INFLUENCE OF BOLL WEEVIL ERADICATION ON COTTON APHID POPULATIONS IN MISSISSIPPI COTTON

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ABSTRACT

During 1998 and 1999 field surveys were conducted to observe the impact of technical malathion treatments, applied as ULV (10 fl. Oz. per acre) during Boll Weevil Eradication Programs (BWEP), on populations of cotton aphids, *Aphis gossypii* Glover, and on incidence of the entomopathogenic fungal disease, *Neozygites fresenii* (Nowakowski). Regions that were entering the second year of BWEP, the Hill Region in 1998 and the South Delta Region in 1999, were of particular interest, because this is historically the year when the greatest number of malathion treatments are required. In 1998, cotton aphid populations clearly were flared in the Hill Region of Mississippi, which received an average of 2.2 applications of malathion by July 1, relative to the Delta Region of the state, which received no malathion treatments. However, in 1999, aphid population curves were similar in the South Delta Region, which received an average of 3.2 malathion treatments by July 1, and the North Delta Region, which received no malathion treatments. Following a period of rapid population increase, cotton aphid populations declined sharply in all survey areas, both in 1998 and in 1999, because of epizootics of the fungal disease, *N. fresenii*. Also, flaring of bandedwinged whiteflies, *Trialeurodes abutiloneus* (Haldeman), was observed in the Hill Region in 1998 and, to a lesser extent, in the South Delta Region in 1999, but no serious outbreaks of caterpillar pests occurred in either year.

INTRODUCTION

Cotton aphid, *Aphis gossypii* Glover, is a common pest of Mississippi cotton. Typically, low level populations begin to develop on seedling cotton, and treatable populations, when they do occur, develop during late June and early July. Compared to pests such as tobacco budworm, *Heliothis virescens* (Fabricius), and boll weevil, *Anthonomus grandis grandis* Boheman, the yield damaging potential of cotton aphids is somewhat limited. Reported yield losses range from 0 (Weathersbee & Hardee, 1995) to 220 lbs of lint per acre (Layton et al., 1996). Factors thought to contribute to increased likelihood of aphid induced yield loss include: drought or other plant stresses, aphid population density, and timing and duration of the infestation. Andrews and Kitten (1989) and Harris et al. (1992) have reviewed the effects of cotton aphids on yield and quality of cotton grown in the Mississippi Delta. Factors thought to influence cotton aphid populations have been reviewed by Slosser et al. (1989). O'Brien et al. (1991) also reported on the seasonal population dynamics of cotton aphids in Mississippi and Louisiana.

Cotton aphids are difficult to control with currently labeled foliar insecticide treatments because of high levels of insecticide resistance. Labeled insecticides that have proven most effective during recent years include dicrotophos and imidacloprid, but carbofuran, which has been available for use under Section 18 Emergency Exemption for the past several years, provides more consistent control. However insecticides only provide short-term reductions in aphid populations and none of these materials are capable of providing effective season-long control.

Fortunately, cotton aphid populations in Mississippi and other Mid-South states are subject to epizootics of a naturally occurring fungal disease, *Neozygites fresenii* (Nowakowski), (Steinkraus et al., 1992). Epizootics of this disease consistently appear during early to mid-July, causing drastic declines in aphid populations and continuing to provide effective population suppression for the remainder of the season. Naturally occurring parasitoids, particularly the braconid wasp *Lysiphlebus testaceipes* (Cresson), and predators, such as lady beetles, also play an important role in suppressing aphid populations and helping to maintain aphid numbers at sub-damaging levels until the *Neozygites* epizootic occurs. Disruption of these predators and parasitoids is considered to be one of the primary reasons for yield threatening outbreaks of cotton aphids.

During the 1998 season the Hill Region of the state entered the second season of a Boll Weevil Eradication Program (BWEP) that began in August of 1997. Intensive use of malathion during the early years of BWEP often increases the potential for outbreaks of secondary pests. Thus a survey was initiated in 1998 to monitor the effects of malathion treatments applied as part of the BWEP on cotton aphid population development and prevalence of the *Neozygites* fungal disease. A similar survey was conducted in 1999, when the Hill Region of Mississippi was in the 3rd year of its BWEP, and the South Delta Region of the state was in the 2nd year of eradication. The 1999 survey also included fields in the North Delta Region, which did not begin eradication efforts until August of 1999. The primary objective of these surveys was to utilize this unique, short-lived opportunity to gain insight into the role of insecticide use patterns in triggering aphid outbreaks.

METHODS

1998 Survey. During early June of 1998 a survey line, consisting of 16 individual cotton fields, was established along US Highway 82 (Fig. 1). From one to three cotton fields were identified in each county along this transect line. Nine of these fields were located in the BWEP area. Of these nine fields, seven were located in a Hill environment, but the two fields nearest the BWEP boundary line were located in a Delta environment.

Beginning the week of June 15, fields were visited weekly and sampled to determine population levels of cotton aphids. Fields were sampled by examining 20 randomly chosen leaves per field (5th leaf below terminal), visually counting the number of aphids per leaf, and determining the average number of aphids per leaf for each sample date. On sample dates when aphid populations in individual fields were sufficient, an additional sample of aphids was collected, preserved in ethanol, and mailed to the University of Arkansas. Fifty aphids from each of these samples were crushed and examined microscopically for the presence of hyphae and spores of the entomopathogenic fungus, *Neozygites fresenii*. Results of these samples were recorded as percent infected aphids.

1999 Survey. During the 1999 growing season there were three distinct BWEPs underway in Mississippi, and a survey line was established to include fields in all three of these regions (Fig. 2). A total of fifteen fields were included in the survey. Four of the survey fields were located in the North Delta (Region 1), which did not begin eradication efforts until August of 1999. Because these fields did not receive applications of malathion until the first week of August, BWEP treatments did not influence aphid populations observed in June and July. Growers in the North Delta did apply insecticides to control boll weevils, as well as tarnished plant bugs and other pests, during the early part of the season, but these treatments involved products such as: methyl parathion, oxamyl, and dicrotophos, rather than malathion. Six of the survey fields were located in the South Delta Region (Region 2), which was involved in the second year of boll weevil eradication. Because early season use of malathion is normally most intensive during year two, this is typically when the greatest problems are experienced with secondary pests (Layton et al., 1999a). The remaining five survey fields were located in the Hill Region of the state (Regions 3 and 4), which was involved in the third season of BWEP.

Beginning the week of June 1, fields were visited weekly and cotton aphid populations were sampled as in 1998. In addition, bandedwinged whitefly, *Trialeurodes abutiloneus* (Haldeman), populations were sampled by collecting 20 randomly selected leaves per field, counting the number of immature whiteflies in one sq. inch sample from each leaf and recording the total number of immature whiteflies per 20 sq. inches.

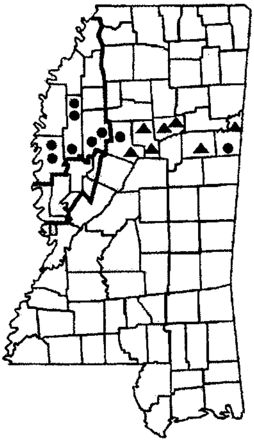

FIG. 1: Distribution of cotton aphid survey fields in 1998. Fields located east of the bold line were inside the Boll Weevil Eradication Program area. Fields marked as triangles (▲) had average aphid populations that exceeded 100/leaf by July 1.

RESULTS AND DISCUSSION

Cotton Aphid Populations, 1998. Seasonal trends of average aphid population levels in the Hills (Eradication Area) and Delta (Non-Eradication Area) are shown in Fig. 3. Aphid populations peaked approximately two weeks earlier in the Hills and reached a maximum level approximately five fold higher than that for Delta fields. During the week of July 1, seven of the nine fields in the Hills exceeded populations of 100 aphids per leaf (Fig. 1). Of the two fields that did not exceed 100 aphids per leaf on this date, one had already been treated with the aphicide, carbofuran, and populations in the other field exceeded 200 aphids per leaf during the subsequent week. Thus, all fields in the Hills either exceeded 100 aphids per leaf or received an application of aphicide by the week of July 8, while the highest aphid population reached in any Delta field by this point was 18.3 aphids per leaf. This was an unusual occurrence because aphid populations and number of insecticide treatments applied to control aphids are normally higher in the Delta Region than in the Hills (Williams, 1996; 1997).

This distinct difference in aphid population levels between the Hills and Delta in 1998 (Fig. 3.) is attributed to the effects of malathion applications applied as part of the BWEP. By July 1, survey fields in the Hill region had received an average of 2.2 applications of malathion for control of overwintered boll weevils, but no malathion had been applied to Delta fields. It is especially noteworthy that there was little difference in the total number of insecticide treatments (ULV malathion treatments + other non-aphicide treatments) that had been applied to fields in the Hills and Delta by July 1, 2.2 and 2.4, respectively. Thus it appears that the flaring of aphid populations that was observed in the Hills in 1998 was due to the insecticide used, or to some other inherent difference between hill and delta fields, rather than to the number or timing of insecticide treatments. However, it must be noted that aphid populations were flared in both survey fields that were located in a delta environment and were also inside the BWEP area, but no aphid treatments were required on the other delta fields that were located outside the BWEP area. Insecticide induced flaring of cotton aphid populations has been reported for insecticides from a number of different classes, including: the inorganic insecticide calcium arsenate (McGarr, 1943); organophosphates such as azinphosmethyl (Brown, 1992); and synthetic pyrethroids such as *lambda*-cyhalothrin (Rummel et al., 1995).

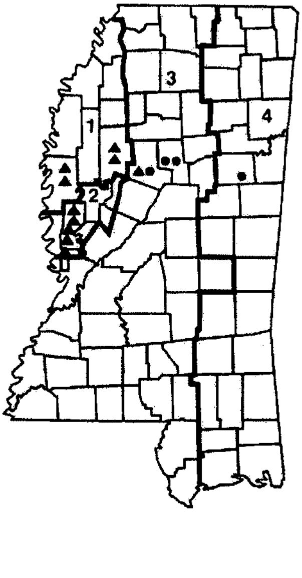

FIG. 2: Distribution of cotton aphid survey fields in 1999. Fields in the North Delta (Region 1) were not involved in boll weevil eradication efforts until the first week of August. The South Delta (Region 2) was in the second year of eradication, and the Hills (Regions 3 & 4) were in the third year of boll weevil eradication.

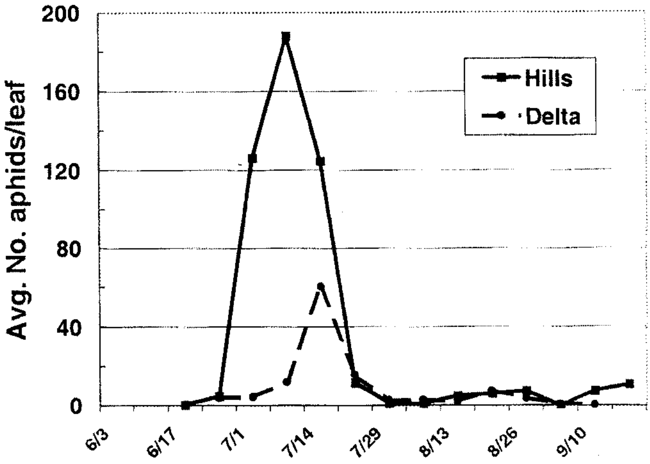

FIG. 3: Average seasonal cotton aphid populations in the Hills (Eradication area, n = 9) vs the Delta (Non-eradication area, n = 7) in 1998.

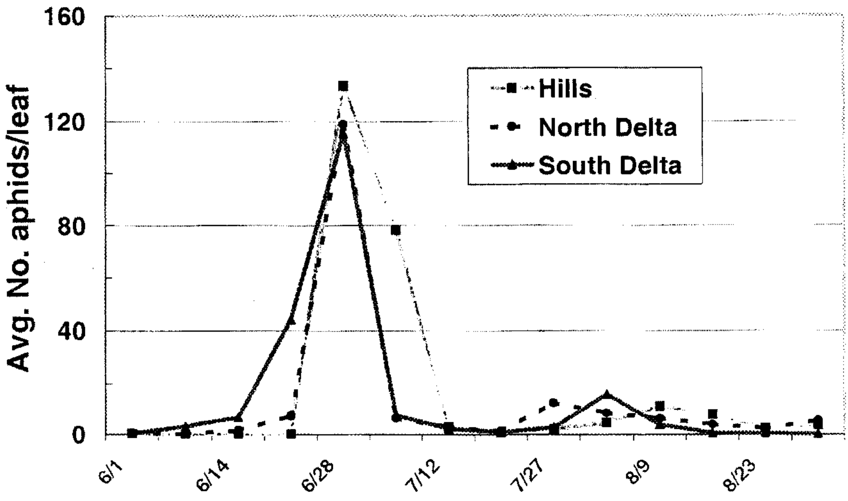

FIG. 4: Average seasonal cotton aphid populations in the Hills (n = 5), North Delta (n = 4), and South Delta (n = 6) in 1999.

Cotton Aphid Populations, 1999. Average seasonal aphid populations for each region for 1999 are shown in Fig. 4. Aphid populations peaked at similar levels on or around June 28 in all three regions. Although aphid populations were similar in all 3 regions in 1999 (Fig. 4), fields in the South Delta and North Delta received considerably more aphicide treatments than fields in the Hill region (Table 1). In fact, all fields in both Delta regions had received at least one aphicide treatment by July 2, but only one of the five Hill fields was treated for aphids. Obviously, these aphicide treatments had a significant impact on the aphid population curves in both Delta regions, and aphid populations in both Delta regions would be expected to have been higher in the absence of these treatments.

It is especially noteworthy that there was little difference between the South Delta and North Delta in either seasonal aphid populations (Fig. 4) or average number of aphid sprays per field (Table 1). This is despite the fact that South Delta fields had received an average of 3.2 malathion treatments and 2.2 other non-aphicide treatments by July 1, compared to 0 malathion treatments and 1.5 other non-aphicide treatments in the North Delta (Table 1). Given the similarity between these two regions in aphid populations and number of aphicide treatments and the difference in malathion treatment history, it does not appear that BWEP efforts flared aphid populations in 1999.

TABLE 1. Average Number of Malathion Treatments, Other Non-Aphicide Treatments, and Total Non-Aphicide Treatments Applied Before July 1, and Average Season-Long Number Of Aphid Treatments Applied to Survey Fields in the Hill Region (N=5), South Delta Region (N=6), and North Delta Region (N=4) in 1999.

Region	No. Malathion sprays before 7/1	No. other non-aphid sprays before 7/1	Total No. non-aphid sprays before 7/1	Average No. aphid sprays
S. Delta	3.2	2.2	5.4	1.3
N. Delta	0.0	1.5	1.5	1.3
Hills	2.4	0.8	3.2	0.2

The fact that the Hill region received approximately twice as many total non-aphicide treatments before July 1 as the North Delta (3.2 vs. 1.5), yet received fewer aphid treatments (0.2 vs. 1.3) may cause one to question the role of early season insecticide treatments in flaring aphid infestations. However it must be noted that producers in the Hill region are generally more tolerant of low to moderate aphid infestations and thus more inclined to wait on the fungal disease to provide control than are Delta producers. In the 1999 season, both strategies, prompt use of aphicides or "waiting on the fungus", resulted in similar seasonal population levels. However, high aphid populations did persist approximately one week longer in the Hill region (Fig. 4).

Neozygites fresenii Incidence. Shortly after reaching their peak, cotton aphid populations declined sharply in all survey areas, in both 1998 and in 1999 (Figs. 3 & 4). These declines in aphid populations were due to epizootics of the naturally occurring fungal disease, *Neozygites fresenii* (Steinkraus et al., 1991; 1992). This disease appears annually in Mississippi cotton aphid populations (Layton, 1999). Once outbreaks of this disease begin, it usually provides effective natural control of cotton aphid populations for the remainder of the season. This is fortunate because the cotton aphid exhibits high levels of resistance to most available aphicides (Hardee & Ainsworth, 1993), and aphid populations are capable of rebounding so rapidly following insecticide treatments that aphicides alone are not capable of providing effective long-term control.

Average seasonal incidence of this disease for 1998 and 1999 is shown in Figs. 5 and 6, respectively. Note that in 1998, *Neozygites* incidence peaked approximately one week earlier in the Hills than in the Delta. Because aphid populations also peaked earlier in the Hills than in the Delta, this suggests that occurrence of this disease is at least partially dependent on aphid population levels. The population dependency of this entomopathogen also was evident in 1999 (Fig. 6). Although this disease was present in all three regions, incidence was much higher in the Hill region. The lower incidence of *N. fresenii* in the Delta regions is attributed to the higher frequency of aphicide treatments which artificially reduced aphid populations and interfered with development and/or detection of the disease.

A second, lower peak in occurrence of the *Neozygites* fungus was observed during mid-August in both 1998 and 1999 (Figs. 5 and 6). This is typical of the situation that occurs annually in Mississippi cotton as aphid populations peak in early to mid-July, crash due to the fungal epizootic, rebound somewhat during August, and are again suppressed by *N. fresenii*.

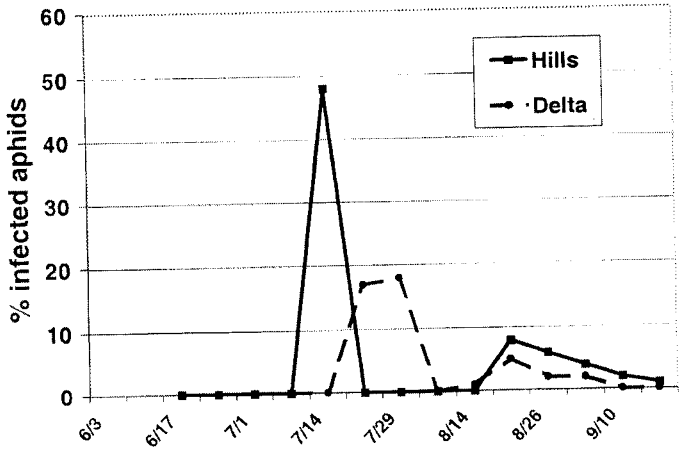

FIG. 5: Average percent infection of cotton aphids with the fungal disease, *Neozygites fresenii*, in the Hills (Eradication area, n = 9) and Delta (Non-eradication area, n = 7) in 1998.

Bandedwinged Whitefly Populations. Detailed counts of bandedwinged whitefly populations were not made during 1998. However, it was apparent that whitefly populations also were flared inside the BWEP area in 1998. Whitefly populations appeared earlier than normal in 1998, with significant numbers being observed during the latter portion of June, and treatments were initiated on some fields during the latter half of July. During August of 1998, whiteflies were one of the most common targets of grower applied insecticide treatments in the Hills, but treatable whitefly infestations were uncommon in the Delta.

Some initial flaring of bandedwinged whitefly populations was observed in the South Delta Region in 1999, but this was short-lived and was less severe than the flaring that was observed in the Hill Region in 1998. Still, late July and early August populations were much higher than in the Hills and North Delta (Fig. 7). Whitefly populations declined in all three regions during late August as a result of early crop cutout.

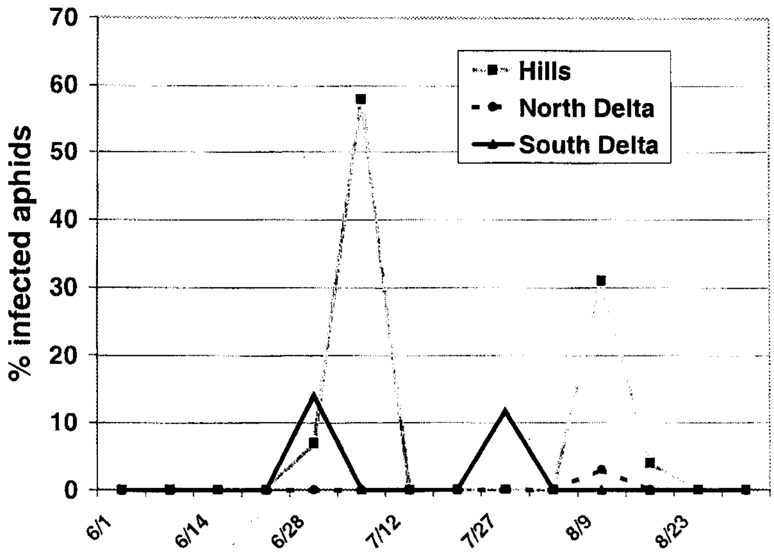

FIG. 6: Average percent infection of cotton aphids with the fungal disease, *Neozygites fresenii*, in the Hills (n = 5), North Delta (n = 4), and South Delta (n = 6) in 1999.

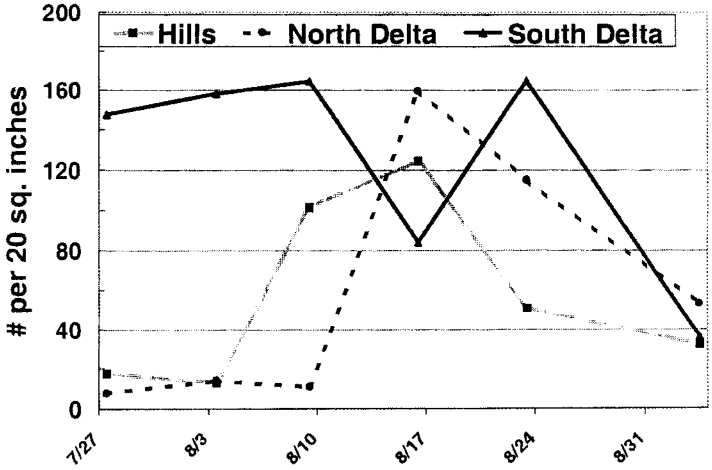

FIG. 7: Average seasonal bandedwinged whitefly populations in the Hills (n = 5), North Delta (n = 4), and South Delta (n = 6) in 1999.

Summary: Results of these two surveys differ considerably. In 1998 cotton aphid populations in the Hill Region of Mississippi clearly were flared as a result of BWEP efforts. In fact, aphids and whiteflies, respectively, were ranked as the 2nd and 3rd most damaging insect pests of the Hill Region in 1998 (Williams, 1999). In 1999 aphid populations and number of aphicide treatments were similar for the South Delta Region, which received an average of 3.2 malathion treatments by July 1, and the North Delta Region, which did not begin the BWEP until August. Although both of these regions experienced an outbreak of cotton aphids in 1999, the BWEP in the South Delta did not appear to flare cotton aphid populations to any greater extent than occurred in the North Delta.

During the early years of BWEPs, there is also increased concern over the potential to flare populations of caterpillar pests, particularly tobacco budworm, *Heliothis virescens* (Fabricius), or beet armyworm, *Spodoptera exigua* (Hubner). Fortunately for Mississippi cotton producers, there were no serious outbreaks of either pest during 1998 or 1999 (Hardee & Herzog, 1999; Hardee & Burris, 2000). In fact these two seasons were notable for having unusually low populations of caterpillar pests. However, it must be noted that approximately 55% to 65% of Mississippi's cotton acreage was planted to transgenic Bt varieties during these years (Layton et al., 1999b, 2000), and Bt cotton is especially effective in reducing risks of caterpillar outbreaks.

While the potential to flare populations of cotton aphids, whiteflies, or caterpillar pests during the early years of a BWEP is a potentially negative consequence of eradication, the long-term benefits of eradicating the boll weevil far outweigh such short-term negatives. Regions where boll weevil has been eradicated not only enjoy reduced control costs and lower yield losses directly due to boll weevils, but also experience fewer losses and expenses due to secondary pests, such as aphids and tobacco budworm (Layton et al., 1999a). Eliminating this key pest will provide numerous, long-term benefits to Mississippi cotton producers.

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LITERATURE CITED

Andrews, G.L., and W.F. Kitten, 1989. How cotton yields are affected by aphid populations which occur during boll set. 1989 Proc. Beltwide Cotton Conference, Vol. I. pp. 291-293.

Brown, P.H., 1992. Effects of Insecticides From Four Insecticide Classes on Resistance, Fecundity, and Related Parameters of the Cotton Aphid, *Aphis gossypii* (Glover) in Mississippi, Masters Thesis, Mississippi State University, 65 pp.

Hardee, D.D. and J.M. Ainsworth, 1993. Cotton Aphid (Homoptera: Aphididae): Effect of in-furrow insecticides on pesticide resistance. J. Econ. Entomol., Vol. 86. pp. 1026-1029.

Hardee, D.D. and E. Burris, 2000. 53rd Annual Conference Report on Cotton Insect Research and Control, 2000 Proc. Beltwide Cotton Conference, in press.

Hardee, D.D. and G.A. Herzog, 1999. 52nd Annual Conference Report on Cotton Insect Research and Control, 1999 Proc. Beltwide Cotton Conference, Vol. II. pp. 757-783.

Harris, F.A., G.L. Andrews, D.F. Caillavet, and R.E. Furr Jr., 1992. Cotton aphid effect on yield, quality and economics of cotton. 1992 Proc. Beltwide Cotton Conference, Vol. II. pp. 652 – 656.

Layton, M.B, H.R. Smith, and G. Andrews, 1996. Cotton aphid infestations in Mississippi: Efficacy of selected insecticides and impact on yield, Proc. Beltwide Cotton Conference, Vol. II. pp. 892-893.

Layton, M.B, 1999. Cotton Insect Control Guide, 1999. Mississippi State University Extension Service Publication 343. 35pp.

Layton, M.B., R.D. Bagwell, & R.W. Seward, 1999a. Insect Management in Mid-South Eradicaton Zones: A Progress Report, 1999 Proc. Beltwide Cotton Conference, Vol. II. pp. 757-783.

Layton, M.B., S.D. Stewart, M.R. Williams, and J.L. Long, 1999b. Performance of Bt Cotton in Mississippi, 1998. Proc. Beltwide Cotton Conf. Vol. II, p. 942-946.

Layton, M.B., M.R. Williams, and J.L. Long, 2000. Performance of Bt Cotton in Mississippi, 1999. Proc. Beltwide Cotton Conf. Vol. II, p. 1037-1039.

McGarr, R.L., 1943. Relation of fertilizers to the development of the cotton aphid in 1941 and 1942. J. Econ. Ent., 36: 640.

O'Brien, B.R. Leonard, and J.B. Graves, 1991. Population dynamics of *Aphis gossypii* Glover. 1991 Proc. Beltwide Cotton Conference, Vol. II. pp. 686 - 688.

Rummel, D.R., M.D. Arnold, J.E. Slosser, K.C. Neece, and W.E. Pinchak, 1995. Cultural factors influencing the abundance of *Aphis gossypii* Glover in Texas high plains cotton, Southwest. Entomol. 20: 395– 406.

Slosser, J. E., W.E. Pinchak, and D.R. Rummel, 1989. A review of known and potential factors affecting the population dynamics of the cotton aphid, Southwest. Entomol. 14: 302 - 313.

Steinkraus, D.C., T.J. Kring, and N.P. Tugwell, 1991. *Neozygites fresenii* in *Aphis gossypii* on cotton. Southwest. Entomol., 16: 118-122.

Steinkraus, D.C., P.H. Slaymaker, and N.P. Tugwell, 1992. Fungal epizootics in the cotton aphid, Proc. Beltwide Cotton Conference, Vol. II. pp. 821-822.

Weathersbee, A.A. and D.D. Hardee, 1995. Yield impact of cotton aphid on 12 cotton cultivars differing in leaf trichome density, Proc. Beltwide Cotton Conference. Vol. II. pp.893-895.

Williams, M.R., 1996. Cotton Insect Losses, 1995. 1996 Proc. Beltwide Cotton Conference, Vol. II. pp. 671-689.

Williams, M.R., 1997. Cotton Insect Losses, 1996. 1997 Proc. Beltwide Cotton Conference, Vol. II. pp. 834-853.

Williams, M.R., 1999. Cotton Insect Losses, 1998. 1999 Proceedings Beltwide Cotton Conference, Vol. II. pp. 785-806.