Post-harvest Control of the Grain Chinch Bug *Macchiademus diplopterus* (Heteroptera: Lygaeidae) on Pears in the Western Cape Province, South Africa

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Abstract

The grain chinch bug (GCB) *M. diplopterus* is endemic to the Western Cape and as such is classified as a quarantine pest. The aim of this project was to evaluate post-harvest methods of control to ensure that packed fruit cartons destined for export are free of live GCB adults and acceptable to international quarantine standards. Cold storage trials were carried out at a commercial cold store in Ceres during three years. GCB adults were subjected to controlled atmosphere conditions (treatment) and regular atmosphere conditions (control) for a period of 6 weeks during 2001 and 10 weeks during 2002. The trials during 2001 and 2002 were carried out by packing GCB and pears into cardboard boxes with plastic liners. During 2003 the trial was repeated, but GCB and pears were placed directly into open plastic lug boxes without plastic liners. The results showed that GCB appear to be very well cold-adapted and that at least nine weeks will be required to achieve 100% mortality under controlled atmosphere conditions if pears are packed with plastic liners. A mortality of 100% was never achieved under regular atmosphere conditions for the duration of the trial. If no plastic liners were used, 100% mortality of GCB occurred one week earlier under controlled atmosphere conditions. Sufficient data was generated here to conclude that low temperature in itself was not sufficient to effectively sterilize pears from GCB infestations. The time required to achieve 100% mortality under controlled atmosphere conditions would probably compromise fruit quality or be unacceptably long.

INTRODUCTION

The grain chinch bug (GCB) *M. diplopterus* (Distant) is endemic to the Western Cape and as such is classified as a quarantine pest. Its distribution appears to correspond primarily with the winter rainfall area of the southwestern Cape, although it has been recorded as far north as the Richtersveld and as far east as Grahamstown (Slater and Wilcox, 1973). It is a direct pest of wheat, but also feeds on cultivated grains and wild grasses (Myburgh and Kriegler, 1967). From the end of spring, when the wheat is harvested and grasses start drying out, GCB adults seek shelter in orchards where they crawl into the stalk and calyx end of fruit. At this time they stop feeding and become quiescent until the following winter (Myburgh and Kriegler, 1967). It is in this dormant phase that they are found in export fruit cartons. The presence of live GCB in packed fruit cartons has lead to the rejection of fruit cartons destined for the USA market. Quarantine restrictions require approved disinfestation treatments before shipment. These treatments are specified by the Animal and Plant Health Inspection Service of the United States Department of Agriculture, Plant Protection and Quarantine, otherwise the importing country sets treatment standards. The aim of this research was to evaluate cold storage as a method of control to ensure that packed fruit cartons are free of live GCB and acceptable to international quarantine standards.

MATERIALS AND METHODS

Cold storage trials were carried out at a commercial cold store in Ceres (33.24S 19.26E), Western Cape (Ceres Fruit Growers). Large numbers of adult GCB's were collected from bluegum trees by peeling the loose bark from the trees in the Ceres area. The GCB were placed in plastic containers and transported back to the laboratory in Stellenbosch in a coolbox.

Controlled Atmosphere Treatment

An estimated 2000 GCB (based on the weight of 1000 GCB's previously counted and weighed in the laboratory) were placed into each of five pear cartons, replicated five times. A total of 50 000 GCB were therefore placed into CA. Third grade Doyenne du Commice pears were used. The pears were packed into plastic liners before being placed into cardboard cartons, according to export requirements. The GCB were placed into sealed nylon gauze bags before placing them in the cartons with the pears. Each gauze bag was placed on the top layer of pears before the plastic liner was folded and the carton closed. The cartons were marked and placed into a controlled atmosphere (CA) storage chamber filled with a gas mixture of 1.5% O_2, 0% CO_2 and 97.0% N_2 at –0.5°C. The cartons were placed in the CA chamber only once the gas mixture and temperature had been reached. This took place on the same day that the GCB were placed into the cartons.

Regular Atmosphere Treatment (Control)

An estimated 500 GCB were placed in each of five pear cartons, replicated five times, after being placed into sealed gauze bags. A total of 12 500 GCB were therefore placed into regular atmosphere (RA). The cartons were again packed according to export requirements and stored in a commercial cold storage chamber containing RA at –0.5°C.

Evaluation

During 2001, five cartons were removed from CA storage and five from RA storage after two weeks; thereafter the cartons were removed at weekly intervals, resulting in a total of six weeks evaluation. Due to low mortality of GCB after 6 weeks in both RA and CA during the first year, the trial was extended to a total of 10 weeks during 2002, where the first assessment took place after 6 weeks with subsequent assessments at weekly intervals. The cold storage trials were repeated as described for 2002 during 2003, except that pears were packed directly into plastic picking crates instead of cardboard boxes with plastic bags. This was done as it was thought that since the oxygen concentration within the plastic liners may be higher than if no plastic liners were used, this may affect GCB mortality. Evaluations took place after 2, 4, 6, 8 and 10 weeks.

Assessment of GCB Mortality

After CA and RA storage, the GCB's were removed from each carton or picking crate and placed in a cool box before being transported back to the laboratory in Stellenbosch. The GCB were then removed from the gauze bags and live bugs counted. The live bugs from each bag were removed and the "dead" bugs were placed in containers with small holes for approximately 24 hours. The following day, the bugs were assessed again. This was done as it was not always possible to establish mortality immediately, as some of the bugs may have taken some time to recover. A 24 hour assessment did not take place during 2001 due the large number of live insects, or on the first inspection date during 2002 (week 6).

RESULTS AND DISCUSSION

Evaluation of GCB Mortality in Boxes with Plastic Liners

During 2001, a mortality of 75% or less was recorded for all inspections of GCB from cartons out of both CA and RA storage when evaluation took place up to six weeks. An accurate mortality assessment could not be done due to the large numbers of live

bugs. It was therefore decided to move the first inspection date to six weeks during 2002, rather than after two weeks, to establish more accurate mortality figures and to determine the precise time period required for effective control.

During 2002, the average percentage survival of GCB for the assessment period (10 weeks) is shown in Fig. 1. Controlled atmosphere was found to be significantly more effective than RA after week nine and ten, and for the total assessment period when data were combined (Table 1). The pears in the control in particular showed signs of fungal infection, which often trapped large numbers of GCB. This could possibly have resulted in their mortality. It is therefore possible that GCB survival could have been much higher, particularly in the control, had the fungal growths not occurred. The perceived increase in survival after 7 weeks in RA could have been as a result of bugs not being assessed after 24 hours after 6 weeks (Fig. 1).

More than ten weeks are required to achieve 100% mortality under RA, while at least nine weeks are required to achieve 100% mortality under CA. Myburgh and Kriegler (1967) similarly did not record 100% mortality after five and eight weeks at –0.5°C and –1°C (regular atmosphere), respectively. These researchers estimated from their study that at least six and ten weeks at –0.5°C and –1°C, respectively, would ensure no survival of GCB. Furthermore, their study showed that rapidly-cooled bugs (bugs placed into the desired end temperature cold store immediately) were more susceptible to cold than pre-cooled bugs (bugs placed into a gradient of declining temperatures before being placed into the desired end temperature). The present study, in effect, dealt with rapidly-cooled bugs, where the experimental cartons were placed into the desired end temperature without prior pre-cooling.

Evaluation of GCB Mortality in Crates without Plastic Liners

During 2003, the average percentage of GCB survival is shown in Fig. 2 for the assessment period (10 weeks). Controlled atmosphere was found to be significantly more effective than RA for weeks 4, 6, 8 and 10, as well as over the total study period when data were combined (Table 2). It is possible that the plastic liners resulted in a higher oxygen concentration developing within the bags, which increased the lifespan of GCB by one week (Tables 1 and 2). 100% mortality was also achieved after 8 weeks in RA without plastic bags, while 100% mortality was never achieved when pears were packed into boxes with plastic liners first.

CONCLUSIONS

These results show that GCB appear to be very well cold-adapted. Packing pears into open crates resulted in 100% mortality of GCB one week earlier and that at least 8 weeks will be required to achieve 100% mortality (CA and RA), despite no prior pre-cooling of bugs which could have made them even more cold-resistant. Although it was possible to achieve 100% mortality after eight weeks, it may probably not be practical to do this as fruit quality may be compromised. It is recommended that other mitigation treatments be considered for GCB control. Sufficient data were generated within this project to conclude that low temperature or CA in itself is not sufficient to effectively sterilize pears from GCB infestations, unless a lengthy cold storage period is an option.

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Literature Cited

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Tables

Table 1. Average transformed means of GCB survival under regular atmosphere and controlled atmosphere conditions in trials conducted during 2002.

Treatment	Average transformed (logit) means of GCB survival *					
	6 weeks	7 weeks	8 weeks	9 weeks	10 weeks	Total
Regular atmosphere (control)	-5.4 a	-3.8 a	-6.1 a	-5.9 a	-6.6 a	-5.6 a
Controlled atmosphere	-5.7 a	-6.0 a	-6.9 a	-8.2 b	-8.2 b	-7.0 b
LSD	3.37	3.22	1.77	1.76	0.5	0.93

* Numbers in a column with the same letters do not differ significantly (P≤0.05), ANOVA, LSD.

Table 2. Average transformed means of GCB survival under regular atmosphere and controlled atmosphere conditions in trials conducted during 2003.

Treatment	Average transformed (logit) means of GCB survival *					
	2 weeks	4 weeks	6 weeks	8 weeks	10 weeks	Total
Regular atmosphere (control)	-3.7 a	-3.8 a	-5.2 a	-6.3 a	-6.3 a	-5.1 a
Controlled atmosphere	-4.2 a	-6.8 b	-7.5 b	-7.8 b	-7.8 b	-6.9 b
LSD	3.66	2.39	2.07	0	0	0.84

* Numbers in a column with the same letters do not differ significantly (P≤0.05), ANOVA, LSD.

Figures

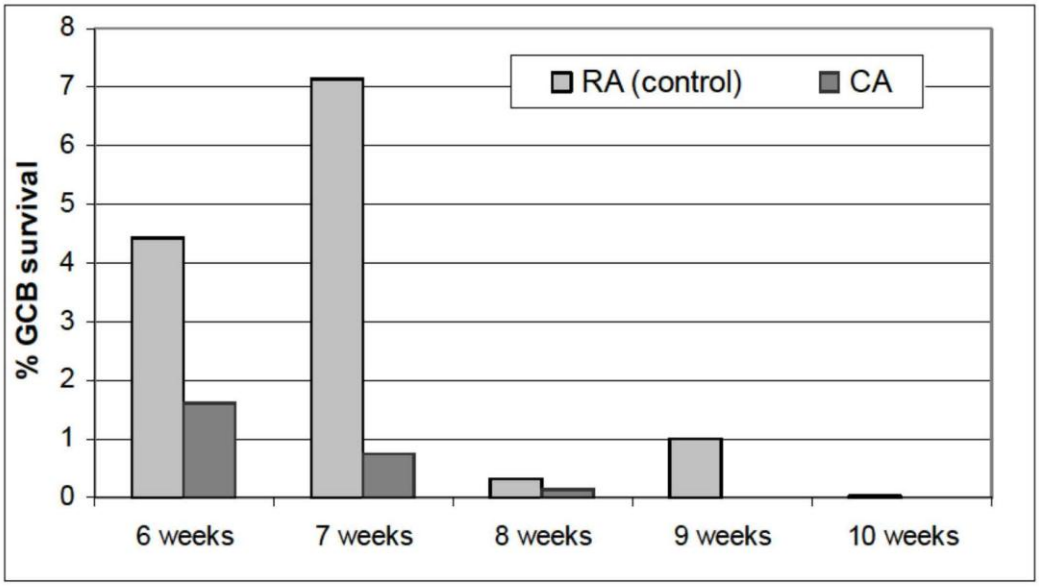

Fig. 1. The average percentage survival of GCB during 10 weeks under regular atmosphere (RA) and under controlled atmosphere (CA) conditions during 2002, where pears were packed into cardboard boxes with plastic liners as for export.

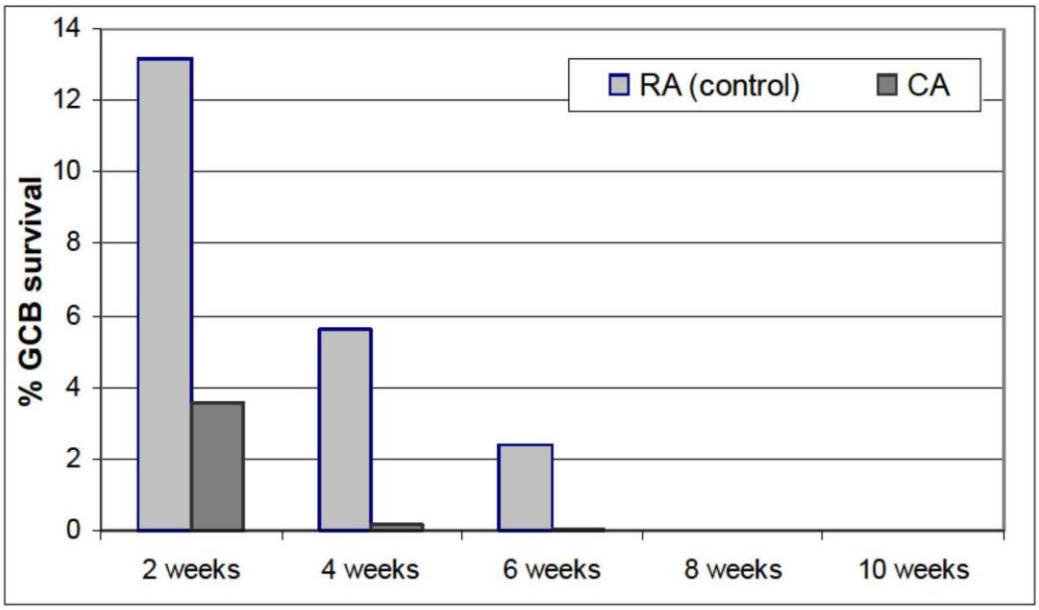

Fig. 2. The average percentage survival of GCB during 10 weeks under regular atmosphere (RA) and under controlled atmosphere (CA) conditions during 2003, where pears were packed into picking crates without plastic liners.