Crop Profile for South Florida Peppers

This crop profile covers fresh market and processing peppers produced south of Lake Okeechobee during the 1997-98 growing season. This area's nine-month production cycle with its intense pest pressure contributes significantly to the winter supply of peppers. This profile is the result of interviews conducted with growers in the south Florida area of Collier, Dade, Hendry, Lee and Palm Beach counties.

Crop Production

During the 1997-98 growing season this area produced 12,500 acres of peppers with a value of $34,587,600 (Table 1). This represents 54% of U.S. production and 66% of Florida's 19,000 pepper acreage (FASS, 1997, 1998a, 1998b). Our survey covered 2376 acres, or about 20% of the regional total, and represents 11 farms ranging in size from 20 to 800 acres, having an average size of 198 acres (Table 2). Of the acreage planted, 99% was harvested, with 94% going to the fresh market and 6% for processing. The average yield was 33,944 lb per acre, with an average value of $0.43 per lb, giving a gross return of $13,950 per acre (Table 3). Production costs and the cost of picking and packing were estimated to be $5,202 and $4,107, respectively, leaving a net return to the farm of $4,641 per acre.

Pest management costs represent a significant outlay, totaling $630 per acre, or nearly 12% of the total production costs (Table 4).

Cultural Practices

Peppers in south Florida, except in Dade County which are produced on a rocky limestone soil (Table 5), are grown on sandy soils. Irrigation of two thirds of the acreage is through seep irrigation (Table 6), which employs a perched water table, approximately 18-24 inches below the bed surface. This water table is maintained by pumping water into a series of lateral ditches, either from an open "rim" ditch or from buried pipes with outlets at each lateral ditch (semi-closed). Most of the remaining acreage is drip irrigated from tubes laid under the plastic mulch. Seepage and drip irrigation have the added benefit of avoiding extended periods of wet foliage.

The irrigation system serves the dual purpose of providing **and** removing water from the field. Open ditch seep irrigated fields are laser leveled without slope. Water removal from these fields is accomplished using large pumps spaced around the rim ditch. Where semi-closed seep and drip irrigation are used, the fields are sloped to allow runoff into swales, which direct the water to the rim ditch. The slope in such fields is maintained with laser leveling. The average interval between leveling operations is 1.4 years (Table 7). Drainage is enhanced with drain tile on a small acreage.

In preparation for a pepper crop, fields are disked several times. Disking is often interrupted during the rainy summer, when about half the acreage is naturally flooded for varying periods. Twenty eight percent of the surveyed acreage was maintained weed free through the off season by mechanical or chemical fallowing, while 42% was planted in sorghum to provide weed suppression and improve soil organic content (Table 7). Sugarcane windbreaks were planted between blocks on 23% of the acreage.

South Florida pepper production is labor and resource intensive. The crop is grown on 6-8 inch high, white or black plastic-mulched beds (Table 8), white for the hot months of September through October and black for the cooler late fall and winter months to raise the soil temperature during plant establishment. With few exceptions, the beds are fumigated and granular fertilizer is applied just ahead of the mulch. The mulch retains the fumigant, reduces fertilizer leaching and provides a physical barrier to weed growth.

The crop is established from 5-6 week old transplants, grown in greenhouses, and manually set into two rows per mulched bed. At the onset of blooming 2-foot high wooden stakes are placed in the beds between the plants (58% of surveyed acreage, Table 8) and joined by one or two rounds of string to provide canopy support. Staking and tying can also create a closed mass of foliage and fruit, which hampers pesticide spray penetration.

The time from transplanting to first harvest averages 10 weeks for early (September-October) plantings and 12 weeks for late (November-December) plantings. Planting dates and breaks are detailed in Table 9. The purpose of the planting break from mid-October to late December is to reduce the amount of crop at risk during peak periods of frost or freezing risk (mid-December through January). Where a planting break is not observed during this period, planting size is significantly reduced.

South Florida peppers are harvested 3-5 times between November and April. Early plantings may be harvested more often throughout this period, although few early plantings are harvested after March, due to the increased risk of nematode, Phytophthora and pepper weevil problems.

Pest management

Pests and their impact

Survey participants were asked to list those pests that had a significant impact on their pepper crops. All growers described levels of pest activity. These pests, the frequency of occurrence and the damage produced are listed in Table 10. The acreage affected and the potential yield lost to each pest are detailed in Table 11. Methods for managing the major pests are discussed below. Management methods of all pests from our survey are listed in Table 12.

Plant diseases

Diseases threaten the crop throughout the growing season. Bacterial spot disease, caused by *Xanthomonas campestris* pv *vesicatoria*, is currently the most destructive, causing defoliation, fruit damage and reduced fruit set. The disease is spread rapidly by splashing rainfall and mechanically during hand labor operations. The estimated loss to this disease was over 9% of potential yield with 63% of the acreage affected. The crop is closely monitored from transplant production through the end of the crop. Control practices include the use of resistant varieties, prompt crop destruction after harvesting, field sanitation and the application of tank-mixes of copper and maneb.

Resistance to races 1, 2 and 3 of the pathogen is available in bell pepper varieties. This control practice faces two major stumbling blocks: 1) inactivation of the resistance genes at temperatures above 90º F and 2) the appearance of new pathogen races. Before resistant varieties were introduced, races 1 and 2 were prevalent. The first varieties were resistant to these races, but literally within months of widespread planting, race 3 appeared and caused severe disease problems. After introduction of varieties resistant to races 1, 2 and 3, disease caused by races 4 and 6 soon appeared. Pepper breeders are trying to incorporate non-race-specific resistance into commercially acceptable varieties.

The pathogen’s resistance to copper-based fungicides reduces chemical control of bacterial spot. The addition of maneb to copper in the spray tank improves the efficacy of the copper fungicide, but the results are often inadequate. Alternatives to this fungicide standard include a viral pathogen of the bacterial spot pathogen, (Agriphage, Agri-phi) and systemic acquired resistance chemistry currently under development (Messenger, Eden Biosciences). Adoption of these alternatives is expected to be slow, due to special application requirements for Agriphage and varying efficacy for Messenger.

The next most destructive pest, Phytophthora blight, caused by *Phytophthora capsici*, occurs commonly in the soil, and is spread by anything that introduces un-fumigated soil into the crop, such as splashing rainfall. Infections result in varying levels of defoliation, fruit damage, loss of vigor and plant loss, and damage is exacerbated by root knot nematode injuries. Control measures for Phytophthora blight include soil fumigation, strict field sanitation, prompt crop destruction after harvesting and soil treatments or foliar sprays with mefenoxam (Ridomil Gold, Novartis). Chemical control is hampered by the need for multiple applications and by the of the pathogen's resistance to this fungicide.

Virus diseases, primarily aphid-borne potyviruses, such as Potato Virus Y, were reported from 33% of the acreage, but growers did not attribute significant losses to them. Other diseases listed in Tables 10 and 11 caused less than 1% yield loss, and are not discussed here.

Insect pests

The leading arthropod pest of peppers was the broadmite, *Polyphagotarsonemus latus*, affecting 7% of the acreage, and causing 7% yield loss by deforming tender growing points and small fruitlets. The broadmite occurs during hot humid weather, and can be suppressed with sulfur. Dicofol (Kelthane, Rohm and Haas, Gowan, et al.) or a tank-mix of avermectin (Agrimek, Novartis) and the oil extract from the neem seed (Trilogy, Thermo Trilogy) is used to control peak populations. Broadmite control is impacted by its ability to increase explosively and by its preference for plant parts that are difficult to cover with sprays.

The pepper weevil, *Anthonomus eugenii*, was the next most destructive insect pest, with 42% of the acreage infested and 2% of potential yield lost. Pepper weevils reduce fruit set and cause fruit drop by feeding and ovipositing in flower buds and thin-walled juvenile fruitlets. Pepper weevils also infest a common weed, black nightshade, *Solanum nigrum*, which provides a year round reproduction site. Pepper weevil control relies on insecticides, notably oxamyl, (Vydate, DuPont). Methomyl, (Lannate, DuPont), imidacloprid (Admire, Bayer) and pyrethroids, such as cyfluthrin (Baythroid, Bayer) and permethrin (Pounce, FMC), also provide varying levels of control. Chemical control is difficult because only the adult form is exposed to sprays. Immature stages occur inside flower buds or pepper pods. Potential alternatives to the FQPA-listed carbamates, oxamyl and methomyl, include thiomethoxam (Actara, Novartis) and cryolite (Kryocide, Elf Atochem).

A complex of lepidopterous larvae, including the beet armyworm, *Spodoptera exigua*, fall armyworm, *S. frugiperda*, southern armyworm, *S. eridania*, and the tomato fruitworm, *Helicoverpa zea*, accounts for almost 2% yield loss, and nearly all acreage is infested. These worms defoliate the crop and damage fruit by their feeding. The primary control is *Bacillus thuringiensis* (B.t.), especially the bio-engineered products, such as Agree from Thermo Trilogy and Mattch from Mycogen. Because B.t. is effective only against small larvae, other insecticides, such as spinosad (Spintor, Dow AgroSciences), methomyl and pyrethroid insecticides are commonly used as “cleanup” insecticides.

While thrips, especially the melon thrips, *Thrips palmi*, threaten widespread crop damage, bio-intensive management techniques avoid significant damage and obviate the need for frequent control applications. When chemical control is needed, methomyl is usually chosen because of its short residual activity and its efficacy against several other pepper pests. Surveyed growers estimated yield losses to thrips at less than 1%. Chemicals chosen to control other pests, especially the pyrethroid insecticides, significantly affect thrips populations. Dramatic increases in melon thrips populations have occurred after a few applications of permethrin or esfenvalerate for pepper weevil control. Whether this population effect results from destroying biological controls, notably the minute pirate bug, *Orius insidiosus*, or enhancing reproduction by exposure to the active ingredient (hormolygosis) is not known. Whatever the cause, the use of pyrethroids in peppers is avoided whenever possible.

Nematodes

Peppers are highly susceptible to damage by the root knot nematode, *Meloidogyne incognita*, which are controlled with methyl bromide/chloropicrin fumigation. Nematode problems are limited to 7% of the acreage. As their activity is most destructive in later crop stages, yield loss is under 1%.

Weeds

Weeds did not cause yield loss, but growers made significant efforts to control them. The principal weeds cited were black nightshade and sesbania. Paraquat dichloride (Gramoxone Extra, Zeneca) is the major herbicide applied in south Florida peppers. Metolachlor (Dual, Novartis), is applied where paraquat resistant weeds, such as nightshade and eclipta occur.

Economic Impact

The impact of key pests on the pepper production system in particular and the entire south Florida vegetable industry is significant. Considering the major pests discussed above and the minor pests together, growers lost 23.8% of their potential yield to pests (Table 11). A 24% loss strains the economic well being of the farming industry, and puts pressure on south Florida’s fragile environment. Examples of this pressure are the greater acreage that must therefore be farmed to meet marketing demands, and the additional inputs needed to reduce yield losses.

The economic impact of these pest losses is outlined in Table 13. Pest losses cost growers over 8060 pounds of peppers per acre, which at the 1997-98 prices is $3,313 per acre in lost revenue. Of the surveyed growers' 2376 acres the revenue lost to pests totaled $7.8 million annually. Clearly growers are justified in their pest management efforts given the magnitude of these losses.

Integrated pest management in south Florida peppers

Survey participants were questioned in detail about their pest management practices. The results are presented in Table 14. These practices were categorized according to the PAMS system put forth by the USDA (NASS, 1998). The acronym, PAMS, stands for Prevention, Avoidance, Monitoring and Suppression. Pest managers are encouraged to incorporate as many prevention and avoidance practices as possible to keep pest problems from arising. When pest problems occur, they are monitored, and when thresholds are exceeded, they are suppressed using the best techniques available. The results of the pest management survey clearly show that south Florida pepper growers employ a wide range of practices to manage pests. Foremost among these are those that fall into the categories of prevention, monitoring and suppression. Avoidance practices, which involve crop scheduling and field location are difficult to implement because of high land values and marketing demands. Pest monitoring or scouting was practiced on all the pepper acreage. The scouts included several independent consulting companies, fully trained farm staff or the growers themselves.

Pest suppression, the final step of the PAMS system, was carried out in a thoughtful, well-planned manner. Pesticide applications to fall and spring plantings are detailed in Tables 15 and 16, respectively. Active ingredients identified for regulatory action under the Food Quality Protection Act (FQPA) appear in **boldface**.

The most widely used pesticides include the fumigants, methyl bromide and chloropicrin, the fungicides maneb and copper hydroxide and the bioengineered formulations of *Bacillus thuringiensis*. These five active ingredients were applied to over 90% of the acreage. The major herbicide, paraquat dichloride, was applied to 84% of the acreage, while the insecticides, imidacloprid, methomyl, oxamyl and B.t. formulations containing the subspecies, *aizawai* and *kurstaki* were applied to 66-77%. The fungicides, maneb and copper hydroxide were applied most frequently, over 17 times per planting, followed closely by crop oil, sulfur and azadirachtin (Neemix, Thermo Trilogy).

Although the threat of bacterial spot is usually lower during the drier, cooler winter and spring seasons, 1997-98 was an especially rainy El Niño season. Higher than usual rainfall and slower crop maturity resulted in an increased number of applications of the critical fungicide, maneb, and a higher amount of active ingredient applied per acre. This result emphasizes the need for flexibility in the regulation and labeling of such critical pesticides to allow for such unforeseen seasonal events. Bacteriaphage has only recently been introduced, and its acceptance is limited to transplant production and a small commercial acreage. Maneb appears on the FQPA list as a B2 carcinogen.

Growers willingly adopt reduced-risk pesticides as shown by the widespread use of B.t. for armyworm control. Growers generally recognize the need to conserve natural enemies of key pests, especially the minute pirate bug for thrips control, and thus have turned to B.t. as their main worm control. However, oxamyl and methomyl are both required to control the pepper weevil, resulting in these insecticides being applied to 63% and 77% of the acreage, respectively. With the reformulation of cryolite (Kryocide, Gowan) and recent field tests demonstrating its efficacy against pepper weevils, applications of methomyl and oxamyl are expected to decrease. The limited number of applications allowed for cryolite and its long preharvest interval may result in continued use of oxamyl to control pepper weevils. Rapid adoption of spinosad and the newly registered insect growth regulator, tebufenozide (Confirm, Rohm and Haas), for worm control should further reduce the need for methomyl.

None of the herbicides applied to the surveyed acreage appear on the FQPA lists. Glyphosate is being field tested as a part of methyl bromide replacement strategies, while MCDS (Enquick, Unocal) is highly effective against several weeds that have developed resistance to paraquat dichloride, especially black nightshade.

None of the fumigants reported in our pepper survey appear on the FQPA lists.

Table 1. Pepper production and value for the 1997-98 south Florida growing season.

	Acres Planted	Acres Harvested	Yield per Acre (lb)	Value per lb	Total Value
US Total	23100	z	z	z	z
Florida Total	19000	18800	29800	$0.49	$272,836,880
Regional Total	12500	z	z	z	z
Included in Survey	2376	2354	33944	$0.43	$34,587,600
US Total	10.3%	z	z	z	z
Florida Total	12.5%	12.5%	113.9%	88.9%	12.7%
Regional Total	19.0%	z	z	z	z
Included in Survey	100.0%	100.0%	100.0%	100.0%	100.0%

[z] These data not available.

Table 2. Acreage planted and harvested on surveyed pepper farms during 1997-98 growing season in south Florida.

Farm code	Crop	Acres planted	Acres harvested	Acreage for fresh market	Acreage for processing	Production region
~D	Pepper	50	50	50	0	Southwest Florida
~J	Pepper	300	300	300	0	Palm Beach County
~T	Pepper	20	20	20	0	Southwest Florida
~V	Pepper	160	160	160	0	Southwest Florida
~Yf	Pepper	98	98	98	0	Southwest Florida
~Ys	Pepper	95	95	95	0	Southwest Florida
1F	Pepper	84	84	84	0	Southeast Florida
BF	Pepper [z]	165	143	6	137	Southwest Florida
JN	Pepper	800	800	800	0	Southwest Florida
LB	Pepper	415	415	415	0	Southwest Florida
MH	Pepper	146	146	146	0	Southwest Florida
PL	Pepper	43	43	43	0	Southwest Florida
Total acreage		2376	2354	2217	137	
Average farm size		198				
Percent			99.1%	94.2%	6.2%	

[z] Jalapeño peppers

Table 3. South Florida pepper yields and returns for the 1997-98 season

Farm code	Acres harvested	Yield (lb/a)	Estimated market price ($/lb)	Gross return per acre	Estimated annual production cost ($/a)	Estimated picking and packing costs (at $0.121/lb)	Estimated return per acre
~D	50	7000	$0.80	$5,600	$5,000	$847	($247)
~J	300	20450	$0.43	$8,794	$4,500	$2,474	$1,819
~T	20	35000	$0.32	$11,200	$5,000	$4,235	$1,965
~V	160	35000	$0.40	$14,000	$5,200	$4,235	$4,565
~Yf	98	35000	$0.40	$14,000	$4,800	$4,235	$4,965
~Ys	95	22500	$0.48	$10,800	$4,800	$2,723	$3,278
1F	84	30000	$0.28	$8,400	$6,200	$3,630	($1,430)
BF	143	23000	$0.37	$8,510	$6,200	$2,783	($473)
JN	800	40625	$0.40	$16,250	$5,000	$4,916	$6,334
LB	415	52500	$0.42	$22,050	$5,800	$6,353	$9,898
MH	146	57500	$0.48	$27,600	$7,200	$6,958	$13,443
PL	43	48750	$0.41	$20,202	$2,722	$5,899	$11,582
Average		33944	$0.43	$13,950	$5,202	$4,107	$4,641

Table 4. Cost of pest management in south Florida peppers (1997-98)

	Annual production cost ($/A)	Average estimated pesticide cost ($/A)	Average estimated cost per acre for other IPM inputs			Pest management share of total production costs
Farm Code			Crop Consultants	Pheromone trapping	Total Pest Management Cost	
~D	$5,000	$500	$50	$0	$550	11.0%
~J	$4,500	$225	$38	$0	$263	5.8%
~T	$5,000	$375	$32	$0	$407	8.1%
~V	$5,200	$800	$0	$0	$800	15.4%
~Yf	$4,800	$762	$0	$0	$762	15.9%
~Ys	$4,800	$746	$0	$0	$746	15.5%
1F	$6,200	$400	$45	$0	$445	7.2%
BF	$6,200	$775	$42	$0	$817	13.2%
JN	$5,000	$675	$25	$2	$702	14.0%
LB	$5,800	$480	$40	$0	$520	9.0%

MH	$7,200	$1,300	$0	$0	$1,300	18.1%
PL	$2,722	$251	$0	$0	$251	9.2%
Average	$5,202	$607	$23	$0	$630	11.9%

Table 5. Soil types where peppers are grown in south Florida (1997-98 season).

Soil type	Acreage	Percent of total
Sand	2292	96.5%
Rock	84	3.5%
Total	2376	100.0%

Table 6. Irrigation practices used in growing south Florida pepper crops (1997-98 season).

Irrigation type	Acreage	Percent of total
Perched water table open	378	15.9%
Perched water table semi-closed	1248	52.5%
Drip	750	31.6%
Total	2376	100.0%
Special drainage practices used in growing south Florida peppers		
Drain tile	29	1.2%

Table 7. Land preparation practices used between growing seasons in south Florida pepper crops (1997-98 season)

Land preparation practice	Acreage	Percent of total
Cover crop (Sorghum was used on all cover crop acreage.)	988	41.6%
Disking	2376	100.0%
Laser leveling	2292	96.5%
Average period between laser leveling events (1.4 years)		
Mechanical fallow	581	24.5%
Herbicide fallow	84	3.5%
Flooding	1032	43.5%

Table 8. Cultural practices used in south Florida pepper production (1997-98 season).

Cultural practice	Acreage	Percent of total
Plastic mulch	2376	100.0%

Windbreaks	558	23.5%
Staking	1383	58.2%
Tying	1383	58.2%
Hand cultivation for weed control	50	2.1%

Table 9. Planting date details for south Florida pepper crops (1997-98 season).

		Acreage
Average beginning fall planting date	8/30/97	
Duration of fall planting where planting break is observed (weeks) [z]	4.7	721
Average end of planting where planting break is observed	10/10/97	
Average beginning spring planting date	12/21/97	
Duration of spring planting where planting break is observed (weeks)	6.9	
Average end of spring planting where planting break is observed	2/8/98	
Average length of planting break where planting break is observed (weeks)	10.4	
Duration of planting where planting break is not observed (weeks)	21.4	1655
Average end of planting where planting break is not observed	1/20/98	
Total		2376

[z] Includes farms where only fall crops are planted (63 acres)

Table 10. South Florida pepper pests: Frequency of occurrence and type of damage produced.

Pest	Frequency	Defoliation	Fruit damage	Reduced fruit set	Plant loss	Loss of vigor
Diseases						
Anthracnose	Sporadic (Winter, Spring)		+			
Bacterial soft rot	Sporadic (Fall)		+			
Bacterial spot	Annual	+	+	+		
Frog eye spot	Infrequent (Fall)	+				
Fusarium	Infrequent (Winter)				+	
Phytophthora	Annual	+			+	+
Pythium	Annual (Summer, Fall)				+	
Sclerotinia	Annual (Winter, Spring)				+	
Virus diseases	Annual					+

Insects						
Aphids	Annual (Spring)					+
Beet armyworms	Annual (Summer, Fall, Spring)	+	+			
Broadmites	Annual (Fall)		+	+		
Fall armyworms	Annual (Summer, Fall, Spring)		+			
Pepper weevils	Annual (Winter, Spring)		+	+		
Southern armyworms	Annual (Summer, Fall, Spring)	+	+			
Thrips	Annual (Spring)	+	+	+		
Tomato fruitworms	Infrequent (Fall)					
Wireworms	Infrequent (Fall)					
Nematodes						
Root knot nematode	Occasional				+	+
Weeds						
Eclipta	Annual					+
Grasses	Annual					+
Nightshade	Annual					+
Nutsedge	Annual					+
Sesbania	Annual					+
White sweet clover	Occasional (Winter, Spring)					+

Table 11. Pest problems occurring in south Florida pepper crops. Estimates of long-term (5-year) acreage affected and yield losses.

Pest	Acreage where control problems occur	Percentage of total acreage	Average grower's estimate of lost potential yield
Diseases			
Anthracnose	97	4.1%	0.1%
Bacterial soft rot	160	6.7%	0.1%
Bacterial spot	1491	62.7%	9.4%
Frog eye spot	15	0.6%	0.1%
Fusarium	97	4.1%	0.9%
Phytophthora	798	33.6%	5.3%
Pythium	80	3.4%	0.0%

Sclerotinia	80	3.4%	0.0%
Virus diseases	800	33.7%	0.0%
Insects			
Aphids	286	12.0%	0.1%
Beet armyworms	524	22.1%	0.2%
Broadmites	175	7.3%	3.2%
Fall armyworms	989	41.6%	0.7%
Pepper weevils	1010	42.5%	2.0%
Southern armyworms	1234	51.9%	0.6%
Thrips	317	13.3%	0.6%
Tomato fruitworms	160	6.7%	0.1%
Wireworms	21	0.9%	0.1%
Nematodes			
Root knot nematode	166	7.0%	0.3%
Weeds			
Eclipta	129	5.4%	0.0%
Grasses	20	0.8%	0.0%
Nightshade	1618	68.1%	0.0%
Nutsedge	203	8.5%	0.0%
Sesbania	400	16.8%	0.0%
White sweet clover	80	3.4%	0.0%
			23.8%

Table 12. Pest management methods for south Florida peppers, 1997-98. **Boldface** indicates active ingredients on the FQPA target list.

Pest	Primary control practice (chemical name)	Trade name	Formulation	% of crop treated	Type of application	Average application rate (lb AI/a)	Average # of applications	Typical preharvest interval (days)
Diseases								
Anthracnose	**Maneb**	**Maneb 80**	**80% WP**	**97.9%**	**Foliar spray**	**0.8**	**18**	**7**

Bacterial soft rot	Field sanitation, insect control							
Bacterial spot	**Maneb**	**Maneb 80**	**80% WP**	**97.9%**	**Foliar spray**	**0.8**	**18**	**7**
	Copper Hydroxide	Kocide 101	77% WP	94.4%	Foliar spray	0.8	19	1
Frog eye spot	Copper Hydroxide	Kocide 101	77% WP	94.4%	Foliar spray	0.8	19	1
Fusarium	Methyl Bromide		Several	97.9%	Fumigation injection	188.0	1	98
	Chloropicrin		Several	97.9%	Fumigation injection	26.6	1	98
Phytophthora	Mefenoxam	Ridomil Gold EC	4 Lb AI/Gal EC	34.4%	Pre-plant banded, post-plant injection or spray	0.3	2	7
Pythium	Mefenoxam	Ridomil Gold EC	4 Lb AI/Gal EC	34.4%	Pre-plant banded, post-plant injection or spray	0.3	2	7
Sclerotinia	Methyl Bromide		Several	97.9%	Fumigation injection	188.0	1	98
	Chloropicrin		Several	97.9%	Fumigation injection	26.6	1	98
Virus diseases	Imidacloprid	Admire 2E	2 Lb AI/Gal EC	77.3%	Post-plant injection or drench, foliar spray	0.2	2	84 (drench). 7 (foliar spray)
Insects								
Aphids	Imidaclporid	Admire 2E	2 Lb AI/Gal EC	77.3%	Post-plant injection or drench, foliar spray	0.2	2	84 (drench). 7 (foliar spray)
Beet armyworms	*Bacillus thuringiensis*	Dipel, Mattch	Several	90.3%	Foliar spray	0.1	5	1
Broadmites	Sulfur	Sulfur 6L	6 Lb AI/Gal EC	27.3%	Foliar spray	1.4	4	1
Fall armyworms	*Bacillus thuringiensis*	Dipel, Mattch	Several	90.3%	Foliar spray	0.1	5	1
Pepper weevils	**Oxamyl**	**Vydate L**	**2 Lb AI/Gal EC**	**66.4%**	**Foliar spray**	**0.5**	**2**	**7**
Southern armyworms	*Bacillus thuringiensis*	Dipel, Mattch	Several	90.3%	Foliar spray	0.1	5	1
Thrips	**Methomyl**	**Lannate WSP**	**90% SP**	**73.9%**	**Foliar spray**	**0.4**	**2**	**3**
Tomato fruitworms	*Bacillus thuringiensis*	Dipel, Mattch	Several	90.3%	Foliar spray	0.1	5	1
Wireworms	Methyl Bromide		Several			188.0	1	98

	Chloropicrin		Several			26.6	1	98
Nematodes								
Root knot nematode	Methyl Bromide		Several	97.9%	Fumigation injection	188.0	1	98
	Chloropicrin		Several	97.9%	Fumigation injection	26.6	1	98
Weeds								
Eclipta	Paraquat Dichloride	Gramoxone Extra	2.5 Lb AI/Gal EC	83.5%	Directed spray	0.5	2	60
Grasses	Paraquat Dichloride	Gramoxone Extra	2.5 Lb AI/Gal EC	83.5%	Directed spray	0.5	2	60
Nightshade	Metolachlor	Dual 4e	4 Lb AI/Gal EC	41.8%	Directed spray	1.8		60
Nutsedge	Methyl Bromide		Several	97.9%	Fumigation injection	188.0	1	98
	Chloropicrin		Several	97.9%	Fumigation injection	26.6	1	98
Sesbania	Paraquat Dichloride	Gramoxone Extra	2.5 Lb AI/Gal EC	83.5%	Directed spray	0.5	2	60
White sweet clover	Paraquat Dichloride	Gramoxone Extra	2.5 Lb AI/Gal EC	83.5%	Directed spray	0.5	2	60

Table 13. Estimated economic impact of pest activity in south Florida peppers.

Total % loss per acre	23.8%
Average marketable yield (lbs per acre) from Table ###	33944
Potential yield (Avg. yield (lbs)*(1+Total % loss)	42004
Difference (lost yield in lbs per acre)	8060
Average gross return per acre from Table ####	$13,950
Potential gross return per acre (Avg. gross return) *(1+ Total % loss)	$17,263
Difference (Lost return in $/A)	$3,313
Total $$$ loss in survey area (lost return *2376)	$7,871,039

Table 14. Frequency of use of selected tomato IPM practices by south Florida tomato growers. Percentages in **boldface** represent the numbers of growers who responded that each practice was used “sometimes", “usually” or “always”.

Prevention	Avoidance	Monitoring	Suppression	Pest management practice
75-100%				
X				Maintain clean fields during the off season.
X				Destroy volunteer crops and/or crop residues to limit the threat of future insect problems.
X				Destroy volunteer crops and/or crop residues (including cull piles) to limit the threat of future disease problems.
X				Manage volunteers in fields not planted with peppers.
X				Manage water table levels as a way of controlling soil borne diseases.
	X			Plant only treated seed.
	X			Select disease or nematode resistant varieties when they are available.
	X			Manage the timing and location of plantings in the same area to avoid pest movement from adjacent fields.
		X		Scout for diseases throughout crop growth.
		X		Have pathogens positively identified to assure proper control measures were chosen.
		X		Maintain written or electronic records of pesticide application dates and rates.
		X		Insist that transplant ranges be scouted for diseases and insects
		X		Inspect transplants upon their arrival at the field.
		X		Scout for weeds periodically during crop development.
		X		Maintain and use written or electronic scouting records in making insect management decisions.
		X		Maintain and use written or electronic scouting records in making disease management decisions.
			X	Farm personnel receive worker protection standard training in the past 12 months.
			X	Calibrate and maintain sprayers before each crop.
			X	Calibrate and maintain granular applicators before each use.
			X	Adjust spray intervals according to insect pressure.
			X	Adjust insecticide application rates according to insect pressure.
			X	Treat field soil before planting.
			X	Begin your fungicide spray program before disease symptoms appear.
			X	Choose fungicides primarily for their efficacy rather than low cost.
			X	Employ only spray applicators who are properly trained and licensed.
			X	Choose biologically friendly pesticides, such as B.t., nuclear polyhedrosis virus, or fungal insect pathogens, over conventional pesticides whenever possible.
			X	Adjust spray intervals according to disease pressure.

			X	Apply insecticides other than B.t. only when scouting reports show that thresholds have been exceeded.
			X	Return or destroy transplants infected with bacterial spot.
50-75%				
X				Manage weeds in field margins or irrigation ditches to prevent insect buildup.
		X		Scout regularly for the presence of beneficial insects.
		X		Monitor pests and beneficials in crop margin areas.
		X		Consultant maintains and uses written or electronic scouting records in making insect management decisions.
		X		Consultant maintains and uses written or electronic scouting records in making disease management decisions.
			X	Spot treat fields with uneven weed distribution.
			X	Adjust spray intervals according to weed pressure.
			X	Use adjuvants to increase the activity of insecticides.
			X	Adhere to resistance management procedures.
			X	Treat parts of fields more or less intensely according to the level of disease.
			X	Adjust fungicide application rates according to disease pressure.
			X	Have hand laborers disinfect their hands periodically during field work.
			X	Choose herbicides based on weed identification.
			X	B.t. used only on demand.
			X	Use adjuvants to increase the safety of insecticide applications (drift control, washoff management).
			X	Destroy and replant areas where disease outbreaks occur in early crop stages (e.g., First 3 weeks).
			X	Rogue young plants showing virus disease symptoms.
25-50%				
	X			Rotate crops to reduce soil-borne disease inoculum, nematodes, weed seeds or insect pests (including double cropping).
	X			Clean field equipment when moving from field to field to prevent disease spread.
	X			Clean field equipment when moving from field to field to avoid spreading weed seeds.
		X		Use pheromone traps to monitor pepper weevil and/or armyworm populations.
			X	B.t. applied on a schedule as a preventative.
			X	Delay applying insecticides, even if a threshold had been exceeded, if beneficial insect activity appears adequate for control.
			X	Modify hand labor practices where bacterial spot has been detected.
			X	Typically apply herbicides only when a scouting report demonstrates a need.
			X	Typically apply herbicides according to a schedule.
0-25%				

	X			Alter planting dates to avoid peak periods when pests can cause economic losses.
	X			Intentionally intercrop with crops that are not susceptible to the same pests as peppers.
	X			Did knowledge of past pest pressure lead you to decide not to grow peppers in any particular fields or parts of fields this year?
	X			Clean harvesting equipment when moving from field to field to prevent disease spread.
	X			Clean harvesting equipment when moving from field to field to avoid spreading weed seeds.
	X			Crop rotation (other than double cropping).
	X			Use reflective mulch to repel insects during transplant establishment.
	X			Plant seed treated with biorational pesticides, such as mycorrhizal fungi instead of with conventional fungicides.
		X		Use crop/pest mapping as a tool for future planning.
		X		Use crop/disease mapping as a tool for future planning.
		X		Use crop/pest mapping to track insect development.
		X		Use crop/pest mapping to track disease development.
		X		Precision ag.
		X		Conduct soil sampling to determine methyl bromide/chloropicrin application rates.
		X		Maintain weed maps to help in weed management and herbicide decision making.
			X	Does your consultant maintain written or electronic records of pesticide application dates and rates.
			X	Employ pepper weevil pheromones to disrupt their mating.
			X	Add mycorrhizal organisms to transplant or field soil to mitigate soil-borne diseases.
			X	Did the buyers of your peppers place any restrictions (other than following label restrictions) on the pesticides or other chemicals that you used?
			X	Release beneficial insects to manage certain pests.
			X	Maintain unsprayed refuges for beneficial insects.
			X	Plant non-crop areas with cover crops to support beneficial insects.
			X	Apply fungicides only when scouting reports indicate they are warranted.
			X	Mechanical tillage for weed control after crop emergence.
			X	Confirm application quality parameters (swath width, calibration, etc.) with your custom applicator.
			X	Adjust herbicide application rates according to weed pressure.
			X	Rotate herbicides to prevent resistance development.

Table 15. Pesticide active ingredients applied to south Florida fall pepper crops and to pepper farms where no planting break was observed during the 1997-98 season. **Boldface** indicates active ingredients on the FQPA target list.

Pesticide type	FQPA list z	Active ingredient	Acres treated at least once	% of crop treated at least once	Average lb AI used per treated acre	Average number of applications	Average application rate	Low	High
Fumigant		Chloropicrin	1609	98.5%	26.6	1	26.6	4.0	69.6
Fumigant		Methyl Bromide	1609	98.5%	188.0	1	188.0	141.4	220.5
Fungicide	**b**	**Maneb**	**1609**	**98.5%**	**11.9**	**17**	**0.8**	**1.0**	**0.3**
Fungicide		Copper Hydroxide	1525	93.3%	17.6	18	0.8	0.4	1.1
Fungicide		Mefenoxam	722	44.2%	0.4	2	0.3	0.2	0.5
Fungicide		Copper Oxychloride	84	5.1%	10.3	9	1.1	1.1	1.1
Herbicide		Paraquat Dichloride	1406	86.1%	1.0	2	0.5	0.3	0.5
Herbicide		Metolachlor	993	60.8%	1.8	1	1.8	1.0	4.0
Herbicide		Glyphosate	551	33.7%	1.7	1	1.3	0.7	2.0
Herbicide		Diquat Dibromide	84	5.1%	0.5	2	0.3	0.3	0.3
Herbicide		MCDS	83	5.1%	69.8	1	69.8	69.8	69.8
Herbicide		Sethoxydim	37	2.2%	0.2	1	0.2	0.2	0.2
Insecticide		B.t. Engineered	1405	86.0%	0.8	7	0.1	0.0	0.5
Insecticide		Imidacloprid	1260	77.1%	0.2	1	0.2	0.0	0.4
Insecticide	**c**	**Methomyl**	**1179**	**72.1%**	**0.9**	**2**	**0.4**	**0.2**	**0.6**
Insecticide	**c**	**Oxamyl**	**1021**	**62.5%**	**0.9**	**2**	**0.5**	**0.3**	**1.0**
Insecticide		B.t. kurstaki	946	57.9%	0.3	5	0.1	0.0	0.1
Insecticide		B.t. aizawai	745	45.6%	0.4	5	0.1	0.1	0.1
Insecticide		Spinosad	576	35.2%	0.2	3	0.1	0.0	0.1
Insecticide		Dicofol	546	33.4%	0.8	1	0.8	0.5	1.0
Insecticide		Sulfur	525	32.1%	9.7	7	1.4	0.4	2.2
Insecticide		Cyfluthrin	400	24.5%	0.3	2	0.1	0.1	0.1
Insecticide		Cyromazine	400	24.5%	0.3	2	0.1	0.1	0.1
Insecticide	**o**	**Chlorpyrifos**	**330**	**20.2%**	**0.7**	**1**	**0.5**	**0.3**	**0.8**
Insecticide		Azadirachtin	268	16.4%	1.2	12	0.1	0.0	0.0
Insecticide		Endosulfan	186	11.4%	0.7	2	0.4	0.4	0.5
Insecticide		Neem Oil Extract	185	11.3%	30.0	12	2.1	1.4	2.7

Insecticide		Permethrin	184	11.3%	0.4	4	0.1	0.1	0.1
Insecticide		Avermectin	160	9.8%	0.002	2	0.001	0.001	0.001
Insecticide		Potassium Soap	146	8.9%	3.8	1	3.8	3.8	3.8
Insecticide		Pyrethrins	146	8.9%	0.01	1	0.01	0.01	0.01
Insecticide		Rotenone	146	8.9%	0.01	1	0.01	0.01	0.01
Insecticide		Esfenvalerate	124	7.6%	0.1	5	0.03	0.03	0.03
Insecticide	**o**	**Dimethoate**	**98**	**6.0%**	**2.5**	**5**	**0.5**	**0.5**	**0.5**
Insecticide		Acephate	84	5.1%	2.3	3	0.8	0.8	0.8
Insecticide	**o**	**Azinphos-methyl**	**84**	**5.1%**	**1.5**	**3**	**0.5**	**0.5**	**0.5**
Insecticide		Crop Oil	83	5.1%	16.8	14	1.2	1.2	1.2
Insecticide		Garlic/Sugar/Capsaicin	25	1.5%	9.7	2	4.9	4.9	4.9
Nematicide		Chitin	25	1.5%	132.0	1	132.0	132.0	132.0

[z] b = B2 Carcinogen, c = Carbamate, o = Organophosphate

Table 16. Pesticide active ingredients applied to south Florida spring pepper crops during the 1997-98 season. **Boldface** indicates active ingredients on the FQPA target list.

Pesticide type	FQPA list [z]	Active ingredient	Acres treated at least once	% of crop treated at least once	Average lb AI used per treated acre	Average number of applications	Average application rate	Low	High
Fumigant		Chloropicrin	717	96.6%	29.75	1	29.8	4.0	66.0
Fumigant		Methyl Bromide	717	96.6%	186.63	1	186.6	134.0	220.5
Fungicide		Copper Hydroxide	717	96.6%	39.99	20	0.9	0.5	2.3
Fungicide	**b**	**Maneb**	**717**	**96.6%**	**14.32**	**19**	**0.8**	**0.3**	**1.5**
Fungicide		Mefenoxam	95	12.8%	1.80	2	0.4	0.1	0.5
Fungicide		Bacteriaphage	25	3.4%	5.62E+11	10	5.62E+10	5.62E+10	5.62E+10
Herbicide		Paraquat dichloride	577	77.8%	1.41	2	0.6	0.5	0.9
Herbicide		Glyphosate	181	24.4%	2.36	2	1.4	1.0	1.7
Herbicide		MCDS	82	11.1%	69.75	1	69.8	69.8	69.8
Insecticide		B.t. engineered	742	100.0%	1.20	6	0.1	0.0	0.5
Insecticide		B.t. kurstaki	742	100.0%	0.34	5	0.1	0.0	0.1
Insecticide		Imidacloprid	577	77.8%	0.23	2	0.2	0.1	0.3
Insecticide	**c**	**Methomyl**	**577**	**77.8%**	**0.47**	**1**	**0.4**	**0.3**	**0.5**
Insecticide		B.t. aizawai	565	76.2%	0.34	4	0.1	0.1	0.1
Insecticide	**c**	**Oxamyl**	**557**	**75.0%**	**1.83**	**3**	**0.7**	**0.5**	**1.0**
Insecticide		Cyfluthrin	400	53.9%	0.63	5	0.1	0.1	0.1
Insecticide		Cyromazine	400	53.9%	0.38	3	0.1	0.1	0.1
Insecticide		Dicofol	400	53.9%	1.00	1	1.0	1.0	1.0
Insecticide		Azadirachtin	222	29.9%	0.04	7	0.01	0.01	0.01
Insecticide		Avermectin	140	18.9%	0.001	1	0.001	0.001	0.001
Insecticide		Neem Oil Extract	140	18.9%	1.37	1	1.4	1.4	1.4
Insecticide		Sulfur	107	14.4%	24.23	15	1.6	1.0	2.2
Insecticide	**o**	**Dimethoate**	**95**	**12.8%**	**2.50**	**5**	**0.5**	**0.5**	**0.5**
Insecticide		Spinosad	95	12.8%	0.09	1	0.1	0.1	0.1
Insecticide		Crop Oil	82	11.1%	16.84	14	1.2	1.2	1.2
Insecticide		Garlic/Sugar/Capsaicin	25	3.4%	9.70	2	4.9	4.9	4.9
Nematicide		Chitin	25	3.4%	132.00	1	132.0	132.0	132.0

[z] b = B2 Carcinogen, c = Carbamate, o = Organophosphate

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