BOLL WEEVIL SURVIVAL IN THE GINNING SYSTEM

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Introduction

The spread of agricultural insect pests from infected to non-infected areas by natural causes, and movement of infected equipment or products has always been a concern to the U.S. farming industry. Cotton pests like the pink bollworm have been introduced from other countries into the U.S. and have caused serious economic damage in certain parts of the cotton belt (Hughs and Staten, 1995). The USDA, Animal and Plant Health Inspection Service (APHIS) has quarantine and cotton trash treatment regulations that segments of the cotton industry must meet in order to curb the movement of pink bollworm from infected to non-infected areas within the continental U.S. Part of the APHIS regulations and control methods depend on the fact that the mechanical ginning process is highly effective in destroying pink bollworms.

Research has shown that the seed cotton cleaning equipment used in cotton gins to clean mechanically harvested seed cotton prior to ginning is very effective in killing a large percentage of the pink bollworm brought to the gin from the field (Graham et al., 1967). Subsequent processing of the ginned lint through saw-type lint cleaners kills any remaining pink bollworm that made it through the gin stand into the ginned lint (USDA, 1963). This information allows bales of ginned cotton to move freely in trade channels without fear of spreading pink bollworm to non-infected areas. Other research has shown that the proper use and design of gin trash handling fans will eliminate live pink bollworm in gin trash (Hughs and Staten, 1995, Robertson et al., 1959). This eliminates or reduces the survival and spread of pink bollworm through trash piles at gins and trash disposal in bollworm affected areas.

Another introduced cotton pest is the boll weevil. The boll weevil eradication program has eliminated the boll weevil from large areas of the cotton belt that were once generally infested. APHIS and other agencies have procedures in place to keep the weevil from being reintroduced into these eradicated areas in the U.S. In addition, other cotton growing countries, that currently do not have the boll weevil, have a concern with the boll weevil being introduced by shipment of baled cotton from the U.S. Current shipping and quarantine regulations include fumigation of baled cotton with methyl bromide prior to shipment to foreign ports. Methyl Bromide may not be available for use as a fumigant in the near future and alternate means of treatment or verification for boll weevil free certification will have to be found.

This is a report on research done to determine the possibility of live boll weevils surviving the cotton ginning and baling system. If it can be established that baled lint processed through the ginning and baling system does not contain any live boll weevil, then baled U.S. cotton can be certified weevil free based on the mechanical process. Alternately, it would be important to determine the possibility of boll weevil or other insect pests being introduced into the U.S. through baled cotton from foreign cotton growing areas.

Experimental Procedure

All U.S. cotton production is highly mechanized and all cotton is processed through a number of machines including a gin stand and at least one lint cleaner. However, a significant amount of foreign cotton is hand-picked and may receive little machining in the gin except for the gin stand and the bale press. It was therefore necessary to investigate what might occur in the ginning system separately from the baling operation itself. The research problem was broken into two parts: 1) could live weevils survive through the ginning system into the bale press, and 2) if a weevil made it to the bale press, could a live weevil survive the compressive forces in a cotton bale? All of the weevils used in the test were obtained live from two sources. The majority were from a lab-reared colony in the USDA, APHIS Pest Detection Diagnostics and Management Laboratory and some from local field locations.

Gin Process Survival Test

A 93-saw Continental saw-gin stand and one saw-type lint cleaner was selected as the test ginning sequence. It is at the gin stand that the fiber is separated from the seed and sent to be packaged. Anything that is removed from the seed cotton by seed cotton cleaning prior to the gin stand stays at the gin site and is not a concern. Only live weevils that might make it through the gin stand and into the bale would be of concern as possible sources of infestation in other cotton growing areas or countries. After the gin stand, the only other opportunity to kill any boll weevils that might be with the ginned fiber would be at the lint cleaner. Essentially all saw-gin stands in the U.S. are followed by one or more saw-type lint cleaners prior to the bale press. A single saw-type lint cleaner was selected as the minimum treatment that a live weevil might see between the gin stand and the bale press.

The expected boll weevil content for a given quantity of seed cotton being fed into a saw gin stand is always variable and unknown. There were no known weevil surveys to draw on for this information. The number of weevils that will be removed by the seed cotton system is also unknown. It was arbitrarily decided to use seed cotton lots of 200 pounds for each ginning lot and to introduce 1,000 live weevils per ginning lot at the gin stand. We used an infestation rate of 5 weevils per pound of seed cotton. Three separate ginning lots were processed that used a total of 600 pounds of seed cotton and 3,000 weevils for the entire ginning test.

The 93-saw gin stand used for the test was operated to gin at the rate of approximately 4 bales per hour. At this ginning rate, the 200 pounds of seed cotton would take approximately 2 minutes to be processed and would result in approximately 70 pounds of ginned lint at the bale press. The 1,000 weevils per ginning lot were hand fed directly into the gin stand during this 2 minute interval.

The point of separation of the fiber from the seed occurs in the gin stand in what is known as the seed roll. It is in the seed roll that any live weevils would be killed by the gin saws. In order to be able to accurately determine a weevil kill percentage by the ginning process, it was necessary to be certain that all 1,000 weevils per ginning lot were placed in the seed roll and were exposed to the ginning process. This was done by placing approximately 60 to 70 live boll weevils in the center of a grapefruit sized mass of seed cotton. The weevils were slightly chilled so that they were not active enough to fly away and would stay in the center of the seed cotton mass for a short time. Each of these seed cotton masses containing the weevils were then hand placed directly into the seed roll at various locations during each 2 minute lot time. The weevils were also coated with a dust that would fluoresce red (test weevils) under a black light. This was done so that any weevils that might make it through the ginning process could be more accurately located.

Once each of the approximately 70 pounds of ginned lint was processed, it was tied separately and removed from the bale press for later examination for weevils. As a check for efficiency of search, a 100 dead whole weevils that had been dyed to fluoresce orange (check weevils) under a black light was randomly placed through each lot of ginned lint prior to it being tied and removed from the press. Each of the three ginning lots of 70 pounds of fiber was then manually examined under a black light for both red (test) and orange (check) weevils.

In addition to the ginned lint, all of the seed, upper and lower motes and lint cleaner trash was caught and bagged. This material was also examined under a black light for test weevils in an attempt to determine what happened to boll weevils during the ginning and lint cleaning process.

Compression Survival Test

A static restraint range of bale density from 14 to 32 lb/ft^3 was selected. This covers the approximate range of cotton bale densities that are currently being traded on the world market. Nearly 100% of U.S. bales are produced at what is known as Universal Density (UD) which is 28 lb/ft^3 for a 480 pound bale. Other lighter bale densities and weights are produced in other parts of the world. It was not practical to use full size cotton bales for this test due to press capacity and handling problems. A small laboratory model fixed volume press was used that made bales whose dimensions were 5.16 in. X 2.69 in. X 2.44 in. Densities were varied by increments of 2 lb/ft^3 over the selected range. The statistical design was a randomized complete block that was blocked on replication with 5 replications per density level.

For each test lot, 20 live boll weevils were placed in the center of each bale. Since a fixed volume was used, the density was varied by pressing differing weights of fiber for each density level. For each test lot, the desired amount of fiber was weighed and then split in half. Half of the fiber was placed flat in the bale chamber. Then the 20 boll weevils for that lot were scattered on the surface of the cotton in the bale chamber. Then the other half of the fiber lot was placed into the chamber and the whole lot was immediately pressed to form a bale. The weevils were kept slightly chilled to prevent them from actively flying or escaping from the bale chamber.

In addition, each density level had two sub-treatments. These sub-treatments were called short- and long-term survival. For each density level and replication two small bales were randomly made, one for short- and the other for long-term survival testing. For the short-term survival test, the bale was compressed and held for one minute. At the end of one minute the pressure was released and the survivors were immediately counted. The procedure for the long-term survival test was to compress the bale and then tie it to maintain its compression. The long-term survival bale was then tagged and stored in a wire insect enclosure (to trap any weevils that might have wiggled out from the bales) for a period of about 6 days before the bale was opened and the weevils were examined for survivors.

Check samples of weevils were kept aside for both the short- and long-term survival tests. Before running each replication, weevils were manually counted out in lots of 20 and placed in small transparent plastic vials. Enough weevils were counted to use in the compression tests as well as to have one check lot of 20 weevils for both the short- and the long-term survival replicates. The check lots were handled and stored in exactly the same way as the test lots except that they were not compressed. The check lots were examined for live weevils at the same time as their respective short- or long-term survival replicate was examined.

The method of examining weevils for survival for all lots was to open the bale and manually remove each weevil from the bale by a pair of tweezers. Each weevil was examined for signs of life, primarily movement, and then placed back into the original vial from which it had come. The numbers of live and dead weevils were recorded. The vials were then stored for 24 hours under room conditions and the weevils were reexamined for signs of life. Weevils have a tendency to play possum when being handled and so must be carefully examined to verify their condition. If additional live weevils were found after the 24 hour storage, the numbers were adjusted and the weevils were disposed of.

Test Results

Gin Process Survival Test

Manually examining the ginned lint for weevils was a painstaking process that took in excess of 150 man hours per 70 pound lot. Table 1 shows the overall results for the 3 gin test lots. The end result was that no live or whole weevils were found in the ginned lint for any of the lots. The efficiency of examination, as estimated by the percentage of orange control weevils found, was approximately 90%. A total of 3,000 weevils were introduced into the process at the gin stand. If only 1%, or 30 weevils, had made it through the ginning process into the baled lint, the efficiency of search number would indicate that a total of 27 weevils would have been found. Only one weevil was found (Lot 2) whose body was primarily intact. This weevil was dead and was obviously missing 3 legs. Upon closer examination, it was determined that even if the weevil had been alive and had been able to survive storage for a period of weeks or months inside the bale, it would have been incapable of functioning because of mechanical damage.

Examination of the ginned seed and the trash from the gin stand showed from a 100 to 200 whole weevils plus other body parts per test lot. Some of the whole weevils in the seed were still alive immediately after ginning. The lint cleaner trash from the 3 lots only contained body parts and most of them were small.

Compression Survival Test

Figure 1 shows the data from the short-term survival compression test. These data show that a significant percentage of weevils can survive densities up to 20 lb/ft^3 for at least a short time. At densities of 22 lb/ft^3 and higher most of the weevils are immediately killed by the compression. Figure 2 shows similar data from the long-term survival compression test. Above 24 lb/ft^3 and higher densities there are no long-term survivors with one exception as explained in the following discussion.

The compression test was actually done in two parts. The first test was done at densities ranging from 14 to 28 lb/ft^3 in increments of 2 lb/ft^3, but skipping 26 lb/ft^3. This first test had a long-term survivor at 28 lb/ft^3 even though there were no short-term survivors at this density. The lone long-term survivor had appeared to be in a hole in a corner of the bale and was able to survive there relatively unscathed. All of its companions had been obviously flattened by the compressive forces in the small bale. It was decided to repeat and extend the high end of the test series in order to do a more thorough job of evaluation. The compression test series was done the second time from 22 to 32 lb/ft^3. These data showed no long-term survivors at any of the densities from 22 to 32 lb/ft^3 even though there were some short term survivors up through 26 lb/ft^3.

Discussion and Summary

The gin process test demonstrated that the mechanical action of the gin stand and the saw-type lint cleaner was very destructive to live boll weevils. Even at a high dosage rate of 3,000 total weevils in 600 pounds of seed cotton, only one partially intact weevil body made it through to the bale press. The relatively high percentage of search efficiency, as documented by the control weevils, makes it highly unlikely that any other whole weevils were present in the ginned fiber lots. This weevil was dead and had suffered serious physical damage so that it would not have been viable even if alive. Concentrated effort was made to get live weevils into the gin stand bypassing the seed cotton cleaning section of the ginning system. It is likely that the seed cotton cleaning process would remove most weevils prior to the gin stand, making it even less likely for a live boll weevil to survive the ginning and lint cleaning process.

The compression test showed that most weevils are immediately killed above bale densities of 22 lb/ft^3. At the standard UD bale density of 28 lb/ft^3 there were no survivors for even 6 days. Typically cotton bales may be in storage for at least several weeks and probably for several months before being broken open and used. This length of time would make it even less likely for weevil survival.

In summary, the overall risk of a live weevil making it through the ginning system in the U.S. and into a cotton bale is so small it is not predicted and could not be measured.. Couple that risk with the chance of a live weevil surviving long term the compressive forces in a standard UD bale of 28 lb/ft^3 and it is extremely unlikely that a live weevil could be transported and released to infest another area or country. Another safety factor is, that at the time of strapping, a 480 pound UD bale is momentarily compressed to a density greater than 30 lb/ft^3 in order to apply the ties. After tying, the bale is released to a restraint density of approximately 28 lb/ft^3. The extra compressive forces at tying will still further decrease the risk of weevil survival.

There is a risk of weevils surviving, if somehow introduced, in underweight U.S. bales even if tied in a UD press, or in bale packages such as flat or modified flat whose normal densities are approximately 14 lb/ft^3. There are only a few thousand modified flat bales currently produced in the U.S, but this type of bale package is still produced overseas. If there is concern about introducing boll weevils into a weevil free area through the shipping of cotton bales, a restriction on underweight UD bales or any bale design with standard densities less than 20 or 22 lb/ft^3 would be important control factors.

Disclaimer

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U. S. Department of Agriculture.

References

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Table 1. Gin process weevil survival.

Lot Number	Number of whole/live test weevils	Percentage of control weevils found
1	0	86
2	0*	95
3	0	90

*One dead weevil was found that was missing 3 legs and had other damage.

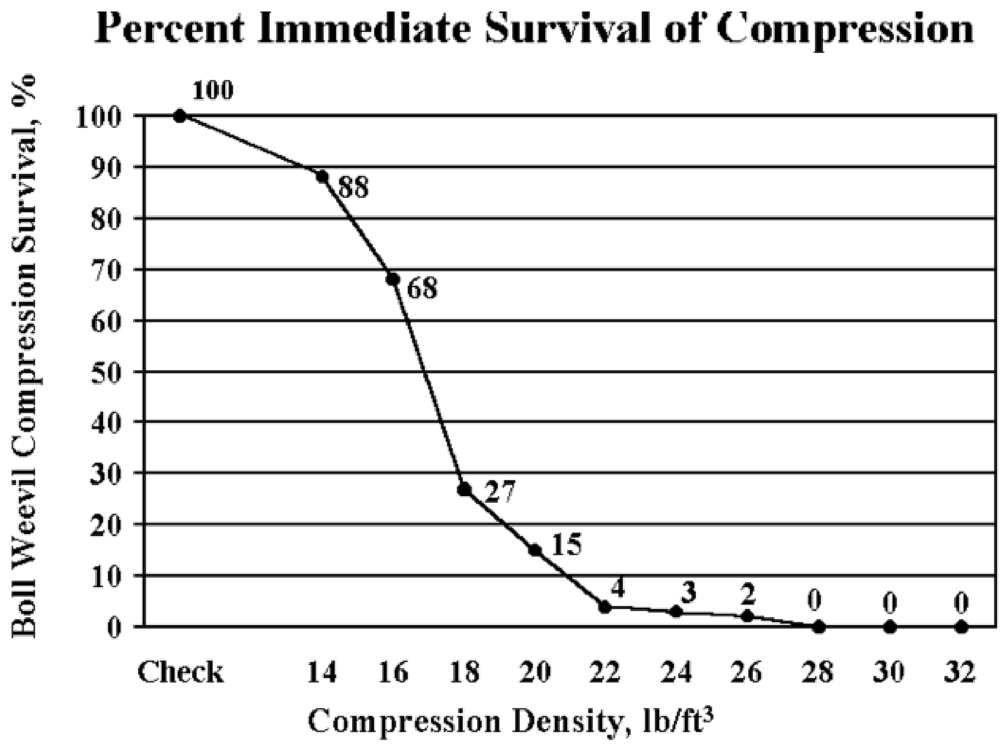

Figure 1.

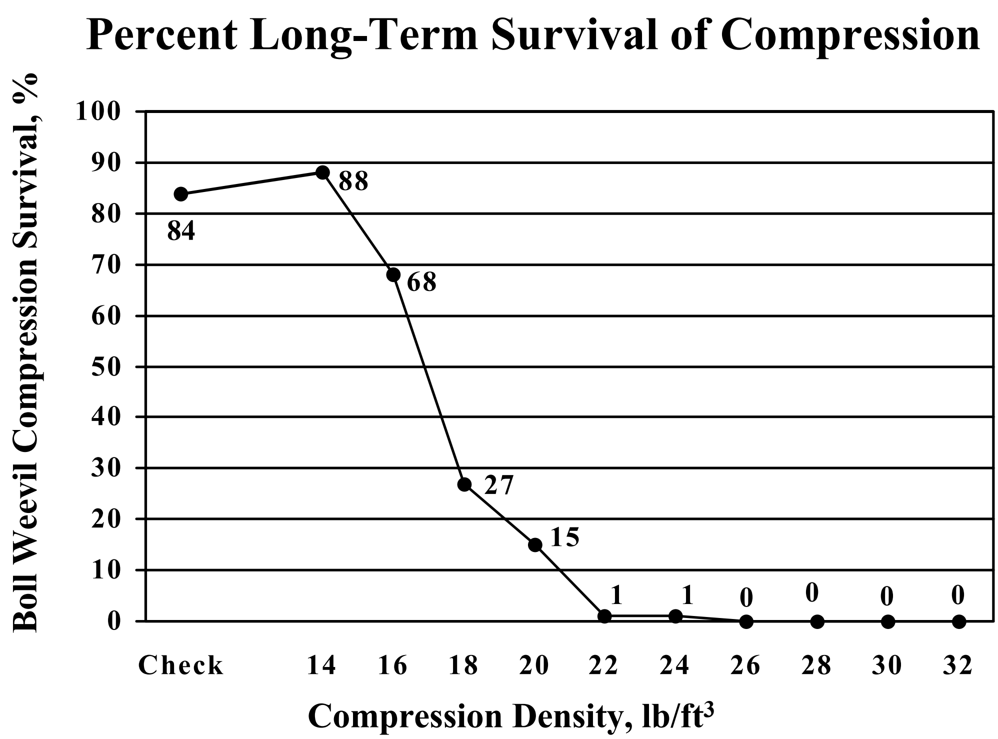

Figure 2.