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Why Do Mississippi Delta and Hills Populations of Tarnished Plant Bugs (Hemiptera: Miridae) Impact Cotton Differently?

Report

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Abstract

Tarnished Plant Bug, *Lygus lineolaris,* is a serious pest of cotton in Mississippi, but damage to cotton and costs for control are not the same in the two cotton growing regions of Mississippi. Economic losses to *L. lineolaris* are higher in the Delta region than in the Hills region. Reasons for the differences may be due to the differences in the landscape between the two regions. The Hills region is a more heterogeneous landscape than the Delta and this difference may affect insecticide resistance rates, levels of beneficial insects and pathogens, and movement of *L. lineolaris*. This report discusses these differences and their effects.

Keywords: landscape ecology; landscape heterogeneity;

Introduction

Tarnished Plant Bug (TPB), *Lygus lineolaris,* (Palisot de Beauvois) (Hemiptera: Miridae) is currently the most damaging and costly pest of cotton in Mississippi. It has been one of the three most costly insect pests of cotton in Mississippi since 1979 and since about 2003 has been the most costly insect pest of Mississippi cotton. Since 2004 *L. lineolaris* damage and insecticides costs have cost Mississippi growers approximately $150 per hectare annually for the years 1979 through 2012 (Williams 1979-2012).

Economic losses to cotton due to *L. lineolaris* feeding are not uniform across Mississippi. Since 1986 Mississippi statewide cotton insect losses have been separated into two regions, the Delta and the Hills. The Delta region is an alluvial flood plain of the Mississippi River that occupies most of western Mississippi from approximately Vicksburg north to the Tennessee state line. The Hills region, for the purpose of the cotton insect loss data, is the rest of the state. However, most cotton production in the Hills region occurs east of state highway 9 and north of state highway 14, so data referring to the Hills in this paper primarily will be drawn from this portion of the Hills region. The data from the annual cotton crop losses suggests *L. lineolaris* is a more serious pest in Delta cotton than Hills cotton based on the number of insecticide applications used, average dollar amount of cotton lost to *L. lineolaris* feeding, and average total cost of insecticides and damage losses. The number of insecticide applications to Delta cotton for *L. lineolaris* has been about 3.1 fold greater than the number of applications in the Hills during the last 26 years. The average amount of cotton lost to *L. lineolaris* in the Delta has been about 2.5 fold greater in the Delta than in the Hills. Finally, the total loss (damage loss + insecticide cost) to Delta cotton growers has been about 3.7 times greater than the total loss to cotton growers in the Hills (Williams 1979-2012).

Recent data have shown some biological differences between populations of *L. lineolaris* from these two regions. Adams (2012), using field-collected colonies reared in a laboratory, found the number of days to 4^{th} instar, 5^{th} instar, and adult development for *L. lineolaris* reared on cotton to be slower for colonies from the Hills than for the colonies from the Delta. Adams (2012) also found that *L. lineolaris* females from colonies from the Delta laid more eggs than females from colonies from the Hills and that the eggs from females from the colonies from the Delta had a higher percentage of viable offspring than the eggs from females from colonies from the Hills. This is the only known evidence of biological differences between *L. lineolaris* from the two regions.

While these biological differences in colonies from the Delta and Hills could lead to greater losses in the Delta than in the Hills, it is unlikely these changes are solely responsible for observed differences in cotton losses. Additional widely accepted explanations for the difficulty in managing *L. lineolaris* in the Delta are based on insecticide resistance evolution and changes in insect pest management resulting from boll weevil eradication and the introduction of Bt transgenic cotton plants to manage lepidopteran pests. Consideration must also be given to landscape differences between the Delta and Hills regions of Mississippi. This paper discusses impacts of insecticide resistance, changes in pest management due to the boll weevil eradication program and Bt cotton plants, as well as how differences in landscape ecology of the two regions impact the pest status of *L. lineolaris*.

Impact of the Insecticide Resistance

Insecticide resistance in *L. lineolaris* was first reported in 1980 (Cleveland and Furr 1980) and has been reported for organophosphate, pyrethroid, and carbamate insecticides (Cleveland and Furr 1980, Cleveland 1985, Snodgrass and Scott 1988, Snodgrass 1994, Snodgrass and Elzen 1995, Snodgrass 1996). There is, however, no record of insecticide resistance occurring in the Hills populations of *L. lineolaris*. This may explain why *L. lineolaris* has been a more serious pest in the Delta than the Hills for many years. Insecticide resistance evolution may have increased as a result of the boll weevil eradication program which began in the Hills in 1997 and the Delta in 1998 (National Cotton Council 2013). During this program every hectare of cotton was sprayed with ultra-low volume (ULV) malathion an average of seven times during the late summer to early fall of the first year of the program and additional applications were made as boll weevils were found in monitoring traps in following years (USDA-APHIS 2007). This large number of insecticide applications may have hastened insecticide resistance evolution in *L. lineolaris*. Published data seem to indicate that boll weevil eradication did lead to increased *L. lineolaris* resistance to malathion and other organophosphate insecticides (Snodgrass and Scott 2003).

Impact of Bt Cotton and Boll Weevil eradication

Based on the data of Williams (1979-2012) the number of insecticide applications for *L. lineolaris* increased in Mississippi beginning in 2001. From 2001 to 2012, the number of insecticide applications in MS cotton targeting *L. lineolaris* exceeded two every year, while in the period from 1986-2000, there was only one year (1996) with more than two applications per cotton acre (Williams 1979-2012). The reason for this increase may have as much or more to do with the introduction of Bt cotton and boll weevil eradication as it does with insecticide resistance. Bt cotton was introduced in 1996 and by 2001 was planted on 80% of Mississippi cotton acres, and the last insecticide applications by farmers targeting the boll weevil were in 1999 (Williams 1979-2012). These changes in cotton pest management resulted in less insecticide usage for control of boll weevil and lepidopteran pests which may have reduced incidental control of *L. lineolaris* populations, thus allowing *L. lineolaris* populations to grow and increase in their importance as a pest. Data from Williams (1979-2012) indicates that in the Delta and Hills the number of insecticide applications targeting these pests from 2000-2005 (after these changes in pest management) were 1 and 0.6, respectively compared to the number of applications targeting these pests from 1990-1995 (before these changes in pest management) which was 6 and 8.8, respectively. These data also indicate a 1.7 and 1.2 fold increase in the number of insecticide applications for *L. lineolaris* in the Delta and Hills, respectively, for these same time periods.

While boll weevil eradication and Bt cotton adoption likely account for increases in insecticide applications targeting *L. lineolaris* across Mississippi, both of these changes occurred in both Delta and Hills regions, so they do not explain why *L. lineolaris* is a more serious pest in the Delta than in the Hills. Before these changes in management (1990-1995), Delta cotton was sprayed 1.8 times more often for *L. lineolaris* than cotton in the Hills. After these changes in cotton pest management (2000-2005), the number of insecticide applications for *L. lineolaris* in the Delta was 2.6 fold higher than in the Hills (Williams 1979-2012).

Differences in Delta and Hills Landscapes

Thus far this paper has discussed the impacts of insecticide resistance, boll weevil eradication and Bt cotton on *L. lineolaris* in Mississippi cotton. However, none of these factors explain why the Delta and Hills populations of *L. lineolaris* impact cotton differently. A look into the differences in the landscape of these two regions may hold a key to understanding the differences in *L. lineolaris* densities in cotton in these two regions.

The Mississippi Delta is an alluvial flood plain of the Mississippi River comprised primarily of large, row-crop agriculture fields. The Mississippi Hills region is a variable geographic region composed of a mixture of hardwood and pine forests, row-crop agriculture fields, open/fallow land, and pasture or forage crop fields. The Hills region has a more diverse landscape with approximately 45% of land in forestry, 20% in row crop agriculture, 30% in other herbaceous plants, and 5% urbanized or non-herbaceous. This is compared to 2% in forestry, 55% in row crop agriculture, 35% in other herbaceous plants, and 7% urbanized or non-herbaceous in the Delta (Fry et al. 2011). The differences in landscapes between the two regions may impact *L. lineolaris* populations by impacting the rate of insecticide resistance evolution, populations of predators or parasitoids, movement from field to field, and perhaps other factors that have not yet been explored.

The more limited insecticide exposure to the overall Hills *L. lineolaris* population may be a reason that Hills populations of *L. lineolaris* do not impact cotton as much as the Delta populations do. The more diverse landscape of the Hills provides the Hills population of *L. lineolaris* with many potential habitats that are mostly insecticide free compared to Delta populations. A larger proportion of the Delta population of *L. lineolaris* resides in row-crop habitat and is more frequently exposed to insecticides than the Hills population. The lower selection pressure from insecticides in the Hills allows for a continual mixing of a large amount of non-exposed *L. lineolaris* back into the populations in cotton, whereas in the Delta the non-exposed proportion of the population is much smaller, thus insecticide resistance can develop at a faster rate.

The more diversified ecosystem of the Hills probably also provides a benefit to parasitoid and predatory insects that may utilize *L. lineolaris* as hosts. This could occur in two ways. First, not only are Hills populations of *L. lineolaris* exposed to less insecticide, but the predatory insects and parasitoids have more habitat to avoid insecticides as well, thus not having their populations suppressed below a level to help maintain *L. lineolaris* populations at manageable levels. The second benefit is the more diverse habitat of the Hills may enhance beneficial insect populations. Research has shown that isolation of crop fields, age of fields, frequency of disturbance, amount of field management, complexity of the landscape, and weed control can have varying degrees of impact on predator/parasitoid diversity, crop yields, and pollinator populations (Ali and Reagan 1985, Carvalheiro et al. 2011, Duelli et al. 1999, Di Giulia et al. 2001, Fahrig and Jonsen 1998, Menalled et al. 1999). Though natural enemies are not reported to provide much control of *L. lineolaris* in southern agriculture landscapes, these differences in the two regions will likely increase the differences in pest pressure observed in each region.

The landscape differences between the two regions could also affect the movement of *L. lineolaris* from field to field. The Delta is a relatively open area with little to no barriers, such as trees or high shrubbery, to limit insect movement;whereas the Hills is a highly varied landscape with large patches of trees and high shrubbery around parts of most fields. Research has shown that habitat fragmentation can impact insect populations by changing the movement patterns of species, species present, populations, and overall trophic processes (Klein 1989, Aizen and Feinsinger 1994, Golden and Crist

1999, Collinge 2000, Valladares et al. 2006). Effects of fragmented Hills landscape could be slowing or preventing the movement of *L. lineolaris* populations from wild hosts to cotton, or it could be having an effect on the relation of *L. lineolaris* with associated insects such as predators and parasitoids that may benefit from the fragmentation. If fragmentation does reduce populations of *L. lineolaris* in cotton in the Hills through limiting *L. lineolaris* movement to new hosts, then lack of fragmentation in open Delta would allow *L. lineolaris* easier movement between fields and a better ability to find new hosts, thus building higher densities in Delta fields than observed in Hills fields.

Conclusion and Importance

Boll weevil eradication and the introduction of Bt transgenic cotton plants may have played a role in increased severity of *L. lineolaris* damage to cotton and increase in number of insecticide applications to control them. These two factors however, do not explain the differences in the Delta and Hills regions. Differences in the landscape between the two regions coupled with insecticide resistance likely explain the differences in the Delta and Hills populations of *L. lineolaris*.

Little, if any research has been conducted evaluating factors that effect *L. lineolaris* in relation to landscape differences. Differences seen between the Delta and Hills regions seem to indicate that a landscape effect is driving the differences seen in the impact of *L. lineolaris* on cotton in the two regions. Research needs to be conducted to quantify the landscape differences of the two regions and to determine what effect these differences have on, not only *L. lineolaris*, but on overall agricultural and insect ecosystems. This research would probably reveal a large amount of new information about non-crop oriented aspects of *L. lineolaris*, along with new information onmovement of *L. lineolaris* from non-crop or row-crop areas to cotton.

Understanding the reason for the differences between these regional populations could result in new understandings of *L. lineolaris*. This new knowledge could then be used to develop new integrated pest management techniques, such as cultural control through landscape management that could be utilized to reduce the amount of insecticide necessary to control *L. lineolaris* in the Delta region and perhaps other similar regions around the country. New management techniques, not relying as heavily on insecticides, are more important today than ever before. As more pressure is put on the agricultural industry to conserve the environment, new knowledge, such as insect-landscape ecology, will be important in maintaining the balance between having a sufficient food and fiber supply and environmental equilibrium.

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