EFFECTS OF HARVESTING AND DRYING ON MAIZE WEEVIL POPULATIONS IN FIELD-INFESTED CORN

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Abstract

A study was conducted to examine how threshing and drying of field-infested corn can reduce maize weevil, Sitophilus zeamais Motschulsky, populations going into storage. Also determined was how well insect counts taken just after harvesting correlate to insect counts taken after six and twelve weeks in storage. Sixty small field plots were planted in one of three hybrids (Funk 4507, DeKalb 1214, or Pioneer 3030) and infested in one of two ways (natural or artificial introduction of 10 weevils per ear). At harvest, the following samples were taken: 10 ears per plot just before harvesting (FIELD), undried seed from just threshed ears (UNDRIED), the debris separated from this undried seed (TRASH), dried seed from just threshed ears (DRIED), and dried seed after 6 and 12 weeks in storage (STOR-6 and STOR-12). Threshing removed 11, 18, and 19% of live weevils and drying reduced weevil populations by 87, 86, and 91% (4507, 1214, and 3030, respectively). Population reductions due to the combined effect of threshing and drying were calculated to be 89, 89, and 92% for hybrids 4507, 1214, and 3030, respectively.

Introduction

The maize weevil, Sitophilus zeamais, has long been considered one of the most destructive insect pests of corn in the field and in storage (VanDerSchaaf et al. 1969, Williams and Floyd 1970, Taylor 1971, Turner 1976). It not only feeds on corn, but its presence on ears of corn can also result in a doubled infection rate by Aspergillus flavus (Link)(McMillian et al. 1980). Despite this economic importance, the transition of maize weevil populations from the field into the storage facility has received very little attention. Most studies on transition have dealt with flight activity, demonstrating that the maize weevil will fly at least 800 m to infest a new site (Singh et al. 1978) and that it will fly from the field to a storage facility and vice versa (Chesnut 1972).

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Practices, such as harvesting, shelling, and drying of crops, can immediately reduce insect populations through physical separation and insect mortality, and can reduce the biotic potential of the insect species by changing its environmental conditions, such as moisture content and texture of the commodity (Himdmarsh and MacDonald 1980, Takahashi and Mizuno 1982). In this study we evaluated the reduction in maize weevil populations due to threshing and drying of field-infested corn, and how this impacted population densities later in storage. We also determined the proportion that were left alive in the field with the potential to infest nearby storage facilities. The study involved a field phase in Tifton, Georgia and a laboratory phase in Savannah, Georgia.

Materials and Methods

Sixty plots of corn were planted with each plot consisting of three 20-ft rows and four border rows on each side. Each plot was designated according to (1) the manner of maize weevil infestation (artificial or natural), (2) the hybrid planted (Funk 4507, DeKalb 1214, or Pioneer 3030), and (3) the replicate (total of 10).

Artificial infestation in half the plots was to ensure adequate insect population levels, and natural infestations in the other plots was for determining if the artificial infestation technique affected results. Artificial infestation was accomplished by placing 10 unsexed weevils on the top ear of each plant. Placement was made by putting the 10 weevils into a small plastic cup, putting the cup into a paper bag, putting the bag securely over the ear of corn, and then manually crushing the bag and cup inside. This allowed the weevils to move out of the cup and onto the ear of the corn, but kept them from getting away. Placement was made in early August 25 days after full silking, and paper bags were removed one week after placement.

The three different hybrids were planted because of their relative susceptibility to the weevil in the field and in storage (MacMillian _et al_., 1980). Funk 4507 is considered to be highly susceptible both in the field and storage, Pioneer 3030 resistant both in field and storage, and DeKalb 1214 resistant in the field and intermediately resistant in storage.

The artificially infested plots just described utilized a weevil strain that had been laboratory reared for many years. Therefore, as a check on competitiveness of the laboratory strain, six more plots (3 corn hybrids x 2 replicates) were planted and infested with a weevil strain recently removed from the field. The two strains were compared on the basis of their observed reproduction and mortality.

Corn was harvested at ca. 16% moisture content, this being 36 days after infestation for Funk 4507 and 43 days after infestation for the DeKalb and Pioneer hybrids. Sampling began at this time. Within 24 hours prior to harvesting, a FIELD sample was taken to quantify the weevil population in the field. Each plot was sampled by collecting the top ear from the first plant and every subsequent fifth plant until 10 ears were collected. These were put into a ziplock bag and, like all samples, were taken to the Savannah laboratory for counting of weevils.

The remaining corn from the middle row was then picked by hand and run through a combine. Debris separated from the seed in this process was collected on a sheet of polyethylene, saved in a large plastic bag, and labelled TRASH. The purpose of this sample was to determine the proportion of weevils removed from the seed and the number that would have been left alive in the field, capable of infesting nearby granaries.

The remaining ears from each plot were then picked and run through the combine. This seed along with that from the middle row was put into a 10-oz burlap bag. One liter was removed and labelled as the UNDRIED sample of seed. The rest was dried overnight at 43.3°C (temperature recommended by the Georgia Cooperative Extension Service) to a moisture content of ca. 12%. This dried seed was taken to the Savannah laboratory where one liter per plot was removed and labelled as the DRIED sample. The remaining seed was put into a fiberboard drum stored in a metal building at ambient temperature and relative humidity. This was then sampled (one liter) at 6 weeks and 12 weeks post-harvest and labelled STOR-6 and STOR-12, respectively.

Insects were counted in the laboratory. For the FIELD sample, seed was still on the ear, so all insects, dead and alive, were visually inspected and the number recorded. For all other samples, a no. 10 U.S. standard sieve was used to separate weevils from other matter. Samples were shaken for 30 seconds and the adult weevils were counted. This was repeated. The interim between shakings was to allow agitated weevils within the seed a chance to crawl out and be detected. Weevil counts for the FIELD and TRASH samples were made in the first week post-harvest, but counts for the DRIED and UNDRIED samples had to be delayed until two weeks post-harvest.

Results and Discussion

The laboratory strain of weevils did not differ from the field strain in terms of reproduction and mortality. Their similarity may be due to the fact that the laboratory strain is reared on corn and not on an artificial diet. Also, weevil populations from the artificially infested plots did not differ from those in the naturally infested ones in terms of rate of population increase or in terms of the proportion removed from seed during threshing. Therefore, samples for both types of infestation were combined for analyses.

Table I shows the number of weevils found in the samples. FIELD counts did not reflect trends in the other samples, possibly because FIELD samples consisted of corn still on the ear and weevils were counted differently than in the other samples that all consisted of shelled corn. With the exception of FIELD counts, all three corn hybrids followed the same trend from one type of sample to another. Despite supposed differences in storage susceptibility to the weevil, all three hybrids had about the same rate of population increase in storage. Also, while the counts of STOR-6 were 8.4 - 9.1 times that of the four week earlier counts of DRIED samples, cold weather apparently greatly diminished population increases during the six week period from STOR-6 to STOR-12.

Table I. Mean number (±SE) of maize weevils per kilogram of corn sampled

	Type of sample					
Hybrid	FIELD[a]	TRASH[b]	UNDRIED[b]	DRIED[b]	STOR-6	STOR-12
Funk 4507	8.6 ±1.7	3.2 ±0.5	26.3 ±4.1	3.4 ±1.2	31.0 ±7.8	62.8 ±15.9
DeKalb 1214	8.8 ±2.0	1.3 ±0.4	5.8 ±1.4	0.8 ±0.3	6.7 ±2.1	17.8 ±7.8
Pioneer 3030	4.4 ±1.1	0.8 ±0.2	3.4 ±1.3	0.3 ±0.3	2.7 ±0.7	4.8 ±1.1

[a]Weevil counts were from corn still on the ear.

[b]Weevil counts were from corn seed.

Values in Table I also give an indirect assessment of the effects of drying on the weevil populations. Note the similarity between counts for the UNDRIED samples (for which counts were made at two weeks post-harvest) and for the STOR-6 counts. This similarity indicates that it required ca. four weeks for weevil populations to recover from drying effects. This four weeks of suppression is very important in temperate climates because weevil populations have only a short period of time to increase between harvest and the onset of cold weather.

The proportion of weevils removed in threshing was calculated by dividing the TRASH counts by the sum of the TRASH and UNDRIED counts (Table II). This proportion is a conservative estimate because the UNDRIED counts were made a week after the TRASH counts causing the relative UNDRIED values to be inflated. Values indicate that a small, but significant proportion of weevils were left in the field from where they could fly to nearby granaries. A significantly ($P<0.05$) smaller proportion were removed from the more field susceptible hybrid, Funk 4507, perhaps because weevils had better penetrated its softer pericarp.

Table II. The estimated proportion of maize weevils removed from the seed during threshing

Hybrid	Weevil status	No. Weevils per kg corn TRASH	UNDRIED	Proportion[a] removed
Funk 4507	Alive	3.2	26.3	0.11
	Dead	5.3	1.0	.84
DeKalb 1214	Alive	1.3	5.8	.18
	Dead	1.0	0.4	.72
Pioneer 3030	Alive	0.8	3.4	.19
	Dead	1.0	0.5	.68

[a]Calculated by dividing the TRASH values by the sum of the TRASH and UNDRIED values.

The proportion of population reduction due to drying was calculated by dividing the DRIED counts by the UNDRIED counts, both counts having been made at two weeks post-harvest (Table III). The reduction was substantial for all three hybrids and may be even greater in typical Georgia farming operations. This is because we harvested our corn at 15.6% - 16.9% moisture content (Table IV), while Georgia farmers harvest corn at a mean moisture content of 18% according to the Georgia Cooperative Extension Service. This means that the typical farmer would have to dry his corn longer in order to reach these reduced storage moisture contents, thereby causing greater weevil mortality. Note that corn regained some moisture during storage but this stabilized by six weeks post-harvest.

Table III. The proportion of maize weevil population reduction due to drying of field-infested corn

Hybrid	No. Weevils (±SE) per kg corn UNDRIED	DRIED	Proportion reduction
Funk 4507	26.3 ± 4.1	3.4 ±1.2	0.87
DeKalb 1214	5.8 ±1.4	0.8 ±0.3	0.86
Pioneer 3030	3.4 ±1.3	0.3 ±0.3	0.91

Table IV. Moisture content (%) of corn at various sampling intervals

Hybrid	M.c. at harvest	Type of sample		
		DRIED	STOR-6	STOR-12
Funk 4507	15.6	11.4	13.4	13.7
DeKalb 1214	16.9	11.8	14.2	14.0
Pioneer 3030	16.8	12.2	14.5	-

The net population reduction through threshing and drying, R_{NET}, was calculated as follows:

$$R_{NET} = R_{THRESH} + [R_{DRY} \times (1 - R_{THRESH})],$$

where R_{THRESH} = proportion population reduction due to threshing

and R_{DRY} = proportion population reduction due to drying.

Therefore, R_{NET} = 0.89, 0.89, and 0.92 for Funk 4507, DeKalb 1214, and Pioneer 3030, respectively. These reductions were due primarily to drying.

Correlations between all types of samples were determined and coefficients of determination (r^2) were calculated. Numerous significant ($P<0.05$), but weak ($r^2<0.20$) correlations were found. The stronger and more interesting correlations are shown in Table V. The r^2-values for the lumped hybrid data indicate that samples taken soon after harvest may be useful in estimating weevil populations in later storage. However, when data were separated according to hybrid, only Funk 4507 samples yielded significant ($P< 0.001$) correlations. In fact, Funk 4507 r^2-values were similar to those for the lumped hybrid data. Perhaps there exists a direct relationship between r^2-values and the susceptibility of a hybrid.

Table V. Coefficient of determination (r^2) for variables found to be most strongly correlated ($P<0.001$)

Var (Y)	Var (X)	Hybrid data lumped	Hybrid data separated		
			Funk	DeKalb	Pioneer
STOR-6	UNDRIED	0.61	0.52	-	-
	DRIED	.64	.59	-	-
STOR-12	UNDRIED	.48	.39	-	-
	DRIED	.61	.64	-	-
	STOR-6	.72	.65	.71	.64

In conclusion, drying greatly reduced maize weevil populations and contributed to lower population densities in storage. Threshing separated a small proportion of weevils from the seed, but left many live weevils in the field to possibly infest nearby granaries. Therefore, when fields are located near granaries it might be better if one could retain these weevils and run them through the dryer.

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