Chapter 3. The Evolution of South Florida Pepper Pest Management Systems and Impacts on Pesticide Use and Reliance

During the 1997-98 growing season South Florida produced 12,500 acres of peppers with a value of $34,587,600, representing 54 percent of U.S. production and 66 percent of Florida's 19,000 pepper acres (FASS, 1997, 1998a, 1998b). The average yield was 33,944 pounds per acre, with an average value of $0.43 per pound, giving a gross return of $13,950 per acre. Table 3.1 reports data for 12 pepper farms surveyed by Glades Crop Care, Inc. (1999) and covers acres harvested, yields, market value, costs, and estimated returns. The distribution of costs and returns across these 12 farms is representative of the industry in the South Florida region.

Note the wide range of net returns per acre – ranging from a loss of over $1,430 per acre to a profit of over $13,000 As in the case with tomato production, the success of pest management systems and their effect on total yield, is one of the dominant variables dividing the profitable seasons from the unprofitable ones. Note as well that the most profitable farm, with a net return per acre of $13,443, had the highest yield per acre but not nearly the highest price. The least profitable farm lost money because of both low yields and quality problems – which [presumably] led to a price discount. For this least profitable farm, the pepper weevil, *Anthonomus eugenii* Cano (PEW) was a major source of loss, especially when the grower attempted to extend the harvesting period in his early plantings.

On average across the 12 farms, production costs and picking and packing costs 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 an average $630 per acre, or nearly 12 percent of the total production costs, as shown in Table 3.2. The most profitable farm had the highest pest management costs per acre ($1,300), more than twice the average of the 12 farms. The high costs paid a significant return, however, since this farm marketed more than 5,000 pounds more peppers than any other farm, worth some $2,400 per acre. The profitability of this and the other high-earning farms in Table 3.2 is primarily the result of extending the harvest season in the earliest plantings, a move which nets the grower an increased return on the cost of production for that acreage. This is a double-edged sword, however, since this extended harvest period requires increased, often intensive, pest management inputs.

The South Florida production area is typified by variable weather conditions, often highly conducive to plant disease development. It also supports an abundance of insect pests, some of which serve as vectors for disease. The pepper pest complex can cause significant economic loss and requires a high level of integrated pest management (Glades Crop Care, Inc., 1999). Despite the efforts of growers to incorporate many different pest management practices into their individual programs, pesticide applications remain a central form of pest suppression and are essential to avoid catastrophic crop losses. Changes in pesticide registrations and labels are bound to follow implementation of the Food Quality Protection Act (FQPA) and will likely have a significant impact on the cost and efficacy of pepper pest management in South Florida. In this chapter we place some of the likely changes in context given other changes in pepper pests and pest management, and in Chapter 5 we use several indicators of pesticide use and IPM adoption to further highlight possible impacts of the FQPA.

Factors Shaping Pepper IPM Systems and Decision-making

As part of a project funded by the USDA's Pest Management Alternatives Program (PMAP), Glades Crop Care, Inc. investigated changes in pepper pest management systems, pesticide use, and the likely impacts of the FQPA. A major area of exploration was the possible contribution of new technology in shaping post-FQPA IPM systems.

Since FQPA passage in 1996, Glades Crop Care, Inc. grower-clients have actively challenged us to help them make the transition from pesticides likely to trigger risk reduction actions by EPA. We have focused our efforts on lessening reliance on the organophosphate (OP) and carbamate insecticides and known carcinogens, especially the EBDC fungicides so essential in our disease management programs.

We investigated incorporation of recently registered alternatives to the FQPA-targeted pesticides into the IPM program at a large bell pepper farm in Immokalee, FL. This was done by systematically recommending the use of such alternatives in the place of pesticides previously used at this farm. These substitutions primarily involved insecticides, as alternatives to the targeted fungicide, maneb, are not currently available for control of bacterial spot, caused by *Xanthomonas campestris* pv *vesicatoria*. Bacterial spot disease is the single greatest cause of economic losses according to growers' estimates, with over 9 percent of potential yield lost to this disease in 1997-98 (Glades Crop Care, Inc., 1999).

Major Insect Pest Challenges in Pepper Production

Arthropods causing the greatest damage included the broadmite, *Polyphagotarsonemus latus* Banks, and the pepper weevil (PEW) which account for losses of potential yield of 3 percent and 2 percent, respectively. Table 3.3 reports estimates of the damage associated with these and other insects. A complex of lepidopterous larvae cause a combined average loss of 1.6 percent, and include the tomato fruitworm, *Helicoverpa zea* Boddie, and the beet (BAW), southern (SAW) and fall (FAW) armyworms, *Spodoptera exigua* Hübner, *S. eridania* (Cramer), and *S. frugiperda* J.E. Smith, respectively.

The pesticides used to suppress these arthropod pests have changed over the years. This is especially true for worm control, where management programs now make use of frequent applications of *Bacillus thuringiensis* Berliner (*B. t.*), alternated with other insecticides to clean up larvae that have escaped *B. t.* control. The choice of pesticides to rotate with *B. t*. is especially important during periods of inclement weather, when sprays are difficult to apply or when applied pesticides are washed off. This group of "cleanup" insecticides was a major focus of this project's on-farm research on likely alternatives to FQPA-targeted pesticides.

Pepper weevil (PEW) control alternatives were a second focus. Conventional practice for control of PEW has historically included multiple applications of the FQPA-targeted carbamates, oxamyl and methomyl. These two broad-spectrum materials have typically been rotated with other insecticides, primarily the synthetic pyrethroids, permethrin and esfenvalerate, for resistance management purposes. This PEW insecticide rotation has proven very hard on beneficials and has led to numerous secondary pest flare-ups over the years. While the carbamates perform well in controlling PEW, extensive use can result in loss of biological control of the leafminer, *Liriomyza trifolii,* Burgess. Similarly, frequent applications of pyrethroids have been associated with flare-ups of another secondary pest, the melon thrips, *Thrips palmi* Karny. Fortunately, some PEW suppression has been observed following applications of imidacloprid, and this pesticide has been incorporated into the control programs on several farms (Glades Crop Care, Inc., unpublished data). Incorporating imidacloprid in the program has allowed growers to drop one or more carbamate and/or pyrethroid applications.

Survey Results for Crop Year 1999-2000

With this background, the pepper crop at an Immokalee, FL farm, Farm LB, was scouted biweekly according to Glades Crop Care, Inc.'s standard practices. Pesticide recommendations were made based on the results of each scouting trip. The grower took responsibility for carrying out the recommendations. The resulting pesticide usage is summarized in Table 3.4 for several fall and spring crops from 1994 through the spring crop, 2000. Data are also reported for two farm managers, LB1 and LB2. LB1 managed the farm from 1994 through the spring crop in 1997; LB2 took over for the fall crop in 1997 and managed the farm through the spring 2000 crop.

These data provide an opportunity to examine the impact on pesticide use over time of two farm managers working the same land, with the same information and related resources but different pest management philosophies. Table 3.4 reports the individual grower's spray records for the indicated seasons, and represent the average amount of active ingredient (AI) applied to at least two representative fields in the fall and spring crops, planted in September and December of each year, respectively.

Table 3.4 also includes statewide pesticide use data for 1994 and 1996 for use in comparing pesticide use at Farm LB to the statewide average (FASS, 1997). The importance of the EBDC fungicides is apparent throughout the six-year period, with little variation in pounds applied. Considerable variation is apparent from crop to crop and over time in insecticide use. Factors driving these changes are discussed in detail in the balance of this chapter.

PEW management is clearly a major economic issue and an area of intense focus among researchers and pepper pest management field consultants. For these reasons, the control program at Farm LB is further compared with programs from two nearby farms (Farms ~Y and BF) for the 1999-2000 season in Table 3.5.

Key insights from Tables 3.4 and 3.5 include that:

1. Farm LB was far less reliant on FQPA-targeted insecticides in the spring crop than the other two farms, but Farm BF was able to manage insects without any OP, carbamate or pyrethroid insecticides in the fall crop.
2. Pesticide use at Farm LB of higher-risk insecticides was reduced following the change in farm management between the spring and fall crop in 1997.
3. Positive experiences gained with alternatives to FQPA-targeted insecticides on Farm LB in 1999 helped set the stage for a marked reduction in insecticide use in the spring 2000 crop.
4. The introduction of new insecticides with novel modes of action (imidacloprid, spinosad, tebufenozide) has apparently helped drive down armyworm populations to levels where an acceptable degree of control can be achieved largely through use of *B. t*.

Comparison with State-wide Pesticide Use Patterns

During the 1994-2000 survey period, Farm LB made use of the same scouts and consultants in formulating pest management strategies and in making day-to-day decisions. While the information base and advice was consistent over the six years, the decisions made in response to the information and advice differed markedly as a function of farm managers.

Reported differences in Farm LB pesticide use patterns (see Table 3.4) in contrast to statewide averages reflect both conscious decisions on the part of farm management and regional trends in pest pressure. Prevailing weather patterns in late summer and early fall when the main South Florida pepper crop is being planted and setting fruit are highly conducive to bacterial spot and the armyworm complex. These early plantings are also those held for extended harvesting, requiring increased pest management throughout the crop. Hence, growers need additional pesticide applications to avoid significant crop losses or quality problems.

The amounts of the fumigants, methyl bromide and chloropicrin applied on farm LB are similar to or lower than the statewide averages for the survey period. There is also no clear trend in herbicide use, except that trifluralin has not been used at Farm LB.

The most striking differences are in the amounts of fungicides applied. The major plant disease, bacterial spot, has historically caused severe problems during rainy fall crops in South Florida. This has resulted in higher amounts of copper hydroxide and maneb being applied at Farm LB than the statewide average. This trend is most consistent for maneb, which has been applied at close to the maximum amount allowed by the label (14.4 lb AI/A) during nearly the entire survey period. Statewide, maneb use for 1994-98 ranged between 10 and 13 lb AI/A.

Lower amounts of maneb have been applied during some spring crops on Farm LB, specifically, 1997 and 1999, when weather conditions resulted in lower disease pressure. For those seasons, approximately 12 lb AI/A was applied. The growers' efforts to apply only the amount of fungicide needed to produce a clean crop are reflected in the general decrease in the use of copper hydroxide. Use of this fungicide peaked during the 1994-96 period at between 38 and 53 lb AI/A, compared to a range of 10-24 lb AI/A between 1998-00.

The second most damaging pepper disease in South Florida, *Phytophthora* blight, has a long history in the pepper fields at Farm LB. The primary chemical control has been mefenoxam (metalaxyl), a fungicide applied every season with the exception of the spring 2000 crop. This was the result of exceptionally dry weather, which led to low disease incidence. Otherwise, mefenoxam has been applied on Farm LB at between 1.5 to 3 times the statewide average, again depending on the weather.

Insecticide use at Farm LB also differs from statewide averages. Generally, the carbamates, oxamyl and methomyl, were applied at lower rates than for the state as a whole, with the exception of the 1998 and 1999 spring crops. During those seasons, methomyl was applied to control thrips and pepper weevil adults. The organophosphate acephate was added to the insect management program used during the fall of 1994 and the spring of 1996 at Farm LB, while the state record shows none used. In 1998, just the opposite occurred. Statewide an average of 2.3 lb AI/A of acephate was applied yet none was needed on Farm LB.

These trends are important in projecting the likely effects of FQPA implementation. From 1994 through the fall crop in 1997, the decisions were relatively risk-averse choices and thus the hardest, most assuredly effective control intervention was used. The consequences of multiple applications of broad-spectrum materials were accepted. After 1997, spray decisions were made in accord with a different management philosophy.

Impacts of Farm Manager Experience and Philosophy on Pesticide Use

A comparison of Farm LB pesticides used between 1994 and the spring crop in 1997, and the fall crop in 1997 through 2000 provides an opportunity to examine the influence of two different personal perspectives on pest management. Data reported in Table 3.4 suggest that LB1 is inclined toward "harder" or more aggressive pest suppression than LB2. However, many factors might explain the temporal differences in pesticide use evident in Table 3.4 on Farm LB.

Observed differences in pesticide use reflect differing management philosophies, loss of efficacy to established products as a result of resistance, major changes in the price per acre treated of alternative products, the emergence of new pests and varying levels of pest pressure. The introduction of new products also made it more feasible for the second manager on Farm LB to back away from hard-chemical solutions. Assessment of pesticide use on Farm LB in contrast to statewide averages suggests that there was, in fact, a change in Farm LB pest management systems and pesticide reliance before and after the change in management.

There were no major changes in the pests facing south Florida pepper growers during this period. Likewise, there were no major shifts in the prices of pesticides falling in different families of chemistry. In fact, the newer pesticides embraced by the LB2 manager tended to cost more per acre treated than more broad-spectrum and established products. In our experience, the willingness to pay somewhat more per acre to experiment with a new family of chemistry is a reliable indicator of a manager's desire to innovate and improve the effectiveness of IPM systems.

In addition, changes in the use of particular active ingredients lend further support to the conclusion that differing philosophies produced marked variation in pesticide use patterns. Use rates of copper hydroxide and dicofol were consistently higher during the 1994-fall 97 crops than during the spring 1997 to 2000 crops. Methomyl use also declined significantly under LB2.

Management change at this farm illustrates a number of facets in IPM decision making and engenders an appreciation for implementing biopesticide use and biological control processes. Differences undoubtedly were the result of the tools each grower had available to him. Both growers readily incorporated new chemistry into the program once its efficacy was demonstrated. For example, imidacloprid was put into use in 1994 by LB1 for control of *Thrips palmi*. This insecticide was not only remarkably effective in controlling thrips, but provided excellent control of aphids as well. The acephate applications made during the 1994 and 1996 seasons occurred either prior to imidacloprid application or long after its efficacy wore off in a fall crop that was held over for extended harvesting.

Perhaps even more notable is the effect of imidacloprid had on PEW control needs. This is indicated by the elimination of the standard PEW insecticide, oxamyl, from the program during the fall 1994 through fall 1995 seasons. Glades Crop Care, Inc. scouts observed in 1995 that when imidacloprid was used for aphid and thrips control, PEW suppression occurred. This did not control PEW by any means, but it helped. We anticipate registration of a new neonicotinoid insecticide, thiamethoxam, which, in small plot tests conducted by the University of Florida, has shown good efficacy against PEW (Stansly and Conner, 2000).

While pyrethroid insecticides such as cyfluthrin and permethrin provide some level of PEW control, frequent use has resulted in uncontrollable population explosions of *Thrips palmi* (Glades Crop Care, Inc., unpublished data). Clearly, retaining the registrations for the carbamate insecticides, methomyl and oxamyl, even if pesticide labels allow significantly less use than currently allowed, would provide for a more robust rotation of modes of action, thus extending the useful life of the neonicotinoids, as well as the carbamates and pyrethroids.

Pepper Weevil Management Drives the System

Pepper weevil control is important for several reasons. Besides the obvious issues of crop damage, the cost of control measures, and farmworker exposure to acutely toxic insecticides, it is impossible to achieve biologically based management of pepper insect pests without a reasonably "soft" strategy for controlling pepper weevils.

As clear from the pesticide records for the fall 1999 and spring 2000 seasons at Farm LB (see Table 3.5), it is possible to grow a crop of peppers while virtually eliminating "hard" insecticides. During the fall 1999 crop, the only hard insecticides used were single applications of dicofol and oxamyl, used to control broadmites during a rainy period in the fall, and later to control PEW. Otherwise, the crop was grown with insecticides that have low risk to humans, and which are known to be at least partially compatible with beneficial insects.

In the spring 2000 season at Farm LB, strong measures were required to keep the PEW under thresholds for economic damage. During that period, unusually early fruit maturity and a strong market led to an early harvest in the beginning of March. Due to a strong market, even medium sized fruits were harvested, leaving only small fruits for subsequent harvest. It took much longer than normal for these small fruit to reach marketable sizes and during this period the PEW became established (Figure 3.1). In a normal year, it is unlikely the grower would have tried to extend the season long enough to harvest these small fruit.

With the long pre-harvest intervals associated with PEW control materials, effective treatment of the planting required more *B. t.* applications than usual**.** Yet, the grower reported no problems at the packinghouse and the economic damage was minimal. While the PEW had earlier become established in the fall crop, it did not reach the levels found in the spring crop. The higher spring population was probably the result of the abundance of small, thin-walled pods favored by PEW for egglaying.

By comparison, two nearby farms, ~Y and BF, also experienced PEW populations. Although PEW were found on pheromone monitoring traps at Farm BF, fruit infestation was not detected (Glades Crop Care, Inc., unpublished data). At Farm ~Y, where PEW have historically caused problems, populations began to develop early in the fall crop and continued to develop through the spring. Again, through frequent application of effective insecticides, the grower was able to escape significant economic loss.

The circumstances surrounding these three PEW scenarios are interesting in that they point out not only the potential for effective use of low-risk pesticides, but they also highlight the importance of non-chemical approaches to pest management. (Recall the pesticide use at the three farms is detailed in Table 3.5). PEW infestation levels are shown in Figures 3.1 and 3.2. The values in these graphs were taken from twice-weekly scouting reports. In performing PEW evaluations, the severity of the infestation was graded on a scale from 0 (no damage) to 5 (severe damage).

In the case of Farm ~Y by January 2000, following several harvests, PEW infestation levels reached such proportions that Glades Crop Care, Inc. scouts invented a grade of 6 (see Figure 3.2). This reflected the fact that the only fruits remaining on the plants were small and preferred by the PEW females for egg laying. The fact that the infestation in the spring crop at that farm did not significantly increase until more than a month after maximum levels were reached in the fall crop was the result of no fruits or flower buds suitable for PEW oviposition being present in the newly planted fields. Once the spring crop was suitable for PEW oviposition, the infestation developed rapidly.

It is significant that the grower reported only low-level losses to PEW in either planting. PEW numbers did not reach a maximum in the fall crop until after the bulk of the fruit had been harvested. The final fruit set, if it indeed occurred, would have developed after 1/14/00 and would have been light, as fruits infested with PEW tend to fall from the plant. While this may have resulted in some loss, the more profitable first harvest from the spring crop matured at about the same time and hence the grower did not need the light final harvest from the fall crop.

On Farm ~Y, however, pods harvested during April and May were set and would have reached a size unsuitable for oviposition before PEW numbers became very high, thus allowing a good spring harvest. The heavily infested fruits developing after early April generally go unharvested in south Florida, because of heat-induced difficulties in shipping and storage of fruits harvested in May. It is important to note that the spring plantings at Farms LB were roughly 5 weeks older than at Farm ~Y. Crop maturation and harvesting would have thus occurred at different times at the two farms. Interestingly, though, the first PEW detection at LB occurred only about 2 weeks earlier than at ~Y, suggesting a temperature or day length influence may also affect PEW infestations in addition to the previously mentioned influence of crop maturity.

Thus, it is seen that the later planted spring crop at ~Y had a greater proportion of its pods in a stage of development susceptible to PEW oviposition than the earlier planting at LB. A higher number of marketable pods was harvested at LB than at ~Y. Because of high PEW infestation both the early stripping of the field at LB and the late maturation of the second- and third-pick fruits at ~Y contributed to reduced numbers of suitable pods for late harvesting.

The infestation record was dramatically different at Farm BF. Despite the fact that Jalapeño peppers, a variety favored by PEW, were grown there, the only detection of

PEW on the crop occurred on 5/20 and 5/27/00. On those dates, a single oviposition puncture and an adult were found. This lack of infestation is remarkable because PEW were present on the farm, as indicated by pheromone traps deployed on the farm as monitoring devices. Similar trapping was conducted during the same period at Farm LB (Figure 3.3). Trap captures between 2/4 and 3/11/00 were similar at both farms, although the captures were slightly lower at Farm BF. After mid-March there were no more captures at BF, while PEW continued to visit the pheromone traps at LB. Several possible explanations for this disparity in infestation levels will be discussed in the following paragraphs.

The fact that trap captures at BF ended in mid-March is significant. It indicates that those PEW captured there were part of a wave of migrating PEW, which ended in mid-March. That the PEW did not become strongly established at this farm suggests that either the regular use of azadirachtin deterred them from laying eggs or that the carbamate insecticides applied upon detection sufficiently suppressed the population. In either case, Farm BF's relative isolation from sources of infestation resulted in a discrete period when infestation might have occurred, compared to the extended period of PEW activity at the other farms, which were closer to sources of infestation.

Proximity to infestation sources was different for the two farms. Farm BF was more isolated from potential sources of infestation than Farm LB. The only nearby pepper production was a regularly sprayed, 3-acre breeding plot approximately 3 miles away. By comparison, the nearest pepper production fields to the spring crop at Farm LB were about 200 acres, 2 miles away. Farm ~Y's fields lay about 2 miles north of a research farm, where untreated plots of peppers were grown to maintain a PEW population for testing purposes in addition to other small acreages about 4 miles in the opposite direction. Previous experience with PEW behavior following crop destruction (GCC, unpublished data) indicated that PEW could disperse quickly over distances up to 5 miles in search of new hosts. The relative isolation of Farm BF from large pepper acreage is therefore a viable explanation for the low observed infestation levels.

The fact that PEW were not present in the fall plantings at BF may be an equally important factor. Both Farms ~Y and LB experienced infestations beginning in December. Yet, there was no sign of infestation at Farm BF until March. Certainly, the infested fall crop served as a PEW source for the spring crops, which were less than 2 miles away at Farm LB and less than ½ mile away at Farm ~Y.

Field Location Impacts on Pesticide Use

When identifying potential sources of infestation, it is important to include alternate hosts in the evaluation. The host range of PEW is limited to plants in the family Solanaceae, primarily, peppers and nightshades (*Capsicum* spp and *Solanum* spp, respectively.) Although PEW have been found feeding or developing on other host plants, most of their reproduction is on these two host groups. Indeed, nightshades have been implicated as important host plants between cropping cycles (Elmore, et al, 1934, Patrock and Schuster, 1987). The prevalence of nightshades within the fields and on field margins at these farms mirrored the PEW infestation levels at each site. Both LB and ~Y had significant populations of nightshade. At Farm BF, while a population of nightshade eventually developed in the planted area, weed control during the off-season had been excellent, with the result that no oversummering host plants were present to serve as alternate PEW hosts.

Notable differences exist between the farms in the pesticides applied to control weeds and insect pests. Weed control differed markedly between Farm BF and the other two farms. Pesticide application records at Farm BF indicate that glyphosate and paraquat dichloride were both applied after beds were laid to control weeds, while there were no herbicides applied in the surveyed fields at the other two farms. The fact that local populations of nightshade are highly resistant to paraquat dichloride suggests that the pre-planting application of glyphosate exerted sufficient nightshade control to reduce the risk of PEW infestation originating within the farmsite.

Dimethoate was the only organophosphate applied on any of these farms (Farm ~Y). Despite the use of imidacloprid at that farm, the grower felt the use of dimethoate provided sufficient additional aphid control to warrant its use. The other farms obtained adequate aphid control using only imidacloprid. Although methomyl is registered for control of aphids, resistance to this active ingredient developed in local aphid populations during the mid 1980s and applications have little or no impact on aphid populations. All three farms made significant use of *B. t.* and incorporated spinosad and tebufenozide into their programs for worm control. There were no significant differences among the farms in worm control.

The most striking differences occur in the pesticides used for PEW control. At Farm BF, routine applications of azadirachtin and crop oil are made throughout the season. While this combination reduces PEW damage, it does not provide complete control (Schuster, et al., 1996). The grower at BF applied methomyl and oxamyl (0.32 and 0.89 lb AI/A, respectively), despite the fact that virtually no PEW activity was noted in his spring crop. These amounts, however, are far less than the amounts of the same active ingredients applied at Farm ~Y. The grower there applied 2.5 lb AI/A of oxamyl in the fall crop and 2.70 and 6.83 lb AI/A of oxamyl and methomyl, respectively, in the spring crop for PEW control.

Farm LB's pesticide usage for both seasons, however, was significantly "softer". Oxamyl was applied only late in the fall crop in an effort to control PEW after it had been decided to extend the fields for late harvesting. The spring crop was treated with Cryolite at the first sighting of PEW, followed by low rate applications of imidacloprid. The grower's reliance on oxamyl at Farm ~Y, while it may have been justified several years ago, was out of place in the 1999-2000 season, since the efficacy of this insecticide against PEW has declined significantly in recent years, especially in fields where it is applied frequently.

From the above discussion of PEW control at these three farms, the following conclusions can be drawn:

1. Isolating pepper plantings from other pepper production fields may be important in avoiding PEW immigration.
2. Eliminating nightshades may provide additional relief from PEW pest pressure by denying them oversummering sites.
3. Chemical control of PEW can be accomplished with a relatively soft approach, although carbamate insecticides may be necessary under some circumstances.

FQPA-targeted insecticides are used regularly but judiciously at Farm LB, with use rates that compare favorably with those of the rest of the state. Eliminating any one of these insecticides might result in higher insect damage, especially from PEW and *Thrips palmi*, both of which are difficult to control. Perhaps more threatening than the potentially higher crop damage is the loss of alternate chemistries for rotation with recently or soon-to-be introduced insecticides, such as imidacloprid, spinosad and thiamethoxam. The lack of good rotation partners with different modes of action could lead to premature loss of efficacy for the newer products. In this light, reducing the use of high-risk pesticides is a worthy and achievable goal but one that must be pursued consistent with the need to also preserve the efficacy of both new and older, established products.

In the end, it is clear that a diversity of tools provides the firmest foundation for long-term, sustained progress along the IPM continuum. For this reason, EPA needs to respond creatively to the challenge of crafting pesticide product labels that allow limited but highly essential uses of some higher-risk materials as a component of an overall strategy to accelerate progress along the IPM continuum.

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Table 3.1. 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 3.2. 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 3.3. 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			

Table 3.3 (Continued). Pest problems occurring in south Florida pepper crops. Estimates of long-term (5-year) acreage affected and yield losses.

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%
Total loss of potential yield			23.8%

Table 3.4. Pesticide use in bell pepper production at Farm LB under two different farm managers (LB1 and LB2). FASS indicates Florida Agricultural Statistics Service statewide usage data for the specified year.

Source		FASS	LB1	LB1	LB1	FASS	LB1	LB1	LB1	LB2	FASS	LB2	LB2	LB2	LB2	LB2
Season Year		1994	F 94	S95	F95	1996	S96	F96	S97	F97	1998	S98	F98	S99	F99	S00
Common Name	Type [x]															
Dicofol	Ac	0.42	0.00	0.00	0.68	0.84	0.13	0.59	0.00	0.00	[z]	0.00	0.00	0.00	0.21	0.00
Neem Extract (Oil)	Ac	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.19	0.00	0.00
Sulfur	Ac	0.00	1.80	3.00	6.00	0.00	2.38	9.45	9.66	15.21	0.00	8.44	9.27	4.77	15.43	5.12
Copper Ammonium Carbonate	Fg	2.58	0.00	0.00	0.00	[z]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper Hydroxide	Fg	8.77	38.58	52.46	52.62	9.38	45.83	22.52	13.32	11.71	5.41	9.82	18.30	12.60	23.69	15.58
Mancozeb	**Fg**	**9.54**	**0.00**	**0.00**	**0.00**	[z]	**0.00**	**0.00**	**0.00**	**0.00**	**7.22**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Maneb	**Fg**	**12.17**	**14.47**	**14.38**	**14.29**	**12.35**	**14.40**	**14.33**	**12.34**	**14.40**	**10.63**	**14.29**	**14.38**	**12.27**	**14.28**	**14.37**
Mefenoxam	Fg	0.54	0.84	0.43	0.75	0.96	1.24	0.46	0.50	1.06	0.23	1.49	0.76	1.05	0.16	0.00
Papain	Fg	0.00	9.44	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chloropicrin	Fm	91.23	49.50	55.68	54.25	65.77	54.36	60.02	66.06	58.82	74.66	70.31	58.98	59.01	57.50	57.50
Methyl Bromide	Fm	188.58	148.50	167.05	162.75	174.95	163.07	180.05	198.17	176.46	178.92	210.94	176.93	177.03	172.50	172.50
Glyphosate	Hb	0.00	0.00	0.00	0.00	0.00	1.40	0.00	3.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lactofen	Hb	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MCDS	Hb	43.62	0.00	0.00	0.00	123.63	0.00	0.00	0.25	0.18	[z]	0.00	0.00	0.00	0.00	0.00
Metolachlor	Hb	0.00	0.00	0.00	0.00	0.00	1.86	2.27	1.13	1.33	0.00	2.45	0.00	0.00	0.00	0.00
Paraquat Dichloride	Hb	0.41	1.63	2.43	0.00	1.15	1.81	1.87	1.04	0.66	0.62	0.77	0.00	0.00	0.00	0.00
Sethoxydim	Hb	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trifluralin	Hb	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00
Acephate	**In**	**0.00**	**1.20**	**0.00**	**0.00**	**0.00**	**0.54**	**0.00**	**0.00**	**0.00**	**2.32**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Avermectin	In	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.001	0.000	0.000
Azadirachtin	In	0.00	0.00	0.00	0.07	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bacillus thuringiensis	In	[y]	3.28	1.10	1.20	[y]	1.08	0.91	0.71	3.90	[y]	4.33	3.55	3.27	5.68	3.71
Crop Oil	In	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cryolite	In	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04
Cyfluthrin	In	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyromazine	In	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Endosulfan	In	1.93	0.30	0.00	0.00	1.06	0.00	0.00	0.00	0.00	4.36	0.00	0.00	0.00	0.00	0.00
Imidacloprid	In	0.00	0.50	0.49	0.31	0.00	0.31	0.29	0.18	0.25	0.25	0.27	0.21	0.07	0.08	0.14
Methomyl	**In**	**2.65**	**2.09**	**2.92**	**3.36**	**3.19**	**2.58**	**2.28**	**3.22**	**3.29**	**1.22**	**2.93**	**0.00**	**1.64**	**0.00**	**0.00**
Oxamyl	**In**	**1.78**	**0.00**	**0.00**	**0.00**	**1.53**	**0.00**	**0.36**	**0.26**	**0.80**	**2.12**	**0.94**	**1.06**	**0.91**	**0.78**	**0.00**
Permethrin	In	0.45	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00
Spinosad	In	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.14	0.00
Tebufenozide	In	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.14

[Z] Data for this AI were not available for this season/year. [Y] This AI is not reported by FASS because of variability in AI content. [X] Ac = Acaricide, Fg = Fungicide, Fm = Fumigant, Hb = Herbicide, In = Insecticide, **Boldface = FQPA-listed.**

Table 3.5. Comparison of pesticide applications at three pepper farms in south Florida. Pesticides targeted for regulatory action under FQPA appear in **boldface**. Pesticides with known or potential efficacy against pepper weevils are underlined.

		~Y	BF	LB	~Y	BF	LB
		Fall	Fall	Fall	Spring	Spring	Spring
Dicofol	Acaricide	0.00	0.00	0.21	0.00	0.00	0.00
Sulfur	Acaricide	10.05	7.75	15.43	6.00	2.68	5.12
Chloropicrin	Fumigant	50.00	50.00	57.50	50.00	50.00	57.50
Methyl Bromide	Fumigant	150.00	150.00	172.50	150.00	150.00	172.50
Copper Hydroxide	Fungicide	11.84	29.95	23.69	10.01	22.95	15.58
Maneb	**Fungicide**	**14.39**	**11.34**	**14.28**	**13.50**	**8.81**	**14.37**
Mefenoxam	Fungicide	0.75	0.00	0.16	0.00	0.00	0.00
Glyphosate	Herbicide	0.00	1.43	0.00	0.00	2.14	0.00
Paraquat Dichloride	Herbicide	0.00	3.57	0.00	0.00	3.57	0.00
Azadirachtin	Insecticide	0.00	0.07	0.00	0.00	0.09	0.00
Bacillus thuringiensis	Insecticide	0.48	0.69	5.68	0.80	0.59	3.71
Crop Oil	Insecticide	0.00	16.62	0.00	0.00	19.99	0.00
Cryolite	Insecticide	0.00	0.00	0.00	0.00	0.00	1.04
Dimethoate	**Insecticide**	**0.63**	**0.00**	**0.00**	**0.31**	**0.00**	**0.00**
Esfenvalerate	Insecticide	0.04	0.00	0.00	0.00	0.00	0.00
Imidacloprid	Insecticide	0.21	0.05	0.08	0.04	0.18	0.14
Methomyl	**Insecticide**	**0.00**	**0.00**	**0.00**	**2.70**	**0.32**	**0.00**
Oxamyl	**Insecticide**	**2.50**	**0.00**	**0.78**	**6.83**	**0.89**	**0.00**
Spinosad	Insecticide	0.34	0.00	0.14	0.09	0.09	0.00
Tebufenozide	Insecticide	0.00	0.07	0.83	0.13	0.00	0.14

Figure 3.1. Pepper weevil evaluations at Farm LB, Immokalee, FL, 1999-2000

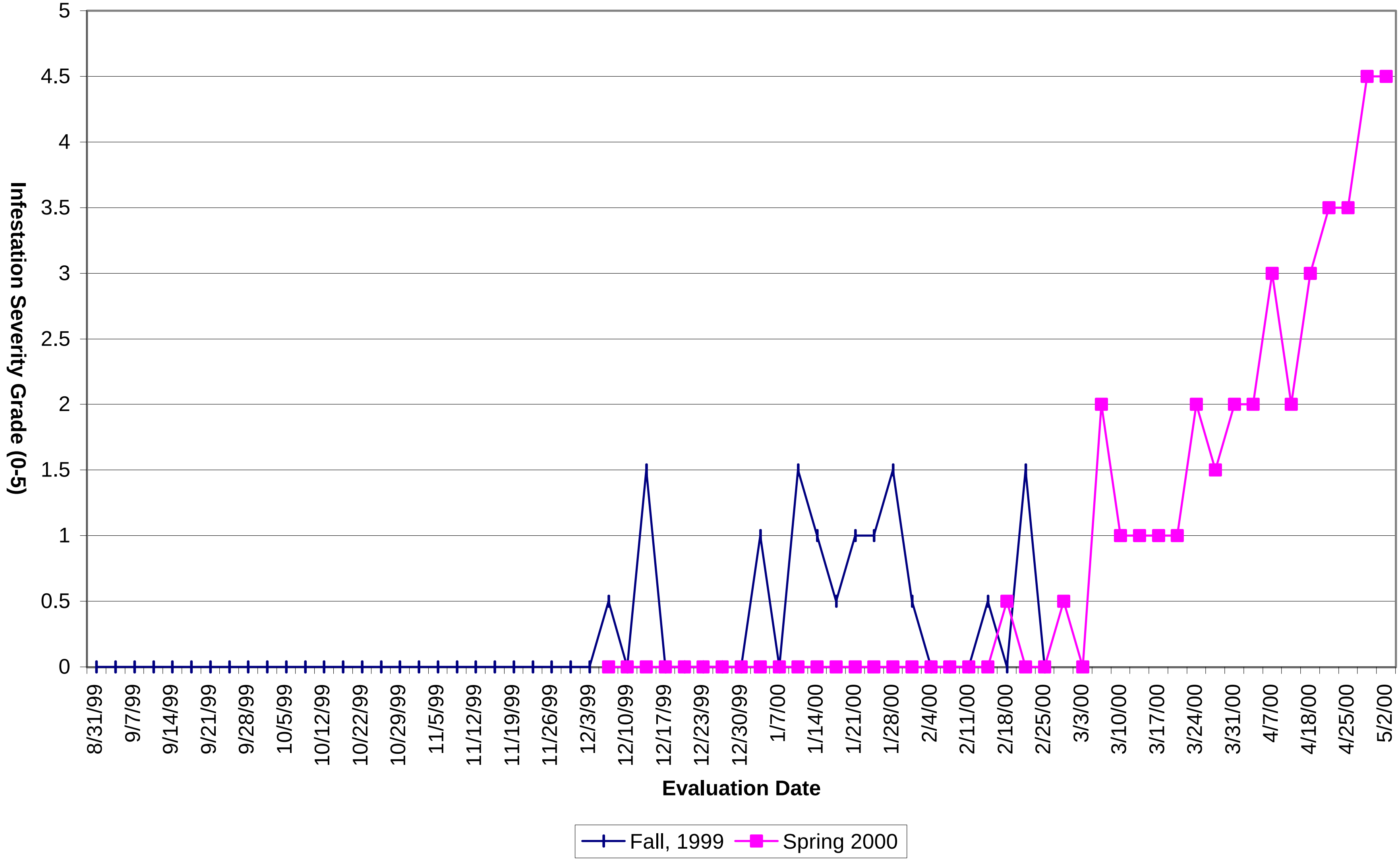

Figure 3.2. Pepper weevil evaluations at Farm ~Y, Immokalee, FL, 1999-2000

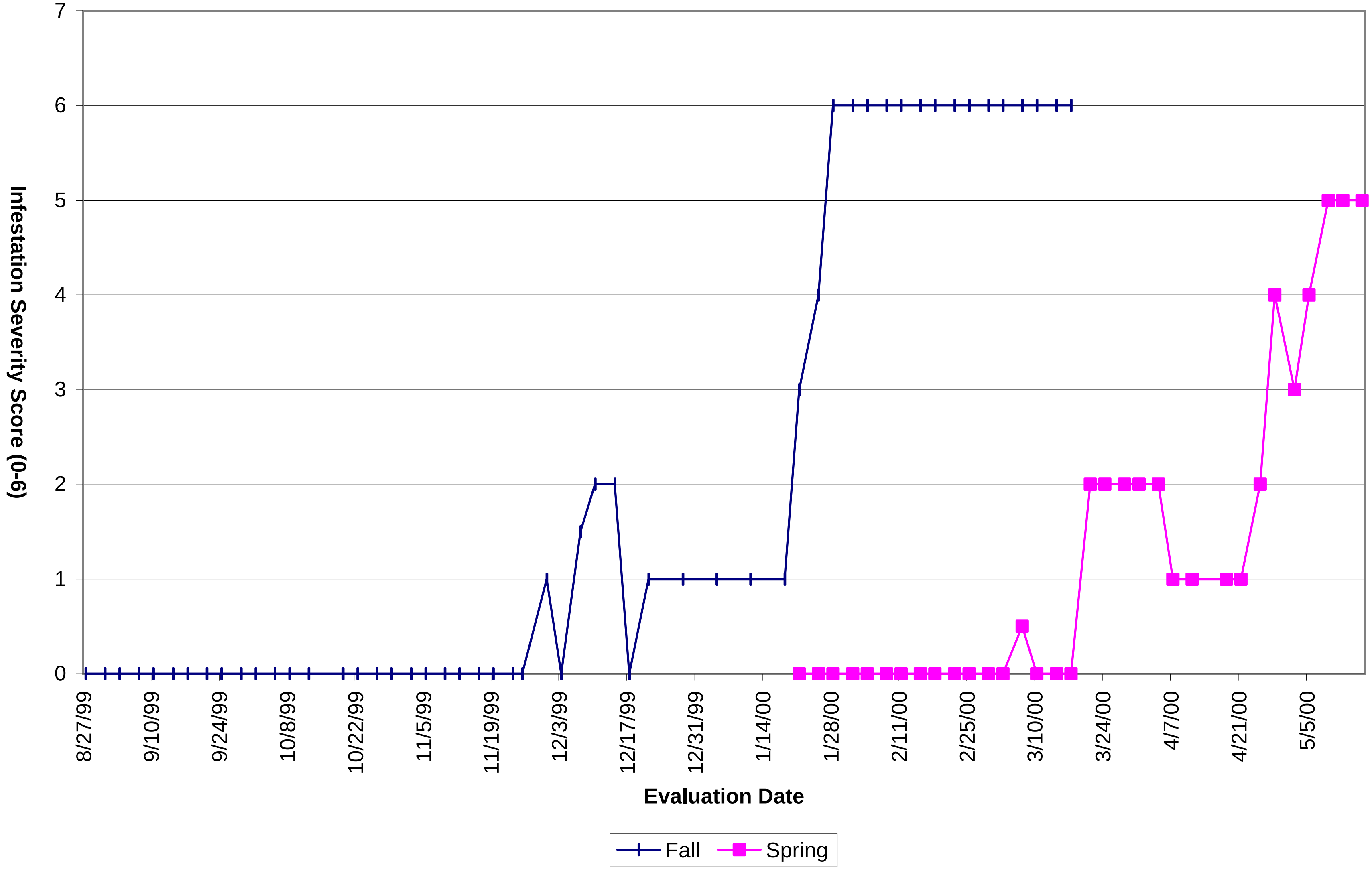

Figure 3.3. PEW Trap Captures at Farms LB and BF, Immokalee, FL, Spring 2000