RISK ASSESSMENT MODELS FOR PINK BOLLWORM ESTABLISHMENT IN SOUTHEASTERN US COTTON

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Abstract

Pink bollworm (PBW), *Pectinophora gossypiella* (Saunders) remains a serious pest of cotton worldwide and in the southwestern US. This project strives to determine the extent that PBW can invade and establish economic infestations in cotton producing areas within the southeastern US. As part of the risk assessment, we first identify regions or states where survival and reproduction of PBW is most likely. Climate matching software (CLIMEX) was used for three independent analyses to determine where PBW might establish and which environmental factors (i.e., extreme heat, cold, drought, or moisture) might prevent establishment. The three methods gave similar results. In the southeast, climatic conditions in Florida, Louisiana, and South Carolina are most suitable for PBW establishment. Within the region, establishment may be prevented by cold stress towards the north and wet stress towards the southeast.

Introduction

In the absence of strict prevention and eradication campaigns, establishment of pink bollworm (PBW), *Pectinophora gossypiella* (Saunders), in all cotton producing regions of the US was once taken for granted (Curl, 1938). Since 1917, when the pest was first detected in the US, populations have spread from Texas to California. Despite infrequent outbreaks of PBW in Florida, Georgia, Louisiana, and Missouri, PBW has been unable to establish economically damaging populations in the midsouthern or southeastern regions of the country. Eradication efforts from the 1930's-1950's may have prevented establishment, and on-going monitoring and spot-eradication programs may keep PBW out of these regions. However, prevention programs can be costly, and may be unnecessary, particularly if climatic constraints limit the probability of establishment. We propose a three tiered approach to assess the probability that PBW will establish in the southeastern US: 1) climate matching; 2) reproduction assessment (Net Reproductive Performance; Venette, 1997); and 3) detailed simulation (PBWSIM; Hutchison, 1988). The first of these analyses are reported herein. Using climate matching software (CLIMEX) and the geographic information system, ArcView 3.0, we generated a first approximation of the areas that are at greatest risk of being invaded by PBW.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1226-1228 (1998)
National Cotton Council, Memphis TN

CLIMEX was used in three ways to assess environmental suitability for establishment of PBW in the southern US. Two methods were employed to develop stress-response functions for hot, cold, wet and dry conditions. First, parameters for stress functions were systematically altered until the predicted distribution matched know occurrences of PBW within a "test" region, Africa. Second, stress functions for the fore mentioned environmental conditions were derived from data given in literature reports. For both analyses, "stress" was the degree of mortality per week. An Environmental Index reflecting the potential for population growth given the degree of cold-, heat-, wet-, and dry-stress was determined for each of 189 weather stations located throughout North America. We also compared the similarity of climates in the US where PBW is known to occur to other regions of the US. All analyses assume that the pest can or will be introduced into all regions of North America.

Discussion

Parameters for stress functions generated by matching the predicted with the known African distribution of PBW suggest that cold temperatures (<6.5°C) and extremely dry soils (<4.0% of moisture holding capacity [MHC]) increased the rate of PBW mortality. High temperatures (>45°C) and saturated soils (>120% of MHC) were equally detrimental to, but had less effect on, PBW survival. From the data presented by Graham *et al*. (1967), temperatures above 37.5°C and below 13.5°C caused significant increases in the mortality rate. Based on data from Richmond and Clark (1965), mortality increases when soil moisture exceeds 65% of MHC. From Chapman and Cavitt (1934), stress increases, albeit at a remarkably low rate, as soil moisture falls below 15% of MHC. Both sets of stress functions applied to prevailing conditions at 189 weather stations suggest that cold and wet stresses constrain the US distribution of PBW.

Climatically, Georgia, Florida, Louisiana, and South Carolina are 50% or more similar to regions known to be infested with PBW (Fig. 1). Other areas in the south tend to be colder and/or wetter than locations in the southwest US where PBW occurs.

The three methods of measuring climatic suitability yielded similar results. In much of the southern US, moist soil conditions and cold winter temperatures preclude PBW survival and reproduction (Figs. 2,3). Establishment of PBW is most likely in Louisiana, Florida, and South Carolina. Unfortunately, the effects of extreme cold and/or wet conditions on PBW demography are not well described in the literature. The limited data that are available may not reflect any selection/adaptation that may have occurred in US populations of PBW since 1917 (Watson *et al*., 1974). Accounting for differences among geographic strains as well as the effects of other ecological and pest-management

stresses will improve the resolution and accuracy of future risk assessments.

Summary

Based on three independent analyses of the climatic suitability for establishment of PBW in the southeastern US, environmental conditions in Louisiana, Florida, and South Carolina are most likely support the reproduction and survival of the pest. Conditions in other parts of the southeast were too wet and/or cold for the pest to establish. Additional laboratory studies to investigate the effects of constant, cold temperatures and wet moistures are planned to improve the rigor of the risk assessment. The severity of potential infestations in these areas will be forecasted in future analyses using a detailed process-oriented simulation model (PBWSIM; Hutchison, 1988).

Acknowledgements

This research was supported by USDA APHIS-PPQ and Cotton Inc.

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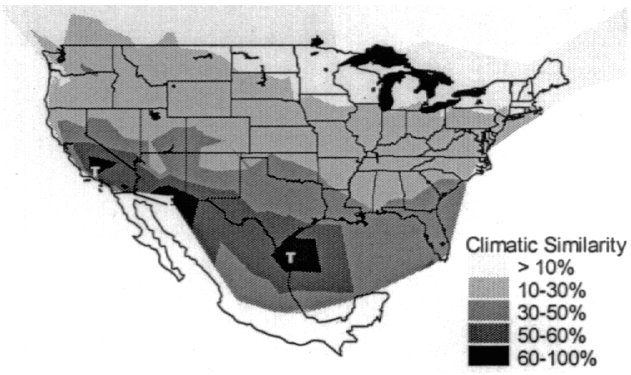

Figure 1. Similarity of climate in PBW-infested regions (Bakersfield CA, Tucson AZ, and Brownsville TX) to other regions in North America

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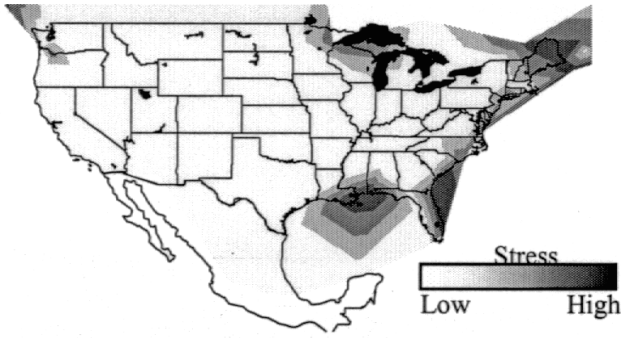

Figure 2. Degree of wet stress likely to be experienced by pink bollworm if introduced throughout North America. Wet-stress function derived from data in Chapman and Cavitt (1934).

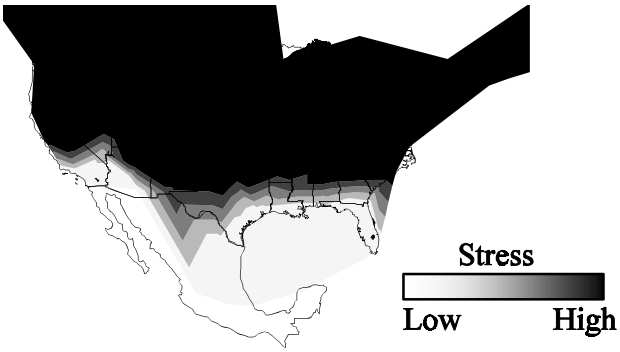

Figure 3. Degree of cold stress likely to be experienced by pink bollworm if introduced throughout North America. Cold-stress function derived from data in Graham *et al*. (1967).