AN INVENTORY OF THE KEY PREDATORS OF COTTON PESTS ON Bt AND NON-Bt COTTON IN WEST TEXAS

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Abstract

Densities of insect and spider predator of cotton pests were sampled and compared on Bt and non-Bt cotton from large acreages on producers fields and from a replicated study on the Texas Tech University Research Farm near New Deal, TX. Insect and spider predators were grouped as those with chewing mouthparts, piercing-sucking mouthparts and the two groups added together for total predators. Some significant differences occurred in the large scale, side-by-side comparisons on producers fields, and the majority of the differences were in favor of higher predator numbers in Bt cotton as opposed to non-Bt cotton. The replicated study resulted in no significant differences in insect or spider predators regardless of how they were grouped. When all samples sites were combined, three piercing-sucking predators, (minute pirate bug, Orius tristicolor, big-eyed bugs, Geocoris punctipes (Say) and the cotton fleahopper Pseudatomoscelis seriatus (Reuter) contained 89 % of the total number of piercing-sucking predators in Bt cotton, and 90 % of those collected in non-Bt cotton. A significant portion of chewing predators came from spiders, Araneae, lady beetles, Cocinellidae, and hooded beetles, Notoxus spp., which accounted for 94 % of the chewing predators in Bt cotton and 96 % in non-Bt cotton. A noticeable trend in predator dynamics was that chewing predators out-numbered the piercing-sucking predators 2 to 1 in the first week of July, while the reverse was true for the second week in August. Total numbers of predators averaged across Bt and non-Bt cotton increased from 55,000 per acre the first week in July to 233,000 by the second week in August. We do not believe there are any differences in the key insect and spider predators inhabiting Bt versus non-Bt cotton. These results are positive in that Bt-cotton may act as a "refuge" for predaceous insects and spiders in large scale cotton production where non-Bt cotton may be sprayed with insecticide.

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Introduction

Two significant changes are occurring in the Texas High Plains cotton production system which in turn will effect the pest species complex and the beneficial arthropods that prey on those pests. The changes include the use of transgenic cotton varieties containing the Bacillus thuringiensis var. kurstaki (Cry1A(c) endotoxin identified as bollgard^{TM}, and the initiation of a boll weevil eradication program aimed at eliminating the boll weevil Anthonomous grandis (Boheman) from many of the Texas cotton growing regions. These large scale management tactics could change the predator to pest ratios as a result of lower insecticide use in the case of Bt cotton, or reduce predator insects when area wide applications of malathion are applied. In Alabama, Bradford and Smith (1999) report that changes in pest and beneficial insects densities are occurring where boll weevil eradication has been in progress and Bt cotton varieties have been planted in large acreages. Major insect pests, such as the bollworm, tobacco budworm and beet armyworms have been recently considered minor pests, while some of the occasional pests such tarnished plant bugs, fall armyworms and stinkbugs are causing more significant economic losses. These changes in pest status are explained by lower insectide use as a result of not spraying for the boll weevil in-season and the use of Bt cotton. The pest status changes are significant enough that Bradford and Smith (1999) are calling for re-evaluations or changes in scouting techniques, insecticide chemistry and other IPM tactics. Perhaps overlooked as insect pests densities change as a result of aforementioned large scale management tactics, are the benefits provided by insect and spider predators that prey on cotton insects of economic importance. A simple hypothesis could be drawn that Bt cotton does not support the major predators of lepidopterous pests because it will reduce a significant portion of the early instar larvae. This has already been observed in cotton fields of the Brazos River Bottom, where fewer bollworm larvae were found on Bt cotton compared to non-Bt cotton, but perhaps more interesting was the fact that surviving larvae found on Bt cotton tended to be located in fruiting structure towards the middle of the plant (Pietranonio and Heinz, 1999). Both these findings would suggest that Bt cotton may not support predator populations as well as non-Bt cotton. The ecological relationship in predator numbers as a result of fewer lepidopteran prey from the use of Bt cotton has received little attention. A significant portion of bollworm and budworm consumption from predators occurs when they are in the egg and early larval stages (McDaniel and Sterling 1979, McDaniel et al. 1981). Conversely, a significant portion of the larvae will die or be incapacitated within 48 hr of consuming Bt cotton tissue (Halcomb et al. 1996). Therefore, it would stand to reason that Bt cotton may not sustain key bollworm\budworm predators as well as a non-Bt cotton. Other predators that prey on medium to large bollworm/budworm and other lepidopteran (i.e. ambush bugs, Phymatidae and assassin bugs, Reduviidae, (Cohen 1998), will have fewer prey when searching in Bt cotton. Aside from the unknown ecology of predators in Bt cotton, sampling for and utilizing the results of predator densities in cotton has been slow to develop because of the time requirements of accurately sampling and quantifying the predators (Knutson and Wilson 1999). In addition to the use of Bt cotton, most regions of West Texas have initiated boll weevil eradication efforts this fall. The objective of this study was to sample and compare the major predators in Bt and non-Bt cotton on the Texas High Plains before the initiation of boll weevil eradication. The results should help in the understanding the of predator densities in Bt and non-Bt cotton previous to boll weevil eradication.

Methods and Materials

Insect predator and spider densities were estimated in Bt and non-Bt cotton using a beat-net technique, similar to the beat-bucket method described by Pyke et al. (1980) and Knutson and Wilson (1999) with the exception that a standard 15' sweep net was used in place of a bucket. The net was placed at the bottom of three consecutive cotton plants within a row from randomly chosen sample sites in a field. The plants were swiftly bent over the net with the hand and forearm, with the distal edge (edge of the net distal from the three cotton plants) raised 8 to 10' to enclose at least 50% of the cotton plants. The plants were quickly shaken five times within the net to dislodge the insects. Following the capture of the insects, the net was swiftly raised straight up from the ground where most of the insects would fall to the bottom. The net was then passed through the air twice as if sweeping, to ensure all insects and spiders were dislodged to the bottom. The bottom 10‘ of the net was then turned inside-out within a two gallon Ziplock^{R} bag where all insects and spiders were enclosed. The captured insects were then placed in a large insulated cooler that contained frozen ice-pack devices used to keep food and drink products cold. The capture bags were placed in a freezer in the laboratory when samplers returned from the study sites. Insect predators were sorted into adults and immatures, identified (Frank and Slosser 1996), and counted.

The key cotton predators collected were big-eyed bugs, Geocoris punctipes (Say), minute pirate bugs, Orius tristicolor (Say), Nabis spp.; lady beetles, Coccinellidae, including Coccinella septempunctata (L.), Olla v-nigrum abdominalis (Mulsant) Hippodamia convergens Guerin-Meneville, Hippodamia sinuata, Stethorus spp.; green lacewings, Chrysopidae, brown lacewings, Hemerobiidae; hooded beetles, Notoxus spp., Collops spp., Collops vittatus (Say) and Collops quadrimaculatus (F.); Predaceous spiders, Aranea, were also counted along with cotton fleahopper, Pseudatomoscelis seriatus (Reuter) because it has been reported as a significant predator of Heliothis virescens (Boddie) eggs (McDaniel and Sterling,1982). Adult and immature stages of all predators were counted with the exception of spiders. Although individual counts were made for each species, the data were grouped for the purposes of analyses. All insects and spiders with chewing mouthparts were combined, while all insects with piercing-sucking mouthparts were combined. The two groups were added together so that the total number of predaceous insects and spiders could be compared in Bt and non-Bt cotton.

Two different study designs were used to estimate predator densities in Bt and non-Bt cotton. The first study was a replicated, randomize study site at Texas Tech University Research Farm near New Deal, TX while the second portion of the study utilized large acreages of Bt and non-Bt cotton varieties planted side-by-side in producers fields. These comparisons were located in Swisher, Castro, and Lamb Counties and two sites were located in Lubbock County. The multi-county sites each had PM2680BGRR (BG = Monsanto's Bollgard^{TM}, *Bacillus Thuringiensis* var. *kurstaki*, Cry1A(c) endotoxin, RR = Monsanto's Roundup Ready^{TM}) planted next to PM2200RR, an isoline containing Roundup Ready^{TM} alone. The cotton sites varied from 80 to 40 acres for each the PM2680BGRR or PM2200RR at all locations, and all were under center pivot irrigation systems with the exception of the Swisher County site that was row irrigated. Upon arriving at any of the locations, a sampler would find the division line of the two varieties, walk thirty paces into one variety and sample with the beat-net as previously described, followed by another thirty paces and sample, for a total of 15 sample sites within the each block of PM2680BGRR containing the Bollgard^{TM} and Roundup Ready^{TM} and PM2200RR containing the Roundup Ready^{TM}. This resulted in a total of 45 plants being sampled within each block of the Bt and non-Bt cotton. Bollworm infestations were estimated by scouting 100 cotton terminals (Sansone, Boring and Leser 1999) in both the Bt and non-Bt cotton. The stage of fruiting was mapped in all fields at the time of sampling and ranged from four to six nodes above white flower.

The site on the Texas Tech University Research Farm near New Deal, TX consisted of four treatments from which predators were sampled using the same beat-net technique. The treatments included cotton varieties PM2326BGRR plus a pyrethroid application when bollworms reached the economic threshold; PM2326BGRR with no pyrethroid application; PM2326RR with a pyrethroid application when bollworms reached the economic threshold, and PM2326RR with no pyrethroid application. Test plots were 16 rows wide (40" centers) by 110' in length, arranged in a complete randomized block design. Predators were sampled on 7 July, just at the initiation of blooms, and 12 August, when tha plants averaged three immature bolls.

Two sample t-test (P > 0.05) for non-paired observations (SAS, 1998) were used to compare the sample means of the15 beat-net samples from Bt and non-Bt cotton from the producer sites. The replicated study was analyzed with the PROC ANOVA, and means tested for significance (P > 0.05) by the Fischer's LSD (SAS, 1998). All predator species were analyzed individually, but further analysis was also accomplished by combining the predators into chewing, piercing-sucking and total (chewing plus piercing-sucking). Total predators per acre were estimated from each location and cotton variety by taking plant stand counts from 100 linear row feet from ten locations at the side-by-side locations, and one from all plots at New Deal, TX. The average number of predators per plant were then multiplied by the estimated number of plants per acre.

Results and Discussion

Texas Tech University Research Farm, New Deal

There were no significant differences in insect and spider predators grouped as piercing-sucking, chewing, or total predators combined from Bt cotton (PM2326BGRR) compared to non-Bt cotton (PM2326RR) on the 7 July or 12 August sample dates (Tables 1 & 2). It should be noted that no pyrethroid applications were made in the PM2326BGRR + pyrethroid or PM2326RR + pyrethroid treatments because bollworms did not exceed the treatment threshold for eggs or small larvae during the entire growing season. When total number of predators per acre were estimated, some large differences did occur although no statistical comparison on a per acre basis were made. These results were more a result of plant stand counts taken from 100 linear row feet, which in some cases were largely different. There is a 6 to 7 fold increase in total predator numbers from the 7 July sample date compared to the 12 August. Mean numbers of chewing predators were higher on the 7 July sample date but by the 12th of August this trend changed to higher numbers of piercing-sucking predators (Table 1 & 2).

Multi-County, Side-by-Side Comparisons

PM2680BGRR had significantly higher piercing-sucking, chewing and total number of predators in Castro county when compared with non-Bt cotton. Pesticide use records for this site showed that only herbicides were applied during the growing season with no insecticide use, however corn was located in closer proximity to the Bt cotton which may have effected the sample results. Predator numbers were significantly higher in PM2680BGRR for Piercing-sucking and chewing insects in Lamb county but not for the total number of predators (Table 3). Significantly lower piercing-sucking and total predators were in Lubbock county #2, but this can not be explained by insecticide use. Both the PM2680BGRR and PM2200RR were sprayed with 0.25 lbs ai/a of oxamyl on the 7th and 15th of July.

In terms of the total number of predators captured by beat-net sampling when all sample sites are combined, fleahoppers averaged from 0 to 1.5 per plant and made up the largest percentage of total predators in Bt and non-Bt cotton (Table 4), Orius testicolor and Geocoris punctipes are also two of the most prevalent piercing-sucking predators captured. Spiders, lady bugs and hooded beetles (Notoxus) are a large portion of the chewing predators (Table 4). Approximately 324 of the 550 total lady bugs captured on non-Bt cotton were from Lubbock county #1, where a significant infestation of aphids were found covering the cotton plants. Considering this, the total number of predators captured by beat-net sampling are very similar for Bt and non-Bt cotton. Although there were some significant differences from the side-by-side comparisons, 4 of 7 resulted in higher numbers from non-Bt cotton (Table 3). These differences may be due to the migratory nature of predators in large-scale landscapes that was not detected in the replicated study. The results indicate that predators will inhabit Bt cotton comparable to non-Bt cotton. This is a positive outcome from the stand point of refuge management, where certain percentages of non-Bt cotton must be planted along with Bt cotton. The quantification of predator numbers is also advantageous from the stand point that some ecological differences that result from large scale acreages of Bt cotton appear to be changing IPM tactics as some major pests become less serious and some minor pests become more serious. Finally, this study of the major predators in Texas High Plains cotton is good from the stand point that boll weevil eradication was initiated this fall, after all of the sampling from these studies were complete. The predator species diversity and numbers is information that can be used as the eradication program advances.

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References

Halcomb, J. L., J. H. Benedict, B. Cook, and D. R. Ring. 1996. Survival and growth of bollworm and tobacco budworm on transgenic and nontransgenic cotton expressing a CryIA insecticide protein (Lepidoptera: Noctuidae). Environ. Entomol. 26(2):250-255.

Bradford, A. M. and R. H. Smith. 1999. Effect of Boll Weevil eradication and planting bollgard™ varieties on changes in the insect spectrum and chemistry needed for cotton IPM in Alabama,pp.1230-1232. In P. Dugger, and D.A. Richter [eds.] Proc. 1999 of the Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Cohen, A. C. 1998. Solid to Liquid feeding: The story of extra-oral digestion in predaceous Arthropoda. American Entomol. 44:103-116.

Frank, W. A. and J. E. Slosser. 1996 An illustrated Guide to the predaceous Insects of the Northern Texas Rolling Plains. Texas Agric. Experiment Station publication MP-1718, 24 pp.

Knutson, A. E. and W. T. Wilson. 1999. The beat bucket: A rapid, reliable, method for sampling predatory insects in cotton, pp. 1120-1123. In P. Dugger, and D.A. Richter [eds.] Proc. 1999 of the Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

McDaniel, S. G. and W. L. Sterling. 1981. Predation of Heliothis virescens eggs on cotton in East Texas. Environ. Entomol. 11:565-572.

McDaniel, S. G. and W. L. Sterling, and D. A. Dean. 1981. Predators of tobacco budworm larvae in Texas cotton. Southwest. Entomol. 6:101-108.

McDaniel, S. G. and W. L. Sterling. 1979. Predator determination and efficiency on Heliothis virescens in cotton using 32P. Environ. Entomol. 8:1083-1087.

Pietranonio, P. V. and K. L. Heinz. 1999. Distribution of Heliothine larvae in Bt and non-Bt cotton in Texas, pp.945-948. In P. Dugger, and D.A. Richter [eds.] Proc. 1999 of the Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Pyke, B. W. L. Sterling and A. Hartstack.1980. Beat and shake sampling of cotton terminals for cotton fleahoppers and other pests and predators. Environ. Entomol. 9: 572-576.

SAS Institute Incorporated. 1998. SAS/STAT Users Guide, Release 7.0, SAS Institute Inc. Cary , NC.

Sansone, C. G., E. P. Boring, and J. L. Leser. 1999. Managing cotton insects in the High Plains, Rolling Plains and Trans-Pecos Areas of Texas. Texas Agricultural Extension Service publication E-6A.

Table 1. Mean number of predators grouped as piercing-sucking, chewing, and total collected by beat-net sampling of Bt and non-Bt cotton, Texas Tech University Research Farm, New Deal, TX, July 7, 1999.

Treatment arrangement	Predator Groups Piercing-sucking	Chewing	Total predators	Total predators/ Acre
PM2326BGRR[1] + pyrethroid	1.0 ns	1.8 ns	2.8 ns	37,505
PM2326BGRR no insecticide	1.3 ns	2.0 ns	3.3 ns	64,902
PM2326RR[2] + pyrethroid	1.3 ns	2.8 ns	4.0 ns	63,749
PM2326RR no insecticide	0.5 ns	1.8 ns	2.3 ns	33,974
LSD, (P = 0.05)	2.13	1.93	2.87	

[1]PM2326BGRR a Paymaster variety containing Bollgard™ and Roundup
Ready™, no pyrethroid applications were made because the bollworms never exceeded the threshold.

[2] PM2326RR is a Paymaster variety containing the Roundup Ready™.

Table 2. Mean number of predators grouped as piercing-sucking, chewing, and total collected by beat-net sampling of Bt and non-Bt cotton, Texas Tech University Research Farm, New Deal, TX, August 12, 1999.

Treatment	Predator Groups Piercing-sucking	Chewing	Total predators	Total predators/ Acre
PM2326BGRR[1] + pyrethroid	7.3 ns	4.3 ns	11.5 ns	225,875
PM2326BGRR no insecticide	6.8 ns	3.8 ns	10.5 ns	212,171
PM2326RR[2] + pyrethroid	8.0 ns	6.8 ns	14.8 ns	239,054
PMHS2326RR no insecticide	10.5 ns	7.0 ns	17.5 ns	255,454
LSD, (P = 0.05)	7.34	3.40	7.95	

[1]PM2326BGRR a Paymaster variety containing Bollgard™ and Roundup
Ready™, no pyrethroid applications were made because the bollworms never exceeded the threshold.
[2] PM2326RR is a Paymaster variety containing Roundup Ready™ .

Table 3. Mean[1] number of predators grouped as piercing-sucking, chewing, and total collected by beat-net sampling of side-by-side comparisons of Bt and non-Bt cotton from five locations of large scale plantings on the Texas High Plains, July 27 & 28, 1999.

Location & Treatment	Predator Groups Piercing-sucking	Chewing	Total predators	Total predators/ acre
Swisher county				
PM2680BGRR	7.1 ns	12.8 ns	19.9 ns	188,102
PM2200RR	5.1	12.0	17.1	111,244
Castro county				
PM2680BGRR	6.9*	7.5*	15.9*	325,031
PM2200RR	3.2	4.7	9.0	269,622
Lamb county				
PM2680BGRR	2.1*	14.1*	16.2 ns	399,794
PM2200RR	10.7	9.6	20.3	504,093
Lubbock county #1				
PM2680BGRR	1.9 ns	6.4 ns	8.3 ns	190,620
PM2200RR	1.5	9.1	10.5	321,938
Lubbock county # 2				
PM2680BGRR	2.1*	8.9 ns	11.0*	97,158
PM2200RR	6.1	11.4	17.5	141,432

[1]Column means within a location for PM2680BGRR and PM2200RR were compared by t-test, (P> 0.05) of having a greater t value, significance indicated by and asterick.

Table 4. Total and percent of total predators sampled by beat-net on Bt and non-Bt cotton from the Texas Tech University Research Farm, New Deal, TX, and five locations of side-by side plantings, summer 1999.

Piercing-sucking Predators	Total Predators sampled from Bt-cotton varieties (% of Total)	Total Predators sampled from non-Bt cotton varieties (% of Total)
Orius testicolor	112 (10.4)	115 (9.0)
Geocoris punctipes	112 (10.4)	45 (3.5)
Nabis spp.	48 (4.5)	41 (3.2)
Fleahoppers	166 (15.4)	198 (15.5)
Chewing Predators		
Lacewing	28 (2.6)	25 (2.0)
Collops spp.	11 (1.0)	9 (0.7)
Spiders	152 (14.1)	175 (13.7)
Lady bugs	294 (27.3)	550 (43.0)
Notoxus spp.	154 (14.3)	120 (9.4)
Total	1077	1278