II.18 Equipment Modification, Swath Width Determination, and Calibration for Aerial Application of Bran Bait With Single-Engine Fixed-Wing Aircraft

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Under certain conditions, bran bait is the best choice for controlling grasshoppers. Bait is commonly applied by ground equipment, but in many cases, rough terrain and/or extensive acreage make application by air necessary. Until recently, the acceptance of aerial application of bran bait has been hindered by the common occurrence of nonuniform application and the difficulty in calibrating the equipment accurately. Both problems are caused by uneven flow of bait from the hopper of the aircraft to the spreader.

This uneven flow usually results from what is commonly referred to as "bridging"—the formation of both a cavity in the lower portion of the bait load and an overlying bridge of bait. As bait flows from the bottom of the hopper to the spreader, the load in the hopper settles. Because the particles of bait are flat, they tend to overlap, layer, and lock together to form a bridge. That portion of the bait load that does not lock together flows to the spreader and is applied and leaves a cavity under the bridge. If the overlying bridge does not break and fall before all of the lower bait is applied, continuous flow of bait will be interrupted and nonuniform application will result.

Over several years, Foster and Roland (1986) solved these problems and demonstrated that bridging can be prevented so uniform aerial application is feasible. Nonuniform flow of bait can be detected by observation from the ground. If during application the observer watches the tips of the spreader and notices puffing or uneven flow of bran, bridging is probably occurring. This chapter will detail the required equipment modifications and procedures for establishing swath widths and consistent calibration and will identify potential problems commonly encountered during calibration and aerial application of bran baits.

Equipment Fabrication and Modification

Aerial application of bait requires the use of what are commonly called granular spreaders. These spreaders are used for aerial application of dry solid materials, such as fertilizers, herbicides, and seeds. Several different spreaders are available commercially, and some acceptable homemade types undoubtedly exist. To ensure a uniform application, each type of spreader must be evaluated with the type of aircraft on which it will be used. To date, the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) has evaluated and approved several aircraft and spreaders for aerial application of bran baits (table II.18–1).

Uniform flow of dry bait is a function of several factors, including the slope of the aircraft hopper, the physical shape (flatness) of the bait particles, the size of the opening of the gate seal assembly through which the bran is released from the hopper of the aircraft into the spreader, and the small amount of bait per acre that is usually desired for delivery. All of these factors contribute to bridging, which prevents a consistent and uniform flow of bait from the aircraft hopper to the spreader.

Three inexpensive, simple additions and modifications to the aircraft are required to ensure uniform delivery of bait. A ram air agitation system—consisting of a ram air tube, air agitation tube, and a vent tube air regulator—must be adapted to the aircraft.

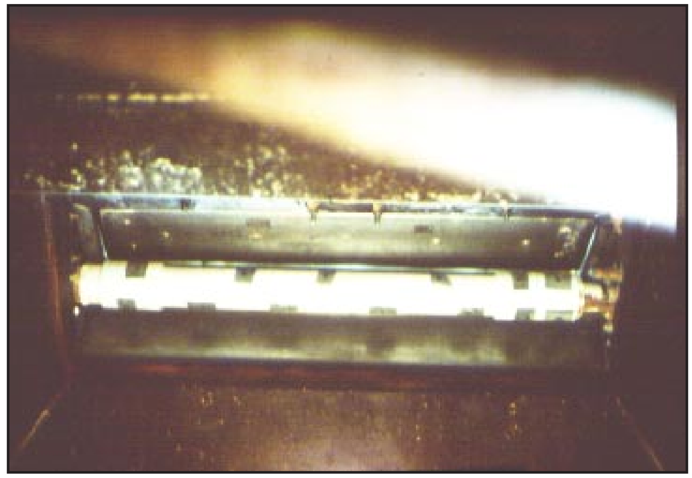
Air Agitation Tube

This tube directs air forced from the ram air tube to the inside lower area of the hopper. The moving air is forced up toward the bottom of the bait load and agitates the bait particles to prevent bridging. In addition, the air mixes with the bait particles to allow a uniform flow of material to the spreader.

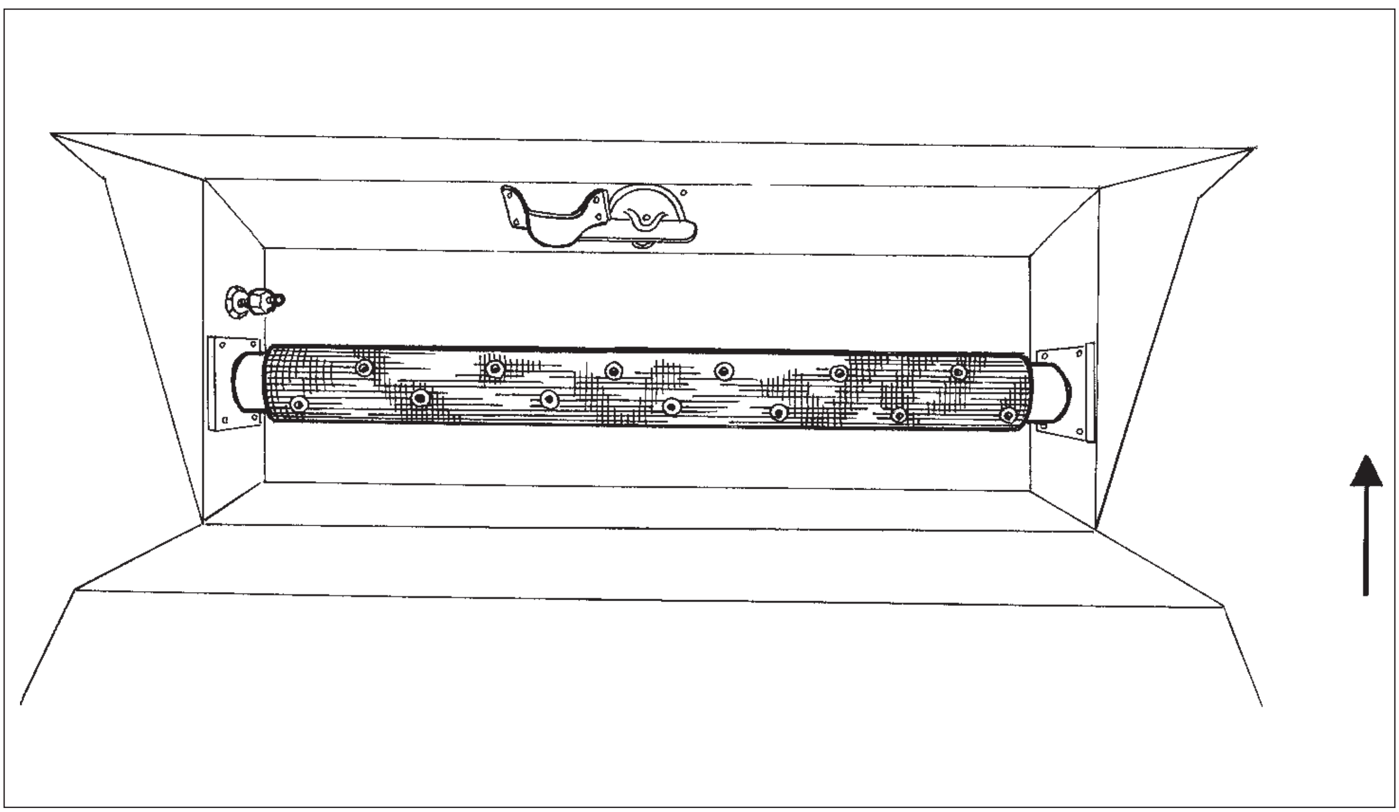
Table II.18–1—Aircraft/spreader combinations that have been certified and swath widths assigned for applying wheat bran bait

Aircraft make/model	Spreader make/model	Altitude	Swath
		(Ft)	
Cessna 188	Transland 20241/20244	50	45
Turbine Thrush	Transland 20250	50	45
Bull Thrush	Transland 22007	100	100

The air agitation tube can be built using Federal Aviation Administration-approved pipe and fittings. The pipe size shall have an inside diameter 1 to 1.5 in and shall be installed across the entire width of the hopper throat just above the gate opening (figs. II.18–1 and –2). A series of $^{1}/_{4}$-inch-diameter, equally spaced holes is drilled across the upper side of the pipe and alternately angled to direct airflow to the fore and aft lower portion of the hopper walls. The number of holes can vary, but their accumulated area must not exceed 75 percent of the pipe's inside diameter area. Therefore, a 1-inch-diameter pipe should not have more than 12 holes, and a 1.5-inch pipe should not have more than 27 holes. All $^{1}/_{4}$-inch holes are covered with window screen to prevent the entry of material into the air agitation tube.



Figures II.18–1 and –2—Air agitation tube installed across entire width of the aircraft hopper throat just above the gate opening.

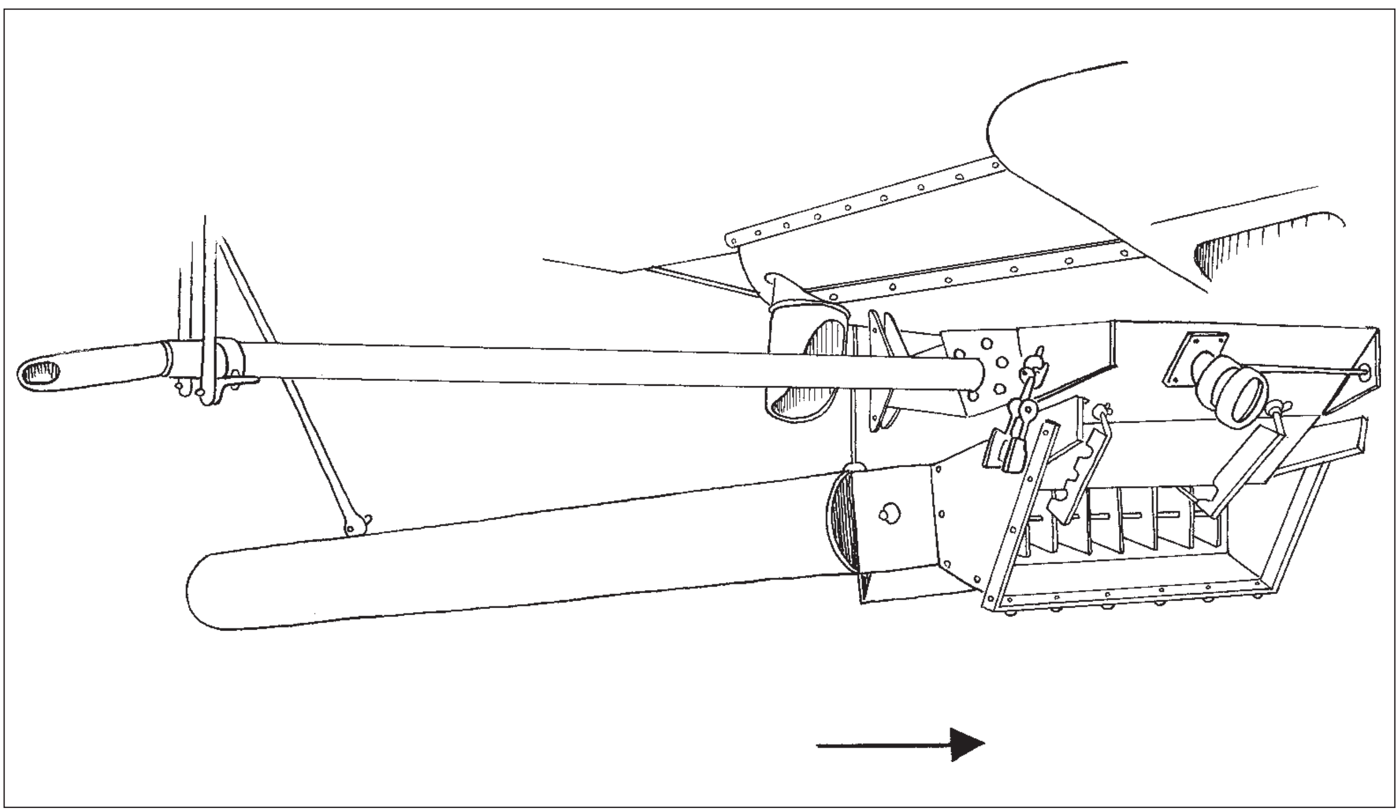


Ram Air Tube

This tube collects and directs forced air from outside the aircraft into the air agitation tube located in the bottom of the aircraft hopper. This supply of forced air can be provided in one of two ways.

1. Insert a pipe through the side opening of the hopper subtank with the spray valve removed and position the open end forward at approximately a 45-degree angle to the slipstream to allow for uninterrupted ram air during flight. The opposite end of the air agitation tube inside the hopper must be tightly sealed (figs. II.18–3 through –5).

Figures II.18–3 and –4—Ram air tube fastened to underside of aircraft provides forced air during flight to the air agitation tube.



2. Install a pipe tee at the proper location in the agitation tube and insert a pipe through the opening that supplies the pump for spray operations. Position the open end forward to allow for uninterrupted ram air during flight (fig. II.18–6). When this modification is used, the ends of the air agitation tube inside the hopper must be tightly sealed (fig. II.18–7).

Figure II.18–5—Ram air tube and air agitation tube before installation on aircraft.

Figure II.18–6—Front-mounted ram air tube for providing forced air to the air agitation tube during flight.

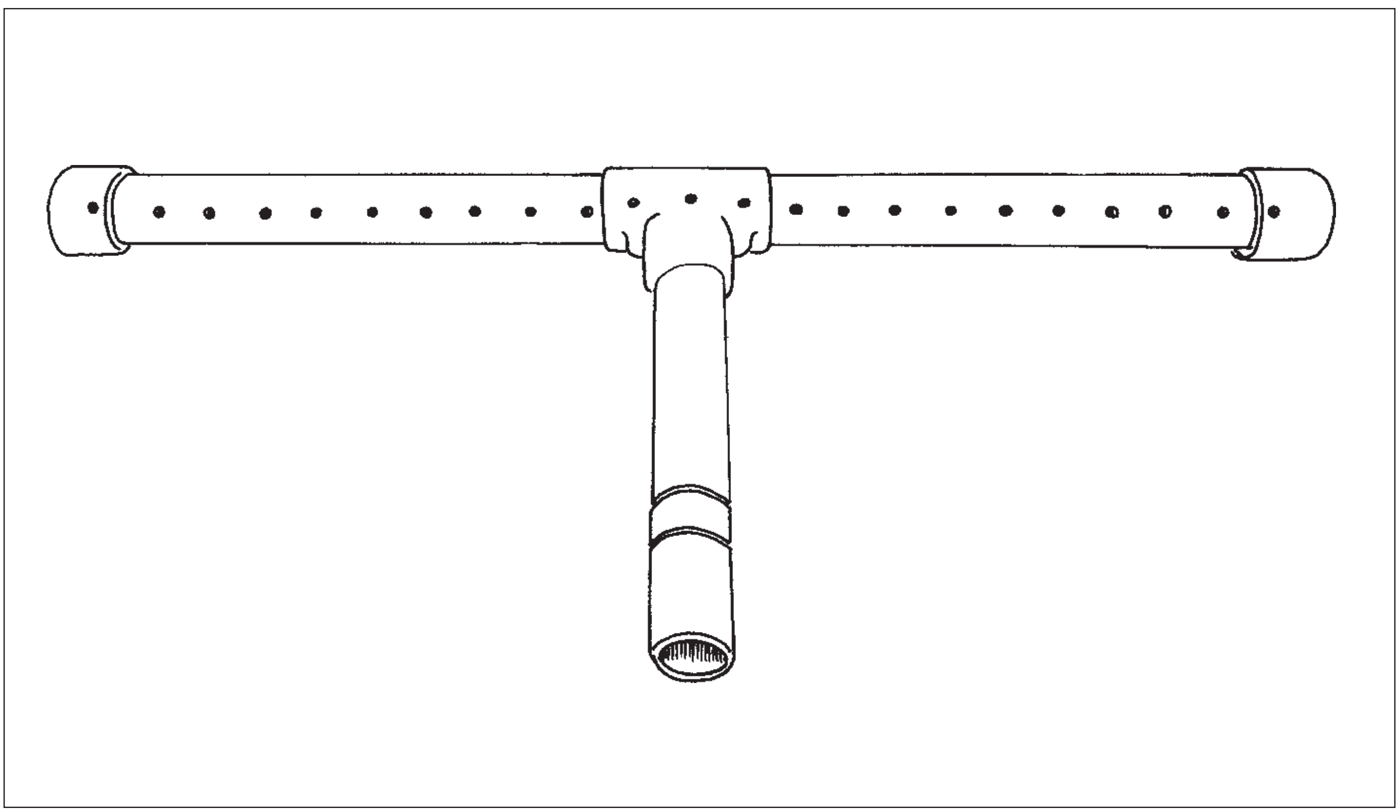


Figure II.18–7—Air agitation tube with both ends sealed when used with front-mounted ram air modification.

Vent Tube Airflow Regulator

The existing hopper vent tube can be modified easily to function as a flow regulator for the bait. The flow regulator works on the same principle as two holes in the top of an oil-can. When fluid is poured out of one hole, the opposite hole serves to prevent a vacuum from building up in the can. In the aircraft system, the hopper opening is similar to the pour hole in an oil-can. The vent tube is similar to the second hole in the oil-can. By simply restricting the amount of air that is allowed to enter the hopper vent tube, one can reduce the speed that bran is delivered through a fixed hopper-gate opening. Very minor changes in the amount of air allowed into the vent tube can cause major changes in the amount of bait delivered.

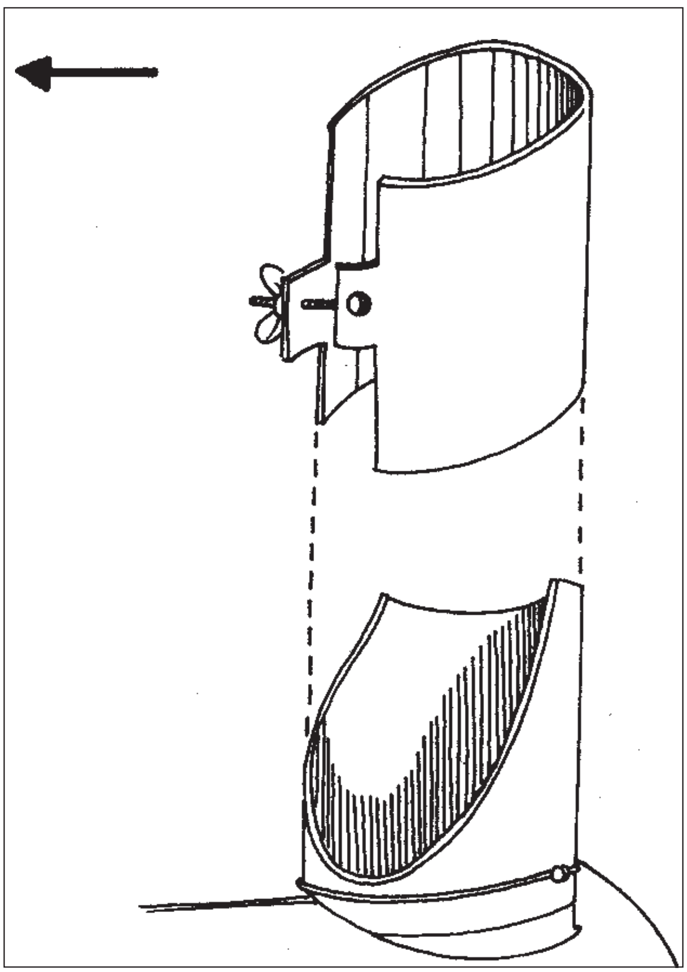


Figure II.18–8—A vent tube flow regulator fashioned from sheet metal is used to adjust the air flow through the vent tube to the aircraft hopper.

A sheet metal sleeve is fashioned and attached to the vent tube to allow adjusting the airflow through the vent tube to the aircraft hopper (fig. II.18–8). Other materials or duct tape can be used to produce similar results.

Other Requirements

The aircraft hopper-gate seal must be clean, dry (not sticky), and in good condition across its entire length to prevent an accumulation of material along the seal and edge of the gate when it is opened. An accumulation of bait on the gate seal can prevent uniform distribution into the spreader and, in some cases, can even promote bridging in the hopper. Linkage between the gate and its cockpit control handle must be in good condition or the gate may not stop in the same position each time it is opened. Gate stops are also required to ensure that the hopper gate is opened to exactly the same position each time. Screw-type stops are preferred.

Seal all openings where the ram air tube enters the subtank of the hopper. Doing this prevents leakage of bait from the aircraft and ensures a sufficient and constant amount of air entering the air agitation tube.

Remove all mechanical agitation components, nonstructured baffles, and other nonstructured obstructions from the hopper interior. Any unnecessary object can act as an anchor for the buildup of bait and thus promote bridging.

If present, the side-loader flapper valve inside the hopper should be sealed and covered to reduce protrusions. Doing that prevents dry material from entering the system when used for liquid application. Covering all protrusions reduces the chance of material buildup, which can promote bridging. The hopper interior must be thoroughly clean and dry to prevent the buildup of bait.

Determining Swath Width

The swath width for both liquid and dry bait applications will differ among types of aircraft. With baits, different types of spreaders on the same type of aircraft can produce different swath widths. Other differences among the aircraft, such as landing gear configuration, automatic flagman equipment, and weight, may also result in different swath widths.

Any combination of aircraft, spreader, and spreader attachments that has not been previously evaluated for swath widths must be characterized. (That is, a detailed study of the uniformity of particle deposition must be made.)

The hopper interior must be completely dry before loading the bait. A proven technique for ensuring this is to fly the aircraft for several minutes with the hopper empty and the hopper gate open.

Load a sufficient amount of bran bait into the hopper to conduct swath evaluations. For determining the swath width, the rate of bait flow (application rate) is unimportant as long as bait being dispensed by the aircraft can be seen in the air by observers from the ground. The hopper gate opening should be set wide enough to make certain that bridging is not occurring. A setting that allows for a gate opening of $^1/_4$ inch or more is usually sufficient.

Conduct swath evaluations in a relatively flat area free of obstructions. Collection devices, such as pans, paper plates, or sticky cards, should be placed in a line 200 ft long perpendicular to the planned flightline. Place collection devices at 5-ft intervals along the line.

Conduct all flights to determine swath widths during no-wind conditions or by flying into a wind that does not exceed 5 miles per hour (mi/hour). The aircraft must be in level flight and at the proper operating speed and altitude for at least 1,000 ft before reaching collection devices. To ensure that bait will hit the collection devices, open the hopper gate at 500 ft before reaching the collectors and leave it open until the aircraft has passed the devices by 1,500 ft.

After each flight, inspect all collection devices and count and record the number of particles in each device. The overall swath width is the distance between the extreme collection devices that caught at least 1 particle of bait. Collection devices in the middle portion of the overall swath will contain many more particles than the devices on either end.

In many cases, the overall swath width ends abruptly on either end and is very obvious. The effective or working swath width (overall swath width minus 10 ft) is the swath width that will be used in the calculations for calibration and during the actual application. The difference between the effective swath and the overall swath is the amount of overlap that will occur during application. Where abrupt ends are not obvious, calculate the average number of particles in the heaviest portion of the swath. For the amount of material being applied on a particular test flight, the average number is the desired amount of material that should be reaching the target. Working toward the extremes of the overall swath, the points are marked at which you find about half of the average number of particles. The distance between these two points is the usable working swath width. At least three good swath-width test flights are recommended.

Calibration

Calibration is simply comparing the amount of material that was applied to a given area for a given period of time during a test flight with what is desired to be applied to that area. Make adjustments in the system until agreement is reached. The wheat bran calibration worksheet at the end of this chapter will be helpful in determining calibration.

After determining the swath width and the groundspeed of the aircraft, determine the number of acres that will be treated in a minute. To do this, multiply the groundspeed times the swath width and divide by 495 (a constant). For example, 120 mi/hour times an 80 ft-swath divided by 495 equals 19.39 acres/min (table II.18–2). By multiplying the acres per minute times the amount of bait desired per acre, you can determine the amount of bait that should be applied in 1 minute. For example, if 1.5 lb of bait per acre is desired, then from the above example, 1.5 lb times 19.39 acres/minute equals 29.09 lb of bait, the amount that should be applied in 1 minute.

For the first flight, the gate opening should be set at $^1/_4$ inch. The shank of a $^1/_4$-inch drill bit can be used as a gauge. You will need an apparatus to drain and recover wheat bran from the aircraft hopper and a scale to weigh the bait. Weigh the bait to be loaded into the aircraft. Actual weight may vary slightly from that printed on the

Table II.18–2—Matrix to determine the number of acres treated per minute

Flying speed	Working swath width (ft) 50	55	60	65	70	75	80	90	100
Mi/hour					*Acres/min*				
75	7.58	8.33	9.09	9.85	10.61	11.36	12.12	13.64	15.15
80	8.08	8.89	9.70	10.51	11.31	12.12	12.93	14.54	16.16
85	8.59	9.44	10.30	11.16	12.02	12.88	13.74	15.45	17.17
90	9.09	10.00	10.91	11.82	12.73	13.64	14.55	16.36	18.18
95	9.60	10.56	11.52	12.47	13.43	14.39	15.35	17.27	19.19
100	10.10	11.11	12.12	13.13	14.14	15.15	16.16	18.18	20.20
110	11.11	12.22	13.33	14.44	15.56	16.67	17.78	20.00	22.22
120	12.12	13.33	14.55	15.76	16.97	18.18	19.39	21.82	24.24
130	13.13	14.44	15.76	17.07	18.36	19.70	21.01	23.64	26.26
140	14.14	15.56	16.97	18.38	19.80	21.21	22.63	25.45	28.28
150	15.15	16.67	18.18	19.70	21.21	22.73	24.24	27.27	30.30

Note: If the above table does not list the swath width or speed, use the following formula to determine acres per minute:

$$\frac{\text{Aircraft groundspeed (mi/hour)} \times \text{Swath width (ft)}}{\text{495 (a constant)}} = \text{Acres per minute}$$

bag. Use the actual measured weight. Load the hopper with approximately 50 lb of bait plus the amount of bait to be applied in 1 minute to ensure that you will not run out of bait during the calibration flight. If there is no bait left in the hopper after a flight, overapplication was occurring; appropriate adjustments must be made, and the flight must be repeated.

Make all calibration flights crosswind and dispense bait for 1 minute. Flying upwind will increase the rate of application, and flying downwind will decrease the rate of application. Use a stopwatch to determine the exact amount of time the hopper gate is open. Timing devices attached to the application system may increase the accuracy.

After the first calibration flight, drain and weigh all bait remaining in the hopper. Make sure bait that may have fallen into the spreader during draining is included. Subtract this weight from the weight loaded. Compare the amount of bait applied to what was desired to be applied. If the application rate per minute is below the desired rate, increase the gate opening and conduct another calibration flight.

If the application rate per minute exceeded the desired rate, do not change the gate opening. Cover about half of the hopper air vent. Use the fabricated airflow regulator or duct tape. Reducing or enlarging the vent opening changes the internal pressure in the hopper, decreasing or increasing the flow rate, respectively. Make a second calibration flight.

If after the second flight the flow per minute still exceeds the desired rate, further reduce the vent opening and conduct another calibration flight. Do this until the application rate equals the desired rate. Calibration accuracy should be within 10 percent of the desired rate. A minimum of five consecutive acceptable calibration flights at the same settings will assure accurate application.

Safety and Storage

Before initiating a treatment for grasshoppers or Mormon crickets with wheat bran bait, always read the label carefully. Keep wheat bran bait dry during storage in enclosed buildings, trailers, or vans to eliminate the risk of the bait's becoming unusable. Also, keep bait in a cool location. Hot storage for long periods of time may cause the bait to become rancid and reduce its effectiveness. Dispose of empty bags or containers according to State and Federal regulations printed on the label.

Potential Problems

The following lists identify some of the problems most commonly seen to occur with calibration and application of wheat bran baits.

Equipment

- Improper or no modifications or fabrication.
- Nonstructural hopper baffles not removed.
- Airholes not covered with screen on agitation tube.
- Hopper gate seal not clean and dry.
- Side-loader flapper valve inside hopper not sealed.
- Air and agitation tube connection and alignment not proper.
- Loose gate linkage.
- Gate-setting stop not in place.
- Gate-setting screw jack moves.
- Hopper doors not covered during rain.

Material

- Lumps in bait from commercial formulation.
- Strings and/or paper in bait from the container or bag.
- Rocks, pebbles, or other objects in bait.
- Clumped bait due to moisture.
- Weight printed on bag or container inaccurate.
- Different types of bran or bran sources.
- Different formulations of bait.

Methodology

- Failure to follow guidelines.
- Failure to open hopper gate firmly and consistently.
- Inaccurate weighing during calibration and application.
- Failure to read scales accurately.
- Bait left in throat of spreader when weighing during calibration.
- Bait left in hopper when weighing during calibration.
- Calibration loads inconsistent in weight.
- Unlevel load during calibration flights.
- Calibration runs not conducted crosswind.

Weather Conditions

- Damp or wet hopper due to condensation or rain.
- Calibration may change due to large humidity changes.

Conclusion

Accurate aerial application of wheat bran bait is no more difficult than applying chemical sprays. The problems associated with accurate calibration and consistent application of bran bait by air have been identified. Solutions to the problems and procedures for implementing the solutions have been developed and refined. Both solutions and procedures are inexpensive. With experience, accurate calibration and application of bran bait by air can now be expected.

Acknowledgments

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References

Foster, R. N.; Roland, T. J. 1986. Grasshopper suppression: techniques for ultra low volume applications of carbaryl wheat bran baits. Bismarck, ND: North Dakota Cooperative Extension Service, North Dakota Agricultural Experiment Station, North Dakota Department of Agriculture: 68–73.

USDA, APHIS, 1994. Prospectus No. 73-M-APHIS-94 for aerial application. Phoenix Methods Development Center. Phoenix, AZ.

Wheat Bran Calibration Worksheet

Date ____

Pilot ____

Aircraft make/model ____

Spreader make/model ____

Aircraft speed (mi/hour) ____

Assigned swath (ft) ____

Material applied ____

Desired rate per acre (lb) ____

Desired rate per minute (lb) ____

Acceptable range per minute (plus or minus 10 percent of desired)

Minimum _____________ lb

Maximum _____________ lb

Calibration Formula

(Speed _______ mi/hour × swath _______ ft) divided by 495 =
_______ acres per minute

Acres per minute ______ × rate per acre _____ lb =
_______ lb per minute

Calibration Worksheet, 6 replications

Load #____________________
Loaded ____________________ lb
Drained ____________________ lb
Applied ____________________ lb
Time ____________________ seconds
Rate ____________________ lb/acre
Percent ____________________ low–high
Adjustments:

Load #____________________
Loaded ____________________ lb
Drained ____________________ lb
Applied ____________________ lb
Time ____________________ seconds
Rate ____________________ lb/acre
Percent ____________________ low–high
Adjustments:

Load #____________________
Loaded ____________________ lb
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