.

Current interpretations for the two colorimeter kits and the ion specific electrode for several vegetables are presented in Table 3. Work is continuing to provide data for additional crops and for other nutrients.

Table 3. Adequate nitrate-N concentrations in fresh tomato petiole sap of most recently matured leaves at various periods in the season using the Hach, Quant-strip, or electrode methods.

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

CRITICAL NUTRIENT CONCENTRATIONS

Interpreting the plant nutrient analyses results requires an understanding of critical nutrient levels. Basically, critical concentrations of nutrients
are those concentrations of nutrients in the leaves above which yield increases would not occur yet below which yield losses might result. Fertilization programs should attempt to maintain nutrient concentrations at or slightly above the critical concentrations. Maintaining nutrient concentrations at levels far in excess of the critical concentration could result in wasted fertilizer and could damage the crop. Critical concentrations of nutrients change during the growth cycle. For example, critical concentrations early in the season might be higher than those critical concentrations later in the season, particularly for nutrients such as potassium and nitrogen. These nutrients might start out at 4% or 5% percent by dry weight early in the season and then reduce to 2% or 3% late in the season. This reduction in nutrient concentration for nitrogen and potassium with the season is normal and does not reflect an impending deficiency as long as the nutrient levels are still above the critical levels for that particular time in the season. Often crop consultants prefer to see high levels of nutrients maintained throughout the season. For example, maintenance of 5% potassium throughout the season would result in excessive potassium fertilization with no increase in crop yield over a program where leaves early in the season are 5% in potassium and later in the season are 3% potassium.

CRITICAL NUTRIENT VALUES FOR TOMATO LEAVES

A substantial amount of research has been conducted for tomatoes. Critical nutrient levels for tomatoes are presented in Table 4 of the Appendix to this Institute Proceedings in the chapter entitled "Tomato Fertilizer Management." These values come from results of detailed fertilizer studies evaluating plant response to added fertilizer. Critical levels of nutrients can only be derived from properly designed and executed fertilizer studies where yields responded to added nutrient. Plant tissue analyzed during the course of these experiments can be used to determine critical levels of plant nutrients at particular periods in the growth cycle.

IMPROVING TOMATO PACKING EFFICIENCY AND PACKOUT QUALITY USING A VARIABLE-SPEED PACKING LINE

Steven A. Sargent, Jeffery K. Brecht, William A. Miller and Richard Gilbert[1].

Commercial tomato packing lines are designed so as to permit flexibility in the volume of product which can be packed. This flexibility is essential for managers to maintain packouts with the highest quality despite quality differences between incoming lots of tomatoes or shortages of grading personnel. The capacity of a packing line is determined by the rate at which the field bins or gondolas are dumped into the water float tank and by the speed of the individual components (elevator rolls, undersize eliminator belt, wash brushes, etc.). For maximum packing efficiency at any particular time, the capacity (or percent coverage) of a packing line should be as near to 100% as possible and running at a speed which permits adequate sorting and grading to meet quality standards. (100% capacity (percent coverage) refers to the full carrying capacity of the individual components, with complete coverage by the tomatoes.) Operation at full capacity also lowers impacts at many transfer points by reducing roll distances down transfer plates.

In traditional packing lines, the only means of changing the capacity is to vary the dump rate; individual components are set at fixed speeds. Therefore, when a packing line is operated at low capacity, it is underfilled and can permit excessive fruit-to-fruit impacts and fruit-to-conveyor impacts at the numerous transfer points, causing bruising and other mechanical injuries (Sargent, et al., 1990). When the fixed-speed packing line is operated at high capacity, overcrowding can occur and result in ineffective removal of undersize fruit, poor washing, waxing and grading.

---

[1]S.A. Sargent is Extension Postharvest Specialist, and J.K. Brecht is Associate Professor, Vegetable Crops Dept., Institute of Food and Agricultural Sciences, University of Florida, Gainesville FL 32611; W.A. Miller is Assistant Professor, Dept. of Industrial & Management Systems Engineering, and R.A. Gilbert is Associate Professor, Chemical Engineering Dept., University of South Florida, Tampa FL 33620.

Studies have shown that graders have a tendency to remove a certain amount of fruit each minute, despite the quality (Wardowski, et al., 1987). At low capacity, the amount removed per grader is determined by the number of fruit which can be picked up, while at high capacity at the same speed, the amount removed is determined by the number of fruit which can be observed. In other words, when the packing line is run at low capacity graders try to appear busy, while when it is run at high capacity graders tend to reject fruit based on the quality. Therefore, productivity (throughput) in packing operations could be increased by varying the packing line speed with the dump rate so as to maintain nearly full capacity while permitting graders to properly grade fruit. This should also result in improved packout and reduced costs.

Description of Modifications to a Tomato Packing Line

The packing line at Tomatoes of Ruskin (Ruskin, Florida) was retrofitted with a computer-controlled system to improve packing productivity by varying the line speed with the dump rate and by integrating an on-line auditing system for packout inventory. The overall goal in the design of this project was to develop a system which could be economically retrofitted to a packing line using commercially available and reliable equipment.

A programmable controller module was installed in the packinghouse which would provide an operational interlock and speed control for the various components of the main grading line, beginning with the elevator rolls and ending with the grading table. Variable frequency drives were installed to vary the speed of the existing drive motors on the components. A thumb wheel was mounted at the grading table to permit the grading supervisor to control the dump rate and accompanying speeds of the packing line components from a single point. A motor control center enforces safety interlocks and protects various motor drives through use of computer control during start up and shut down procedures. Manual overrides are provided for each of the components.

The audit system provides immediate information on quality, grade and size for each lot packed and continuous information on daily packout totals. The system consists of micro switches, photo-sensitive eyes and position sensors connected to the packinghouse's computer.

Benefits on Packing Line Productivity

A comparison of hourly packout before and after implementation of the system showed a 26% increase in the number of boxes packed per hour (Table 1). After two years, the hourly packout

increased a total of 35% (data not shown). In addition to maintaining a higher capacity over the range of dump rates, the system also reduces the time between grower lots by allowing the packing line speed to be increased during this "dead time".

Printed copies of packout information are given to accounting and to the ripening room supervisor; electronic copies are available to management and brokers. Increases in productivity resulted in the offering of wage incentives to packinghouse workers. They typically could earn at least $20.00 more per week by an increase in base pay of $0.25/hour and an additional $0.25/hour bonus if they worked the entire season.

Effects on Impacts at Transfer Points and Tomato Quality

Peak impacts were determined for five transfer points on the packing line using an Instrumented Sphere data logger (Techmark, Inc., Lansing, Michigan). The analyses were made for four dump rates, 80, 100, 130 and 200 bins/hour (Table 2). Interestingly, as the dump rate increased to 130 and 200 bins/hour, the impact intensities decreased for two transfer points. The impact mean for the roll to the dryer brush bed decreased by 32% at 130 bins/hour and by 54% at 200 bins/hour; the impact mean for the roll to the size belts decreased by 21% at 130 bins/hour and by 63% at 200 bins/hour (Table 2). Also, the number of recorded impacts decreased at the highest dump rate. This confirmed visual observations that, at the two faster dump rates, the percent line coverage was higher than at the slower dump rates. The higher percent coverage caused gentler transfers at these two points by reducing the roll distance since more tomatoes covered the transfer plates.

Thus, we determined that the speeds of the dryer brushes and the size belts were better correlated with the dump rates of 130 and 200 bins/hour than the speeds at the lower dump rates. The drop to the trash eliminator remained fairly constant since this transfer involved a direct drop of each tomato onto the eliminator (no fruit-to-fruit contact); the speed of the sort rolls may have been too fast to permit backup of the fruits on the previous transfer plate.

Mature green tomatoes were sampled at each of the dump rates, from the float tank and on the grading rolls after final grading but prior to transfer to the size belts. Internal bruising (IB) was rated after the tomatoes reached firm-ripe stage. For tomatoes sampled at 80 bins/hour, 22% had IB after final grading (cultivar unknown), while those sampled at 100 bins/hour had 14% IB (cv. Heatwave) (data not shown). Tomatoes sampled at 130 and 200 bins/hour had negligible amounts of IB (cv. Sunny). 'Sunny' has been shown to be more resistant to IB than some other cultivars (Sargent, et al., 1990).

There was a slight increase in external bruises and cuts/punctures from 130 to 200 bins/hour. For tomatoes sampled after grading at 130 bins/hour, 2.1% had at least one bruise greater than 1/2 inch in diameter; 4.2% of those sampled at 200 bins/hour were bruised (Table 3). Tomatoes with cuts and/or punctures greater than 1/2 inch accounted for 5.2% and 11.5% of all tomatoes for 130 and 200 bins/hour, respectively. These values were not sufficiently high to affect grade and were significantly lower than those for tomatoes sampled in the float tank, indicating the importance of the grading operation. The differences in injuries between the two dump rates may be attributed to impacts on the packing line, such as in brush beds, which were not measured with the Instrumented Sphere.

The modifications made so far to the packing line have improved productivity, and resulted in packouts with higher tomato quality. Packout quality has improved because the packing line speed can be quickly adjusted based on the quality of the tomatoes being packed. Continued refinements will be made to the system this fall, most importantly, determining optimal speeds for each of the packing line components at all dump rates. By correlating percent coverage of the conveyors with efficient grading, impacts at transfer points should also be lower.

References

Sargent, S.A., J.K. Brecht and J.J. Zoellner. 1990. Analyses of tomato and bell pepper packing lines using the Instrumented Sphere. ASAE Paper No. 90-6024. American Society of Agricultural Engineers. St. Joseph, Michigan.

Wardowski, W.F., W.M. Miller and W. Grierson. 1978. Packingline machinery for Florida citrus packinghouses. Bul. 239. Cooperative Extension Service, Institute of Food and Agricultural Sciences. University of Florida, Gainesville. 33 pp.

Table 1. Packout comparisons for two-week periods before and after implementation of the variable-speed computer controls.

Before Implementation First Two Weeks of December 1988			After Implementation First Two Weeks of December 1989		
Date	No. of Boxes	Hours	Date	No. of Boxes	Hours
3 Dec.	29,808	10	4 Dec.	--	-
4 Dec.	33,600	12	5 Dec.	26,040	7
5 Dec.	12,022	4	6 Dec.	35,110	10
6 Dec.	24,750	9	7 Dec.	30,325	8
7 Dec.	32,236	11	8 Dec.	23,942	7
8 Dec.	28,718	10	9 Dec.	32,496	9
9 Dec.	--	-	10 Dec.	39,490	11
10 Dec.	23,496	9	11 Dec.	41,403	12
11 Dec.	17,430	6	12 Dec.	14,480	4
12 Dec.	16,810	7	13 Dec.	21,188	6
13 Dec.	27,054	9	14 Dec.	22,475	7
14 Dec.	31,814	12	15 Dec.	46,937	13
15 Dec.	25,650	9	16 Dec.	--	-
16 Dec.	29,247	10	17 Dec.	35,904	10
Total	332,635	118	Total	369,790	104
Average boxes per hour	2888.9		Average boxes per hour	3555.7	

26% increase in packout from 1988 to 1989.

Table 2. Peak impacts recorded at several transfer points on a main tomato packingline operating at four dump rates[1].

TRANSFER POINT		80 BINS PER HOUR			100 BINS PER HOUR			130 BINS PER HOUR			200 BINS PER HOUR		
		MAXIMUM ACCELER. (g's)[2]	VELOCITY CHANGE (m/s)[2]	NO. OF IMPACTS >25 g	MAXIMUM ACCELER. (g's)	VELOCITY CHANGE (m/s)	NO. OF IMPACTS >25 g	MAXIMUM ACCELER. (g's)	VELOCITY CHANGE (m/s)	NO. OF IMPACTS >25 g	MAXIMUM ACCELER. (g's)	VELOCITY CHANGE (m/s)	NO. OF IMPACTS >25 g
1) DROP TO TRASH ELIMINATOR	MEAN	69.0	1.2	8	54.5	1.0	7	76.4	2.4	9	70.4	1.7	8
	MIN.	33.6	0.6		27.5	0.3		29.8	1.2		36.9	0.6	
	MAX.	122.2	2.3		97.8	2.7		148.1	3.4		154.2	3.7	
	STD.DEV.	28.3	0.6		25.6	0.7		37.4	0.7		35.4	1.0	
2) ROLL TO SORT ROLLS	MEAN	101.1	1.0	10	138.3	1.2	10	85.1	1.0	10	101.2	1.0	10
	MIN.	42.1	0.6		33.8	0.5		39.9	0.7		41.0	0.5	
	MAX.	136.9	1.5		279.8	1.6		140.4	1.5		267.8	2.1	
	STD. DEV.	28.6	0.3		67.8	0.3		32.1	0.3		66.1	0.5	
3) ROLL TO DRYER BRUSH	MEAN	94.5	1.1	10	86.6	1.0	10	59.2	1.0	7	40.3	0.5	5
	MIN.	62.4	0.9		46.7	0.9		38.0	0.6		26.6	0.3	
	MAX.	144.7	1.3		157.1	1.3		86.6	1.4		74.9	1.0	
	STD. DEV.	23.2	0.1		31.3	0.1		18.7	0.3		17.9	0.3	
4) ROLL TO GRADE ROLLS	MEAN	89.7	1.0	10	91.7	1.0	10	-	-		-	-	
	MIN.	61.7	0.7		55.1	0.6							
	MAX.	153.2	1.6		114.4	1.4							
	STD. DEV.	27.5	0.2		21.7	0.3							
5) ROLL TO SIZER	MEAN	125.3	1.4	10	135.7	1.6	10	107.5	1.4	10	86.3	1.4	9
	MIN.	74.6	1.1		109.3	0.9		82.6	0.9		52.1	0.9	
	MAX.	179.0	1.5		167.7	1.8		130.6	1.7		120.8	1.8	
	STD. DEV.	32.3	0.1		16.9	0.2		14.3	0.2		19.7	0.3	

[1]Tests made on December 3, 1990 and May 16, 1991.
[2]Threshold set at >25 g's. (1 gravity = 32.2 ft/sec^2, or 9.81 m/sec^2).
[3]No. of recorded impacts out of 10 replicates for each transfer point. (m/s = meters/sec, where 1 meter = 3.28 ft).

Table 3. Mechanical injury for tomatoes sampled in the float tank and after grading at two dump rates[z].

SAMPLE LOCATION/ DUMP RATE		% EXTERNAL BRUISE		% CUT/PUNCTURE		DECAY (%)
		SLIGHT	MOD/SEVERE	SLIGHT	MOD/SEVERE	
Float Tank 130 bins/hr	Mean[y]	42.7	31.2	7.3	7.3	5.2
Grading Table 130 bins/hr	Mean	44.8	16.7	7.3	5.2	2.1
Grading Table 200 bins/hr	Mean	43.8	21.9	9.4	11.5	6.3

[z]Samples harvested and taken on 5/17/91 at mature-green ripeness stage, treated with ethylene and evaluated at firm, red-ripe stage. (cv. Sunny).

[y]Sample size: 96 tomatoes/location.

POTENTIAL IMPACTS ON THE FLORIDA TOMATO INDUSTRY FROM U.S. MEXICO FREE TRADE

By

Dr. J. J. Vansickle

and

Samuel Scott

INTRODUCTION

Importance of the Industry

Total cash receipts of the United States vegetable industry are currently estimated at over $9 billion annually (Table 1-1). The winter fresh marketing season, which runs from December to April, was valued at $1 billion in 1984 (Buckley et al., 1986). This study is focused on this winter period when the majority of shipments are from Florida and Mexico.

Since 1980 the vegetable industry has grown at a rate of 6.6 percent per year. In 1988 tomatoes accounted for over 15% of total cash receipts for produce (Tables 1-1 and 1-2). This industry is vital to the sustenance of Florida's agriculture. In the 1984/85 season, Florida farmers supplied over $555 million of produce in the winter fresh vegetable marketing season, while Mexican growers supplied over $287 million (Buckley et al., 1986). In 1988, cash receipts for tomatoes accounted for 14% of the produce industry total with a value of over $1.4 billion. Annual revenues from tomatoes in Florida are currently estimated $600 million.

Over the last ten years there has been large increases in production, importation and consumption for tomatoes (Table 1-3). Domestic production in Florida rose from 982 million pounds in 1981 to approximately 1.5 billion pounds in 1989, an increase of 51%. Imports from Mexico rose from 470 million pounds in 1981 to 801 million pounds in 1987, an increase of over 70.4%. Per capita consumption increased from 11.2 pounds in 1980 to 16 pounds in 1989.

Table 1-1. Estimated value of the vegetable industry 1970-1988.

Year	All Vegetables
	($1,000)
1970	2,813,521
1971	3,010,833
1972	3,285,439
1973	4,350,796
1974	5,335,513
1975	5,346,116
1976	5,230,823
1977	5,609,314
1978	6,127,461
1979	6,480,010
1980	7,306,561
1981	8,771,913
1982	8,063,495
1983	8,458,651
1984	9,557,752
1985	8,557,752
1986	8,825,521
1987	9,717,705
1988	9,819,393

Source: Economic Research Service, United States Department of Agriculture.

Table 1-2. Value of the selected vegetables based on cash receipts 1979-1988.

Year	Cucumbers	Green beans	Peppers	Tomatoes	Total
	($1,000)				
1979	182,229	129,096	115,696	1,020,320	1,447,341
1980	176,728	101,628	126,706	903,874	1,308,936
1981	188,127	99,059	142,360	941,068	1,370,614
1982	56,870	112,541	90,610	1,244,848	1,504,869
1983	62,062	92,190	125,596	1,137,016	1,416,864
1984	160,137	117,265	154,404	1,239,586	1,671,392
1985	181,476	137,857	149,399	1,198,246	1,666,978
1986	170,072	93,781	163,132	1,264,914	1,691,899
1987	187,594	98,614	229,489	1,284,741	1,800,438
1988	195,804	73,204	151,534	1,407,880	1,828,422

Source: Economic Research Service, United States Department of Agriculture.

Table 1-3. Domestic production, imports and consumption of tomatoes 1980/81-1989/90 (October-June).

Season	Florida	Mexico	Per Capita Consumption (lbs)
	(10,000 lbs)		
1980/81	73287	57334	11.4
1981/82	98237	47094	11.2
1982/83	105652	47094	11.4
1983/84	108291	61759	11.6
1984/85	106966	70313	13.0
1985/86	125788	69917	13.7
1986/87	126445	75344	14.6
1987/88	134017	80189	14.2
1988/89	146207	62462	15.2
1989/90	148981	55307	16.0

Source: Economic Research Service, Bulletin #749 & 773 and Market News Branch, United States Department of Agriculture.

With the introduction of the Caribbean Basin Initiative (CBI) in 1982, twenty eight Caribbean countries were given duty free access to the United States market for 12 years. A close analysis of treatment to horticultural exports under CBI as compared with that under the Generalized System of Preferences (GSP) showed that most commodities already received duty free treatment. Also, for those commodities where duties were charged, waivers were already granted during the period January to March (Cook and Amon 1987). It is suggested, therefore, that the CBI initiative did not provide any real new incentive for increased production. But from a political point of view, it created a mechanism for marginal increases in foreign investment. It is against this background that exports from the region rose during the period 1984-86 (Table 1-4). However, quantities imported did not and have not posed any significant competition to Florida producers. In 1989 it was shown that imports from CBI countries accounted for only one percent of winter fresh vegetables consumed (VanSickle, 1990).

Table 1-4. Value of U.S fresh or frozen fruits and vegetables imported from Caribbean Basin Countries 1985-1986.

		1985	1986
		million dollars	
U.S. Fresh or Frozen Fruit Imports			
	Central America	15.80	29.80
	Caribbean	12.20	11.80
	Subtotal	28.00	41.60
U.S. Fresh or Frozen Vegetable Imports			
	Central America	25.60	39.20
	Caribbean	28.10	28.10
	Subtotal	53.70	67.30
	Total	81.70	108.90

Source: Adapted from Cook and Amon, 1987.

Macroeconomic Factors Affecting Trade

Levels of exports are likely to be influenced by macroeconomic factors. These factors will affect prices which will ultimately affect the net returns to growers. Both in Mexico and Florida these macroeconomic factors will influence production costs and the prices received by the producer.

In testing competitiveness over time, these factors must be taken into consideration. Zepp and Simmons (1979), Bredhal et al. (1983) and Buckley et al. (1986) identified two main macroeconomic factors which have impacted competition. These are devaluation of the Mexican peso and rapid increases in input price levels (inflation). Another factor which might be considered is the tariff.

Exchange rate and devaluation of Mexican peso. An exchange rate denotes the price of two countries currencies relative to each other. An overvalued currency imposes an implicit tax on exports.
An undervalued exchange rate provides an implicit subsidy. Devaluation therefore should have two effects. From a commercial policy point of view it functions as both an export subsidy and a tariff.

In the case of Mexico the exchange rate was removed from the fixed system in August, 1976, when it was 12.5 pesos per dollar. Since then the peso has consistently depreciated to the point where the exchange rate equalled 2461.5 in 1990 (Table 1-5). The question remaining concerns the impact that depreciating exchange rates have had on the production of fresh winter vegetables in Mexico and Florida. Zepp and Simmons (1979) showed that over the period 1975 to 1979 input prices generally increased. Wages paid to labor, the major component in vegetable production in both Florida and Mexico, substantially increased as a result of devaluation.

While it was conceded that the devaluation of the peso could increase the net returns for Mexico vegetables in the short run, over time it caused prices of inputs to increase and negate benefits from increased prices.

Input prices and inflation. Generally prices of inputs have increased in Mexico. If, as the theory suggests, the percentage increase in prices of

products exported will at most be equal to the proportional change in the exchange rate, then the upper bound on the exchange rate elasticity is one. Then we can comfortably suggest that a 100 percent devaluation/depreciation of the peso will increase the Mexican export prices by 100 percent. Therefore, it is reasonable to suggest that inflation in input prices could be offset by a proportional devaluation of the peso in the short-run.

Table 1-5. Mexico exchange rates 1979-1989.

Years	Exchange Rate (peso/U.S. dollars)
1979	22.82
1980	22.89
1981	24.97
1982	24.52
1983	56.40
1984	120.10
1985	167.80
1986	256.90
1987	611.80
1988	1378.00
1989	2273.10
1990	2461.50

Source: International Financial Statistical Yearbook International Monetary Fund, World Bank,1990.

It may therefore be concluded that a change in the exchange rate will influence competitiveness between Mexico and Florida in the short-run. Also, the magnitude of exchange rate elasticity will indicate the direct and indirect influence the Mexican government and growers can have on vegetable trade.

Tariffs. Protectionist policies are generally based on economic and political arguments. One of the most used commercial instruments of protection is tariffs. As related to this study tariffs are charged in two

forms, import duties payable at border crossing to the importing country, and export duties paid at the border to the government of the country of origin.

The Tariff Act of 1883 assessed a 10% duty on fresh vegetables but not on fruit. At that time tomatoes were not strictly classified as vegetables, but the court ruled later that year, "in the common language of the people," tomatoes are vegetables. As a result, a tariff was then levied against tomato importers (Bredhal et al. 1987). The Act of 1938 further allowed for charging of duties on imports of other vegetables from Mexico. However it was observed that changes in the current tariffs structure have been quite marginal; and for the selected vegetables have not changed over the previous ten seasons. Generally, a specific tax is charged on most vegetables imported from Mexico. The current tariff structure ranges from 1.65 cents/lb for period mid-November through February to 2.3 cents/lb for the periods January through mid-July and September through early November. In the study a weighted average of 2 cents/lb for the period December through April was used.

Background of Proposed North American Free Trade Agreement (NAFTA)

Over the years, concerns have been expressed by Florida produce growers about Mexico entering the United States market. Smith (1947) suggested that Mexico had at that time established a major foothold in the North American fresh winter vegetable market.

Florida producers have sought to protect their markets by various means. A chronology of this can be seen in Bredahl et al. (1983). This has ranged from legal petition in late 1960's to other substantial trade barriers. Despite these actions Mexico continues to sell produce in the United States market, with market share increasing for some major vegetables and decreasing for others. Major contributors to the different strands of literature suggest that Florida producers have failed in their fight to sufficiently protect their markets by means of trade barriers. Signifying the importance of the

issue is a recent report from the Florida Commissioner of Agriculture which states:

(a) A further increase in imports of vegetables will reduce the income of Florida growers. This reduction in income will have substantial adverse economic impact on Florida's Agriculture.

(b) Free trade in the selected commodities over and above certain levels will affect the share in the market and will have severe economic effects on the State of Florida Agriculture.

Cook and Amon (1987) suggested in their article that any substantial increase in the acreages of winter vegetables grown by either Florida or Mexico could devastate market prices. They suggested that research is needed to the determine what policies are needed to assist Florida growers.

Free trade involves the removal of all tariff and nontariff barriers to trade that may exist between trading areas. A U.S.-Canadian Free Trade agreement was initiated in 1988 with the intent of removing these barrirs to trade by the year 1998. The U.S. and Mexico began discussions for a free trade agrrement in 1989. In February, 1991 Canada officially joined the negotiations which will most likely lead to a North American Free Trade Agreement (NAFTA). President Bush was given "fast-track" authority earlier this year for negotiatting this agreement. Fasty-track authority would require Congress to approve or disapprove an agreement in its entirety within a fixed period of time, and would preclude congressional amendments.

Recently the Florida Fruit and Vegetable Associationand the Florida Tomato Exchange announced opposition to the proposed North American Free Trade Agreement. This opposition was based on the premise that differing wages, environmental and pest-management regulations have placed United States producers on an unequal footing with Mexico competition (FFVA, August 1990). These groups argue for the need for more transparency on what is happening in Mexico. Further, it is the general agreement of the groups that the major shortcoming of any snapback provision in a Free Trade Agreement (FTA) is the absence of reliable statistics on production and shipments of Mexican produce.

As the winter fresh vegetable market continues to be a source of discussion, the impacts of alternative policies are of eminent importance. Past research has addressed elements of competition between Mexico and Florida (Firch and Young 1968, Andrews et al. 1975, Zepp and Simmons 1979, Emerson 1980, Buckley et al. 1986 and VanSickle 1990).

The need exists to assess the competitiveness between Florida and Mexico and to identify the economic factors that influence international competition in the tomato industry

Objectives of the Study.

The overall objective of this study was to assess the potential impacts on the Florida tomato industry from free trade with Mexico. The specific objectives of the study are to:

(a) evaluate the market shares for Florida and Mexico in the winter fresh tomato industry.

(b) relate trends to relative price changes over the period as an indication of competitiveness between Florida and Mexico; and

(C) estimate potential impact of NAFTA on market shares.

METHODOLOGY

With intense international competition, domestic suppliers are becoming more concerned with their market share in the marketplace. In any study of industry competitiveness an analysis of market share can provide some indication of product performance (particularly the demand) and the degree of competition.

In theory, market share is used as a market performance index. The ultimate result of understanding the cause and effect relationships between market shares and market variables will determine the firm(s) or industry profitability. Market shares are generally calculated from two sets of data. These are point of sale data (POS) at the wholesale level and at the retail or household level (Cooper and Nakanishi, 1981). This study will focus on points of sale at shipping point (wholesale).

Market share analyses have three basic characteristics. First is the characteristic of competition, in that it implies that the effect of one's action must be analyzed in conjunction with its market position and the actions of competitors.

Second, market share analyses are descriptive as well as predictive in that they provide the needed information on the structure of the market, competition, the influences in the market and action of the competing product performance. When simulated, market shares can be used to predict trends in the marketplace.

Third, market share analyses also have the characteristic of being profit oriented, in the sense that movements in the market shares can have profit consequences depending on the elasticity of the commodity. This can stimulate producers to revise plans to expand market shares.

Market shares are analyzed by assessing competition at the shipping point levels. By estimating elasticities of substitution one can make inferences about the direct elasticities of demand (Sirhan and Johnson, 1971). Studies of market share have been used to measure the short run and long run

price elasticities of agricultural commodities in international markets. Such information on the sensitivity of market share to price changes provides a basis for testing the hypothesis that a higher own price relative to competitors' prices can lead to a decline of that commodity in that market.

The share of any given market for a commodity can be expressed as a function of its own price and the price of a competing supplier to that market (Telser, 1962, Cooper and Nakanishi, 1988), i.e.,

$$(1) \qquad M_{Fit} = f\ (\ P_{Fit}\ ,\ P_{Mit}\ )$$

where M_{Fit} is the market share of Florida commodity i in time period t, P_{Fit} is the shipping point price for Florida commodity i in time period t and P_{Mit} is the shipping point price for Mexico commodity i in time period t. For the commodity (i) tomato; the market share is calculated as follows:

$$(2) \qquad M_{Fit} = \frac{q_{Fit}}{Q_{it}}$$

where q_{Fit} is the quantity of commodity i shipped from Florida in time period t and Q_{it} is the total quantity of commodity i shipped from all shipping points in period t.

If the prices of Florida commodities increase in comparison to other foreign (Mexico) competitor's prices, the result would be that some wholesalers, retailers, and consumers would switch to Mexican produce. This would then result (ceteris paribus) in a decline in Florida's market share. Thus, Florida market share is assumed to be a decreasing function of its own price. It should be noted however that prices are commonly correlated in this model. In that instance, relative shipping point prices (P_{it}) are used. This ratio is used in the analysis to avoid severe multicollinearity between the two shipping point prices. The elasticity of Florida's market share with respect to relative price is

$$(3)\quad \epsilon^{M_{Fit}} = \frac{\partial M_{Fit}}{\partial P_{it}} \cdot \frac{P_{it}}{M_{Fit}} \quad .$$

This elasticity provides an indication of the magnitude of competition between Florida and Mexico. A relatively high coefficient in absolute terms will be indicative of a high degree of competition.

Changes in the market share reflects changes in the demand. One can distinguish between the short-run and long-run market share of a supplying region. A shipping area's/shippers long-run market share equilibrium reflects the desired level of purchases of this product in the market. Since it is assumed that purchasers adjust their pattern of consumption gradually, only a fraction of the expected or long run market share can be achieved within a specified period. By specifying the long run market share function and the partial adjustment function, one can derive the partial adjustment reduced form equation from the following structural relationship;

$$(4)\quad M_{Fit} = \gamma\alpha + \gamma\beta P_{it} + (1-\gamma) M_{Fit-1} + \gamma\mu_t$$

where P_{it} is the relative price ratio (Telser, 1962). The parameters to be estimated are $\gamma\alpha, \gamma\beta$ and $(1-\gamma)$. The coefficient $\gamma\beta$ represents the short run response of market share to relative price changes, β denotes the long run response and γ the rate of adjustment.

This study uses the semi-log functional form in the regression equations for the different commodities to estimate the short-run and long-run elasticities of Florida market share. This is expressed as

$$(5)\quad M_{Fit} = b_0 + b_1 \ln P_{it} + b_2 \ln M_{Fit-1} + \mu_t .$$

μ is the error term which is assumed to be normally and independently distributed. The short-run response is estimated as b_1 and the long-run response is b_1 divided by $(1 - b_2)$ the rate of adjustment. For conversion into elasticities these are normalized by the respective mean market shares.

Results and Interpretation

As an indication of competitiveness between Florida and Mexico, the market shares for Florida tomatoes were analyzed. The semi-log functional form yielded satisfactory results which are plausible and consistent with the theory in estimating market share. The parameter estimates of market shares from equation (5) were obtained for tomatoes by regressing market shares on the relative price ratio and the lagged market shares. The estimates and other statistics are presented in table 1-6. Generally, the signs of the estimated parameters were as expected. It can be seen that the coefficient of the relative price variable for tomatoes is significant at the 5 percent probability level and have the proper signs.

A relatively high coefficient in absolute terms is seen for tomatoes with respect to the relative price variable. This is indicative of a high degree of competition between Florida and Mexico for this commodity. Also the coefficient related to the long-run response (lagged market shares) is statistically significant. Average market share was 48.38% for tomatoes.

Table 1-6. Estimates of Florida's market shares of tomatoes in the U.S. market 1979/80-1988/89 (December-April).

Equations/ commodities	Constant term	Relative price variable	Lagged market-share variable	R	F value	Mean market share
Tomatoes	-66.9686* (8.4414)	-11.5360* (4.6397)	31.4739* (2.0046)	0.90	169.36	48.38

Standard errors are expressed in parentheses below the parameter estimates
* Indicates coefficients significant at the 5 percent probability level presented with asterisk.

Table 1-7 presents the elasticities of market shares with respect to relative price for tomatoes, as well as the coefficient of adjustment corresponding to the estimated equation.

Table 1-7. Estimates of short-run and long-run elasticities of Florida's market share of tomatoes in the U.S. market 1979/80-1988/89 (December-April).

Equations/ commodities	Relative price coeff.	Short-run elasticities	Long-run elasticities	Rate adjustment
Tomatoes	-11.536	-0.2384	-0.9005	0.3495

The short-run elasticity is calculated by taking the relative price coefficient and dividing by the mean market share. The long-run elasticity is calculated by dividing the relative price coefficient by one minus the coefficient of the lagged market share having divided by the mean market share. The rate of adjustment is the difference between one and the coefficient of the lagged market share normalized by the mean market share (i.e., lagged market share parameter divided by mean market share).

It can be seen that the short-run elasticity for tomatoes is lower in absolute value than the long-run elasticity. These elasticities imply a higher degree of competition in the long-run. The short-run elasticity is -0.2384 for tomatoes. The long-run elasticity is -0.9005. On the basis of these estimates, it is concluded that a high degree of competition exists in tomatoes market. This is supported by the results of the average market shares over the ten seasons.

Table 1-8 presents a compilation of market shares over the ten seasons based on shipping quantities for tomatoes in the December to April marketing period.

Table 1-8. Average seasonal market shares for tomatoes expressed as percentage 1979/80-1988/89 (December - April).

	Tomatoes	
	Fla	Mex
1979/80	44.89	54.54
1980/81	52.64	43.09
1981/82	57.60	38.54
1982/83	55.06	42.76
1983/84	50.66	47.61
1984/85	50.28	48.24
1985/86	49.83	47.44
1986/87	54.55	43.52
1987/88	61.46	35.73
1988/89	67.68	29.79

Source: Marketing News Branch, United States Department of Agriculture.

The results are consistent with the empirical estimation based on market share estimates. Florida market share after the 1979/80 season increased for three seasons, attaining a high of 57.6 % in 1981/82 season. It declined for four seasons to 49.8% in the 1984/85 season. Subsequently, it has been increasing reaching a high of 67.6% in 1988/89 season. Mexico market share for tomatoes declined after the 1979/80 season, but held somewhat steady for the five seasons starting from 1982/83. In the last two seasons huge declines in market share can be seen with lows of 35.73% in 1987/88 and 29.79 % in 1988/89.

Another question that arises is that of the impact of other variables on market shares. The effects of monetary and trade policies reflect this concern. The effects of these policies would be transmitted through the exchange rate and tariff variables respectively.

However, the structure of the winter fresh vegetable industry, particularly the distributorship of Mexican produce, is suspected of reducing the full impact and transmission effects of exchange rates and tariffs. For example, because 60% of the distributorships in Arizona are owned by Mexicans (Buckley et al. 1986, Cook and Amon, 1987), this suggests that in the transaction of payments, exchange rate does not matter. This is supported empirically in the attempt to test the effects of exchange rates in the model. Estimates for exchange rates for the various model equations were not statistically significant. It is offered that while it is likely to affect the prices of inputs, it does not have the full impact on the prices of the outputs.

In the case of tariffs, these have not changed over the previous ten seasons. It is therefore likely that these are treated as a given in the pricing policy used by the distributors. Based on intuitive reasoning and supported by empirical evidences (Andrew et al.,1975), it would appear that the tariffs largely affect the United States consumers, distributors and Florida growers and workers in the vegetable industry in Florida. The tariff effect (like a toll gate tax) will result in higher prices to consumers. These higher prices increase rents which go to the Florida growers and workers in the form of higher prices and wages.

It is therefore concluded that international competition at the shipping points in the winter vegetable market is affected mainly by the relative price. It is primarily through this relative price that tariffs affect international trade in the fresh vegetable industry.

In summary, the relatively large estimates of the short-run and long-run responses are indicative of a high degree of competition in the case of tomatoes. Calculation of elasticities showed that while in the short-run Florida faces a high degree of competition, in the long-run the Florida industry faces even higher degrees of competition.

Summary and Conclusions

Given the nature of the proposed North American Free Trade Agreement, the Florida Fruit and Vegetable Association (FFVA) and the Florida Tomato Exchange consider Florida growers to be on an unequal footing with their Mexican counterparts because of lower labor costs and weaker environmental regulations. The result has been lobbying efforts to slow negotiations by showing the threat that increasing competition from Mexico supplies presents to Florida growers.

Consistent with the overall objective of assessing competitiveness between Florida and Mexico was an appraisal of the sensitivity of market shares to changes in relative prices. Market shares of Florida tomatoes were regressed against the relative price ratio and the lagged market shares. It was hypothesized that changes in U.S. prices will affect supplies from both regions, recognizing that the shift will be dependent on the price advantage that each area possesses. The results indicate that the average Florida market share for the period studied is 48.38% percent for tomatoes. A high degree of competition exists between Florida and Mexico for the tomato market. The short-run and long-run elasticities for tomatoes are -0.24 and -0.90, respectively. These indicate that a one percent increase in the relative price for tomatoes will result in a decline of the Florida market share for tomatoes of 0.24 percent in the short-run and 0.9 percent in the long-run. Also, competitiveness between Florida and Mexico was influenced mainly by shipping point prices and not necessarily by monetary and trade policies.

Table 1-10. Changes in Florida's market share in response to changes in relative price ratio due to elimination of tariff 1988/89 (December-April).

	Relative price ratio with tariff	Current market share (%)	Relative price ratio without tariff	Projected Market share (%)
Tomatoes	0.99	67.68	1.04	63.18

An assessment of market shares for Mexico showed that their market share for tomatoes has fallen for the last three seasons. It has been documented that Mexico has embarked on horizontal expansion of its winter fresh vegetable industry. Policy makers should not allow a reduction of competition in the tomato markets to be a general signal that the domestic winter fresh vegetable industry is healthy for the long term.

The results of the analysis indicate that competition in the tomato market is keen and may become more of a problem to Florida growers once a free trade agreement is finalized. Mexico already demonstrated in the 1970's and 80's a willingness to control shipments to the U.S. market so that trade talks with the U.S. policy makers would not be jeopardized (Bredhal et al., 1987). The question left unanswered is, what will Mexico do if a free trade agreement is finalized?.

REFERENCE LIST

Andrew, C. O., T. DeBoon and W. W. McPherson (1975). "Effects of Trade Policies on Competition Between Florida and Mexico in the United States Cucumber Market." Southern Journal of Agricultural Economics, 7: 197-324.

Bredhal, M. E., J. S. Hillman, R. A. Rothenberg and N. Gutierrez (1983). Technical Change, Protectionism and Market Structure: The Case of International Trade in Fresh Winter Vegetables. Bulletin #249, College of Agriculture, University of Arizona. Tucson, Arizona.

Bredhal, M. E., A. Schmitz, and J. S. Hillman (1987). "Rent Seeking in International Trade: The Great Tomato War." American Journal of Agricultural Economics, 69: 1-10.

Buckley, K. C., J. J. VanSickle, M. E. Bredahl, E. Belibasis and N. Gutierrez (1986). Florida and Mexico Competition for the Winter Fresh Market. U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report #556. Washington, D.C.

Bunch, K. L. and J. Putman (1985). Food Consumption, Prices and Expenditures. U. S. Department of Agriculture, Economic Research Service Bulletin #749. Washington, D.C.

Bunch, K. L. and J. Putman (1987). Food Consumption, Prices and Expenditures. U. S. Department of Agriculture, Economic Research Service Bulletin #773. Washington, D.C.

Conner, D. (1987) "Position Paper on the Caribbean Basin Initiative." Florida Department of Agriculture and Consumer Services. Tallahassee, Florida.

Cook, R. and R. Amon (1987). "Competition in the Fresh Vegetable Industry." K. Moulton and D. Runsten eds. Marketing California Specialty Crops: Competitiveness at Home and Abroad: 13-35, Agricultural Issue Center. University of California. Davis, California.

Cooper, L. G., and M. Nakanishi (1988). Market Share Analysis. Klumer Academic Publishers Norwell, Massachusetts.

Florida Fruit and Vegetable Association "FFVA to Look into Formation of Caribbean Group" The Packer: 6A, August 25, 1990.

Sirhan, G. and P. R. Johnson (1971). "A Market Share Approach to the Foreign Demand for U.S. Cotton." American Journal of Agricultural Economics. 53: 593-599.

Smith, M. G. (1947). The Mexican Winter Vegetable Industry. U.S. Department of Agriculture, Foreign Agriculture Report #21. Washington, D.C.

Telser, L. G. (1962). "The Demand for Branded Goods as Estimated for Consumer Panel Data." Review of Economics and Statistics 44: 300-324.

VanSickle, J. J. (1990). "Import Competition in the Winter Fresh Vegetable Industry: A 1989/90 Update." Citrus and Vegetable Magazine Feb.: 85-96.

Zepp, G. A., and R. L. Simmons (1979). Producing Fresh Winter Vegetables in Florida and Mexico. U. S. Department of Agriculture, Economic, Statistics, and Cooperative Service, ESCS-73. Washington, D. C.

APPENDIX A

TOMATO VARIETIES FOR FLORIDA

D. N. Maynard
Gulf Coast Research & Education Center
Bradenton, FL 34203

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; 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, jointlessness 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 acreage.

'Sunny' is the leading variety accounting for over 70% of the state's acreage in the 1990-91 season. The proportion of acreage on which 'Sunny' was planted increased for several years, and has remained about constant from 1987-88 through the 1990-91 season. 'Sunny' accounts for most of the acreage in the Southwest, Palmetto-Ruskin, and East Coast production areas as well as being the predominant variety in North Florida for the spring crop.

'Bonita' was the second most important variety grown in Florida in the 1990-91 season but represented only about 7% of the state's acreage. However, 'Bonita' accounted for over half of the Dade County acreage.

'BHN 26' was grown on about 4% of the state's acreage, mostly in Southwest Florida where it was the second most important variety.

'Duke' represented about 3% of the state's acreage and almost 30% of the Dade County acreage.

'Agriset 761' was grown on almost 3% of the state's acreage, mostly in the Palmetto-Ruskin area.

'Heatwave' was grown on about 1% of the state's acreage and was grown on much of the fall acreage in North Florida.

A number of other varieties, including 'Olympic', 'Colonial', 'Solar Set', 'Pacific', 'Mountain Pride' and 'All Star' were used on less than 1% of the Florida acreage in 1990-91. And, more than 20 other varieties and experimental lines were grown on a very limited commercial scale.

Tomato Variety Trial Results

Summary results listing outstanding entries in order from the Gulf Coast Research and Education Center, Bradenton; Ft. Pierce Agricultural Research and Education Center; and the North Florida Research and Education Center, Quincy for the fall 1990 season are shown in Table 1. High total yields and large fruit size were produced by IFAS 7384 at Bradenton and Ft. Pierce. IFAS 7264 produced both high yields and large fruit size at Bradenton. High total yields and large fruit size were produced by 'Solar Set' at Ft. Pierce and Quincy. Several other entries produced high yields or large fruit size at one or more locations.

Table 1. Summary of IFAS tomato variety trials, Fall 1990.

Location	Reference	Total Yield	Large Fruit Size
Bradenton	1	IFAS 7384	IFAS 7384
		Agriset 761	Heatwave
		IFAS 7385	XPH 5796
		IFAS 7264	Solar Set
		IFAS 7306	IFAS 7264
Ft. Pierce	5	Solar Set	IFAS 7306
		IFAS 7264	IFAS 7384
		IFAS 7308	Solar Set
		Sunny	IFAS 7307
		IFAS 7384	IFAS 7303
Quincy	3	Solar Set	PSR 803688
		IFAS 7283	Olympic
		IFAS 7349	Solar Set
		Agriset 761	IFAS 7264A
		Sunny	IFAS 7266A

Seed Sources:
Agrisales: Agriset 761
Asgrow: Solar Set, Sunny, XPH 5796
Gulf Coast Research & Education Center: IFAS 7264, IFAS 7266, IFAS 7283, IFAS 7303, IFAS 7306, IFAS 7307, IFAS 7308, IFAS 7349, IFAS 7384, IFAS 7385.
Petoseed: Heatwave, Olympic, PSR 803688.

Summary results listing outstanding entries in order from the Gulf Coast Research and Education Center, Bradenton; Ft. Pierce Agricultural Research & Education Center; and North Florida Research & Education Center, Quincy for the Spring 1991 season are shown in Table 2. A combination of high total yields and large fruit size were produced by IFAS 7264, IFAS 7306, and 'Solar Set' at Ft. Pierce.

Table 2. Summary of IFAS tomato variety trial results, Spring 1991.

Location	Reference	Total Yield	Large Fruit Size
Bradenton	2	XPH 5796	Merced
		IFAS 7385	IFAS 7306
		Solar Set	IFAS 7384
		IFAS 7308	Sunbeam
		IFAS 7307	Cobia
			PSR 864189
Ft. Pierce	6	IFAS 7264	IFAS 7306
		IFAS 7308	IFAS 7384
		IFAS 7306	Solar Set
		Solar Set	IFAS 7264
		Sunny	IFAS 7307
Quincy	5	Colonial	Agriset 761
		Sunny	Merced
		Sunre 6590	IFAS 7306
		XPH 5796	Mogambo
		IFAS 7307	Cobia
		Agriset 1000	Solar Set

Seed Sources:
Agrisales: Agriset 761, Agriset 1000
Asgrow: Solar Set, Sunbeam, Sunny, XPH 5796
Gulf Coast Research & Education Center: IFAS 7264, IFAS 7306, IFAS 7307, IFAS 7308, IFAS 7384, IFAS 7385
Petoseed: Colonial, PSR 864189
Rogers NK: Cobia, Merced
Sunseeds: Mogambo, Sunre 6590

For fall 1990 and spring 1991 combined, 'Solar Set' had high total yields and/or large fruit size in eight instances, IFAS 7264, IFAS 7306, and IFAS 7384 in five instances, 'Sunny' in four instances, and 'Agriset 761' and XPH 5796 in three instances each.

It should be noted that in some of these trials, there were 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 IFAS 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, jointless hybrid. Fruit are deep globe and green shouldered. Resistant: Verticillium wilt, Fusarium wilt (race 1 and 2), Alternaria Stem Canker, Gray Leaf Spot.

Bonita (Rogers NK). A midseason, jointless hybrid. Fruit are globe-shaped. Resistant: Verticillium wilt, Fusarium wilt (race 1 and 2), Gray Leaf Spot.

Colonial (Petoseed). A midseason, jointless hybrid. Fruit are deep globe shape with green shoulders. Resistant: Verticillium wilt, Fusarium wilt (race 1 and 2), Alternaria Stem Canker, Gray Leaf Spot. **FOR TRIAL**.

Duke (Petoseed). An early, determinate, jointless hybrid. Fruit are large, green shouldered, and moderately flat-round shaped. Resistant: Verticillium wilt, Fusarium wilt (race 1 and 2), Gray Leaf Spot, Alternaria Stem Canker.

Heatwave (Petoseed). An early, large, uniform-green fruited hybrid. Determinate. Fruit is set under high temperatures (90-96°F day/74-78° night). Resistant: Verticillium wilt, Fusarium wilt (race 1 and 2), Alternaria Stem Canker, Gray Leaf Spot.

Olympic (Petoseed). An early determinate, jointed hybrid. Fruit are deep oblate with green shoulders. Resistant: Verticillium wilt, Fusarium wilt (race 1 and 2), Alternaria Stem Canker, and Gray Leaf Spot. **FOR TRIAL**.

Solar Set (IFAS-Asgrow). An early, 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.

Summer Flavor 6000 (Abbott & Cobb). A midseason, jointless, determinate hybrid. Large, deep globe fruit. Resistant: Verticillium wilt, Fusarium wilt (race 1 and 2). **FOR TRIAL**.

Sunny (Asgrow). A midseason, jointed, determinate hybrid. Fruit are large, flat-globular in shape, and are green-shouldered. Resistant: Verticillium wilt, Fusarium wilt (race 1 and 2), Alternaria Stem Canker, Gray Leaf Spot.

References

1. Howe, T. K., J. W. Scott, and W. E. Waters. 1991. Tomato cultivar trial results for fall 1990. GCREC Res. Rept. BRA1991-4.

2. Howe, T. K. 1991. Personal communication.

3. Olson, S. M. 1991. Tomato variety trial results. p. 78-79 In D. N. Maynard (ed.) Vegetable Variety Trial Results in Florida for 1990. Fla. Agr. Expt. Sta. Circ. S-382.

4. Olson, S. M. 1991. Personal communication.

5. Stoffella, P. J. 1991. Tomato variety trial results. p. 75 In D. N. Maynard (ed.) Vegetable Variety Trial Results in Florida for 1990. Fla. Agr. Expt. Sta. Circ. S-382.

6. Stoffella, P. J. 1991. Personal communication.

APPENDIX B

TOMATO FERTILIZER MANAGEMENT

G. J. Hochmuth
Vegetable Crops Department
University of Florida

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 avail- able. 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 $N\text{-}P_2O_5\text{-}K_2O$) 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 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 with blossom-end-rot, especially on the first one or two fruit clusters. Blossom-end rot (BER) is basically a Ca deficiency but is often more related to water stress than to Ca concentrations in the soil. This is because Ca movement in the plant is with the water stream. Anything that impairs the ability of the plant to obtain water will increase the risk of BER. These factors include damaged roots from flooding or mechanical damage, clogged drip emitters, inadequate water applications, and alternating dry-wet periods. Other causes include high fertilizer rates, especially potassium and nitrogen. High fertilizer increases the salt content and osmotic potential in the soil reducing the ability of roots to obtain water.

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

BER is most effectively controlled by attention to irrigation. Maintaining adequate and uniform amounts of water are keys to reducing BER potential. Growers who keep N and K 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 applications	
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 super or triple super form should be placed in the drill or under the plug-mix to supply an adequate amount for germinating seedlings or transplants.

Micronutrients

For virgin, sandy soils, or sandy soils where a proven need exists, a general guide for fertilization is the addition of micronutrients (in pounds per acre) manganese -3, copper -2, iron -5, zinc-2, boron-2, and molybdenum-.02. Micronutrients may be supplied from oxides or sulfates. Growers using 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 up to 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 of harvest period. A shallow cultivator sweep will cover the fertilizer and help correct bed erosion. Liquid fertilizer can be used by knifing it into the soil, using caution to avoid root damage.

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

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, 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 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. 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 is needed on soils such as 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 the remaining nitrogen and potassium through the drip system in increments as the crop develops.

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

Suggested schedules for fall and spring crop nutrient injections are presented in Table 3. These schedules have been successful in both research and commercial situations, but might need slight modifications based on potassium soil-test indices and grower experience.

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

Sources of N-P_2O_5-K_2O. At least 30 to 50 percent of the total applied nitrogen should be in the nitrate form for soil treated with multi-purpose fumigants.

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

Normal superphosphate and triple superphosphate are highly recommended for phosphorus needs. Both contribute calcium and normal superphosphate contributes sulfur.

Recent research has shown that all sources of potassium can be used for tomatoes. Potassium sulfate, sodium-potassium nitrate, potassium nitrate, potassium chloride, and potassium-magnesium sulfate are all good K sources. If the soil test predicted amounts of K_2O are applied, then there should be no concern for the K source or its associated salt index.

Tissue analyses. Analysis of tomato leaves for mineral nutrient content can help guide a fertilizer management program or assist in diagnosis of a suspected nutrient deficiency. 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. At least two kits have been calibrated for Florida tomatoes, the Hach and Quant kits (3). Interpretation of these kits is provided in Table 5. More information is available on plant analysis (6).

LITERATURE CITED

1. Hanlon, E. A., and G. J. Hochmuth. 1989. Calculating fertilizer rates for vegetable crops grown in raised-bed cultural systems in Florida. Univ. Fla. Coop. Ext. Special Series, SS-SOS-901.

2. Hochmuth, G. J. 1988. Commercial vegetable fertilization guide. Univ. Fla. Coop. Ext. Circ. 225-C.

3. Hochmuth, G. J., P. R. Gilreath, E. A. Hanlon, G. A. Clark, D. N. Maynard, C. D. Stanley, and D. Z. Haman. 1988. Evaluating Plant-N status with plant sap quick-test kits. Proc. 1988 Florida Tomato Institute. SS-VEC-801, pp 6-14.

4. Hochmuth, G. J. and E. A. Hanlon. 1989. Commercial vegetable crop nutrient requirements. Univ. Fla. Coop. Ext. Circ. 806.

5. Hochmuth, G. J., and G. A. Clark. 1991. Fertilizer application and management for micro (drip) irrigated vegetables in Florida. Univ. Fla. Coop. Ext. Serv. Special Series Public. SS-VEC-45.

6. Hochmuth, G., D. Maynard, C. Vavrina, and E. Hanlon. 1991. Plant tissue analysis and interpretation for vegetable crops in Florida. Univ. Fla. Coop. Ext. Serv. Special Series Public. SS-VEC-42.

7. Kidder, G., E. A. Hanlon, and G. J. Hochmuth. 1989. IFAS standardized fertilization recommendations for vegetable crops. Univ. Fla. Coop. Ext. Special Series, SS-SOS-907.

8. Lorenz, O. A., and D. N. Maynard. 1980. Knott's handbook for vegetable growers, Second ed. Wiley-Interscience, New York.

9. Shuler, K. D., and G. J. Hochmuth. 1990. Fertilization guide for vegetables grown in full-bed mulch culture. Univ. Fla. Coop. Ext. Circ. 854.

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.

		Week														Season
	Dry fert.[y]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	total
Season	(lb/A)	lb per acre per week[z]														(lb/A)
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

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

[y]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	3.0	0.3	3.0	1.0	0.3	0.3	40	30	25	20	5	0.2
			range	5.0	0.6	5.0	2.0	0.5	0.8	100	100	40	40	15	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	2.8	0.2	2.5	1.0	0.3	0.3	40	30	25	20	5	0.2
			range	4.0	0.4	4.0	2.0	0.5	0.8	100	100	40	40	15	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	2.5	0.2	2.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			range	4.0	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	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	2.0	0.2	2.0	1.0	0.25	0.3	40	30	20	20	5	0.2
			range	3.5	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
			High	>3.5	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
	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	2.0	0.2	1.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			range	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

TOMATO WEED CONTROL

W. M. Stall
Extension Vegetable Specialist

Weeds are a major problem in tomato production in Florida. Weeds can reduce yields through direct competition for light, moisture and nutrients as well as harbor insects such as white fly and thrips among others and can be a reservoir of pathogens (virus and bacteria) that may be transmitted to tomatoes.

Tomatoes are present in the field in some area of Florida every month of the year. Over this period, the variable climatic conditions influence the diversity of weed species present and their severity. Growers should plan a total weed control program that integrates mechanical and cultural methods of weed control along with chemical means to fit their weed problems and production practices.

Herbicide performance depends on weather, irrigation, soil type and pH as well as proper selection for weed species to be controlled and accurate application and timing. Nightshade has developed varying levels of resistance to some post-emergent herbicides in different areas of the state. Control of this weed as well as others must be accomplished by a combination of control practices as well as tank mix combinations. In post-directed contact herbicide applications in several studies have shown that gallonage above 60 GPA can dilute some tank-mix combinations and reduce efficacy. Proper nozzle selection and pressure regulation is a key to coverage while controlling drift. Read the herbicide label and other information on about proper application and timing of each herbicide.

At least two herbicides are in the process of registration for use in row middles. When applying a herbicide for the first time, use only in a small trial first. Before application of a herbicide, CAREFULLY READ AND FOLLOW THE LABEL.

TOMATOES

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. ai./acre)
DCPA (Dacthal)	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 of 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 to 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.

MCDS (Enquik)	Tomatoes	Postemergence directed-shielded in row middle	5 - 8 gal

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 gal. 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.

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. ai./acre)
Metribuzin (Sencor)	Tomatoes	Postemergence Posttransplanting after establishment	0.25 -0.5

REMARKS: Controls small emerged weeds after transplants are established. May be applied after direct seeded plants reach 5-6 true leaf stage. Apply in single or multiple applications with 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, Lexone)	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 maximum 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)	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)	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.

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. ai./acre)
Paraquat (Gramoxone Super) (Gramoxone Extra)	Tomatoes	Premergence Pretransplant	0.5 - 1.0

REMARKS Controls emerged weeds. Use a non-ionic spreader and thoroughly wet weed foliage.

Metribuzin (Sencor, Lexone)	Tomatoes	Directed spray in row middles	0.25 - 1.0
Paraquat (Gramoxone Super) (Gramoxone Extra)	Tomatoes	Post directed spray in row middle	0.47

REMARKS: Controls emerged weeds. Direct spray over emerged weeds 1 to 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.

Paraquat (Gramoxone Super) + Enquik	Tomatoes	Post directed spray in row middle	0.47 + 3 - 5 gal

REMARKS: Controls emerged weeds only. Apply 3-5 gal Enquik and 2 1/2 pt Gramoxone Super in 20 - 50 gal of spray mix per acre. A non-ionic surfactant must be added at 1 -2 pt per 100 gal spray mix. Read the precautionary statements on Enquik before use. Follow all restrictions on both labels.

Sethoxydim (Poast)	Tomatoes	Postemergence	0.188 - 0.28

REMARKS: Controls actively growing grass weeds. A total of 4 1/2 pt product per acre may be applied in one season. Do not apply within 20 days of harvest. Apply in 5 to 20 gallons of water adding 2 pt of oil concentrate per acre. Unsatisfactory results may occur if applied to grasses under stress. Use 0.188 lb a.i. (1 pt) to seedling grasses and up to 0.28 lb a.i. (1 1/2 pt) to perennial grasses emerging from rhizomes etc. Consult label for grass species and growth stage for best control.

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. ai./acre)
Trifluralin (Treflan)	Tomatoes (except Dade County)	Pretransplant incorporated	0.75 - 1.0

REMARKS: Controls germinating annuals. Incorporate 4 inches or less within 8 hours of application. Results in Florida are erratic on soils with low organic matter and clay contents. Note label precautions of planting non-registered crops within 5 months. Do not apply after transplanting.

Trifluralin (Treflan)	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 soil between the rows and incorporate.

APPENDIX D

TOMATO PLANT DISEASE CONTROL GUIDE

T.A. Kucharek
Plant Pathology Dept.
University of Florida
Gainesville, Florida 32611

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases on label	Pertinent Diseases not on label but controlled	Special Remarks
Tomato						
	FOR EFFECTIVE BACTERIAL SPOT CONTROL IN TOMATOES, A MANCOZEB FUNGICIDE MUST BE TANK MIXED WITH A COPPER FUNGICIDE.					
	Benlate WP or DF	1/2 - 1 lb.	NTL	Gray mold Leaf mold White mold (Sclerotinia) Phoma leaf spot	Target spot Rhizoctonia Fruit rot	Field & Greenhouse
	Botran 75 W	1 lb/100 gal. water	NTL	Botrytis stem canker		Seedlings or newly set transplants may be injured by drenching. Greenhouse use only.

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases on label	Pertinent Diseases not on label but controlled	Special Remarks
	Bravo 720	1 3/8 - 3 pts.	1	Early blight Late blight	Phoma leaf spot Target spot	Do not use with Copper Count-N in concentrated spray mixtures.
	Bravo DG	1 1/8 - 2 1/4 lbs.	1	Gray leaf spot Leaf mold Septoria leaf spot		
	or Bravo W-75	1 1/2 - 3 lbs.	1	Gray mold Black mold Rhizoctonia fruit rot		
	Chloronil 500	2-4 pts.	1	Same as Bravo	Same as Bravo	Same as Bravo
	Manex II	1.3-2.5 qts.	5	Leaf mold Early blight Late blight Gray leaf spot Septoria leaf spot Bacterial spot		

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases on label	Pertinent Diseases not on label but controlled	Special Remarks
	Dithane M-45	1 1/2 - 3 lbs.	5	Anthracnose Late blight Early blight Leaf mold Septoria leaf spot	Phoma leaf spot Bacterial spot & Bacterial speck	
	Penncozeb DF	1 1/2 - 3 lbs.	5	Early blight Late blight Gray leaf mold Leaf mold	See Dithane M-45 Bacterial spot	
	Dithane F-45	1.2-2.4 qts.	5	Early blight Gray leaf spot Late blight Leaf mold Septoria leaf spot Anthracnose		For field or greenhouse use
	Dithane DF	1 1/2-3 1/4 pts.	5	Same as Dithane F-45		
	Ridomil-Bravo 81W	1 1/2 - 2 lbs.	7	Early blight Late blight Gray leaf spot		Do not make more than 4 Appl/crop

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases on label	Pertinent Diseases not on label but controlled	Special Remarks
	Manzate 200 DF	1 1/2 - 3 lbs.	5	Early blight Late blight Gray leaf spot Gray leaf mold Bacterial spot		
	Dyrene (not for use in greenhouse)	2-5 lbs.	NTL	Botrytis Early blight Late blight Septoria leaf spot		If temperatures exceed 85°F do not use more than 1 lb. if tank mixed with a copper fungicide.
	Kocide 101, Blue Shield or Champion WP'S		2-4 lbs.	NTL Bacterial speck	Early blight Bacterial spot	Minimum days to harvest is 5 if* used with a Dithane or Manzate fungicide.
	Kocide 606, Cuproxat, Champion or Champ FL'S	2 2/3 - 5 1/3 pts.	NTL	Early blight Bacterial speck Bacterial spot		Same as Kocide 101.

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases on label	Pertinent Diseases not on label but controlled	Special Remarks
	Tri-basic Copper Sulfate	2-4 lbs.	NTL	Bacterial spot Bacterial canker Early blight Late blight Leaf mold Septoria Stemphyllium leaf spot		Same as Kocide 101.
	Basicop	2-4 lbs.	NTL	Bacterial spot Bacterial canker Early blight Late blight Leaf mold Septoria		Same as Kocide 101
	CP-Basic Copper TS-53 WP	2-4 lbs.	NTL	Same as Tri-basic Copper sulfate		Same as Kocide 101.
	JMS Stylet Oil	3 qts.	NTL	Potato virus Y Tobacco etch virus	Tomato yellows	Must be applied with ground rig at 400 psi using Tee Jet TX5 SS nozzles. READ LABEL.

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases on label	Pertinent Diseases not on label but controlled	Special Remarks
	Ridomil 2E[1] (Soil application)	2-4 pts. (Broadcast only)	PPI for plant beds.	Pythium damping off in Late blight Phytophthora stem canker	treatment	May not be a necessary plant bedstreatment for Pythium if beds are fumigated prior to seedling and recontamination of fumigated soil is avoided. Not for use in greenhouses.
	Ridomil 2E[1] (Soil application)	4-8 pts.[2] (Broadcast rate)		Pythium damping off for field Late blight	Phytophthora stem cankerabove.	Same as Ridomil 2E
	Ridomil 2E[1] (Soil application)	4 pts.[3]		Phytophthora or Pythium fruit rots.	Late blight	Same as Ridomil 2E above.
	Copper-Count -N	1/3-3/4 gal.	NTL	Bacterial spot		
	Ridomil MZ-58[1] (Foliar spray)	1 1/2 - 2 lbs.	5	Late blight	Phytophthora stem canker Pythium fruit rot	[2]

[1] Do not apply more than 12 pints Ridomil 2E/season.

[2] PPI (via mechanical device) or POPI (via irrigation) broadcast or banded.

[3] Soil surface 4-8 weeks before harvest followed by irrigation. If plastic used on beds, apply as a band next to bed in middle if roots have developed beyond plastic. Ridomil translocates upward in plant from roots. If plastic is not used, band on soil below drip line.

APPENDIX E

INSECT CONTROL IN TOMATOES

Dr. Freddie A. Johnson, Professor-Extension Entomologist
IFAS, University of Florida, Gainesville, FL 32611

Ants

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
carbaryl (Sevin)	5 B	20 - 40 lb	0

Aphids

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
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	4 EC	1/2 pt	1
dimethoate (Cygon)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl oz per 1000 ft row	30
endosulfan (Thiodan) (green peach aphid)	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	5 EC	1 1/2 - 2 pts	1
methamidophos (Monitor)	4 EC	1/2 - 1 1/2 pt	7
methomyl (Lannate)	1.8 L	2 - 4 pt	1
mevinphos (Phosdrin)	4 EC	1/4 - 1/2 pt	1
methyl parathion	4 EC	1 - 3 pt	15
oil (Sun Spray)*	98.8%	1 - 2 gal/100 gal H2O	warning-read label

Aphids (continued)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
parathion, ethyl	8 EC	1/2 pt	10
pyrethrins + piperonyl butoxide (Pyrenone) (green peach aphid)	66% liquid (EC)	2 - 6 oz per 100 gal	0
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H2O	0

* 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.

Armyworms

See also: Beet, Fall, Southern, and Yellow-Striped Armyworm

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
Bacillus thuringiensis	See individual brand labels		
carbaryl (Sevin)	5 B	20 - 40 lb	0
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lb	28
diazinon (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
malathion	5 EC	1 1/2 - 2 pt	1
methomyl (Lannate)	1.8 L	1 - 2 pt	1
methyl parathion	4 EC	1 - 3 pt	15
parathion, ethyl	8 EC	1/2 pt	10

Beet Armyworms

See also: Armyworms

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
esfenvalerate (Asana XL) (aids in control)	0.66 EC	5.8 - 9.6 fl oz	1
methomyl (Lannate)	1.8 L	2 - 4 pts	1
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of harvest
(Pounce)	3.2 EC	2 - 8 oz	

* 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 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Fall Armyworms

See also: Armyworms

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
diazinon	4 EC	3/4 - 1 pt	1
methomyl (Lannate)	1.8 L	2 pt	1
methoxychlor	4 L	1 - 3 qt	1 for 1 3/4 qt 7 for 1 3/4+ qt

Southern Armyworms

See also: Armyworms

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
diazinon	4 EC	3/4 - 1 pt	1
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
methomyl (Lannate)	1.8 L	2 - 4 pt	1
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of harvest
(Pounce)	3.2 EC	2 - 8 oz	

* 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 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Yellow-Striped Armyworms

See also: Armyworms

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2L, 2S (EC)	3 - 6 pt	up to day of harvest for 3 pts 14 - 3+ pts
endosulfan (Thiodan)	3 EC	1 1/3 qt	2
esfenvalerate (Asana XL) (Western Yellow Striped)	0.66 EC	5.8 - 9.6 oz	1

Banded Cucumber Beetles

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	0
diazinon	4 EC	3/4 - 1 pt	1

Blister Beetles

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
endosulfan (Thiodan)	3 EC	2/3 - 1 1/3 qt	2
methoxychlor	4 L	1 - 3 qt	1 for 1 3/4 qt 7 for 1 3/4+ qt
parathion, ethyl	8 EC	1/2 pt	10

Cabbage Loopers

See also: Loopers

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
Bacillus thuringiensis	See individual brand labels.		0
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
endosulfan (Thiodan)	3 EC	2/3 - 1 1/3 qt	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
malathion	5 EC	1 1/2 - 2 pt	1
methyl parathion	7.5 EC	1 - 1 1/2 pts	15
methomyl (Lannate)	1.8 L	2 - 4 pt	1
parathion + methyl parathion	6 - 3 EC	1/2 - 1 pt	15
permethrin* (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest

* 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 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Colorado Potato Beetles

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
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) (early season reduction)	8 EC	1.2 - 3.5 fl oz per 1000 ft row (any row spacing) or 1 - 3 pt per acre (38" row spacing)	30
endosulfan (Thiodan)	3 EC	2/3 - 1 1/3 qt	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
methoxychlor	4 L	1 - 3 qt	1 for 1 3/4 qt 7 for 1 3/4+ qt
methyl parathion (Penncap M)	2 EC	4 pts	15
parathion, ethyl	8 EC	1/2 pt	10
permethrin* (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
pyrethrins + piperonyl butoxide (Pyrenone)	66% liquid (EC)	2 - 6 oz per 100 gal	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pts	0
rotenone (Rotenox)	5% liquid	2/3 gal	0

* 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 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Corn Earworms

See also: Tomato Fruitworms

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
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

Crickets

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
carbaryl (Sevin)	5 B	20 - 40 lb	0

Cucumber Beetle

See also: Banded Cucumber Beetle

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion) (banded cucumber beetle)	2 S, 2 L (EC)	1 1/2 - 2 pts	up to day of harvest

Cutworms

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
Bacillus thuringiensis	See individual brand labels		0
carbaryl (Sevin)	80S (WP)	2 1/2 lb	0
carbaryl (Sevin)	5 B	20 - 40 lb	0
diazinon	14 G	14 - 28 lb	preplant
diazinon	4 EC	2 - 4 qt	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) (varigated cutworm)	1.8 L	2 pt	1
parathion, ethyl	2 B	30 - 40 lbs	10
permethrin* (Ambush) (Pounce) (granulate cutworm)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest

* 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 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Darkling Beetles

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
carbaryl (Sevin)	5 B	20 - 40 lb	0

Drosophilas (fruit flies, vinegar flies)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	0
diazinon (vinegar fly)	4 EC	1/2 - 1 1/2 pt	1
malathion	5 EC	1 1/2 - 2 pts	1

European Corn Borers

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
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

Flea Beetles

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest
carbaryl (Sevin)	80S (WP)	2/3 - 1 1/4 lb	0
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl. oz per 1000 ft row (any row spacing) or 1 - 3 pt per acre (38" row spacing)	30

Flea Beetles (continued)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
endosulfan (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	4 EC	1 - 3 pt	15
methyl parathion (Penncap M)	2 EC	2 - 4 pt	15
methoxychlor	4 L	1 - 3 qt	1 for 1 3/4 qt 7 for 1 3/4+ qt
parathion, ethyl	8 EC	1/2 pt	10
pyrethrins + piperonyl butoxide (Pyrenone)	66% liquid (EC)	2 - 6 oz per 100 gal	0

Fleahoppers

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1

Garden Symphylans (Symphylans)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
fonofos (Dyfonate)	10 G	20 lb	preplant, broadcast
diazinon (D.z.n.)		70 lb	preplant
(D.z.n. 500)	4 EC	10 qt	broadcast
parathion, ethyl	2 B	30 - 40 lbs	preplant
parathion, ethyl	8 EC	1 qt	preplant

Grasshoppers

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest
carbaryl (Sevin)	5 B	20 - 40 lb	0
	80 S	2/3 - 1 7/8 lbs	0
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
mevinphos (Phosdrin)	4 EC	1/2 - 1 pt	1
parathion, ethyl	8 EC	1/2 pt	10

Hornworms (tomato hornworm, tobacco hornworm)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
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 (Thiodan)	3 EC	2/3 - 1 1/3 qts	2
esfenvalerate (Asana XL) (tomato hornworm, tobacco hornworm)	0.66 EC	2.9 - 5.8 fl oz	1
methomyl (Lannate)	1.8 L	2 - 4 pt	1
methyl parathion (Penncap M)	2 EC	4 pt	15

Hornworms (tomato hornworm, tobacco hornworm cont.)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
parathion, ethyl	8 EC	3/8 pt	10
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of harvest
(Pounce)	3.2 EC	2 - 8 oz	
trichlorfon (Dylox)	80 SP	20 oz	21

* 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 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Lace Bugs

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0

Leafhoppers

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest
carbaryl (Sevin)	80S	2/3 - 1 1/4 lb	0
dimethoate (Cygon)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl oz per 1000 ft row (any row spacing) or 1 - 3 pt per acre (38" row spacing)	30
methoxychlor	4 L	1 - 3 qt	1 for 1 3/4 qt 7 for 1 3/4+ qt
methyl parathion	4 EC	1 - 2 pt	15
mevinphos (Phosdrin)	4 EC	1/2 - 1 pt	1
parathion, ethyl	8 EC	1/2 pt	10
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H2O	0

Leafminers

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	up to day of harvest
diazinon (dipterous leafminer)	4 EC	1/2 pt	1
diazinon	50 WP	1/2 lb	1
dimethoate (Cygon)	4 EC	1/2 - 1 pt	7

Leafminers (continued)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl oz per 1000 ft row (any row spacing) or 1 - 3 pt per acre (38" row spacing)	30
malathion (serpentine)	5 EC	1 1/2 - 2 pt	1
methamidophos (Monitor) adults (fresh fruit only)	4 EC	1/2 - 1 1/2 pt	7
oxamyl (Vydate L) (serpentine leafminers) except Liriomyza trifolii	2 EC	2 - 4 pt	1
parathion, ethyl	8 EC	1/2 pt	10
Penncap-M	2 EC	2 - 4 pt	15
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of harvest
(Pounce)	3.2 EC	2 - 8 oz	
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
trichlorfon (Dylox, Proxol)	80 SP	20 oz	21

* 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 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Loopers

See also: Cabbage Looper

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
Bacillus thuringiensis	See individual brand labels		
methomyl (Lannate)	1.8 L	2 - 4 pt	1
parathion, ethyl	8 EC	1/2 pt	10
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0

Mealy Bugs

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1

Mites

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
MITES (GENERAL):			
dicofol (Kelthane) (Pacific, tropical, two-spotted, tomato russet	MF (4 EC)	3/4 - 1 1/2 pt	2
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl oz per 1000 ft row (any row spacing) or 1.3 pt (38" row spacing)	30
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1
methyl parathion	4 EC	1 - 2 pt	15
mevinphos (Phosdrin)	4 EC	1/2 - 1 pt	1
parathion, ethyl	8 EC	1/2 pt	10

Mites (continued)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
TOMATO RUSSET MITE:			
dicofol (Kelthane)	MF- 4 EC	3/4 - 1 1/2 pts	2
endosulfan (Thiodan)	3 EC	1 1/3 qt	2
malathion	5 EC	1 1/2 - 2 lb	1
parathion + methyl parathion	6 - 3 EC	1/2 - 1 pt	15
parathion, ethyl	8 EC	1/2 pt	10
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H2O	0
sulfur	see individual brand labels		
SPIDER MITE:			
dicofol (Kelthane)	MF- 4 EC	3/4 - 1 1/2 pts	2
malathion	5 EC	1 1/2 pt per 100 gal	1

Mole Crickets

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
diazinon	14 G	7 lb	preplant
diazinon	4 EC	1 qt	preplant, broadcast

Pinworms (tomato pinworm)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
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	28
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)	1.8 L	2 - 4 pt	1
methyl parathion (Penncap M)	2 EC	4 pts	15
parathion, ethyl	8 EC	3/4 - 1 pt	10
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of harvest
(Pounce)	3.2 EC	2 - 8 oz	

* 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 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Plant Bugs

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
carbaryl (Sevin) (tarnished plant bug)	80S (WP)	1 1/2 - 2 1/2 lb	0
parathion + methyl parathion	6 - 3 EC	1/2 - 1 pt	15
parathion, ethyl (plant and leaf footed)	8 EC	1/2 pt	10
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H2O	0

Psyllids

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
methyl parathion	4 EC	1 - 3 pt	15
parathion, ethyl	8 EC	3/8 pt	10

Saltmarsh Caterpillars

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
Bacillus thuringiensis	See individual brand labels		0

Sowbugs

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
carbaryl (Sevin)	5 B	20 - 40 lb	0

Stinkbugs

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
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 (Thiodan)	3 EC	2/3 - 1 1/3 qt	2
parathion, ethyl	8 EC	1/2 pt	10
pyrethrins + piperonyl butoxide (Pyrenone)	66% liquid (EC)	2 - 6 oz per 100 gal	0

Thrips

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	up to day of harvest
carbaryl (Sevin XLR) (suppression)		2 qts	0
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1
parathion, ethyl	8 EC	1/2 pt	10
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H2O	0

Tomato Fruitworms (corn earworm)

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
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	28
cryolite (Krocide)	96 WP	15 - 30 lb	wash fruit
endosulfan (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)	1.8 L	2 - 4 pt	1
methyl parathion (Penncap M)	2 EC	4 pts	15
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of harvest
(Pounce)	3.2 EC	2 - 8 oz	

* 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 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Tuberworms

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	2 1/4 - 3 pt	0

Vegetable Weevil

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
parathion, ethyl	8 EC	1/2 pt	10

Whiteflies

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	up to day of harvest
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lbs	28
endosulfan (Thiodan)	3 EC	2/3 qt/100 gal H2O- use 100 - 200 gal/A	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl oz	1
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1
methamidophos (Monitor) (apply in tank mix with pyrethroids)	4 EC	1 1/2 - 2 pts	7
parathion, ethyl	8 EC	1/2 pt	10
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gal/100 gal H2O	0

White Grubs

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
parathion, ethyl	2 B	30 - 40 lbs	preplant

Wireworms

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
diazinon	14 G	21 - 28 lb	preplant
	4 EC	3 - 4 qt	preplant, broadcast
dichloropropene (Telone)	II, C-17	see labels	
(Vorlex)	L	see labels	
lindane (Isotox)	#200	2 - 2 1/2 pt	preplant
parathion, ethyl	2 B	30 - 40 lb	preplant, broadcast or 10
parathion, ethyl	8 EC	1 - 2 qts	apply to soil surface preplanting & work 6-9" into soil

NEMATICIDES REGISTERED FOR USE ON FLORIDA TOMATO

J. W. Noling
Extension Nematology
CREC, Lake Alfred

APPENDIX F

NEMATICIDES REGISTERED FOR USE ON FLORIDA TOMATO

Row Application (6' row spacing - 36" bed) [4]

PRODUCT	BROADCAST (Rate)	CHISEL SPACING	CHISELS Per Row *	RATE/ACRE	RATE/1000 Ft/Chisel
FUMIGANT NEMATICIDES					
Methyl Bromide					
98-2	240-400 lb	12"	3	120-200 lbs	5.5-9.1 lb
80-20	225-350 lb	12"	3	112-175 lbs	5.1-8.0 lb
75-25	240-375 lb	12"	3	120-187 lbs	5.5-8.5 lb
7-30	300-350 lb	12"	3	150-175 lbs	6.8-8.0 lb
67-33	225-375 lb	12"	3	112-187 lbs	5.1-8.5 lb
57-43	350-375 lb	12"	3	175-187 lbs	8.0-8.5 lb
50-50	340-400 lb	12"	3	175-250 lbs	8.0-11.4 lb
Chloropicrin [1]	300-500 lb	12"	3	150-250 lbs	6.8-11.4 lb
Telone II [2]	12-15 gal	12"	3	6-7.5 gal	35-44 fl oz
Netham Sodium	50-100 gal	5"	5	25-50 gal	88-176 fl oz
Vorlex Vorlex 201 [3]	30-50 gal	8"	3	6.7-11.1 gal	39-65 fl oz

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] Vorlex used at higher rate for weeds, fungi, nematodes and soil insects.

[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 August 1, 1991 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 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.

Implications

It has been determined that changes in tariff structure and its effects are transmitted through the relative price ratio. Any loss in price advantage will cause Florida to lose market share. In effect, any Free Trade Agreement must take into account the consequences of eliminating tariffs, changes in relative price ratios and the resulting effects on market share. Any elimination of tariff would have caused the relative price for tomatoes to fall by 5 percent in the 1988/89 season (table 1-9) and result in Florida losing, on average, 4.5 percent of the market share in the long-run for tomatoes (table 1-10), other factors remaining constant.

Table 1-9. Price advantage between Florida and Mexico for tomatoes 1988/89 (December-April).

		Fob shipping price/carton	Tariff rate/carton	Shipping Price without tariff
		$/carton		
Florida	Tomatoes	11.06	-	11.06
Mexico	Tomatoes	11.13	0.50	10.63
Florida's Fob shipping price advantage per carton		With tariff	Without tariff	
		$/carton		
	Tomatoes	0.07	-0.43	