COTTON INSECT CONTROL STRATEGY PROJECT: COMPARING BT AND CONVENTIONAL COTTON MANAGEMENT AND PLANT BUG CONTROL STRATEGIES AT FIVE LOCATIONS IN MISSISSIPPI, 1995-1997

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Abstract

Three years of cooperative effort have resulted in information concerning the use and benefits or risks associated with the use of transgenic Bt cotton as compared with cotton varieties commonly grown in Mississippi that do not possess the Bt gene for endotoxin production. Comparison of an early season strategy for management of tarnished plant bug was also evaluated in the field-sized units at five locations in the state. Bt cotton appears to be a very competitive alternative to traditional insect management for the Mississippi cotton system. On average, yields were higher and insect-control costs were lower in Bt cotton than in fields of conventional cotton. Bt cotton was particularly important in preventing crop failure when tobacco budworm populations were high. Our data suggests that Bt cotton fields may be at greater risk to attack by other important pests, such as tarnished plant bugs and boll weevils, presumably due to the reduction of insecticidal inputs. However, attempts to prophylactically control plant bugs in this study did not have a significant benefit. Comparisons between certain sampling procedures are made, and our database may help determine the best or develop better sampling methods for pest and beneficial insect populations.

Introduction

For the years of 1995-1997, field-sized research plots were established at five locations in Mississippi to evaluate different insect management regimens in Bt transgenic (Bollgard™) cotton and conventional (non-transgenic) cotton varieties. This research was funded as a special research initiative from the Mississippi Agriculture and Forestry Experiment Station as part of a larger project entitled "Development of Sustainable, Cost-efficient Strategies for Managing Cotton Insects". The primary objectives of the large-plot, field-sized studies was to compare what effects different approaches of insect control had on insect populations, pest management, and the profitability of the cotton crop.

By using grower's fields replicated in several locations throughout Mississippi, we were able to overcome some of the shortcomings associated with small plot, single-site research that gives results not always translatable to the farm. One focus of this research was to evaluate the impact that Bt transgenic technology had on arthropod populations and crop management compared with conventional varieties. We also focused on the impact that aggressive, early-season control of tarnished plant bugs had on subsequent crop management and profitability. This research gave us the opportunity to compare different methods of sampling arthropod populations when applied to field-scale environments.

Materials and Methods

Insect management protocols were applied to field-sized research units as described below for the years 1995-1997. Sampling was generally done twice a week and included examination of 25 terminals and 25 squares for each of 4 sites within a field. One sweep-net sample (25 sweeps each) and/or a drop-cloth sample was also taken at each site. Some of the data collected included the total number of heliothine eggs or larvae in terminals, numbers of heliothine infested terminals, larvae in squares, heliothine-damaged squares, boll-weevil punctured squares, and the numbers of tarnished plant bugs and beneficial insects in sweep net and drop cloth samples.

Each year, fields were located in two hill counties (Lee and Madison, 1995; Itawamba and Madison, 1996-1997) and two or three delta counties (Leflore, Tallahatchie and Yazoo, 1995-1996; Leflore and Tallahatchie 1997). Fields ranged in size from about 20-30 acres. The Leflore county site included four field-sized replicates of each treatment protocol in 1995 and 1996. The other locations included only one field for each of the treatment protocols.

Treatment Protocols

1995: Fields of Bt transgenic cotton (Nucotn33B) and DPL5415 (conventional parent variety of Nucotn33B) were managed according to the Mississippi Cotton Insect Control Guide (CICG), and two fields of a grower-chosen variety were used to compare an aggressive, early-season tarnished plant bug management with the CICG management regime. The aggressive strategy consisted of one scheduled application of acephate (Orthene 90S, 0.33 lb AI/acre) at the fourth true leaf stage, an application the first week of squaring if two plant bugs were found per 100 sweeps with a 15-inch sweep net, an application the second week of squaring if four plant bugs were found per 100 sweeps, and subsequent pest control according to the CICG. At three locations, (Leflore, Yazoo and Tallahatchie counties) additional fields of conventional cotton were also managed aggressively for tarnished plant bugs, but a pyrethroid was used instead of acephate. The fields within each county were spatially close.

1996: The protocol for 1996 included Bt cotton (Nucotn33B) managed using an aggressive strategy for

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tarnished plant bug control and Bt cotton managed according to the CICG, both compared to a conventional variety of the grower's choice managed according to the CICG. The aggressive tarnished plant bug management strategy for 1996 was similar to that of 1995 except that the acephate was applied at the 4th true leaf stage and again at weekly intervals for two additional applications. This decision was made so that other parameters, such as the effect of these sprays on natural enemies, could be monitored even if plant bug populations were too low to trigger an application. In 1996, the Bt cotton fields at the Itawamba and Tallahatchie locations were separated from the conventional fields by about two miles. Thus, the assumption that each field within these locations is subject to the same insect populations and population densities may be questionable.

1997: The protocol for 1997 was identical to 1996. However, an additional field of an earlier-maturing Bt variety was also included and managed according to the CICG at three locations (Leflore, Madison and Itawamba counties).

Analyses

For the purposes of this paper the various treatment protocols were categorized as either CICG versus aggressive plant bug control (ATPB) and Bt cotton versus conventional varieties (Cv). The varieties used in this study are summarized in Table 1.

There was more replication of the above treatments than indicated by the number of locations within the state because of the replication within Leflore county in 1995 and 1996 and other additions to the protocol. The number of replicates for each treatment was also not consistent across years (Table 1). However, most of the results presented in this paper were from data that was averaged by year, location and treatment prior to analysis. This eliminated a significant amount of replication apparent in the data, but it greatly simplified analyses and balanced the potential impact that year, location or variety could have on the results. July 15 was used each year to differentiate data between early and late season.

Treatment categories were analyzed as a 2 X 2 factorial using location (county) as a blocking factor and Duncan's Multiple Range Tests for mean separation (Proc GLM, SAS Institute, 1987). Variety and management strategy were potential interacting factors, and there were a few interactions evident between varieties and treatment protocols when the data were analyzed. With a few noted exceptions, these interactions were uncommon, so the data are summarized as either Bt versus Cv or CICG versus ATPB. Linear regressions (Proc Reg, SAS Institute, 1987) were also performed between some data to determine how different variables related to each other, such as sweep net and drop cloth data. Regressions were done using averages calculated from each sample unit (i.e., field), location and date. Comparisons between sweep-net and drop-cloth information were done only using averaged data that were paired by field and date. Because averages were used in all analyses, sample sizes (N) reported in the tables represent the number of mean values used in the calculation and not the number of individual samples.

Results and Discussion

General Observations

Heavy infestations of tarnished plant bugs were not consistently observed in any location or year. A field average equaling or exceeding 2.0 individuals per drop cloth occurred in only 14 of 375 samples taken during the three year period. In sweep nets, a field average of higher than 10 plant bugs per 100 sweeps was recorded in 14 of 757 samples. In 1995, the protocol for aggressively controlling tarnished plant bugs in the early-season consisted only of the automatic applications made at the fourth true leaf, despite using a treatment thresholds lower than recommended in the CICG. Thus, the aggressive control protocol did not result in a greatly increased number of early-season insecticide applications in 1995.

A significant epizootic of insecticide-resistant tobacco budworms occurred in much of the hill area of the state in 1995, including test locations in Madison and Lee counties. The conventional varieties in the Lee county location were severely damaged. Insect control efforts in Lee County were frustrated by the inability to obtain critical insecticides and difficulty in making timely applications at short intervals. Besides the Lee and Madison county locations in 1995, tobacco budworm populations would be characterized as generally low to moderate in size. An average field count of equal to or higher than 4 and 8 worms per 100 terminals was observed on 122 and 59 occasions, respectively, out of 900 heliothine samples taken during this experiment.

In 1995, the Boll Weevil Eradication Program made multiple, in-season applications for boll weevil control in the eastern portion of Mississippi, including the Lee county site. Multiple applications of malathion for fall diapause control of boll weevils by the eradication program were also made in 1997, at the Itawamba and Madison counties locations, beginning late in the season (ca. 4 August) and continuing at about 5-7 day intervals. So, the eradication program influenced the populations (and management) of boll weevil, plant bugs, other pests and beneficial arthropods in those locations, particularly in 1995.

Aphid populations were variable, but were characteristically high during the parts of some seasons at several locations, and were managed accordingly. During the course of the study, there were few insecticide applications made that did not specifically target boll weevils, plant bugs, aphids or the heliothine complex.

Insecticide Applications, Costs and Yield

Except for the prophylactic sprays for plant bugs in some treatments, all remaining insecticide applications were made based on pest densities according to a standardized protocol (i.e., CICG). Therefore, data for numbers of insecticide applications and, to some extent, the kinds of insecticide used are unbiased. A summary of average insecticide usage, cost and yield is presented in Table 2. Each product in a tank mix was counted as a separate application. Control costs include only the costs of foliar-applied insecticides and the Bt technology fee ($32). At-planting treatments, application costs and fees for boll weevil eradication are excluded. Yield was estimated from ginned, whole-field lint weight divided by the number of acres in each field.

On average, there were fewer applications of insecticides (4.9 applications/acre), lower insecticide costs ($6.67/acre) and higher yields (98 lb/acre) in Bt fields compared with conventional cotton fields. Number of insecticide applications, control costs and yields varied widely between fields in this study from 1-26 applications, $17-156 per acre, and 253-1222 pounds of lint per acre. Difference in yield and control costs could not be statistically distinguished.

On one occasion (Lee county, 1995), yield was drastically reduced in a conventional cotton field owing to a severe infestation by tobacco budworms. The yields from two other conventional fields in Lee county (1995) were omitted from analysis because of hail damage, but their yields were similar to the remaining conventional field and were about 40% of the yield in the Bt field. Insecticide control costs were unusually high in Lee and Madison during 1995 due to budworm control efforts, but even in the absence of heavy budworm populations, Bt cotton fields were economically competitive with conventional fields. However, the yield of two Bt fields were about 25% lower (170 lbs. of lint/acre) than the conventional variety at one location and year (Yazoo county, 1996). This did not appear to be the result of pest infestation.

As might be expected, the greatest reduction in insecticide inputs associated with the use of Bt varieties was for heliothine control, eliminating costly applications to control resistant tobacco budworms. In 1996, 1-2 pyrethroid applications were made to control cotton bollworm in Bt cotton fields at Leflore county, but several additional worm sprays were needed in conventional cotton. Bollworm sprays to other Bt cotton fields were not necessary.

In some fields, more insecticide applications specifically targeting boll weevils and/or plant bugs were made to Bt fields than were made to conventional fields. Insecticide costs were elevated in fields aggressively treated for plant bugs, but generally only to the extent of the costs associated with these applications. These costs were often small relative to applications made late in the season because banding techniques were sometimes used. We did not trigger significant secondary pest outbreaks in fields treated aggressively for plant bugs but neither did we significantly increase yields.

Bt Transgenic vs. Conventional Varieties

The relative impact of Bt versus conventional varieties on key pest populations and natural enemies is summarized in Table 3. Throughout the experiment, Bt cotton had a profound effect on tobacco budworm and cotton bollworm populations and their management. Seasonally, Bt cotton had about 56% fewer worms found in terminals, despite receiving fewer insecticide applications targeting worms and having higher egg numbers than the conventional fields. Egg numbers were about 6-fold higher late in the season than in the early season, and there was about 15% more eggs in Bt cotton fields than in conventional fields, but this difference was not significant ($P = 0.09$). A higher number of eggs in Bt cotton would not be surprising because the primary variety of Bt cotton grown in this study (Nucotn33B) was a later maturing variety than were the conventional cottons. Moths may have been more attracted to the "less mature" plants in Bt fields. Seasonally, there was also a 77% reduction in the number of squares damaged by heliothines.

Seasonally, numbers of the weevil-punctured squares were 38% less in conventional fields than in Bt fields. Essentially all this difference occurred in the late season when punctures were about 15 times more common than in the early season. Tarnished plant bug numbers were nearly identical in drop-cloth samples of conventional and Bt cotton but were about 50% higher in sweep-net samples of Bt cotton during the late season. Again, most of this difference occurred in the late season when plant bugs were about 3 times more common than in the early season. There was a tendency for higher numbers of beneficial arthropods in Bt fields as compared with conventional fields (Table 3), but when data for individual species were analyzed, these differences were usually not significant. We might have expected a greater increase of beneficial arthropod populations in Bt cotton associated with the reduction of sprays, especially pyrethroid sprays, targeting heliothines. However, boll weevil control efforts were maintained in all fields. In Bt fields, the material of choice was usually methyl parathion except in areas with active eradication efforts. These data may suggest that methyl parathion, at least at the rates used, may be relatively more damaging to beneficials than to weevil populations as compared with pyrethroid insecticides. They may also indicate that beneficial populations are generally more susceptible to insecticide disruption than are pests such as the boll weevil.

CICG vs. Aggressive Control of Plant Bugs

In the first half of the season and regardless of variety, tarnished plant bugs numbers in fields aggressively controlled for plant bugs were slightly, but not-significantly, smaller than the already low numbers present in fields treated according to the CICG (20% and 34% less in sweep and drop samples, respectively). Averaged over the season, there was also no significant difference in plant bug numbers between CICG and ATPB fields (Table 4). Because numbers were generally low, these data can not be used to suggest aggressive, early-season control of plant bugs will not increase yield or did not control this pest. However, it is not surprising that prophylactic sprays for plant bugs had little value when populations were generally low. Aggressive, early-season control did not result in a measurable reduction in late-season plant bug populations.

There were no main effects of aggressive plant bug control on numbers of heliothines, beneficial insects, heliothine-damaged squares, or boll weevil punctures (Table 4). It is interesting that a substantial reduction in natural enemy populations was not associated with aggressive control of plant bugs, even during the early season. Again, this may suggest that these natural enemies are easily perturbed by other early-season insecticide sprays, for example those used for boll weevils or aphids.

Interactions Between Variety and Management Approach

Two significant interactions between treatment protocol and variety (Bt or Cv) were found. One interaction was for the number of heliothine worms found in terminals during the early-season ($F = 5.05$, df = 1, 377, $P < 0.03$). More worms (27%) were found in the terminals of conventional cotton fields treated aggressively for plant bugs than in those treated CICG (1.34 vs. 0.98 per 100 terminals). In contrast, 36% fewer worms were found in Bt fields aggressively treated for plant bugs than in those treated CICG (0.09 vs. 0.14 per 100 terminals). This interaction may reflect a “flaring” of worms in conventional fields, caused by aggressive plant bug control, that was not evident in Bt fields. A second interaction was found for plant bugs caught in sweep nets during the early season ($F = 4.22$, df = 1, 397, $P < 0.05$). Fewer plant bugs (42%) were caught in conventional fields treated aggressively for plant bugs than in those treated CICG (0.42 vs. 0.73 per 100 sweeps). Only 10% fewer plant bugs were caught in Bt fields treated aggressively for plant bugs than in those treated CICG (0.87 vs. 0.97 per 100 sweeps). The cause of this interaction is unclear but may be explained by inadvertent control of plant bugs in conventional fields by insecticides targeting heliothines.

Sampling Comparisons

One of the interesting components of this experiment is that we have amassed a huge database of different sampling measurements that can be compared. For example, when doing terminal samples, total numbers of heliothine eggs and larvae were counted as well the number of egg- or larval-infested terminals. There was a nearly perfect linear correlation between the total numbers of worms in a given number of terminals and the numbers of infested terminals (Table 5). A very strong relationship was also found between numbers of eggs and numbers of egg-infested terminals. This suggests that, for the range of heliothine pressure observed during this experiment, these sampling procedures give an equally reliable estimate of heliothine populations. We expected autocorrelation between numbers of insects in terminals and the number of infested terminals because the same terminals were sampled for each, and were not independent. Zero averages of worm counts were not included in regression because a lack worms in 100 terminals obliged a 0% infested-terminal count.

In contrast, correlation coefficients relating sweep-net and drop-cloth samples for total tarnished plant bug and natural enemy populations were low, despite being highly significant (e.g., Table 5). We also consistently differentiated between adult and immature stages of tarnished plant bugs, lady beetles and big-eyed bugs during our sampling. Sweep-net and drop- cloth samples were found to estimate the different developmental stages of these insect populations with varying degrees of effectiveness (Table 6). Adults composed a significantly higher portion of plant bugs, lady beetles and big-eyed bugs caught in the sweep net relative to drop-cloth samples ($P < 0.05$, Chi-square analyses). Obviously then, immature stages composed a higher portion of these populations in drop cloth samples. It is not clear when, or if, sweep net or drop cloth samples give the best estimate of the absolute insect populations. If a sweep net is the best sampling method for adults, and the drop cloth is best for immature stages, then these data suggest that neither sampling method can be used independently to accurately ascertain plant bug populations during the course of an entire season.

Summary

The data presented here are from limited analyses of a very large data set. This project is expected to evolve and continue for at least an additional year according the needs of Mississippi cotton producers, and future analyses will be more comprehensive. Nevertheless, several broad conclusions can be made. Bt cotton appears to be a very competitive alternative to traditional insect management in the Mississippi cotton system. On average, yields were higher and insect-control costs were lower and less variable in Bt cotton than in fields of conventional cotton. Another important component was that serious yield loss, caused by heliothine, was not observed in Bt cotton fields. Bt cotton may be particularly important in preventing crop failure during years when tobacco budworm populations are high, as demonstrated by the Lee county site during 1995. The development of a greater array of Bt transgenic varieties may further increase the benefits of this technology unless heliothine resistance to the Bt toxin rapidly develops. Although averages are generally reported in this paper, the economic benefit of Bt cotton was clearly associated with the severity of tobacco budworm populations. In areas with traditionally low tobacco budworm populations, we would expect less benefit from utilizing the Bt technology. Also, this discussion has not addressed comparative information about applications costs or other management costs associated with the different crop management scenarios.

Our data suggests that Bt cotton fields may be at greater risk to attack by other important pests, such as plant bugs and boll weevils, presumably due to the reduction of insecticidal inputs. This observation has been put forth by numerous individuals and seems intuitively obvious. However, attempts to proactively and prophylactically control plant bugs did not have a significant benefit, at least in this study when plant bug populations were not high. It should be considered that low to moderate populations of plant bugs during the early-season are typical in much of Mississippi. There was no obvious indication in our data that aggressive control of plant bugs increased the risk of secondary pest outbreaks, but slightly higher numbers of heliothine worms were found in conventional fields treated aggressively for plant bugs.

Our data may determine the best or help develop better sampling methods for pest and beneficial insect populations. For example the data could potentially be used to develop more refined sequential sampling techniques or further compare the utility of drop cloth or sweep net samples. This will require deeper analyses of the database.

References

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Table 1. Cotton varieties used at the different locations in 1995-1997 for each treatment. Location by county: I= Itawamba (1996-1997) or Lee (1995), L= Leflore, M = Madison, T = Tallahatchie, Y = Yazoo, All = all test locations for that year.

Treatment	Varieties	Year		
		1995	1996	1997
Bt-CICG	Nucotn33B	All	All	All
	DPL20-BG	---	---	M
	PM1215-BG	---	---	I
	PM1244-BG	---	--	L
Bt-ATPB	Nucotn33B	---	All	All
Cv-CICG	DPL5415	All	---	---
	DPL5409	---	I	I
	DPL50	I, L	---	---
	LA887	L, T	---	---
	PM1244	L	---	---
	SG125	M, Y	M, Y	M, T, L
	STN474	---	L	---
	STN495	---	T	---
Cv-ATPB	DPL50	I, L	---	---
	LA887	L, T	---	---
	SG125	M, Y	---	---
	PM1244	L	---	---

Table 2. Three-year averages of insecticide costs, number of insecticide applications and yield for each treatment, including the price of Bt transgenic technology ($32) and excluding application costs and fees for boll weevil eradication. Each product in a tank mix was counted as an application.

County	Treatment	Mean	± SD	N
Insecticide costs ($)	Bt	61.48	20.97	23
	Cv	68.15	38.66	19
	CICG	62.39	32.20	28
	ATPB	68.71	25.83	14
Number of insecticide applications	Bt*	6.74	4.26	23
	Cv	11.66	6.70	19
	CICG	8.45	6.01	28
	ATPB	10.00	5.96	14
Yield (lbs.)	Bt	876.2	199.6	23
	Cv	788.6	170.5	17
	CICG	827.4	201.8	27
	ATPB	863.1	170.0	13

* Indicates a significant difference between Bt and Cv fields or CICG and ATPB fields (Duncan's Multiple Range Test, $P < 0.05$).

Table 3. Three-year seasonal average number of selected arthropods, heliothine-damaged squares, and weevil-punctured squares in Bt and conventional (Cv) cotton fields. Data are for 100 terminal or square samples (T), 100 sweep net samples (S), or 4 drop cloth samples (D).

Sample	Insect	Fields	Mean	± SD	N
T	Heliothine worms*	Bt	1.06	3.22	383
		Cv	2.40	4.53	336
	Heliothine eggs	Bt	8.34	18.69	388
		Cv	6.71	12.61	340
	Worm damage*	Bt	0.91	2.14	357
		Cv	4.04	8.22	296
	Weevil punctures*	Bt	1.30	2.93	332
		Cv	0.81	2.13	250
S	Plant bugs*	Bt	1.78	4.34	324
		Cv	0.88	2.14	288
	Big-eyed bugs	Bt	1.00	2.48	289
		Cv	0.78	2.60	253
	Lady beetles*	Bt	9.04	12.85	296
		Cv	6.61	11.66	255
	Spiders	Bt	3.73	4.80	243
		Cv	3.25	5.54	149
	Ants	Bt	1.33	3.19	241
		Cv	1.27	2.64	147
	Minute pirate bugs	Bt	1.56	4.09	239
		Cv	1.11	2.82	148
D	Plant bugs	Bt	1.12	2.56	179
		Cv	1.14	2.32	132
	Big-eyed bugs	Bt	0.80	2.52	177
		Cv	0.49	1.92	127
	Lady beetles	Bt	6.29	8.35	179
		Cv	5.09	9.18	128
	Spiders	Bt	4.19	4.02	152
		Cv	4.02	3.97	76
	Ants*	Bt	3.07	6.56	152
		Cv	1.64	3.09	75
	Minute pirate bugs	Bt	1.06	3.02	149
		Cv	1.11	3.81	74

* Indicates a significant difference between Bt and Cv fields during at least one-half of the season, i.e., early or late (Duncan's Multiple Range Test, $P < 0.05$).

Table 4. Three-year seasonal average number of selected arthropods, heliothine-damaged squares, and weevil-punctured squares in field treated CICG or aggressively for plant bugs (ATPB). Data are for 100 terminal or square samples (T), 100 sweep net samples (S), or 4 drop cloth samples (D).

Sample	Insect	Fields	Mean	± SD	N
T	Heliothine worms	CICG	1.73	4.05	487
		ATPB	1.60	3.72	232
	Heliothine eggs	CICG	7.44	15.39	491
		ATPB	7.86	17.66	237
	Worm damage	CICG	2.09	5.06	441
		ATPB	2.84	7.47	212
	Weevil punctures	CICG	1.03	2.35	391
		ATPB	1.03	3.10	191
S	Plant bugs	CICG	1.36	3.47	409
		ATPB	1.34	3.59	203
	Big-eyed bugs	CICG	0.94	2.63	363
		ATPB	0.81	2.34	179
	Lady beetles	CICG	7.62	12.01	368
		ATPB	8.51	13.06	183
	Spiders	CICG	3.59	5.30	262
		ATPB	3.45	4.66	130
	Ants	CICG	1.49	3.41	260
		ATPB	0.94	1.84	128
	Minute pirate bugs	CICG	1.32	3.18	260
		ATPB	1.53	4.49	127
D	Plant bugs	CICG	1.28	2.62	206
		ATPB	0.83	2.08	105
	Big-eyed bugs	CICG	0.65	2.27	202
		ATPB	0.69	2.34	102
	Lady beetles	CICG	5.80	8.84	204
		ATPB	5.76	8.49	103
	Spiders	CICG	4.39	4.15	152
		ATPB	3.62	3.63	76
	Ants	CICG	2.78	5.70	151
		ATPB	2.23	5.67	76
	Minute pirate bugs	CICG	1.10	3.41	148
		ATPB	1.03	3.06	75

All difference between CICG and ATPB fields were not significant.

Table 5. Parameter estimates from linear regressions between several variables sampled over a three year period. TPB = tarnished plant bug, LB = lady beetles, BEB = big-eyed bugs, and MPB = minute pirate bugs.

X	Y	Intercept (± SE)	Slope (± SE)	P, R^2
Terminals with egg	Total eggs in terminals	-0.20 (± 0.09)	1.30 (± 0.02)	<0.01, 0.89
Terminals with worms	Total worms in terminals	-0.01 (± 0.01)	1.03 (± 0.01)	<0.01, 0.99
TPB in 1 drop cloth	TPB in 25 sweeps	0.26 (± 0.04)	0.19 (± 0.05)	<0.01, 0.06
LB in 1 drop cloth	LB in 25 sweeps	1.06 (± 0.24)	1.08 (± 0.08)	<0.01, 0.45
BEB in 1 drop cloth	BEB in 25 sweeps	0.13 (± 0.03)	0.48 (± 0.04)	<0.01, 0.42
MPB in 1 drop cloth	MPB in 25 sweeps	0.11 (± 0.05)	0.47 (± 0.05)	<0.01, 0.25

Table 6. Three-year seasonal average number of adult and immature tarnished plant bugs, lady beetles and big-eyed bugs per 4 drop cloth samples (D) and 100 sweeps (S), and the percent of the population that were adults.

Insect	Sample	Mean	± SD	N	% Adults
TPB adults	S	1.08	1.96	227	86.0
nymphs	S	0.17	0.61		
TPB adults	D	0.36	1.20	227	34.6
nymphs	D	0.69	1.86		
LB adults	S	7.82	11.26	228	64.5
larvae	S	4.31	7.93		
LB adults	D	3.12	4.59	228	42.6
larvae	D	4.20	7.84		
BEB adults	S	0.72	1.52	228	80.4
nymphs	S	0.18	1.05		
BEB adults	D	0.44	1.25	228	56.6
nymphs	D	0.34	1.62		