PINK BOLLWORM POPULATION DISTRIBUTIONS IN A LARGE ACREAGE OF GENETICALLY ENGINEERED COTTON WITH REGARD TO RESISTANCE MANAGEMENT

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Abstract

This paper discusses spatial analysis of sterile and native pink bollworm (*Pectinophora gossypiella* (Saunders)) populations in the Imperial Valley of California. Native and sterile moths were monitored season-long with traps checked once per week and numbers of moths recorded. Trap locations and the geographic boundary of each field was recorded. Release of sterile moths began early in an effort to have high numbers of sterile moths in the field before native populations could develop. In the last two years, following the development of genetically modified cotton, early to mid-season releases were directed toward the conventional cotton refugia. Native moth populations typically increase dramatically in late season at which point sterile release is shifted away from refugia and onto the genetically modified cotton fields as a hedge against resistance. Sterile moths act as *pseudo-refugia* since mating of native and sterile moths produce no offspring, resistant or otherwise. We are investigating the role of sterile insects and the dispersal of refugia as resistance management tactics.

Introduction

Sterile insect technology has been used for 25+ years to prevent establishment of the pink bollworm, or PBW, as an economic pest in the San Joaquin Valley, CA (Staten et al. 1993). This is an exclusion program dependent largely on sterile insects over a very large area against targeted low level adult populations. Migration of native moths into the San Joaquin Valley from southern desert growing regions is indicated by trap catches in the desert between these two areas. In the past, sterile insect technology was not applicable against the high populations of the southern desert because releasing sufficient numbers was cost prohibitive. This scenario has changed due to the combination of significant improvements in mass-rearing technology, cost-effective pheromone technology and shifts to determinant cotton in a compressed season. In the past 6 years we have used the Imperial Valley as a large area test site to conduct exploratory programs (Staten et al., 1995,1999, Walters et al., 1995, 1998a, 1998b, 1999). Although this area does not have adequate isolation for eradication, high levels of suppression are measurable. Data was convincing enough to expand this experimental phase to the Palo Verde Valley in 1998-1999. The introduction of genetically modified cotton varieties (a *Bacillus thuringensis* endotoxin producing plant referred to here as GM cotton) made these programs even more promising. The Bt toxin is fatal to PBW and other Lepedopteran pests. However, there is a concern that the insects affected by the Bt toxin will develop resistance to it. Therefore, the US Environmental Protection Agency mandated that a percentage of a grower's cotton production must be in susceptible, non-GM, cotton. This conventional cotton acts as *refugium* in that it supports the natural reproduction of moths. Sterile insect technology, as well, may prove to be valuable in resistance management since their matings do not produce moths, resistant or otherwise. We are investigating the role of sterile insects and the dispersal of refugia as resistance management tactics.

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Materials and Methods

The Imperial Valley, CA used pheromones and sterile insects in conjunction with a well-regulated season from 1994 through 1996. Fields were monitored biweekly with a minimum of 2 Gossyplure baited traps per field. Boll samples were collected from 10 randomly selected fields from each "treatment" category. Bolls were incubated in boll boxes as in previous studies in the Imperial Valley (Chu et al. 1996). Sterile insect management and release is detailed in Pierce *et al*, 1995 with variables as per Table 1.

Pheromone treatments were used in 1997 - 1999 on all treatable refugia (<=80 GM cotton and >=20% conventional cotton). Untreatable refugia (>= 4% of the grower's total acreage) were all planted "in-field" within the Imperial Valley. 100% GM cotton fields also received sterile release. Thus, treatments were 1) Pheromone + sterile release, 2) GM cotton + sterile with untreatable, in-field refugia, or 3) 100% GM cotton + sterile release. Distribution of sterile releases was altered based on field type and ratio of sterile to native moths caught in traps. See Walters et al. 1998b for a discussion of the database/GIS decision support system.

Results and Conclusions

Geostatistical analysis was conducted on PBW population values. Geostatistics emphasizes mapping of spatially distributed populations, typical of insect populations. Geostatistics supports autocorrelations and irregular sampling patterns. Sample (trap or boll) data for PBW is often sparse and invariably occurs on irregular grids - because cotton is not planted in an entire valley, for instance.

Spatial analysis (Table 2) indicates a clumped population distribution of native PBW adult male populations trapped in the Imperial Valley, California, based on season-long, average native males/trap. Analysis showed that not all fields with refugia had higher numbers of native PBW moth catches than fields that did not have refugia. It also showed that moths were not distributed evenly within fields. It has long been observed that PBW and other moths display a strongly clumped, or discrete, population distribution (Walters et al. 1990) and that factors beyond the use of sterile insects and GM cotton affect moth biology and behavior. Further analysis of this data will include analysis of the data week by week. In addition, data from non-cotton based trap lines will be used to help separate the migratory influence from the development of the local population. We will test for a correlation between existence and proximity of refugia to native PBW numbers. Sterile insect data will be analyzed as well, using the same methods. Continued analysis will help us better understand the importance of the placement of refugia within regions planted primarily in GM cotton and the use of sterile insects as a hedge against resistance development.

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Table 1. Imperial Valley 1994 – 1999 Program Review

Year	1994	1995	1996	1997	1998	1999
Sterile Release	250	175	350	100	100	50
Pheromone Treatment	Rope + MEC	Rope + Fiber	Rope + Fiber	Rope	Rope	Rope

Notes: Sterile Release = average number of moths per acre per day, calculated on a 7 days per week basis. Delivery was on a 6 day a week basis for 1994-1996 and on a 3-day per week basis for 1997-1999.

Table 2. Spatial Analysis for Imperial Valley trap data, for the entire 1999 season (averaged per trap). The first pass through the data, using ArcView®, Spatial Analyst® and S-Plus®, produced the following statistics.

Spatial Autocorrelation Analysis for the Average of Native Moths/trap, season long
Statistic = Geary, Sampling = free Correlation: 0.535 Variance: 0.007092 Standard Error: 0.08421 Normal Statistic: -5.521 Normal --value (2-sided): 3.362e-8 Null hypothesis: no spatial autocorrelation
Spatial Autocorrelation Analysis for the Average of Sterile Moths/trap, season long.
Statistic = Geary, Sampling = free Correlation: 0.7742 Variance: 0.007092 Standard Error: 0.08421 Normal Statistic: -2.682 Normal --value (2-sided): 0.007327 Null hypothesis: no spatial autocorrelation