QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

DIVISION OF PLANT INDUSTRY BULLETIN No. 821

STORED PRODUCTS INSECT PESTS IN COMBINE HARVESTERS ON THE DARLING DOWNS

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SUMMARY

In four surveys of combine harvesters on the Darling Downs between October 1976 and October 1978, pest insects were found in 66 of the 72 headers sampled. *Tribolium castaneum* (Herbst.), *Rhyzopertha dominica* (F.), and *Sitophilus oryzae* (L.) together accounted for 91·7% of insects found. Three headers were cleaned once, and six others twice. The average weight of residue found in previously uncleaned headers was 46·4 (± standard error 9·0) kg, containing an estimated 3238 (95% confidence interval 2421–4055) major pest adults.

During grain harvests, most insects in the inside parts of the header were flushed into the newly harvested grain, but approximately 250 remained in protected areas. Cleaning headers is effective in reducing populations. In one survey uncleaned headers contained mean major pest populations of 2142 ± 842, compared to only 77 ± 32 in cleaned headers.

I. INTRODUCTION

Contamination of newly harvested grain by storage pests may occur at a number of points within the grain handling system. Infestation may occur in the field, or in field bins, trucks, and silos by direct contact with infested grain, or in temporarily stored grain by migration of adults from infested grain residues in farm buildings. Combine harvesters have been regarded as a major source of insect infestation in newly harvested grain (Greening 1969, 1973; Williams 1969). However, there are no published quantitative data on the size of these populations.

We studied pest insect populations in headers as part of an investigation of infestation throughout the grain handling system in which we will evaluate various pest management strategies. In the header investigation, surveys were carried out on the Darling Downs to determine the frequency of header infestations and the mean size of pest species populations. The effects of harvesting and cleaning on these pest populations were also investigated.

II. MATERIALS AND METHODS

Surveys

In each of the four surveys, the farms sampled were selected by District Departmental advisers. The surveys were:

JIMBOUR—October 1976, just prior to the wheat harvest. A total of 74 samples (0·1 to 4·0 kg each) was taken from 21 headers on 18 farms in the Jimbour area, and from two headers on two farms near Norwin. From one to eight samples were taken from each header. Previous cleaning of the header by the farmer was recorded.

MACALISTER—January 1977 to January 1978. Samples were taken monthly from each of three headers on three farms near Macalister to determine seasonal population changes. From areas within the grain stream samples were taken from combs, bin, walkers and riddles, and drum, and on the outside—from the top of front elevator, axles, and top of fan housing. In all, 242 samples ranging from 0·01 to 0·4 kg were obtained.

GENERAL—April 1977 to May 1978. A total of 93 samples (0·005 to 0·93 kg) was taken from various header parts on 40 farms between Chinchilla and Warwick.

CLIFTON—November 1977 to October 1978. Six headers in the Clifton–Allora area were used. The headers were cleaned after the 1977 wheat harvest and again after the 1978 sorghum/sunflower harvest. Samples consisted of the entire residue collected during cleaning, totalling 373·9 kg for the first cleaning and 190·1 kg for the second.

Samples treatment

Samples from the Clifton survey were initially reduced in volume by sieving twice on a large sieve and discarding the fraction that did not pass the 2·5-mm apertures. The finer portion, and samples from the other survey were sieved for one minute on a mechanical orbital shaker (300 r.p.m.) in a small nest of sieves. Fractions greater than 0·4 mm were sprinkled in a thin layer on to a white surface from which live insects were collected.

Flushing of insects from headers

Two plastic-lined paper bags (25-kg capacity) were left with each header in the Jimbour survey for the farmers to collect samples of the first grain through the header. Within 10 days of collection the grain in the sealed bags was sieved to detect insects. The Clifton survey also provided data on the extent of removal of pest populations during harvests.

Header cleaning

All the headers cleaned had been left in the condition in which they came from the field. All inspection hatches were opened and the riddles removed. The main grain elevators were cleaned by running them with a bag under the open bottom inspection plate. The remaining parts were cleaned with industrial vacuum cleaners, except for large residues of stalks and straw which were collected by hand. A variety of extension, and flexible nozzles assisted access and in many cases scrapers and wire probes were also used. In a few instances it was necessary to use compressed air, and then collect the material subsequently from where it had fallen. During cleaning the machine was run occasionally to alter front elevator position, so improving access to the drum and revealing any residue that may have been missed.

The brands of headers were: Massey Ferguson (M.F.) 510 (1 machine), M.F. 585's (3), M.F. 760 (1), John Deere 7100's (2), New Holland 1545 (1), and Oliver 431 (1). Three headers were cleaned at Jimbour after the 1976 wheat harvest. In the Clifton survey, to show the number of insects present after a harvest and their subsequent build up, half the headers were cleaned within a week of the completion of the 1977 wheat harvest, and again immediately after the 1978 sorghum/sunflower harvest whilst the remainder were cleaned three months after the wheat harvest, and again five months after the sunflower harvest.

III. RESULTS

Frequency of infestation

In the three surveys in which sampling was most intense pest insects were found in 31 of the 32 headers. In the general survey in which sampling was less intense, pest adults were found in 35 of the 40 headers.

Insect types found

The rust-red flour beetle, *Tribolium castaneum* (Herbst), (Tenebrionidae), the lesser grain borer, *Rhyzopertha dominica* (F.) (Bostrychidae), and the rice weevil, *Sitophilus oryzae* (L.) (Curculionidae), were the most common species recorded, together accounting for 91·7% of adult insects found (table 1). Averaged over all surveys, the densities of these three species were respectively 8·2, 6·6, and 3·2 adults per kilogram of residue sampled. Of the other insects, *Carpophilus spp.* (Nitidulidae) were the most common, but their overall density was only 0·7 adults per kilogram of residue. Other species were recorded only occasionally.

TABLE 1

NUMBERS OF ADULT INSECTS FOUND IN HEADERS DURING SURVEYS 1976–1978

Survey	Total Sampled (kg)	Number of Adults			
		Tribolium castaneum	*Rhyzopertha dominica*	*Sitophilus oryzae*	Others
Jimbour ..	41·2	1 397	534	1086	128
Macalister ..	42·9	784	1 170	461	365
General ..	19·1	699	845	431	361
Clifton ..	564·0	2 483	1 806	156	217
Total ..	667·2	5 363	4 355	2 134	1 071

In the remainder of this paper reference to the 'major species', or 'major pests' will refer to *T. castaneum, R. dominica,* and *S. oryzae* treated as a group.

Residue in uncleaned headers

The weights of residue removed from headers in the Jimbour and Clifton surveys are shown in table 2. The lower weight found in the inside parts of the Jimbour headers is believed to be due partly to our inexperience during the cleaning of the first header, resulting in an underestimate for some parts. One bin contained an unusually large amount of wheat (35·6 kg). The reduced weight of residue on the inside parts found in the second cleaning of the Clifton survey compared to the first, was caused by the lower density of sunflower residue compared to that left after a wheat harvest. Most parts inside the headers appeared equally dirty and clogged with material at each cleaning. The exception, the increased weight found in walkers and riddles was caused by the large number of sunflower stalks caught in this area.

Whilst the inside areas appear to accumulate maximum residue within one harvest, a number of harvests is required to completely fill all outside areas. In the second cleaning of Clifton headers, much less residue was collected from outside areas than in the first. One of the Jimbour headers cleaned was new before the harvest, and had relatively little outside residue.

TABLE 2

MEAN WEIGHT OF RESIDUE (kg) (± STANDARD ERROR) IN VARIOUS HEADER PARTS AFTER HARVESTS

——	Jimbour	Clifton		Combined
Preceding Harvest	Wheat 1976	Wheat 1977	Sorghum/Sunflower 1978	
Number of Headers	3	6	5*	
HEADER PART				
Combs	2·7 ± 0·9	4·1 ± 1·4	3·9 ± 2·3	3·7 ± 1·0
Front Elevator	1·6 —	2·6 ± 1·1	1·4 ± 0·4	2·0 ± 0·5
Drum and Stone Trap	6·1 ± 1·7	11·5 ± 4·1	5·2 ± 2·0	7·9 ± 1·9
Cross Augers	2·1 ± 1·9	0·6 ± 0·1	0·8 ± 0·4	1·0 ± 0·3
Walkers and Riddles	1·1 ± 0·4	5·1 ± 1·6	7·5 ± 0·6	5·2 ± 0·9
Grain Pan	0·6 —	4·5 ± 2·3	2·5 ± 1·0	3·1 ± 1·1
Main Elevators	0·4 —	1·3 ± 0·2	0·6 ± 0·3	0·9 ± 0·2
Bin	15·8 ± 9·9	7·1 ± 1·0	3·4 ± 0·8	7·4 ± 2·1
Sub Total " Inside "	29·4 ± 9·5	36·8 ± 8·1	25·3 ± 5·9	30·7 ± 4·3
Sub Total " Outside "	9·6 ± 1·8	25·5 ± 10·3	5·3 ± 1·6	14·9 ± 5·0
Total	30·9 ± 11·0	62·3 ± 18·1	31·7 ± 8·6	46·4 ± 9·0

* One header was cleaned twice inside during this period, for 6 results, but only once outside.

Density, and populations, of pests in uncleaned headers

The mean density of the major species over all surveys is shown in table 3. The data are very variable, and comparison between the densities in various parts was not attempted.

TABLE 3

MEAN DENSITY AND ESTIMATED POPULATIONS OF THE ADULTS OF MAJOR PEST SPECIES (*Tribolium castaneum, Rhyzopertha dominica, Sitophilus oryzae*) IN HEADER PARTS: ALL SURVEYS 1976–78

Header Part	Adult Density		Estimated Population	
	No. of Samples	Mean per kg (±S.E.)	No.	95% Confidence Limits
Combs	32	67·8 ±27·1	251	8– 494
Front Elevator	13	84·6±45·1	169	0– 369
Drum and Stone Trap	15	43·3±20·3	342	0– 703
Cross Augers	26	94·2±25·9	94	17– 171
Walkers and Riddles	16	19·1±12·6	99	0– 234
Grain Pan	7	2·7± 2·7	8	0– 26
Main Elevators	14	36·7±14·4	33	3– 63
Bin	43	84·3±34·7	624	0–1 252
Sub Total 'Inside'	..	..	1 620	814–2 426
Sub Total 'Outside'	75	108·6±16·5	1 618	439–2 797
Total	..	..	3 238	2 421–4 055

The mean estimated populations of major pests, in uncleaned headers, obtained from mean residue amounts and mean pest densities, are also shown in table 3, with the 95% confidence interval of the estimate. We considered that estimates for individual species were not warranted because of the large variation.

Outside parts of the header carry approximately 50% of the total population. Of the parts inside, combs, front elevator, drum and stone trap, and bin, are the major sources of insect population with 15%, 10%, 21%, and 39% of the inside population respectively.

Seasonal variation in populations of pests in headers

Analysis of the densities of pests in the monthly samples of the Macalister survey failed to show seasonal variation. Population increase from summer to autumn is indicated in the Clifton survey, in which average pest density in the headers cleaned immediately after the wheat harvest was 3·9 ± 2·1 adults per kilogram compared to 37·7 ± 14·6 in headers cleaned after three months. In the winter and spring, growth was negligible, there being no significant increase in the immediate post-harvest densities in the five months following the sunflower harvest. Probably both lower temperatures and the less suitable food of sunflower residues contributed to this.

Pests flushed from headers by harvests

Samples of first grain harvested were collected from 21 of the headers in the Jimbour survey. Mean sample size was 29·0 ± 3·9 kg. The mean density of major pests in this grain was 0·57 ± 0·15 adults per kilogram.

This grain was collected from approximately one-half tonne of grain in the header bin, so the number of insects dislodged at that stage would be 135 to 440, or 10 to 30% of the mean number inside a header. Insects would continue to be dislodged as the harvest progressed.

However, not all insects were removed during harvest. In the Clifton survey, a mean of 251·3 ± 136·6 pest adults were found in the inside parts of the headers within a week of completion of the wheat harvest. Important pockets of residue which are not flushed out during harvests are the stone trap (in one header 434 insects were found here after harvest) and the ledge supporting the curtain behind the beater (388 pest adults in one header).

We estimate that of the 1600 adult pests inside the average uncleaned header, 250 remain alive in the header after harvest.

Effect of cleaning headers on pest populations

The results of the Jimbour survey indicate clearly how effective cleaning is in reducing pest populations in headers (see table 4). Insecticide had not been applied to these headers.

TABLE 4

EFFECT OF CLEANING IN REDUCING PEST POPULATIONS IN HEADERS (JIMBOUR SURVEY) (INSECTICIDE NOT APPLIED)

Treatment	Number	Estimated Total Pests per Header ± S.E.
Uncleaned ..	14	2 142±842
Cleaned	6	77±32

Cleaning alone reduced pest populations by more than 95%. In the cleaned headers, not only was there less residue, but that remaining had lower insect densities (49·1 ± 23·7 adult pests per kilogram compared to 117·6 ± 57·2 adults per kilogram in residues from dirty headers). In three other uncleaned headers, insecticide had been applied, with variable results One header was treated with dieldrin and had an estimated population of 1,110 major pest adults, another with DDT in which we could find no insects, and the third with dichlorvos which had an estimated 248 pest adults. We could not determine the rates of application used.

IV. DISCUSSION

Headers must be regarded as a major site of stored products pest populations on farms, although the contribution of these populations to central storage infestation is not so clear. Whilst it was shown that a large number of insects are removed from the header by the upheaval of harvest the number of these delivered alive to storage was not established. On the larger farms in the western parts of the Darling Downs, it is apparently usual for farmers not to deliver the first half to one tonne of grain harvested. This would immediately remove 130 to 900 insects from the system. However, the practice is not common on the smaller farms in the east and south, where all grain is usually delivered. While the initial flushing effect is greatest, it is probable that at all harvest stops insects continue to move into the new grain from sheltered

areas inside the header and from outside areas. The mechanical trauma involved in harvesting and transporting grain probably kills some insects, but published data conflict on the extent of mortality caused by mechanical grain handling systems (e.g. Cogburn, Fulton and Brower 1972; Watters and Bickis 1978). More work is required on this although we believe that headers contribute a significant proportion of the pest insects that enter central stores with newly harvested grain, and measures to control header pest populations are necessary.

Our results show that cleaning alone substantially reduces pest numbers. There were insufficient data to assess the effect of insecticide application without cleaning, but we believe that it would generally be unsatisfactory because of poor penetration of the material into residue, and such applications could increase the risk of selecting for insecticide resistance. The chemicals used in the three headers surveyed were not satisfactory; DDT and dieldrin have undesirable residues, and dichlorvos has too short a residual life.

Other work has shown that malathion application after cleaning is satisfactory (Williams 1969) but no headers treated in this way were seen in these surveys. Fumigation before harvest is also satisfactory (e.g. Greening 1978) but re-infestation can occur after fumigation so that between fumigations the header remains a major site of pest populations. Cleaning appears to be the most effective single measure for long term reduction of pest insect populations in these machines. Despite difficult access to many parts of the header, satisfactory cleaning is relatively easy by the methods developed by Bloome and Grevis-James (1978). Nevertheless, further modifications of header design to reduce the amount of retained residue, and improve access to all parts (e.g. Bloome and Grevis-James 1978) are desirable.

V. ACKNOWLEDGEMENTS

Our thanks are due to officers of the Entomology Branch: Mr Haddrell for assistance with the processing of samples, and Mr Donaldson and Mr Galloway for assistance with the identification of insects. The project was supported financially by the Wheat Industry Research Council.

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(Received for publication 1 August 1979)

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