Recent Developments in the Disinfestation of Hessian Fly Puparia in Baled Hay

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ABSTRACT

To comply with phytosanitary and quarantine regulations, baled hay has to be disinfested of Hessian fly [*Mayetiola destructor* (Say)] puparia before exporting to Japan. Several laboratory and field trials to destroy Hessian fly puparia in baled hay were either successful or unsuccessful. After the unsuccessful attempt to destroy Hessian fly puparia in the last confirmatory field test, laboratory tests were performed to identify any problem areas and validate the possible causes of insect survival during the field trials. Three different quantities of infested wheat seedlings contained in mesh bags designated types "A", "B" and "C" test cages were used in the tests. Moisture content of the infested wheat seedlings contained in test cages was determined by the oven method. A recirculating forced-air dryer unit was used to determine the time required for the temperatures within the bulk of the infested wheat seedling to reach 60^{o}C, and to confirm the thermal kill temperature for the Hessian fly puparia when the puparia were still located in the seedlings intact. Three thermocouple sensors were inserted into the bulk of the wheat seedlings to monitor the temperature. Three replicates were conducted for each test cage size. Heat disinfestation and control (unheated and heated) tests were conducted in a heat treatment unit on timothy hay bales. Thermocouple sensors were inserted into the bales and the wheat seedlings to monitor their temperature profiles. The heating time was influenced by the packing density of the infested wheat seedlings contained in the test cages. The survival of the Hessian fly puparia was influenced by the moisture content and the packing density of the infested wheat seedlings.

INTRODUCTION

To comply with phytosanitary and quarantine regulations, baled hay has to be disinfested of Hessian fly [*Mayetiola destructor* (Say)] puparia before exporting to Japan. Several laboratory and field trials to destroy Hessian fly puparia in baled hay were either successful or unsuccessful (Sokhansanj 1998; Tabil et al. 1999a; Tabil et al. 1999b; Tabil et al. 2001; Opoku et al. 2002). After the last unsuccessful attempt to destroy Hessian fly puparia in a confirmatory field test, laboratory tests were performed to identify any problem areas and validate the possible causes of insect survival during the field trials.

OBJECTIVES

1. Determine the moisture content of the infested wheat seedlings packed into different sizes of test cages and compare them to the hay bales used in laboratory and field tests,
2. Determine the effect of packing density of infested wheat seedlings on the thermal death of the Hessian fly puparia and the time required to raise the temperature within the

wheat seedlings to 60^{o}C and remain at this temperature for 3 min in a recirculating forced-air dryer unit,
3. Monitor the temperatures of the infested wheat seedlings during heating tests in a laboratory heat treatment unit to determine the temperature profiles within the test cages and to compare them to the temperature profiles in the bales, and
4. Use a laboratory heat treatment unit to heat-treat timothy bales embedded with different-sized test cages to determine the mortality of the Hessian fly puparia.

MATERIALS & METHODS

Test Materials

Hessian fly infested wheat seedlings were packed into test cages designated as types "A", "B" and "C".
Type A had a cage size of 70 x 100 mm and was packed with an estimated 187 infested wheat seedlings. A Styrofoam container, packed with wet paper towels and cold gel packs, was used to ship the test cages. Samples were air-dried for 3 h at room temperature.
Type B test cage also had a size of 70 x 100 mm but was packed with only 150 infested wheat seedlings. Type B test cages were packed with cold gel packs in a Styrofoam container. No air-drying was done on the samples..
Type C test cage size was 125 x 165 mm and it was packed with 125 infested wheat seedlings. Type "C" test cages were packed in a Styrofoam container with cold gel packs. Samples were air-dried for 3 h at room temperature
Timothy hay bales were obtained from Elcan Forage Inc. located in Broderick, SK. Seventeen good quality bales were selected. The bales were stored in a cold room at a temperature of 5 – 7^{o}C

Procedures Used

Infested wheat seedlings and timothy hay moisture contents were determined by the oven method: ASAE Standard S358, 1999.
Recirculating force-air dryer unit (Figure 1) was used to determine the thermal death of Hessian fly puparia and the time required to raise the temperature within the test cages to 60^{o}C and maintain at this temperature for 3 min. It consists of an air conditioning unit, vaneaxial circulating fan, drying chamber with scale-mounted trays, and a connecting duct system. Thermocouples were placed within the test cages and they were placed on trays during heating.
Laboratory heat treatment unit (Figure 2) was used to heat-treat timothy bales embedded with different-sized test cages to determine Hessian fly puparia mortality. The unit consists of a heat treatment chamber, a centrifugal fan, steam heat exchanger, steam injection system, instrumentation, and data acquisition system. The steam heat exchanger system was manually controlled by adjusting the steam supply valves to control the inlet air temperature. Thermocouples were placed both within the test cages and the bales. The test cages were placed within the bales during heat treatment (Figure 3). The plenum air pressure and air velocity were measured.
The infested wheat seedlings that were heat-treated in the recirculating forced-air dryer unit and in the heat treatment unit together with the controls were sent back to

Agriculture and Agri-Food Canada (AAFC) in London, ON for a standard 75-day post-treatment emergence.

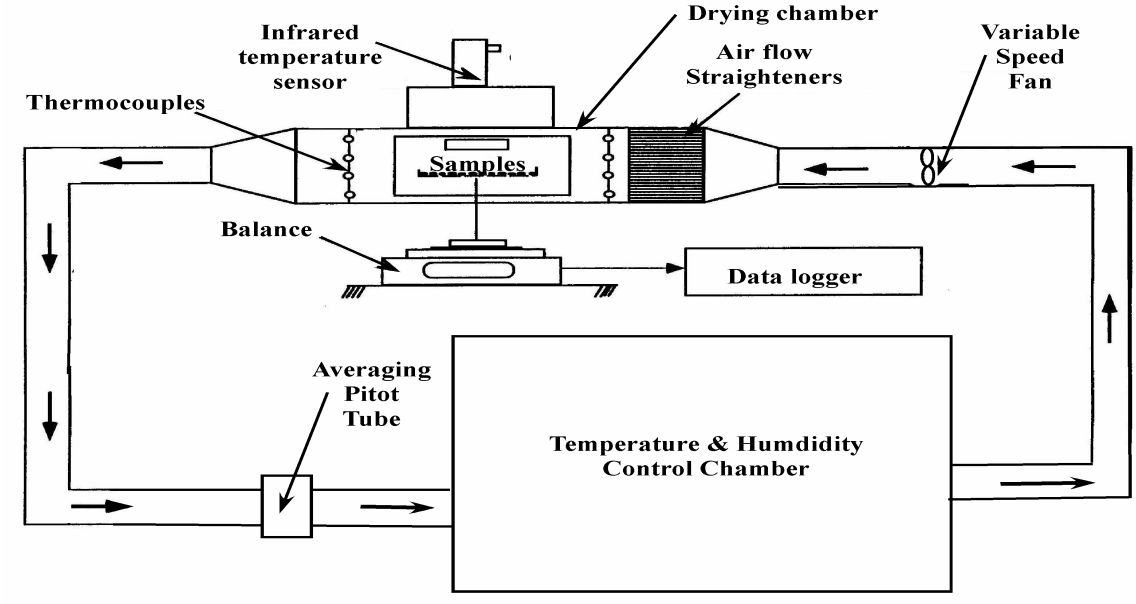

Figure 1. Schematic diagram of the recirculating forced-air dryer unit

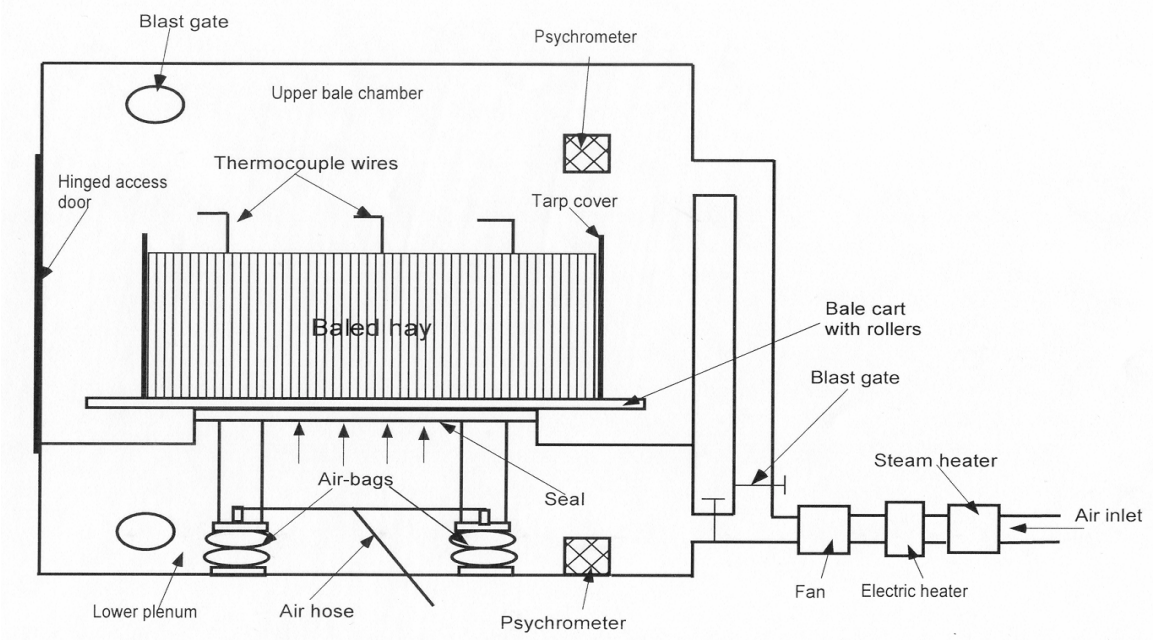

Figure 2. Schematic diagram of the laboratory heat treatment unit

Figure 3. Preparation of a timothy bale for heat disinfestation test.

RESULTS

Table 1 shows the moisture contents of infested wheat seedlings and hay used in the field and laboratory trial. The ranges of the moisture contents of the infested wheat seedlings (15.1 – 29.0%, w.b.) were higher than the hays (8.5 – 14.7%, w.b.).

Table 1. Moisture contents of infested wheat seedlings and hay

Tests	Moisture content range (%, w.b.)
Wheat seedlings in type A test cage	18.9 – 19.9
Wheat seedlings in type B test cage	15.1 – 29.0
Wheat seedlings in type C test cage	15.9 – 18.5
Timothy hay used in Cremona, AB, 2001	12.6 – 14.7
Timothy hay used in Cremona, AB, 2001	11.2 – 14.5
Alfalfa/bromegrass hay used in Saskatoon, SK, 2001	8.5 – 9.9
Timothy hay used in Saskatoon, SK, 2001	11.1 – 12.8

Table 2 shows the time required to heat different-sized test cages to 60°C in the recirculating forced-air dryer unit. The type A test cages with the highest packing density took a longer time to reach 60°C compared to types B and C. The packing density affected the heating time. There were no Hessian fly survivors when the test cages were heated to 60°C and the temperature was maintained for 3 min.

Table 2. Time required to heat different-sized test cages to 60°C in a recirculating forced-air dryer unit

Test cage label	Size of test cage (mm x mm)	Number of infested wheat seedlings	Time required to reach 60°C (min)	Number of Hessian fly survivors
OA1	70 x 100	187	94.3	0
OA2	70 x 100	187	135.7	0
OA3	70 x 100	187	131.7	0
OB1	70 x 100	150	64.4	0
OB2	70 x 100	150	84.7	0
OB3	70 x 100	150	85.0	0
OC1	125 x 165	125	24.0	0
OC2	125 x 165	125	57.0	0
OC3	125 x 165	125	26.0	0

Table 3 lists the bale characteristics and the total number of Hessian fly survivors when the test cages were placed within the bales and heat-treated for 18 min. There were Hessian fly survivors in the types A and B test cages. However there were no Hessian fly survivors in the type C test cages.

Table 3. Bale density, moisture content, heating time and total number of Hessian fly survivors during heat treatment in a laboratory heat treatment unit

Test cage label	Bale bulk density (kg/m^3)	Hay moisture content (%, w.b.)	Heating time (min)	Total number of Hessian fly survivors per four cages
CHA1	104.2	11.3	18.0	131
CHA2	109.3	11.4	18.0	107
CHB1	109.5	12.8	18.0	163
CHB2	116.0	11.8	18.0	129
CHC1	109.4	11.1	18.0	0
CHC2	106.0	12.7	18.0	0
ControlA	102.4	12.7	18.0	461
ControlB	109.5	10.7	18.0	350
ControlC	103.0	11.7	18.0	648

Figure 4 shows the temperature profiles within the bale (top) and test cages (bottom). The figure shows that the temperature profiles within the test cages (type A) lagged behind the temperature profiles within the hay bale. Some of the temperature profiles within the test cages never reached 60^{o}C.

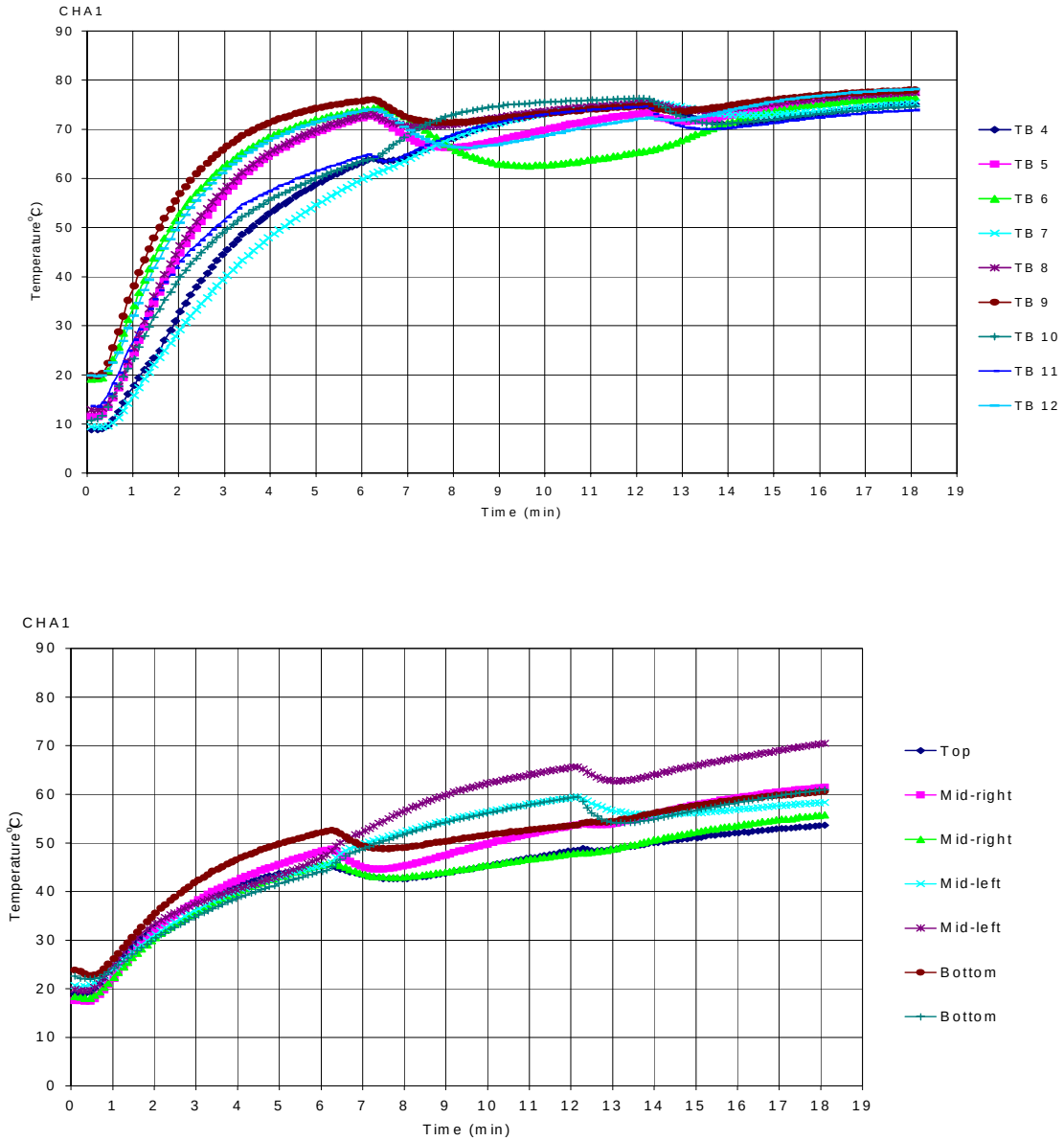

Figure 4. Temperature profiles during heat disinfestation test using a laboratory heat treatment unit: (top) within a bale, (bottom) within the test cages for type A.

The temperature profiles within the bale (top) and test cages (bottom) for type C test cages are shown in Figure 5. The figure shows that the temperature profiles within the test cages followed closely the temperature profiles within the bale. All the temperature profiles within the test cages reached 60^{o}C for more than 3 min. The packing

density of the infested wheat seedlings in the type C test cage was significantly lower than the type A or B.

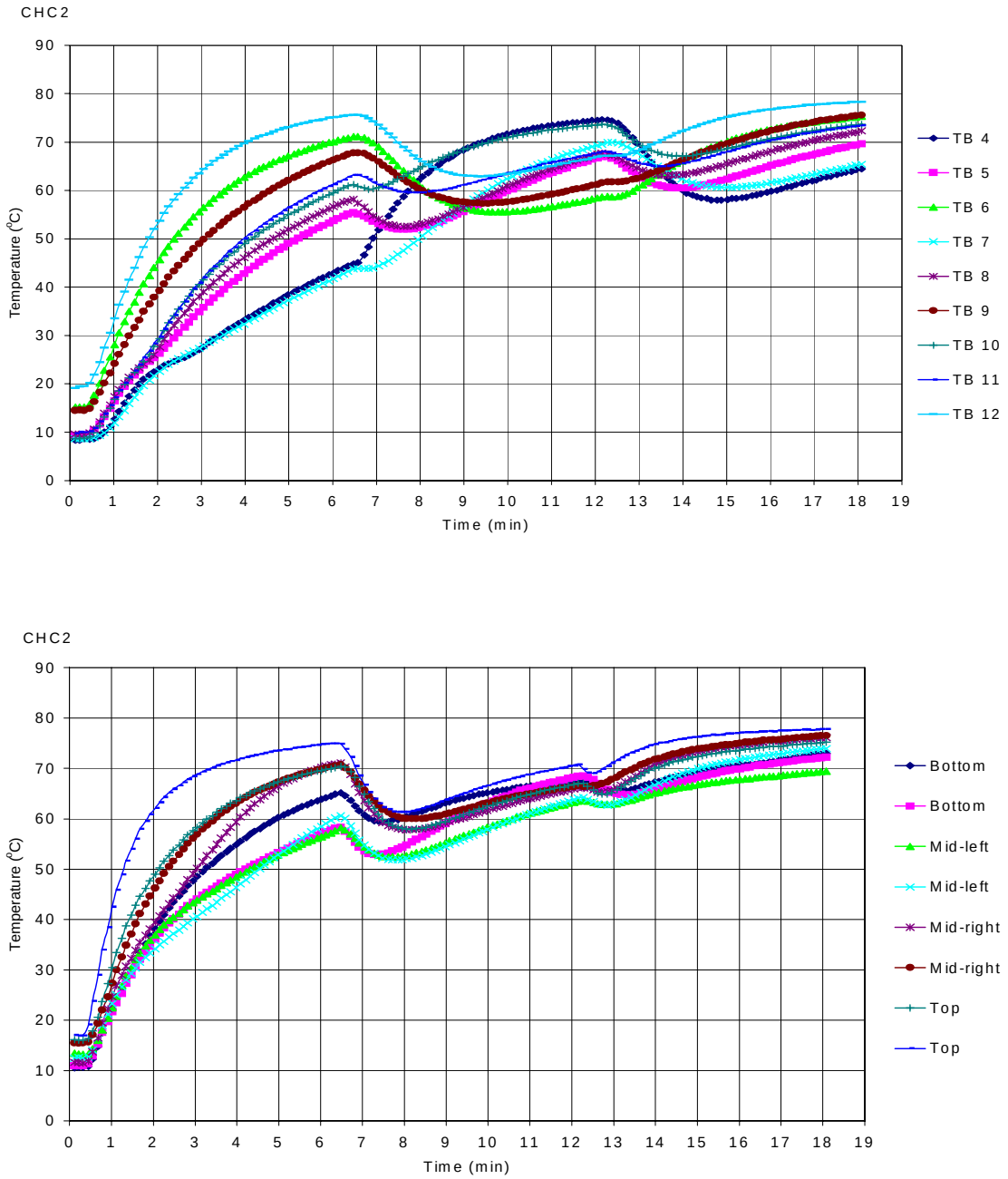

Figure 5. Temperature profiles during heat disinfestation test using a laboratory heat treatment unit: (top) within a bale, (bottom) within the test cages for type C.

CONCLUSIONS

a) The moisture contents of the infested wheat seedlings (15.1 to 29.0%) were relatively higher than the moisture contents of the bales used in the Cremona field trials (12.6 to 14.7%) and the Saskatoon tests (8.5 to 12.8%)..

b) The packing density of the infested wheat seedlings had a significant effect on the heating time. There were no Hessian fly survivors when all the temperature points within the test cages reached 60^{o}C and remained at this temperature for 3 min.
c) The temperature profiles within the infested wheat seedlings for types "A" and "B" test cages lagged behind the temperature profiles within the bales. Temperatures measured within the infested wheat seedlings for the type "C" test cages followed closely the temperatures within the bales.
d) There were Hessian fly survivors in the infested wheat seedlings contained in types "A" and "B" test cages during the heat disinfestation tests. There were no Hessian fly survivors during the heat disinfestation tests for the infested wheat seedlings contained in the type "C" test cages.

ACKNOWLEDGEMENT

This project was financed by Saskatchewan Agriculture and Food, Agriculture Development Fund (ADF) program. Agri-Food Innovation Fund financed the renovations of the Bioprocessing Engineering Laboratories

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