POTENTIAL FOR BOLL WEEVIL TRANSPORT TO GINS ON MODULES

Thomas W. Sappington
USDA-ARS, IFNRRU
Weslaco, TX
Alan D. Brashears and Roy V. Baker
USDA-ARS
Lubbock, TX
Stanley C. Carroll, Mark D. Arnold and Megha N. Parajulee
Texas Agricultural Experiment Station
Lubbock, TX
John W. Norman, Jr.
Texas Agricultural Extension Service
Weslaco, TX
Allen E. Knutson
Texas Agricultural Extension Service
Dallas, TX

Abstract

Because of the cost and difficulty involved in eradicating the boll weevil (*Anthonomus grandis*) from designated zones, the threat of reintroduction and reinfestation is always of concern. As several eradication zones in Texas approach functional eradication, there has been growing unease at the prospect that gins serving customers in neighboring infested zones may serve as sites for reintroduction of weevils. We began a series of experiments in three regions of Texas designed to determine the potential for boll weevil transport on or in cotton modules to the gin yard. Surveys indicated that there were surprising numbers of adult weevils present in defoliated cotton just prior to harvest, especially if green bolls were still present on the plants. Live weevils were recovered in samples of harvested cotton taken from module builders, and averages of calculated weevils per module in the three different areas of Texas ranged from 203 to 3,750, and weevils calculated to be on the surface ranged from 3 to 52. The latter represent weevils that could disperse from the module during or after transport to the gin. We released marked weevils on the top (under a tarp) and sides (not under a tarp) of stationary modules and estimated the percentage of weevils that dispersed within 10-24 hr. In another experiment, marked weevils were released on the top, side, and end of a module which was then transported 6 or 30 miles. Our results indicate that most weevils disperse from the release sites if temperatures are warm enough -- by flight if not under a tarp, by walking and burrowing if under a tarp on top of the module. Most weevils died under the tarp when temperatures were high, but some were unaccounted for and may have escaped lethal temperatures by burrowing into the loose cotton on top of the module. Overall, our results indicate that one can expect at least a small number of weevils to make it to the gin alive inside a module depending on the starting population of weevils in the defoliated cotton. The percentage of weevils remaining on the surface of a module from the time of its construction can be expected to decrease the longer the module remains in the field, especially with high (>80^{o}F) temperatures, because of the observed high propensity of weevils to disperse from modules by flight.

Introduction

Since 1983, major efforts have been devoted to solving the boll weevil problem by progressively eradicating it from the U.S. Cotton Belt (Smith 1998, El-Lissy and Grefenstette 2001). The boll weevil has been eradicated from most of the southeastern and far-western cotton production regions, and current programs are active in large parts of Texas and bordering states. Within each state, large eradication zones consisting of several counties each are established by vote of cotton producers who must provide the bulk of the funding for the eradication program. The programs consist of intensive monitoring and insecticide treatment within the zone until the weevil has been eradicated, which generally requires 4-5 years. After eradication, monitoring continues in order to detect and prevent reinfestations.

Due to the enormous expense involved in these eradication efforts, reinfestation is a major concern. Boll weevils can disperse many kilometers by flight (e.g., Jones et al. 1992, Raulston et al. 1996), and the apparent influx of migrants into active eradication zones from neighboring infested zones can impede progress in reducing populations (Allen et al. 2001). In addition, the movement of weevil-bearing materials from infested zones into or through weevil-suppressed zones are a potential source of reinfestation. This threat is particularly acute for an eradication zone that borders an infested zone or a zone that is not as far advanced in the eradication process. Such situations are particularly common in Texas where blocks of counties have entered the program in a patchwork fashion in both time and space based on timing of referenda passage, rather than on a plan of systematic progression. The question has arisen whether cotton gins located in an eradication zone can safely serve customers farming in a nearby infested zone without serving as a site of weevil reintroduction. It may take only a steady trickle of a few surviving immigrants to cotton gins in an eradication zone to delay or frustrate eradication attempts, with consequent substantial increases in costs to the program and producers. On the other hand, ginners are understandably reluctant to turn away customers or to install elaborate and expensive procedures to contain weevils if there is no real threat of immigrant weevils arriving at the gin alive, or of surviving the ginning process if they do.

We have undertaken a study to determine the extent of boll weevil transport on or in cotton modules from the field to the gin yard. This is part of a larger project that includes detailed assessment of survival of weevils that enter the gin itself. Our ginning experiments are starting to provide a picture of a very low probability of survival of boll weevils that pass into the gin in seed cotton (e.g., Brashears et al. 2002). But reintroduction into an eradication zone can occur before weevils ever enter the gin if they are transported on a module and disperse on route or at the gin yard. We report here results from the first year of the module study conducted in three areas of Texas, in which we examined boll weevil movement on the surface of a module before and during transport. We also report recovery of live weevils in harvested cotton before module formation, and estimate the number of live weevils on or in modules sampled from different regions of Texas.

Materials and Methods

Presence of Boll Weevils in Defoliated and Harvested Cotton

Fields and harvested cotton were sampled to determine the extent to which boll weevils can be expected to enter cotton modules via the cotton picker or stripper. The experiment was conducted in 2001 during peak harvest in each of three regions of Texas: Weslaco (Lower Rio Grande Valley) August 6-10, Waxahachie (Northern Blacklands) September 21-25, and Lubbock (Southern High Plains) October 22-26. Adult boll weevils present in defoliated cotton were sampled by beat bucket from four fields in each location. Each field was sampled in five locations along 25 m of row. Green bolls or dry incompletely opened bolls were sampled along the same 25 m of row and were dissected to determine percent infestation and stage distribution of infesting weevils. All samples were taken the day of, or the day before, harvest.

Cotton was harvested with pickers in Weslaco and one field in Lubbock, and with strippers in Waxahachie and three fields in Lubbock. Ten quarter-barrel paper bags of harvested cotton were collected from module builders at each field, and the resulting sample represented at least three different dumps of the harvesters. The cotton in the bags was weighed and sorted carefully by hand to determine the presence of adult weevils or of bolls. Boll weevils per module were estimated from the number of weevils per pound of seed cotton, based on a 15,000-Lb module. The number of weevils expected to be within 1 cm of the surface was calculated from the estimated number of weevils per module, based on a module of dimensions 8x9x32 feet (WxHxL).

Boll Weevil Mortality on, and Dispersal from, the Surface of Cotton Modules

Experiments were conducted in Weslaco and Waxahachie to examine the fate of boll weevils released on various surfaces of stationary cotton modules. Twenty-five weevils were marked with enamel paint or fluorescent powder and released onto the surface of modules within a 2-ft diameter release zone marked with module paint in each of five locations per module (Fig. 1). Three releases were made on the top of each module and immediately covered with the module tarp. Two more releases were made, one on each of the long sides of the module. Weevils remaining on the modules were recovered after 10 (at night using black lights) to 24 hr. In Waxahachie, aliquots of weevils in 1-pint cups with screened lids were placed on the ground on the north (shaded) side of a cotton module to serve as controls for mortality.

In Lubbock, experimental modules were used to determine if weevils were more prone to disperse from modules transported a long distance (30 miles) than a short distance (6 miles). Three sets of 25 weevils marked with fluorescent powder were released per module, one on top, one on a long side, and one on the end that faced out of the module truck. Weevils were released within 15 min of loading onto the truck. After return from the trip, the module was placed on a pallet, loaded on a trailer, and pulled into a dark shed to be inspected for weevils using black lights. If some weevils were not present in the release circle, they were searched for out to 3 m away from the circle. Cotton within the circle on the top of the module was searched to a depth of about 8 inches.

Results and Discussion

Presence of Boll Weevils in Defoliated and Harvested Cotton

In Weslaco, adult boll weevils were found in surprisingly high numbers in defoliated cotton just prior to harvest (Table 1). In Waxahachie and Lubbock, free adult weevils were present but in much lower numbers. It is not clear why weevils would remain in cotton after defoliation. In Weslaco, there were many green bolls remaining on the plants (Table 2), and it is possible that they provided a food source in an area where very little green cotton remained in the fields. Two-5% of the bolls were infested in Weslaco, and up to 12% were infested in Lubbock where the bolls were incompletely opened, dry, and not green (Table 2). Thus, it is possible that most of the adult weevils recovered in the beat bucket samples were newly emerged and had not yet dispersed from the defoliated field. Age estimates of the collected weevils await cuticular hydrocarbon analysis (Sappington et al. 2000).

Live boll weevils were recovered in cotton samples drawn from module builders after passing through either pickers or strippers (Table 1), with as many as 1 weevil per 1.6 Lb of cotton found in cotton harvested from Field 2 in Lubbock. This suggests an astounding 9,480 adult weevils per module and 132 weevils within 1 cm of the surface at the time of module formation in that field. Averages of weevils per module in the three different areas of Texas ranged from 203 to 3,750 and weevils on the surface ranged from 3 to 52 (Table 1). Thus, weevils can be expected to be present inside and on the surface of newly constructed modules, even when populations in the harvested field are very low, as was the case in Waxahachie. No green bolls were found in the harvested samples, but a few were visible on the surface of the modules indicating that at least a small number make it through the harvesters, including pickers. Several of the weevils recovered in the module cotton samples were found encased in pupal chambers, suggesting that they eclosed from pupae just before or soon after harvest.

Boll Weevil Mortality on, and Dispersal from, the Surface of Cotton Modules

Our results indicate that many weevils disperse out of the release sites as long as air temperatures or solar radiation are high enough for weevil flight (Tables 3-4, Fig. 2). Many weevils were not recovered after 10-24 hr post-release, and these represent the maximum number of weevils that may have dispersed off the module. In the case of those released on the sides or ends of modules (not under the tarp), the vast majority were observed to fly off the module within 15 min of release -- flight was sometimes almost immediate on days with temperatures over 80^{o}F. Under the tarp, recovered weevils were usually (but not always) dead, presumably from high temperatures (Table 4). A substantial proportion were often unaccounted for, even though it is unlikely that many could have left the module. Results of the module transport experiments suggest that weevils may burrow into the cotton when temperatures are high (Fig. 3). Cotton on the top surface of the module is not packed as tightly as it is on the sides, and a weevil could easily walk downward into it, at least until it became tangled in the fibers. One marked weevil was recovered 20 cm deep inside the release zone. The fate of those that may have burrowed into the cotton on stationary modules is unknown, but the cotton may insulate them from surface heat enough to allow longer survival. There was no difference in propensity to disperse from modules transported 6 or 30 miles. However, there was a tendency to increased dispersal from the sides and the ends of the modules with increasing temperature.

Although our data indicate that weevils on the untarped surface of a module will disperse from it rapidly if temperatures are warm enough, and that in hot weather most weevils on the surface under a tarp will die, one can expect a small percentage of weevils to make it to the gin yard on a module before dispersing or dying. This will be especially true on days with temperatures less than 60^{o}F and with cloud cover. We observed no natural weevils alighting on modules. The behavior of the released weevils suggests that a module is a relatively hostile environment, and it is likely that most if not all weevils occurring on modules originated in the cotton as it was harvested.

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Table 1. Boll weevils (BW) recovered by beat bucket from preharvest defoliated cotton plants, and recovered from five quarter-barrel bag postharvest seed cotton samples per field.

Location	Harvester	Field	BW/25 m	Estimated BW/Ac	BW/Lb of harvested cotton	Estimated BW/mod.	Estimated BW on Surface
Weslaco	Picker	1	11.0±2.21	1782	0.271		
		2	2.2±0.79	352	0.048		
		3	8.6±2.44	1393	0		
		4	2.8±1.07	454	0		
		Mean	**6.20±1.62**	**995**	**0.80**	**1200**	**17**
Waxahacie	Stripper	1	0.2±0.2	32	0		
		2	0.2±0.2	32	0		
		3	0	0	0.054		
		4	0.2±0.2	32	0		
		Mean	**0.15±0.05**	**24**	**0.014**	**203**	**3**
Lubbock	Stripper	1	0.2±0.2	32	0.366		
		2	0.6±0.6	96	0.632		
		3	0.2±0.2	32	0		
	Picker	4	0	0	0		
		Mean	**0.25±0.16**	**40**	**0.250**	**3750**	**52**

Table 2. Number and percent infestation of green bolls calculated from five samples of 25 row-m per field taken just before harvest.

Location	Field	Bolls/ac.	% Infested	%L	BW Stage %P	%A
Weslaco	1	11,799	4.7	77	14	9
	2	35,802	4.2	53	43	13
	3	15,228	2.0	27	0	73
	4	33,242	4.7	40	25	35
Waxahachie	Avg. 4 fields	162	0	-	-	-
Lubbock	1	3,601	3.8	29	43	29
	2	16,957	12.0	0	2	98
	3	6,569	2.0	50	0	50
	4	2,912	0	-	-	-

Table 3. Marked boll weevils released and recovered after 10-24 hr on untarped sides of cotton modules.

Location	Date	No. of Modules	No. Released	No. Recovered Alive	No. Recovered Dead	Control Alive	Control Dead
Weslaco	Aug 6	2	84	1	1		
	Aug 7	3	142	2	2		
	Aug 9	3	149	2	2		
Waxahachie	Sep 21	6	300	0	21	39	11
	Sep 23	3	150	2	0	124	1
	Sep 24	3	150	10	5	45	5

Table 4. Marked boll weevils released and recovered after 10-24 hr under tarp on top of cotton modules.

Location	Date	No. of Modules	No. Released	No. Recovered		Control	
				Alive	Dead	Alive	Dead
Weslaco	Aug 6	2	150	0	67		
	Aug 7	3	216	4	121		
	Aug 9	2	150	0	90		
Waxahachie	Sep 21	4	300	0	51	39	11
	Sep 23	3	225	0	81	124	1
	Sep 24	3	150	5	69	45	5

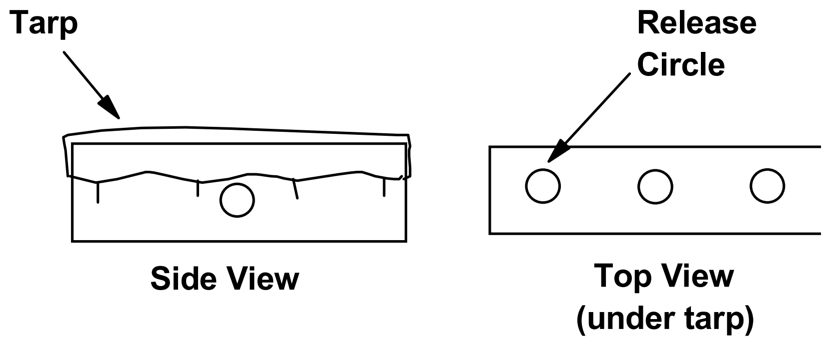

Figure 1. Schematic of release sites for marked boll weevils on stationary cotton modules, Weslaco and Waxahachie, TX, 2001.

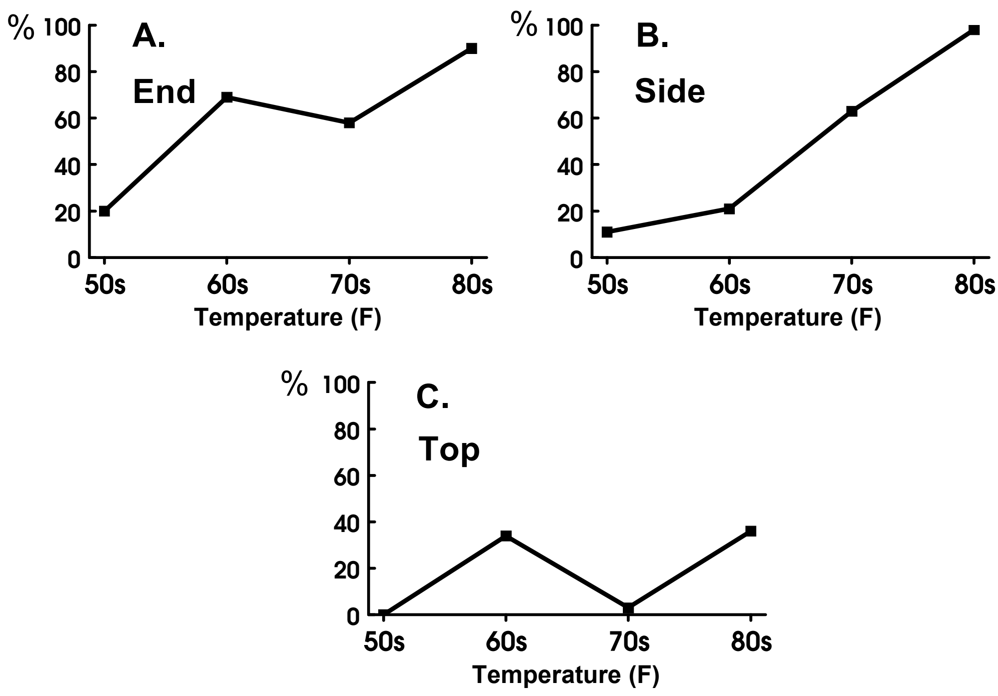

Figure 2. Percent dispersal of marked boll weevils from release sites on the **(A)** end of the module facing out of the module truck, **(B)** side of the module, and **(C)** top of the module (covered by a tarp). Dispersal was calculated from the number of released weevils that could not be found in or within 3 m of the release site after transport of 6 or 30 miles (data pooled). One experiment (consisting of the two distances) was performed under each of the general temperature conditions indicated, except that two experiments were conducted with temperatures in the 70sF.

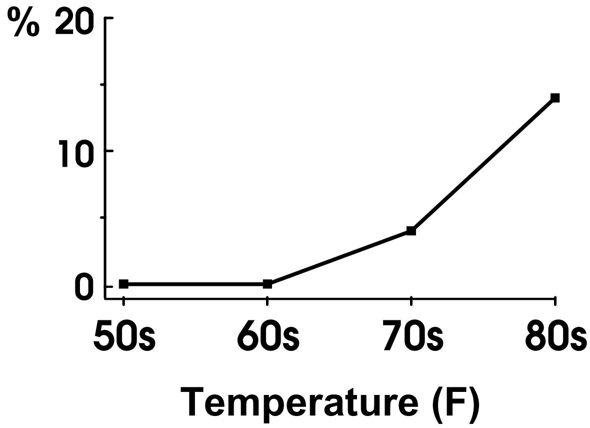

Figure 3. Percent of marked and released boll weevils recovered $\geq$ 2.5 cm deep in cotton on top of module (under tarp) after transport 6 or 30 miles (data pooled). One experiment (consisting of the two distances) was performed under each of the general temperature conditions indicated, except that two experiments were conducted with temperatures in the 70sF.