

**RESISTANCE MANAGEMENT IN PINK BOLLWORM IN CALIFORNIA**

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Since 1966 the pink bollworm, Pectinophora gossypiella, has devastated the cotton in the southern desert valley growing areas of California. Losses of over one bale per acre are common and costs for insecticides average \$200 to \$300 per acre. In Southern California, instituting short season growing practices would be the best pest management strategy to control pink bollworm.

The US Farm Bill each year provided subsidy payments meant to support the cotton farmer when world cotton prices swung below production costs. However, since subsidy payments were based on an average yield over three years, to grow cotton in a short season, the individual grower would be faced initially with continued pink bollworm infestation and lower yield, which in turn would lead to lower support price income.

Although resistance to insecticides was a well-documented phenomenon, pest control operators have merely switched from less effective insecticides to newer more potent compounds and thereby kept ahead of the resistance problem. Moreover, the constant development of resistance continually created new markets for alternative insecticides, and planners merely took this into consideration in forecasting trends. This practice of planned obsolescence was only possible with a steady supply of new insecticides, a supply that no longer exists.

The pink bollworm can have five generations in one year especially in hot desert conditions (Anonymous 1984), and except for early and late season when migration is more likely to occur (Stern 1979), usually remain in a cotton crop once hostable fruiting bodies or flowers are present.

### **Yield loss due to pink bollworm**

Insecticide treatment for pink bollworm can start in June and continue until September (see Table one). The historical yield losses attributed to the pink bollworm are relatively simply to document (Table 2). Because the time immediately prior to the arrival of the pink bollworm was relatively pest-free, the loss in yield after 1965 of over a bale per acre is dramatic.

### **Control methods for pink bollworm**

There has been a minor acceptance of the use of pheromones to control pink bollworm (the so-called mating disruption technique) early in the season typically until August. This method is selective, does not affect other insects, especially beneficials, and fits ideally into a pest management program. The newer Mitsubishi Rope pheromone technique for PBW control has been studied. Results show that pheromone technology must be applied with care (Natwick and Staten 1986, Staten 1987).

The more normal method of controlling PBW, however, is as shown in Table 1. Although this example is at one extreme in that it relied on twelve treatments of one product, the pyrethroid insecticide, Pydrin (fenvalerate), the example does illustrate how one can come close to satisfying many of the conditions necessary for rapid development of resistance under existing pest control practices in the desert growing regions.

The field documented in Table 1 has exposed pink bollworm to a single product; nearly every generation was selected; the commercial dosage used was high; the entire population in this field was treated; and treatment was delivered at least part of the time before mating.

The pyrethroid insecticides are similar in their mode of action to DDT, therefore, the insects were previously exposed to a related

material, another condition contributing to rapid development of resistance. The compound used, Pydrin (fenvalerate), is photostable and has a residue life of at least several days in the field, therefore prolonged exposure no doubt contributed to resistance development.

#### **Resistance monitoring**

The pink bollworm cannot be brought into the laboratory from the field and adopted to artificial medium without substantial mortality and a great deal of effort. Therefore, a novel resistance monitoring method had to be created for pink bollworm. This method, termed the attracticide resistance monitoring method, employs Delta traps baited with pheromone that are ordinarily used for assessment of populations of male adult pink bollworms (Haynes et al 1987).

To monitor resistance of adult pink bollworm, the Delta trap was purchased without sticky adhesive. Cards trimmed to fit in the bottom of the Delta trap were smeared with a mixture of sticky material and an insecticide to be tested. Each card had a different concentration of insecticide and a series of three to five concentrations was prepared besides a control without insecticide. The series of doses were replicated for each insecticide at least one, but the more the replicates the more reliable the statistics.

Modified Delta traps with dosed cards were placed in cotton fields overnight. The traps were collected in the morning before sunrise. The cards with their trapped adult male pink bollworm were removed and stored at room temperature (21°C). After two days the number of dead moths and the total number per card were determined. These data together with the mortality of controls for each insecticide were analysed by probit analysis program (Raymond 1985). Resistance data has been collected since 1985.

### **Results of resistance monitoring of pink bollworm**

Results from the first two years of resistance monitoring on pink bollworm confirmed the expectations that resistance would eventually develop, but with some interesting exceptions. One growing area in the Imperial Valley (the area around Westmoreland, Fig. 1,W) showed about a ten-fold tolerance to the pyrethroid insecticide fenvalerate which was the highest value recorded in the United States in 1985.

It is noteworthy that other areas of the United States have not attained the same tolerance to pyrethroid insecticides. In particular the area of the Imperial valley adjacent to the Mexican border seems to have escaped the development of tolerance. We suspect this has happened because PBS migrate to a limited extent. The large mid-season populations in Mexico would tend to bleed across the border to US cotton fields to a low, but steady extent. Since the Mexican fields are not treated with pyrethroid insecticides, this would seem to serve as a source of susceptible genes to dilute the developing tolerance on the American side of the border.

The resistance value recorded in Westmoreland in 1985, was eclipsed recently in the Wuertz field of Palo Verde Valley of California where pink bollworm resistance in the overwintering population (measured in Spring 1987) reached values ten times higher than those in the Westmoreland area (Figure 2). The Wuertz value was even more remarkable in that it was recorded in early June among the overwintering individuals, and before hostable squares were available and therefore, before treatment was necessary.

Alerted to the developing resistance at Wuertz, the pest control advisor chose organophosphorus insecticides early in the season. When pyrethroids were used later, there was no sign of the resistance. The Wuertz field was in its fifth year planted to cotton; a condition well-known to exacerbate the pink bollworm problem and leading to large intrinsic populations. It was also remarkable that cotton

fields adjacent to Wuertz (two miles away) showed no resistance at all.

Monitoring resistance in pink bollworm has provided a much improved view of the trends of field populations towards tolerance. With an extensive monitoring program in place it has been possible to spot resistance problems before they cause crop damage due to insecticide failures. The hidden advantage of the resistance monitoring program is its ability to test the effectiveness of insecticides in the field and provide the grower alternative choices at the same time.

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bollworm *Pectinophora gossypiella* over Southern California.  
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**Table 1.** An example of chemical use on a cotton field in the Imperial valley in 1984 (144 acres)

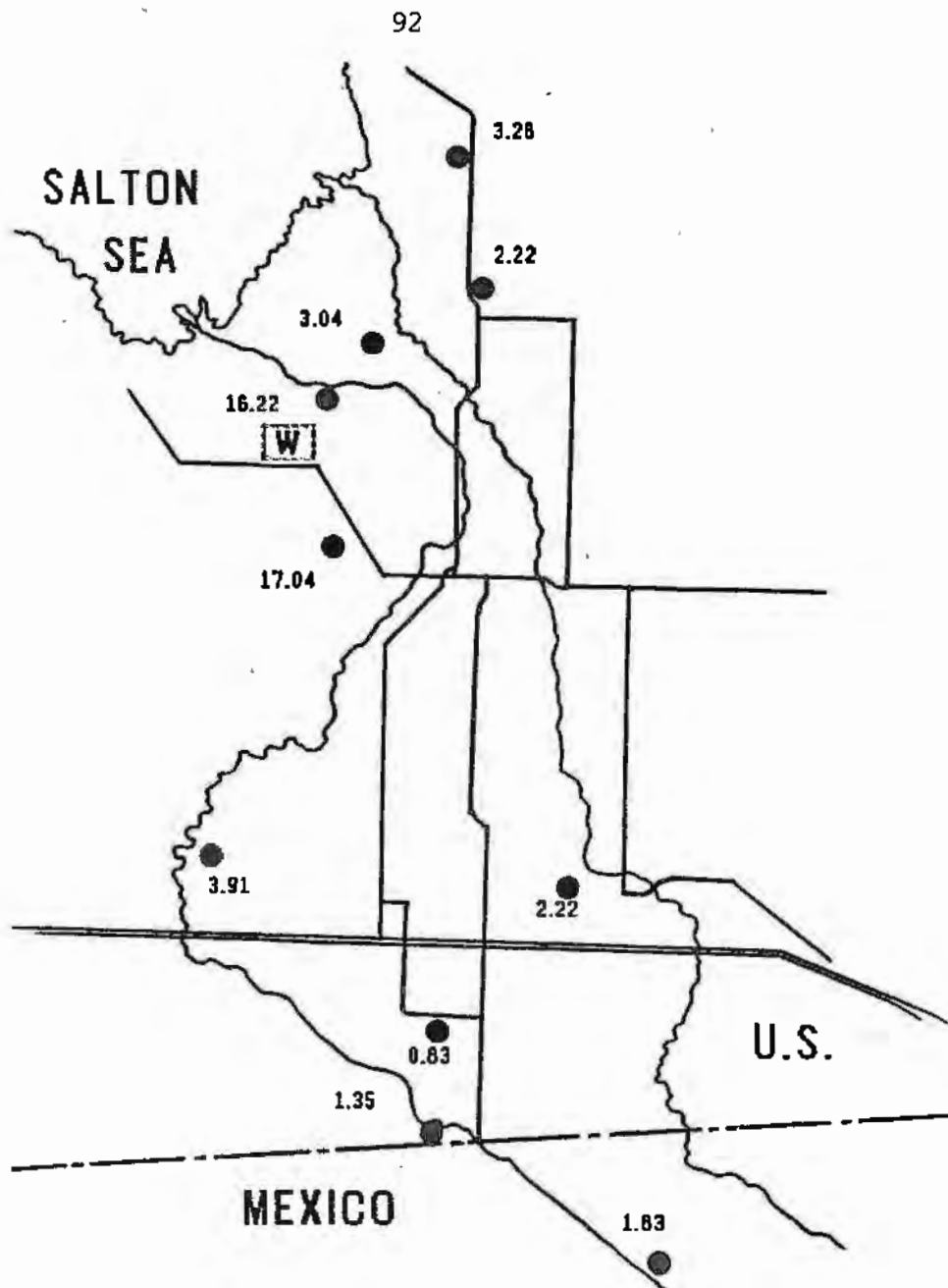
| Date        | Materials                        |
|-------------|----------------------------------|
| April 22    | Azodrin + Fertiliser             |
| May 5       | Kelthane + Fertiliser            |
| June 19     | Orthene + Fertiliser + PIX       |
| 30          | Orthene + Fertiliser + Supracide |
| July 6      | Guthion + COTE                   |
| 13          | Pydrin                           |
| 18          | Pydrin + Galecron + COTE         |
| 21          | Pydrin + COTE                    |
| 23          | Pydrin                           |
| 29          | Pydrin + Galecron + COTE         |
| August 4    | Pydrin                           |
| 8           | DEF + ISOBAC                     |
| 11          | Pydrin                           |
| 16          | Pydrin + Comite                  |
| 22          | Pydrin + PIX                     |
| 28          | Pydrin + Galecron + COTE         |
| September 2 | Pydrin + Comite + COTE           |
| 10          | Pydrin                           |
| 19          | Bolstar + Galecron               |

**Table 2.** Average yield and selective value of cotton produced in the Imperial Valley before and after the arrival of the pink bollworm in five year steps

| Years     | Bales/acre | Value (.60/lb) |
|-----------|------------|----------------|
| 1961-65   | 3.43       | \$1,029        |
| 1966-70 * | 2.25       | 675            |
| 1971-75   | 2.13       | 639            |
| 1976-80   | 2.23       | 669            |
| 1981-85   | 2.53       | 760            |

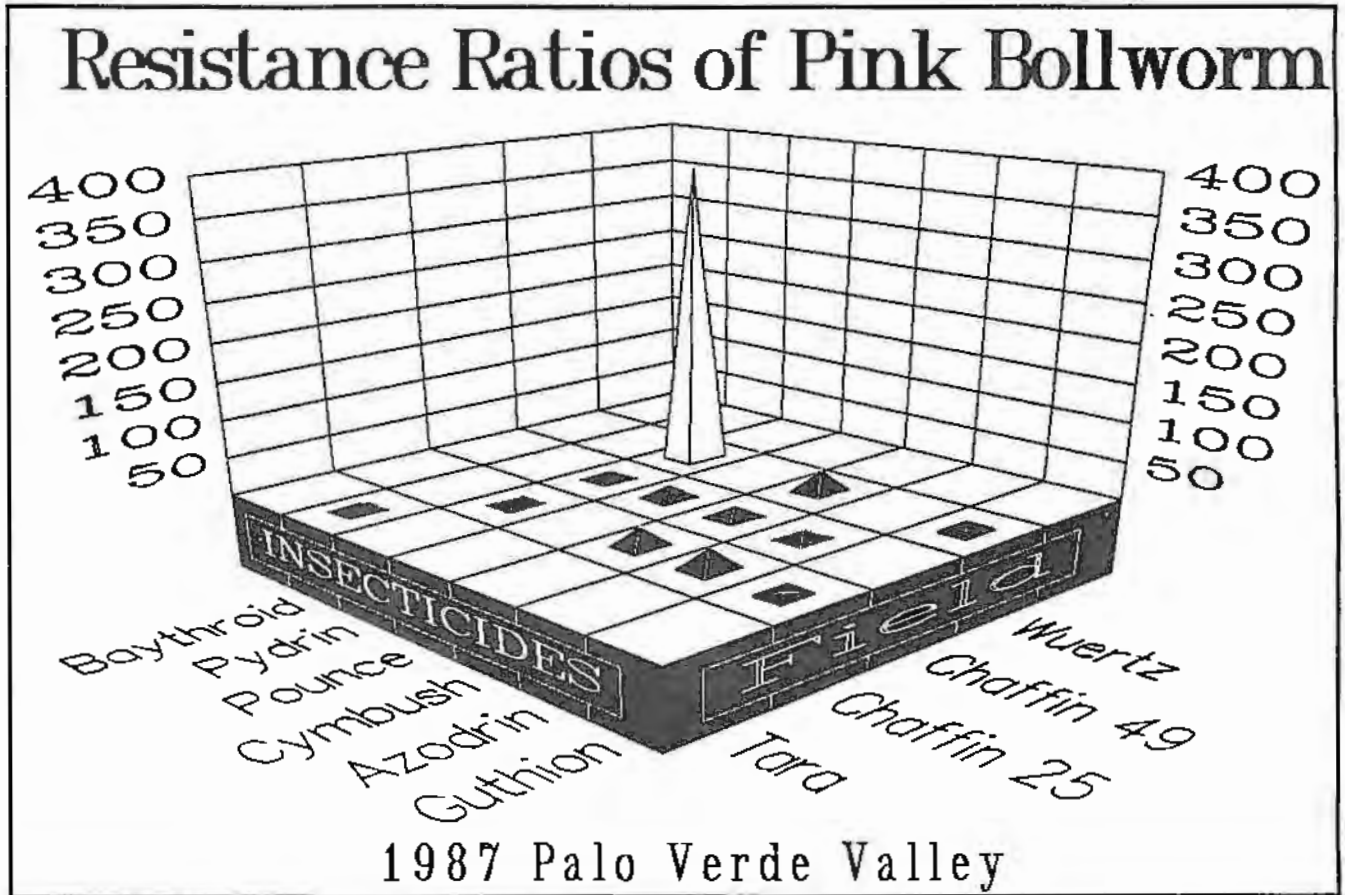
\* The pink bollworm was established by 1966.

Data from an unpublished report by R.T. Staten.



**Figure 1.**

A. Map of the Imperial Valley showing major roads and rivers, Salton Sea is upper left. Resistance ratios are given ( $LD_{50}$  field/ $LD_{50}$  susceptible) for fenvalerate on pink bollworm by the attracticide method in 1985. Values near one are susceptible. Higher values show greater tolerance to fenvalerate. Note the resistance pocket at the north west corner of the Valley; W - Westmoreland.



**Figure 2.**

Resistance ratios for fenvalerate on pink bollworm measured in the Palo Verde Valley in April and May, 1987 for several insecticides. One site (Wuertz) showed very high tolerance (nearly 400-fold) to fenvalerate. The Chaffin sites (about two miles away from Wuertz) showed values near susceptibility.

