AREA-WIDE MANAGEMENT OF THE TARNISHED PLANT BUG BY REDUCTION OF EARLY-SEASON WILD HOST PLANT DENSITY

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ABSTRACT

An experiment was conducted in Sunflower and Washington Counties in the Delta of Mississippi in 1998 that evaluated control of tarnished plant bugs (TPB), *Lygus lineolaris* (Palisot de Beauvois), in cotton, *Gossypium hirsutum* L., by reduction in numbers of wild host plants found near fields with herbicides in April. Four experimental areas (three check areas and one treated area) each approximately square and 4.8 km on a side were used. Marginal areas at least 100 m in length around ditches, fields, and roads with good stands of wild hosts in all four experimental areas were chosen for treatment and/or sampling. Wild host plant densities in the sample areas in the four experimental areas were not significantly different in pre-treatment counts. Treatment of the sample areas with a combination of mecoprop + 2, 4-D + dicamba at 1.55 + 0.54 + 0.17 kg AI/ha significantly reduced host plant density as compared to host plant density in the check areas. TPB populations on wild hosts in the sample areas were numerically higher in the treated area than they were in the three check areas prior to application of the herbicides. TPB populations in the treated sample areas declined 4.1-fold as compared to TPB populations found in the sample areas in the three check areas, when sampled 2-3 weeks after treatment. Small areas with good stands of plant hosts were also spot-treated with glyphosate, but these areas were not sampled. In the treated experimental area, an estimated 28.7 ha of marginal areas with wild host plants were present, and 7.9 ha (27.5%) were treated with the two herbicides. Cotton fields were sampled weekly in the treated area (14 fields) and three check areas (33 fields) for TPB from the 2nd week in June through the 1st week of August. TPB numbers found in the cotton were very low and no effect on TPB numbers found in cotton in the treated area could be detected.

INTRODUCTION

Hosts of the tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beauvois), include more than 300 wild and cutivated plant species (Young 1986). In the delta region of the mid-south in Arkansas, Louisiana, and Mississippi 169 host plant species have been found, most of which are weed species (Snodgrass et al. 1984). The presence of weed hosts in the spring allows TPB populations to increase before moving into cotton, *Gossypium hirsutum* L., which is the main crop in the mid-south damaged by TPB (Tugwell et al. 1976, Cleveland 1982, Snodgrass et al. 1984). Cotton is most susceptible to damage early in its growth prior to the opening of its flower buds (Scales and Furr 1968, Hanny et al. 1977); however, damage can occur at any time

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prior to fruit maturity. TPB are controlled in cotton almost exclusively with insecticides, and are considered to be a key early season pest of cotton in the mid-south (Scott et al. 1985). When boll weevil, *Anthonomus grandis* Boheman, eradication has been completed in the mid-south, TPB could be the main early season pest of cotton in this area in most years. Treatment of cotton in early season with insecticides for TPB control could negate many of the benefits dervived from boll weevil eradication. Control methods for TPB not solely based on insecticides are badly needed. Area-wide management aimed at reducing numbers of TPB that move into cotton has never been tested.

The delta region of the mid-south is intensively farmed and only a small area of the land is undisturbed by agriculture. Wild hosts of the TPB are mostly restricted to marginal areas around fields or ditches or along roads. Snodgrass et al. (1991) found that these marginal areas comprised only 2.4% of the land in a 6.4 km square area of Washington County, Mississippi. Eliminating broadleaf host plants with herbicides or by mowing would be economically feasible in such a small area. Destruction of broad leaf weeds would also reduce the amount of *Geranium dissectum* L. and *G. carolinianum* L., which are the main wild hosts utilized by F_1 bollworm, *Helicoverpa zea* Boddie, and tobacco budworm, *Heliothis virescens* (F.) in the mid-south (Stadelbacher 1981).

Fleischer and Gaylor (1987) thought that management of selected growth stages of selected host species over a short time frame might result in effective area-wide programs for TPB in heavily cropped agroecosystems such as the Highland Rim area of Alabama. They singled out daisy fleabanes *[Erigeron annuus* (L.) Persoon and *E. strigosus* Muhlenberg ex Willdenow], as having the densest populations of TPB during the time cotton was in an early square growth stage, and thought that management of the two fleabanes could affect TPB populations in cotton in the Highland Rim area. Fleabane was also thought to be the most important host that influenced early season TPB populations in cotton in the delta of Arkansas (Tugwell et al. 1976) and Mississippi (Cleveland 1982). Both species of fleabane (*E. annuus* and *E. strigosus*) bloom and are attractive to TPB in May and June in the mid-south and are reproductive hosts for F_1 adults produced on other wild hosts in March and April. An area-wide program for control of TPB that destroyed wild hosts utilized by F_1 adults would kill nymphs and eggs laid in the hosts, but the adults would move to other hosts. Reproductive adult TPB can live an average of 54.8 d in the laboratory when reared at 70°F (Bariola 1969), and adults from hosts destroyed in May could move into cotton when square production begins in June. A better approach would be to target the host plants on which the F_1 adults are produced in March and April. A broad leaf herbicide used in March or April would destroy these hosts in bloom and seedlings of hosts used by F_1 adults in May and June. In the mid-south the most abundant reproductive hosts utilized by overwintering adults during March and April are henbit, *Lamium amplexicaule* L.; vetch, *Vicia angustifolia* Reichard; fleabane, *E. philadelphicus* L.; sour dock, *Rumex crispus* L.; shepherd's-purse, *Capsella bursa-pastoria* (L.); cutleaf geranium, *Geranium dissectum* L.; cutleaf evening-primrose, *Oenothera laciniata* Hill; showy evening-primrose, *O. speciosa* Nuttall; and spotted burclover, *Medicago arabica* (L.) Hudson (Snodgrass et al. 1984).

An experiment designed to evaluate whether or not TPB could be controlled in cotton by reduction of numbers of wild host plants in marginal areas around fields in April was conducted in Washington and Sunflower Counties in the Delta of Mississippi in 1998. Treatments were applied only to areas with good stands of hosts that could easily be identified by growers who wanted to implement such a control program. Results from the 1st year of a three-year experiment are presented in this manuscript.

MATERIALS AND METHODS

The experiment was conducted in 1998 in Sunflower and Washington Counties in the Delta of Mississippi. Four approximately square test areas 4.8 km on a side were used in the test. In one area (treated area) herbicides or mowing treatments were used in the 3rd and 4th wks of April in marginal areas by fields, ditches, and roads which had the best stands of wild host plants. The other three test areas were checks and received no mowing or herbicide treatments. Three of the test areas were located in Washington County, with the treated area located just west of Tribbett and one check area 1.0 km due south of the treated area. A 2nd check area was just east of Hollandale. The 3rd check area was 2.6 km east of the treated area near Kenlock in Sunflower County. Herbicides were applied with a John Deere® 2355 tractor (John Deere Co., Moline, IL) fitted with a 18.3 m spray-boom having 36 cone 2x nozzles, and calibrated to deliver 43.2 liter/ha at 13.6 kg/cm^2. A John Deere bushhog (Model 609, 1.8-m-cut) was also used with the tractor for mowing treatment. Herbicides used were glyphosate (Roundup Ultra RT®, Monsanto Co., St. Louis, MO) and a combination of mecoprop, 2, 4-D, and dicamba (Trimec®, PBI/Gordon Corp., Kansas City, KS) . Use rate for Trimec was 1.55 + 0.54 + 0.17 kg AI/ha for mecoprop, 2, 4-D, and dicamba, respectively, and it was applied with the tractor to most treated areas to kill broad leaf weeds but not grasses. Glyphosate was applied as a spot treatment to small areas with dense stands of hosts using an all terrain vehicle (Honda Foreman®, Honda, Inc., Marysville, OH) fitted with a hand-held wand spray system (Bell Manuf., Inverness, MS). Its use rate was 2.2 kg AI/ha. Treatments were applied during the 3rd and 4th weeks of April.

Each of the four test areas was divided into approximately equal quadrants for sampling purposes. Marginal areas with good stands of wild hosts extending at least 100 m in length were identified and located on aerial maps of the four test areas. These maps were obtained from the Geographic Information Satellite Center at the Delta Research and Extension Center, Stoneville, MS. The identified marginal areas with good hosts were used for sampling TPB and to determine host plant species and densities. All of these marginal areas in the treated area were treated with Trimec, except for one area which was closely mowed (within 1.25 cm of the ground). Quadrants in all of the four test areas contained from one to five of these sample areas. Samples were taken at four locations within each sample area. The distance from the beginning of each sample area to the first sample location, and distances between each sample location, ranged from 5 to 25 m and were selected at random. At each sample location, a rope 7.62 m in length marked in 0.31-m- intervals was placed lengthwise through the middle of the area of wild hosts being sampled. The width of the sample area varied, since it extended from a ditch to a field edge, or road edge to field or ditch edge, or field edge to adjacent field edge. The width of each sample area was determined at each end and near the middle of the rope using a Wheel-Roadrunner® (Model RR418, Keson Co., Neperville, IL). These width measurements were used along with length measurements from the maps in the treated area to estimate the total area treated. Width measurements were also taken from all other marginal areas with host plants (non-treated areas) in the treated area to estimate the area occupied by these untreated hosts. These were also taken with the Wheel-Roadrunner at intervals of 150 m or less. Wild hosts within the area were sampled with a sweep net and the numbers of TPB adults and nymphs captured were counted and recorded. No effort was made to separate the numbers of TPB captured by host since the hosts usually occurred mixed together. The number of sweeps taken was recorded for each sample. Sweep net sampling was performed prior to taking width or plant density measurements to avoid disturbing TPB on the hosts in the sample area before the hosts were sampled. Host plant density was determined by counting the broad leaf plants known to be hosts found within a wire ring which encompassed an area of 0.25 m^2. Counts were recorded by plant species and were taken at four places along the 7.62 m rope by random selection of four

of the 25 distances marked at 0.31- m-intervals along the rope. The ring was laid beside the rope at each distance selected and the counts were taken. Placement of the ring on the left or right side of the rope was also selected at random for each of the four counts. Sampling to determine host plant density and TPB populations on wild hosts were taken in all four test areas during the 1st two weeks of April and again after the treatments were applied in the treated area during the 2nd and 3rd weeks of May.

Cotton fields in all four test areas were sampled for TPB each week beginning in the 2nd week of June and ending in the 1st week of August. All cotton fields in each quadrant of each test area were located and identified on maps. Approximate field size was determined by counting the number of rows in each field and by measuring field length with the odometer of a truck. Sample fields were chosen at random each week from each quadrant. A total of 14 out of 30 fields were sampled in the treated area while 33 out of 75 fields from the three check areas were sampled in most weeks. Sampling was done by sweep net, and each sample was 10 sweeps with a standard (38-cm diam.) sweep net swept back and forth across a single row of cotton. Number of samples taken was determined by field size and varied from 10 to 100. Numbers of TPB adults and nymphs captured were recorded in the field.

Data from counts of wild host densities and TPB counts from wild hosts and cotton were analyzed using analysis of variance with the PROC MIXED procedure of SAS (Littell et al. 1996). Data were transformed prior to analysis using log or square root transformations to determine if either transformation made the data more normally distributed. The square root transformation improved the distribution of the data from the plant density counts and was used in the analysis of these data. Data from pre-treatment counts were analyzed using within area variance (quadrant to quadrant) as the error term. Since there were no significant differences in wild host plant densities in the sample areas in the four experimental areas in the pre-treatment counts, after-treatment plant densities were compared using the mean for the treated area and the mean for all three check areas. The error term was the between area variance. Neither transformation improved the distribution of the TPB counts from wild hosts or cotton, since these data frequently had counts of zero. Therefore, a non-parametric approach was used to compare TPB counts from wild hosts in the treated and check areas. These comparisons were made by constructing contingency tables and using the maximum likelihood chi-square procedure (PROC FREQ, SAS Institute 1989). Mean numbers of TPB per sweep were put into four categories zero (0.00), low (0.01-0.30), medium (0.31-1.00), and high (>1.00). The percentages of the total number of observations found in each of the four categories were compared between the treated and three check areas. Because of the non-replication of the treated area and the high number of samples with counts of zero, no analyses could be performed on the sampling data from cotton.

RESULTS AND DISCUSSION

The experimental area treated with herbicides and mowing was estimated to have 28.7 ha in marginal areas with TPB hosts out of the 2332 ha in the 23.3 km^2 area. This was only about 1.2% of the total area, and is lower than the 2.4% estimate made for marginal areas with hosts in a similar area of Washington County in 1986 by Snodgrass et al. (1991). However, crop production practices in the Delta have changed since the 1986 estimate was made. In each of the past three years, producers in most areas of the Delta have treated their fields with aerial applications of gyphosate or paraquat in late February and March to destroy weeds. These applications destroy all vegetation along field roads and ditches which reduces the amount of marginal areas with wild hosts that can be measured. Producers treated most of the fields in the experimental area in March of 1998, and this was the main reason for the smaller percentage of

marginal area with hosts in the total area. Of the 28.7 ha of marginal hosts, 7.9 ha (27.5%) were estimated to have been treated with Trimec or glyphosate as part of the experiment during the 3rd and 4th wks of April. Only about 0.5 ha of the 7.9 ha was spot-treated with glyphosate. The one marginal sample area that was mowed on April 15 had regrowth of many of the wild hosts when it was sampled on 12 May. It was treated with Trimec after it was sampled. To use mowing as a treatment, mowed areas will have to be checked and mowed again as needed. Mowing is still a useful treatment option near houses or fish ponds.

The six most abundant wild hosts along with their pre-treatment densities in all four experimental areas are shown in Table 1. Pre-treatment means (all hosts) were 18.1, 28.2, 19.8, and 29.9/m^2 for the treated area and check areas 1, 2, and 3, respectively. These were not significantly different ($F = 2.41$; $df = 1, 12$; $P = 0.15$). The treated area had a wild host plant density of 7.8/m^2 post treatment, which was significantly lower ($F = 12.76$; $df = 1, 2$; $P = 0.07$) than the host density of 26.0/m^2 found in the three check areas. The use of Trimec on the sample areas with good host densities significantly reduced the numbers of hosts, but did not totally eliminate them. The surviving hosts were probably those not contacted with a lethal dose of herbicide because of thick vegetation.

Numbers of TPB found by sweep netting hosts in the treated area in the pre-treatment counts were higher in numbers per 10 sweeps than in all three of the check areas (Table 2). After treatment, numbers in the treated area declined from 2.34 TPB per 10 sweeps (pre-treatment) to 1.10 per 10 sweeps, a reduction of 53%. Post-treatment counts in all three check areas showed that numbers of TPB increased from pre-treatment counts an average of 165%. The average post-treatment TPB count of 4.51 per 10 sweeps in the three check areas was 4.1-fold higher than the post-treatment count in the treated area. The post-treatment numbers of TPB found per sweep on the wild hosts in the four test areas were placed into four response categories and analyzed for differences in the distribution of the percentages of the counts in each category (Table 3). The distributions were significantly different (chi-square = 111.3, $df = 9$, $P = 0.001$). In the treated area most samples (90%) had mean numbers of TPB per sweep in the lowest (0.00,

TABLE 1. Most Abundant Tarnished Plant Bug Wild Host Plant Species Around Fields in the Delta of Mississippi During April 1998.

	Mean[a] no./m^2			
Plant species	Treated area	Check area 1	Check area 2	Check area 3
Geranium dissectum	2.6	5.7	3.4	11.7
Rumex crispus	5.0	10.3	7.7	10.4
Vicia angustifolia	4.1	2.3	2.6	1.5
Oenothera speciosa	2.7	2.3	0.9	0.0
O. laciniata	1.4	0.0	0.4	0.1
Medicago spp.	1.3	4.3	3.0	0.5
Sum	17.2	25.0	17.9	24.2

[a]Means are based on 256 samples in each of the four test areas.

TABLE 2. Numbers of Tarnished Plant Bugs Collected from Good Stands of Wild Host Plants in the Mississippi Delta Before and After a Herbicide Treatment was Applied.

	Mean no. of tarnished plant bugs/10 sweeps	
	Pre-treatment	Post-treatment
Treated area[a]	2.34	1.10
Check area 1	2.29	7.30
Check area 2	1.30	2.80
Check area 3	1.50	3.40
Mean 3 check areas	1.70	4.51

[a]The herbicide treatment was mecoprop + 2,4-D + dicamba applied at 1.55 + 0.54 + 0.17 kg AI/ha, respectively, during the 3rd and 4th weeks of April. Pre-treatment samples were taken during the 1st two weeks of April, while post-treatment samples were taken during the 2nd and 3rd weeks of May.

TABLE 3. Results from Sweep Net Sampling of Tarnished Plant Bugs on Good Stands of Wild Hosts 2-3 Weeks after Herbicide Treatment of the Hosts, or from Untreated Wild Hosts in the Delta of Mississippi.

	% of total no. of samples in each category			
	Sample category (mean no./sweep)			
Sample area	0.00	0.01-0.30	0.31-1.00	>1.00
Treated area[a]	51.5	38.2	10.3	0.0
Check area 1	4.7	37.5	31.3	26.6
Check area 2	1.6	68.8	25.0	4.7
Check area 3	1.9	65.4	25.0	7.7

The distributions of the samples in the four areas were significantly different (chi-square = 111.3, P = 0.001).
[a]See footnote Table 2.

or 0.01-0.30) categories. In the three check areas less than 5% of the samples were in the 0.00 category. Most samples in check areas 2 and 3 were in the 0.01-0.30 or 0.31-1.00 categories, while check area 1 had lower numbers of samples in these two categories and about 27% of all samples in the 1.00 or greater category.

Treatment of cotton fields with insecticides and/or rain decreased the number of cotton fields sampled in some weeks, and in one week (July 13-17) no samples were taken because of heavy rain (Table 4). Very low numbers of TPB were found in cotton during June through the 3rd week in July. Numbers of samples with TPB increased in the last week of July and 1st wk of August but were still very low. Statistical analyses of the data were not possible and no

treatment effect on TPB numbers found in cotton could be determined. One main cause of the low numbers of TPB in cotton was treatment with insecticides for boll weevils in June in all of the experimental areas. Questionnaires on insecticide use were sent to 30 producers found in the experimental areas in the fall of 1998. However, their response to these was very poor. In 1999 producers will be contacted weekly to obtain this information. Throughout the Delta of Mississippi an average of 3.3 insecticide applications for boll weevils were estimated to have been made in 1998 (Williams 1999). All four of the experimental areas will be in the boll weevil eradication program with fall diapause insecticide applications beginning in August of 1999. This should greatly reduce the need for early season insecticide use in the areas in 2000. In 1999 bait sticks (Boll Weevil Attractant and Control Tubes, Plato Industries, Houston, TX) will be placed around selected fields in all four experimental areas in an effort to control boll weevils without using insecticide treatments in the cotton. This might be possible if low numbers of overwintering boll weevils are present, since Villavaso et al. (1998) found that bait sticks were about three times more efficient than pheromone traps in removing boll weevils from a population. The fields with bait sticks will be scouted weekly for boll weevils and they will also be sampled for TPB. Two of the experimental areas will be treated with herbicides to reduce numbers of wild host plants in 1999, and the results will be compared to data from two check areas. The use of two treated areas will greatly improve statistical analyses of data collected in the experiment.

TABLE 4. Results from Sweep Net Sampling of Cotton in an Area of the Mississippi Delta in Which Good Stands of Wild Host Plants Found in the Area were Treated with Herbicides in April and in Three Areas in Which the Wild Hosts were Untreated.

	% of samples in cotton with no tarnished plant bugs		No. of samples (10 sweeps/sample)	
Date	Treated area[a]	3 check areas	Treated area	3 check areas
June 8-12	100.0	97.8	656	1431
June 15-19	95.7	98.5	419	1374
June 21-26	94.0	98.6	413	1220
June 29-July 3	96.5	97.4	398	876
July 6-10	89.4	93.9	322	1175
July 20-24	85.3	86.3	361	1075
July 27-31	80.8	85.5	348	1135
August 3-7	70.0	82.9	285	984

[a]See footnote Table 2.

In summary, treatment of marginal areas with good stands of wild host plants of the TPB with herbicides in April significantly decreased the density of these hosts as compared to host density in untreated check areas. TPB populations found in the treated wild host areas were 4.1-fold lower than TPB populations found on wild hosts in non-treated check areas. TPB

populations found in cotton in the treated area and in the check areas were very low and no differences in their populations in these areas were found.

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