CSAE SCGR

PAPER NO. 79-1006

GRANULAR HERBICIDE APPLICATOR TESTING

by

K. W. Drever, Development Engineer

and

E. H. Wiens, Senior Engineer

Prairie Agricultural Machinery Institute
c/o LCC Campus
Lethbridge, Alberta T1K 1L6

For presentation at the 1979 Summer Meeting
of ASAE and CSAE

University of Manitoba
Winnineg, Canada
June 24-27, 1979

SUMMARY:

The test procedures used in the laboratory and field evaluation of nranular herbicide applicators is discussed. Evaluation results on four applicators, commonly used on the Canadian Prairies, are summarized to illustrate test procedures. The requirement for improved granular application equipment, based on evaluation results, is illustrated.

American Society of Agricultural Engineers

St. Joseph, Michigan 49085

GRANULAR HERBICIDE APPLICATOR TESTING

INTRODUCTION

Granular herbicides are becoming increasingly more popular on the Canadian prairies since they have several advantages over conventional liquid forms. They are usually less volatile in granular form, so fall applied granules do not lose efficacy as quickly as liquids. Fall application eliminates the need to apply the herbicide during the busy seeding season, resulting in more efficient allocation of a farmer’s time. Granular herbicides are more effective than liquids on trash or straw covered fields. The granules are more apt to fall through the trash, whereas liquid does not. No water is required, eliminating the danger of frost damage experienced with sprayers when applying liquid herbicides in late fall.

The increased popularity of granular herbicides has resulted in the development of several applicators. During the 1977 crop season, the Prairie Agricultural Machinery Institute was involved in the evaluation of three dribble type and one pneumatic applicator. This paper presents the results of that testing program.

TEST PROCEDURES

INITIAL SET-UP

Granular herbicide applicators submitted for evaluation were initially inspected and set up in accordance with the manufacturer’s instructions. Manufacturer’s were encouraged to have a representative present at any time throughout the test period, and especially during the initial stages to ensure proper set-up and applicator operation.

LABORATORY TESTING

Calibration and Metering Accuracy: Laboratory tests were conducted to determine calibration and metering accuracy. Granule mass flowrates from individual meter openings, through a range of applicator settings, were measured to determine calibration accuracy and variation. Data was also taken to determine the effects of ground speed, 10% fore and aft slope, 5% side slope, field roughness and depth of material in the hopper.

Spreading Accuracy: The distribution of granules on the ground was determined in stationary laboratory trials. Granules delivered by dribble applicators were collected in a patternator which collected granules in 15.9 mm wide intervals (FIGURE 1). Depth of granules in each column of the patternator was measured. These data were correlated with the calibration data to determine the distribution pattern on the ground across the width of spread as follows:

$$\text{application rate for individual division of patternator (kg/ha)} = \frac{\text{mean application rate (kg/ha)}}{\text{mean depth of granules (mm)}} \times \text{Individual depth of Granules (mm)}$$

The distribution across the width of spread for the pneumatic applicator was determined by dividing the area behind the applicator boom into 150 mm strips. Granules spread on the floor (FIGURE 2) were collected from each strip, using a vacuum cleaner-cyclone collection apparatus (FIGURE 3). Granules were weighed and application rate for each strip calculated. The patternator shown in FIGURE 1 was also slowly drawn through a section of the distribution pattern to determine distribution on the ground for a smaller sample width in an attempt to establish differences in the two sampling techniques and to determine the validity of comparing the results from the two techniques.

The distribution of granules in the direction of travel was obtained by passing a patternator (FIGURE 4) under one discharge opening. Distribution was determined by the depth of granules in the bottom of each division of the patternator.

In all spreading accuracy determinations, the coefficient of variation (CV)[1] was used to express distribution accuracy.

FIELD TESTING

The applicators were operated in a variety of field conditions while applying granular herbicides. Ease of operation and adjustment, rate of work, quality of work and operator safety were evaluated.

Hoppers were assessed for weather tightness and ease of transporting was determined.

EQUIPMENT EVALUATED

GANDY MODEL 448-8 SNF GRANULAR APPLICATOR

The Gandy model 448-8 SNF granular applicator was a trailer mounted, dribble type spreader. It consisted of four hoppers, with a total capacity of 0.65 m^3. Granules were metered from the hopper bottom (FIGURE 5) through 96 adjustable orifices spaced at 150 mm, resulting in a 14.6 m spreading width. Granules were spread by dropping through expanded metal deflectors.

A hydraulic motor on each side of the applicator drove feed rotors in the bottom of each hopper. Stopping the rotor stopped application. A flow control valve on each hydraulic motor provided constant rotor speed for different tractor hydraulic systems.

Application rate was controlled by adjusting the orifice opening or forward speed of the tractor. Orifice opening size was set with a cam gauge on each hopper.

BARBER 11 m GRANULAR APPLICATOR

The Barber 11 m granular applicator was a trailer mounted, dribble type spreader. It consisted of two hoppers, with a total capacity of 0.65 m, supported on four wheels. Granules were metered from the hopper bottom (FIGURE 6) by ground driven feed screws through 72 openings spaced at 150 mm, resulting in an 11 m spreading width. Granules fell directly to the ground from each hopper opening. A rotary agitator was located above each feed screw.

Application rate was proportional to forward speed of travel and was controlled by changing sprockets on the feed screw drive. An acre meter and catch pan were provided to assist in calibration.

BELINE LINEAR III GRANULAR APPLICATOR

The Beline Linear III granular applicator was a trailer mounted, dribble type spreader. It consisted of four hoppers with a total capacity of 0.28 m^3 supported on a six wheel trailer. Granules were metered through 48 holes in the hopper bottom (FIGURE 7), spaced at 178 mm, resulting in an 8.5 m spreading width. Nylon metering wheels below the holes were driven by two, 12 volt electric motors, one for each side of the applicator. Granules fell from the metering wheels into collectors which directed the granules into delivery hoses. Spreaders at the bottom of the hoses broadcast the granules on the ground. Application rate was controlled by changing meter wheel speed or ground speed. Meter wheel speed was adjusted from a control panel mounted on the tractor.

---

[1] The coefficient of variation (CV) is the standard deviation of the application rates, expressed as a percent of the mean application rate. A low CV represents uniform application whereas a high CV indicates non-uniform application. One granular herbicide manufacturer has suggested that the CV should be no greater than 10%.

HORSTINE MODEL TMA 4, 10m AIRFLOW GRANULAR APPLICATOR

The Horstine model TMA 4 was a trailer mounted pneumatic granular applicator (FIGURE 8). Granules were metered from a 0.38 m^3 hopper by eight fluted feed metering mechanisms and were pneumatically conveyed across the machine width by four fans feeding eight distribution nozzles. The nozzles, spaced at 1.2 m, discharged onto impact plates, resulting in a spreading width of 9.8 m. The fans and metering mechanisms were driven from the tractor power take-off. Application rate was controlled by changing meter drive sprockets and selecting an appropriate tractor gear.

RESULTS

GANDY MODEL 448-8 SNF GRANULAR APPLICATOR

Calibration: Each hopper on the Gandy applicator delivered different amounts of material for a given applicator setting (FIGURE 9). One hopper agreed with the manufacturer's calibration while remaining hoppers delivered less. The most inaccurate hopper applied 6 kg/ha less than the manufacturer's calibration. The manufacturer attributed this difference to improper alignment of the diamond shaped adjustable orifices shown in FIGURE 5. These diamond shaped orifices must be properly aligned for correct flowrates through each orifice. Hoppers could also be set for uniform application by individually setting the cam gauge on each hopper. This entailed a separate calibration of each hopper and was considered inconvenient.

Field roughness, level of material in the hopper, or fore and aft field slope had insignificant effect on flow through the orifices. A 5% side field slope caused about a 3% increase in flowrate.

Operating the rotor at speeds from 15 to 50 rpm had no effect on application rate. Rotor speeds less than 15 rpm caused a significant increase in application with a 25% increase in application rate measured at 7 rpm.

Application rate was inversely proportional to forward speed since delivery from the orifices was constant for a given cam gauge setting.

Metering Accuracy: Delivery rates from adjacent orifices in each hopper were very uniform (FIGURE 10). The application rates from individual orifices varied from 12 to 13.7 kg/ha, resulting in a CV of only 4% over the normal range of application rates.

Spreading Accuracy: Although metering from the hoppers was very uniform, distribution on the ground was less uniform (FIGURE 11). Granules metered from the hoppers fell through the expanded metal deflectors which improved the distribution pattern by banding between each orifice. Application rates across the pattern varied from 7 to 22 kg/ha resulting in a CV of 27%. Although this distribution pattern was obtained under stationary laboratory conditions, the variation in application across the spreading width indicated that thorough soil incorporation would be necessary to get uniform distribution of chemical in the soil.

Distribution of granules also varied slightly in the direction of travel. As each rotor fin passed over the orifices, the orifices were partially blocked, reducing instantaneous flowrate by about 30%. This instantaneous reduction in application occurred simultaneously across the full width of each hopper since the rotor fins were parallel.

BARBER 11m GRANULAR APPLICATOR

Calibration: FIGURE 12 compares the manufacturer's calibration for Avadex-BW with calibration results obtained in smooth and rough fields. The manufacturer's calibration chart was in error over the normal range of application rates used for Avadex BW. For example, at a manufacturer's setting for 13.5 kg/ha, the actual application rate was 11 kg/ha on rough fields and 9.5 kg/ha on smooth fields. Application rates were consistently 1.5 kg/ha higher on rough fields than on smooth fields.

Application rate was not significantly affected by level of granules in the hopper or by ground speed. A 5% side slope caused the application rate to increase about 0.6 kg/ha if the feed screw was operating downhill and to decrease about 0.6 kg/ha if operating uphill. A 10% fore or aft slope caused application to decrease about 1kg/ha.

Metering Accuracy: Delivery rates from adjacent discharge openings were very uniform (FIGURE 13). The application rates from individual discharge openings varied from 12.7 to 15.6 kg/ha, resulting in a CV of only 6% over the normal range of application rates.

Spreading Accuracy: Although metering from the hopper was uniform, – distribution on the ground was not (FIGURE 14). Granules were deposited in adjacent 75 mm wide bands below each discharge opening with an uncovered 75 mm strip between each band. This resulted in metering accuracy CV of 6% increasing to 170% when actually applying granules on the ground. This trend was evident at all application rates.

Distribution in the direction of travel varied significantly (FIGURE 15), since delivery surged as the screw flight passed each opening. The application rate in the direction of travel varied from 11 to 23 kg/ha. Surges from adjacent openings did not occur simultaneously since the feed screw did not pass each discharge opening at the same time. Although these distribution patterns were obtained under stationary laboratory conditions, the banding and surging indicated that thorough soil incorporation would be necessary to get uniform distribution of chemical in the soil.

BELINE LINEAR III GRANULAR APPLICATOR

Calibration: FIGURE 16 compares the manufacturer's calibration for Avadex-BW with calibration results obtained for each hopper in a simulated smooth field at 9 km/h. Calibration of all four hoppers varied and was less than the manufacturer's calibration. For example, at a control meter reading of 70, application from hoppers varied from 10.5 to 12.7 kg/ha compared to the manufacturer's application rate of 14.0 kg/ha. Hoppers could not be individually set for uniform application since each electric motor drove the metering wheels on two hoppers. Operating on a rough field caused application to increase by about 10%.

Application rate was not affected by level of granules in the hopper. A 3% change in application was typical when operating on a slope. Application rate was inversely proportional to forward speed since delivery from the meters was constant for a given control meter reading.

Metering Accuracy: Delivery rates from adjacent meters in each hopper were usually uniform (FIGURE 17). Occasionally foreign material or large granules partially plugged meter openings resulting in less uniform meter delivery. When granules were flowing through all meters, the application rates from individual meters varied from 13.6 to 15.6 kg/ha, resulting in a CV of only 4% over the normal range of application rates.

Spreading Accuracy: Although metering from the hoppers was very uniform, distribution on the ground was not (FIGURE 18). Granules metered from the hoppers fell onto spreaders. Most granules were deposited in adjacent 100 mm wide bands below each spreader with very little coverage or a 75 mm strip between each band, resulting in a CV of 95%. Although this distribution pattern was obtained under stationary laboratory conditions, the banding indicates that thorough soil incorporation would be necessary to get uniform distribution of chemical in the soil.

Distribution of granules with no detectable surging. in the direction of travel was uniform

HORSTINE MODEL TMA 4 AIRFLOW GRANULAR APPLICATOR

Calibration: FIGURE 19 compares the manufacturer's calibration for Avadex-BW with calibration obtained for granular Avadex BW and Treflan. The manufacturer's calibration chart for Avadex BW was about 10% lower over the normal range of application rates. Application rates were not affected by field roughness or level of material in the hopper, field slope or tractor engine speed. However, since the metering mechanism was driven from the tractor power take-off, changing tractor gears caused the application rate to change since the ratio between metering mechanism and ground speed changed.

Metering Accuracy: Delivery rates from the eight fluted feed metering mechanisms were very uniform (FIGURE 20). The application rates from individual metering mechanisms varied from 14.2 to 14.6 kg/ha, resulting in a CV of only 1% over the normal range of application rates.

Spreading Accuracy: Granules metered by the fluted feed were pneumatically conveyed to eight nozzles and spread by striking an impact plate. FIGURE 21 shows a typical Avadex BW distribution with application rates varying from 10 to 16 kg/ha across the spreading width, resulting in a CV of 10%. Spreading uniformity for Avadex BW was similar over the normal range of application rates from 12 to 24 kg/ha.

Distribution pattern uniformity for granular Treflan was quite dependent on the application rate and poorer distribution patterns usually occurred with Treflan than with Avadex. This was attributed to a higher ratio of granules to airflow with Treflan and to differences in the physical properties of the two granular herbicides. FIGURE 22 shows a typical granular Treflan distribution at a mean application rate of 26 kg/ha. Application rate varied from 18 to 41 kg/ha across the spreading width, resulting in a CV of 23%. At reduced application rates, spreading uniformity improved. For example, when applying 17 kg/ha the CV was only 9%. Recommended application rates for granular Treflan range from 17 to 28 kg/ha.

Distribution patterns for both Avadex BW and granular Treflan deteriorated if the power take-off was operated at reduced speed, especially at higher application rates. It was important to run the power take-off at 540 rpm to obtain best distribution.

The above distribution patterns obtained with the Horstine pneumatic applicator were obtained under laboratory conditions. High winds and boom bounce on rough fields would change these patterns considerably. Since there were no supporting wheels under the outer booms, large boom height variation occurred on rolling land, significantly influencing the distribution patterns. Thorough soil incorporation was necessary to get uniform distribution in the soil.

Distribution in the direction of travel was uniform with no detectable surging

DISTRIBUTION PATTERN COLLECTING TECHNIQUES

All distribution patterns reported on were obtained under laboratory conditions. The distribution patterns of the dribble applicators were obtained using a 1.2 m wide patternator (FIGURE 1) divided into 15.9 mm columns. The depths of material in the columns were converted into application rates. The distribution patterns for the pneumatic conveyor were obtained by picking up the granules spread on the floor, from 150 mm wide strips across the entire width of spread (FIGURE 2). The amount of granules collected in each 150 mm wide strip was converted into application rates.

Tests, using the pneumatic applicator, were conducted with both collecting techniques to determine the validity of comparing the results obtained by the two methods. FIGURE 23 and 24 show the distribution for a section of the pneumatic applicator based on both 150 mm and 15.9 mm collection intervals. The patterns obtained were similar which indicated that valid comparisons of distribution patterns, using the two techniques could be made.

FIELD TESTING

Further results of field tests, as outlined under "Test Procedures", can be obtained by referring to the individual reports on each applicator evaluated.

SUMMARY AND CONCLUSIONS

Test equipment and test procedures for determining calibration, metering and spreading accuracy for granular applicators are described. A general description of the four applicators evaluated is given. Additional information sought in field testing is also listed.

Laboratory results on calibration, metering and spreading accuracy for the four applicators have been summarized. In general, large variations were found between the manufacturers calibration curves and those obtained from the tests. In the case of multi-hoppered applicators, significant variation in calibrations was found among hoppers.

The metering accuracy of all four applicators was very good. The CV of metering rates from adjacent spouts for the Gandy, Barber, Beline and Horstine were 4%, 6%, 4% and 1% respectively. However, the distribution patterns of the dribble applicators were poor, due to inadequate spreading of granules after they left the metering devices, resulting in considerable banding of granules. Typical CV's of the distribution patterns of the Gandy, Barber and Beline, at normal application rates were 27%, 170% and 95% respectively. Distribution patterns obtained with the pneumatic applicator in the laboratory were generally better with a CV of 10%. However, high winds, boom bounce and rough fields would cause a deterioration of the pattern due to the high, unsupported booms. Thorough soil incorporation, for all the applicators tested, was necessary to get uniform chemical distribution in the soil.

In summary, metering accuracy on all applicators was very good but this did not usually result in good distribution patterns on the ground. Some of the applicators attempted to spread the granules using some form of deflector. Although this did improve the patterns over those without deflectors, the improvement was still inadequate. There is a need for further research and development to improve distribution accuracy. There is also a need for more research to establish how uniform a pattern is required to obtain good weed kill. The present applicators being used are doing a job, but as the tests show, they are far from perfect.

REFERENCES

1. Prairie Agricultural Machinery Institute. 1978. Test Procedure No. PAMI T772-R78, Detailed Test Procedures for Granular Applicators.
2. Prairie Agricultural Machinery Institute. 1978. Granular Applicator Evaluation Report Numbers E2177A, E2177B, E2177C, E2177D.

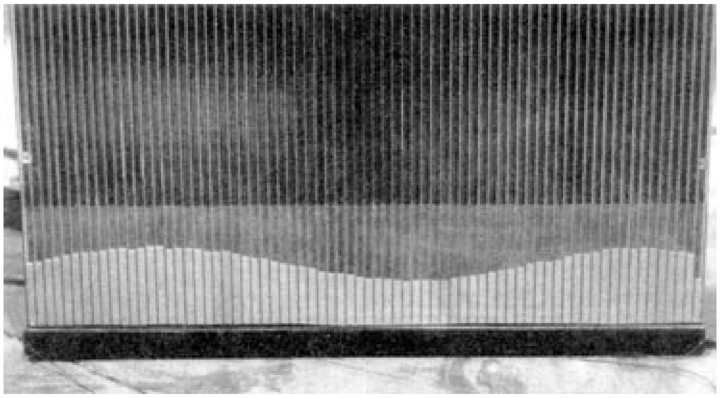

FIGURE 1. PAMI Patternator for Determining Distribution of Granules across the Width of Spread.

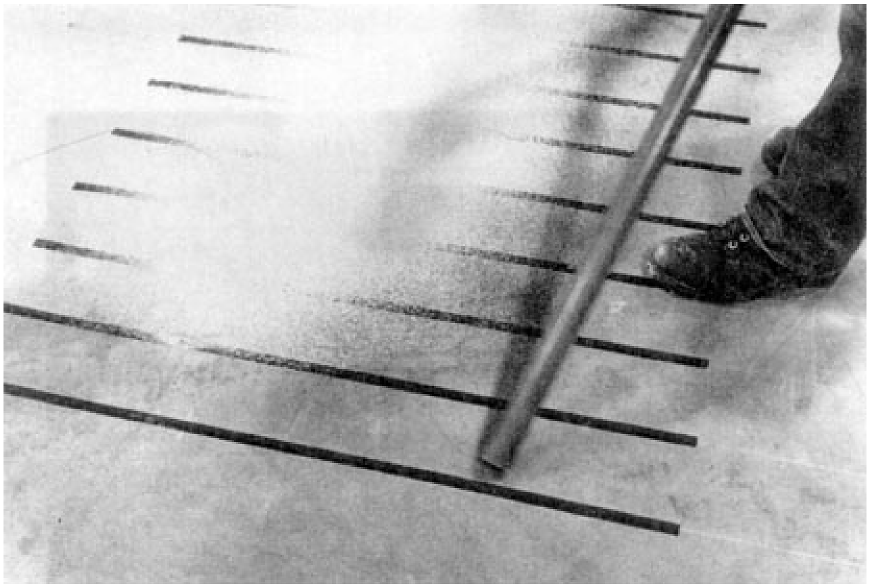

FIGURE 2. Pneumatic Applicator Distribution Pattern being Picked up in 150 mm Wide Strips.

FIGURE 3. Vacuum Cleaner-Cyclone Collection Apparatus.

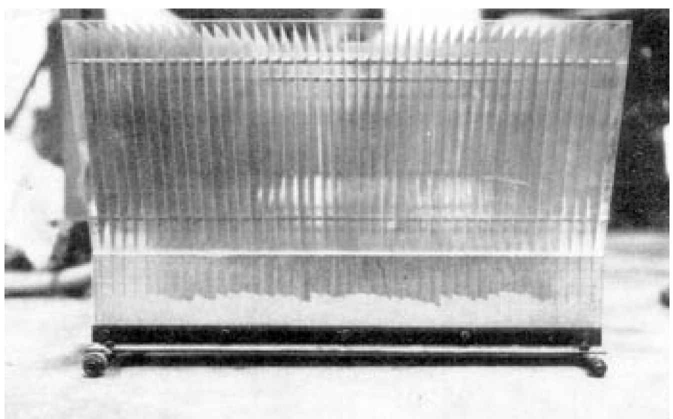

FIGURE 4. Patternator for Determining Distribution of Granules in the Direction of Travel.

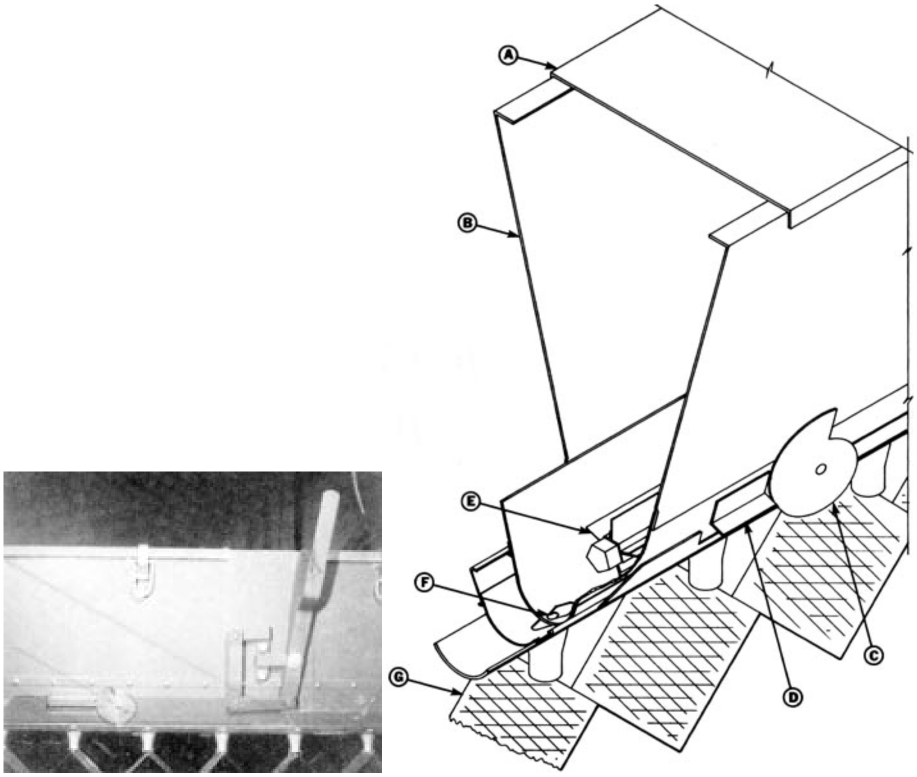

FIGURE 5. Schematic View of Gandy Granular Applicator: (A) Hopper Lid, (B) Hopper, (C) Cam Gauge, (D) Cam Gauge Stop Bracket, (E) Feed Rotor, (F) Adjustable Orifice, (G) Expanded Metal Deflector.

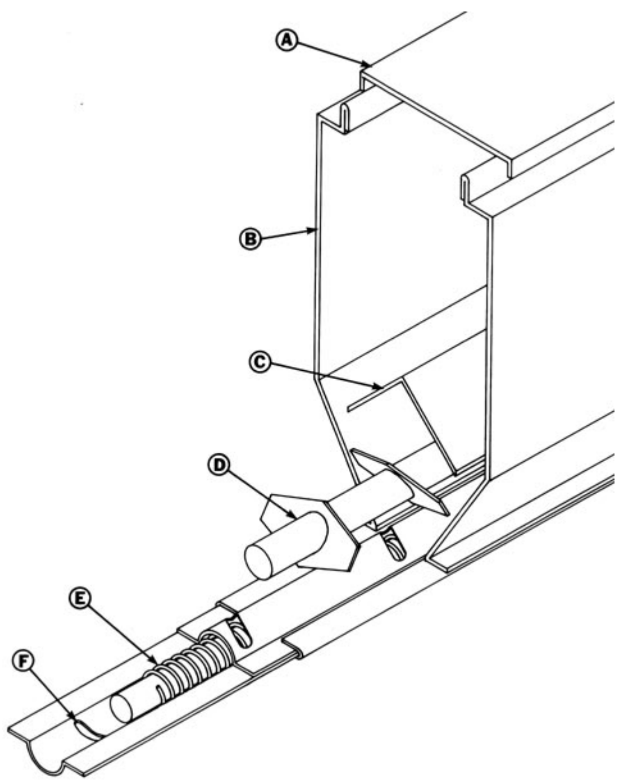

FIGURE 6. Schematic View of Barber Granular Applicator: (A) Hopper Lid, (B) Hopper, (C) Agitator Shield, (D) Agitator, (E) Micro Feed Screw, (F) Discharge Opening.

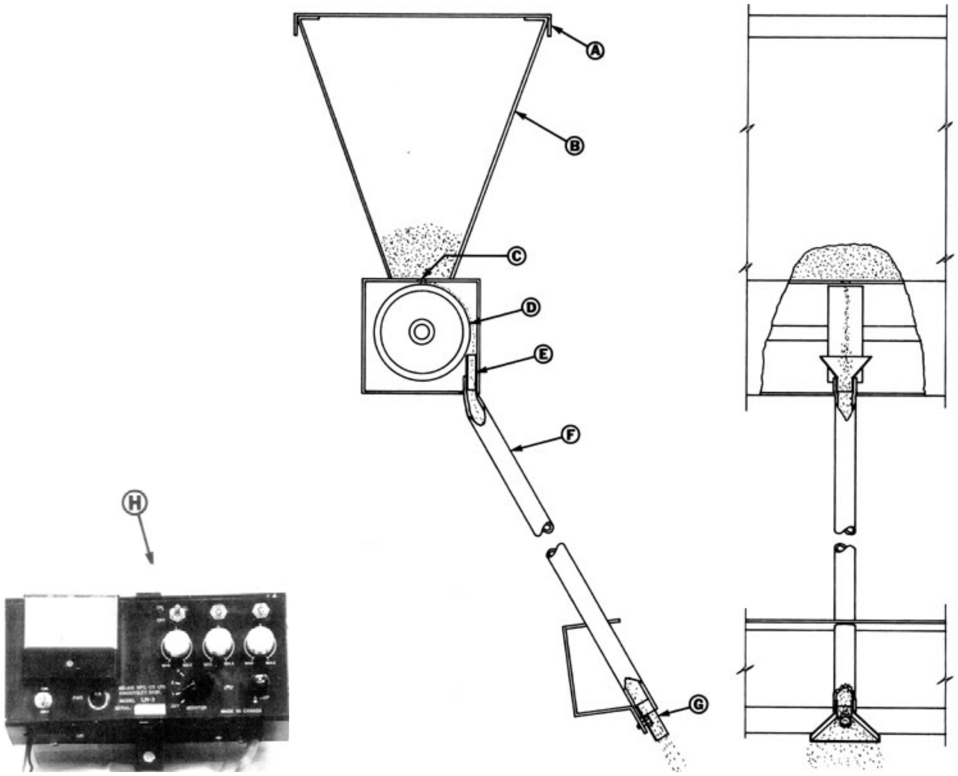

FIGURE 7. Schematic View of Beline Linear III Granular Applicator: (A) Hopper Lid, (B) Hopper, (C) Hole, (D) Metering Wheel, (E) Collector, (F) Delivery Hose, (G) Spreader, (H) Control Panel.

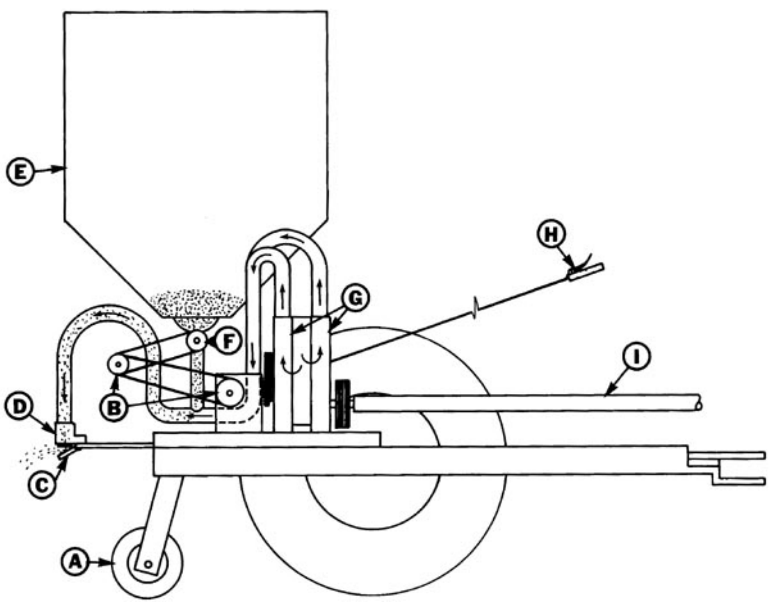

FIGURE 8. Schematic View of Horstine Granular Applicator: (A) Rear Wheel, (B) Interchangeable Meter Drive Sprockets, © Impact Plate, (D) Nozzle, (E) Hopper, (F) Meter, (G) Fans, (H) Meter Drive Clutch Control, (I) Power Shaft.

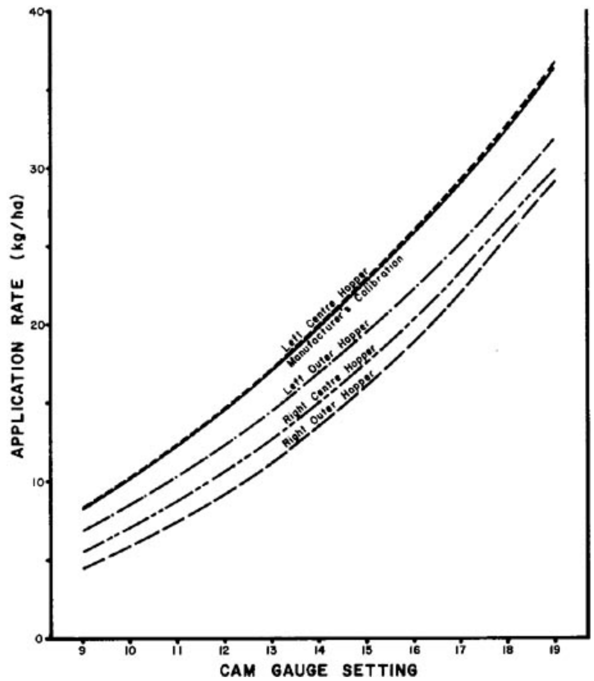

FIGURE 9. Calibration Curves for Avadex BW at 9 km/h for Hoppers on the Gandy Applicator.

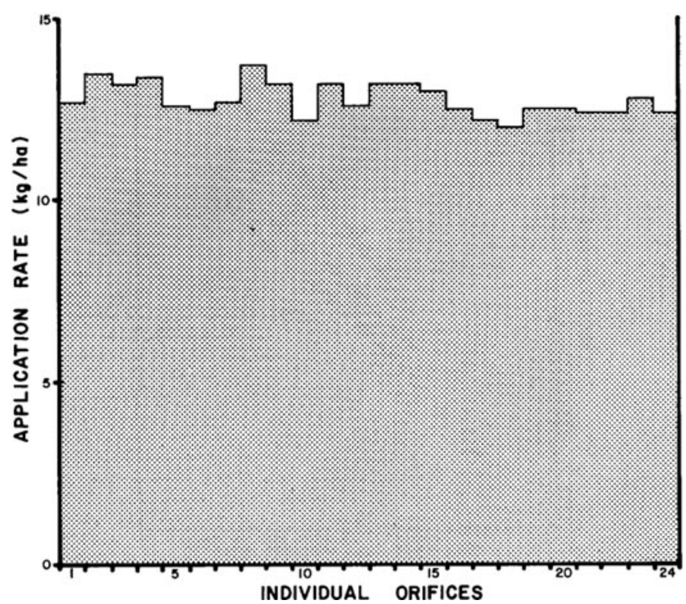

FIGURE 10. Variation in Delivery Rates From Adjacent Orifices when Applying 12.8 kg/ha of Avadex BW at 9 km/h.

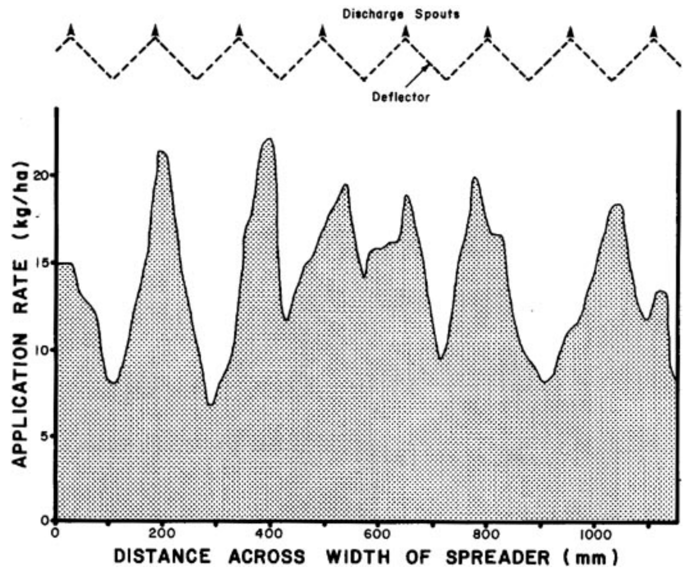

FIGURE 11. Typical Distribution of Avadex BW Granules on the Ground under a 1.14 m Wide Section of the Gandy Applicator when Applying 14 kg/ha at 9 km/h.

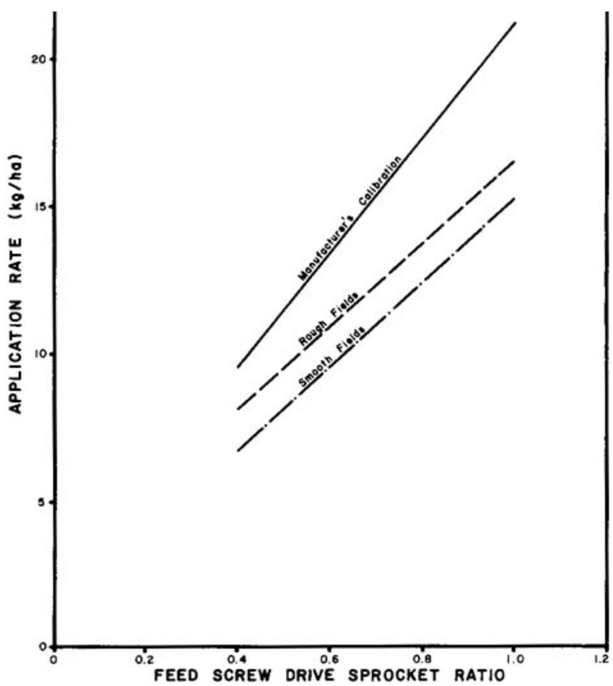

FIGURE 12. Calibration Curves for Avadex BW for the Barber Applicator.

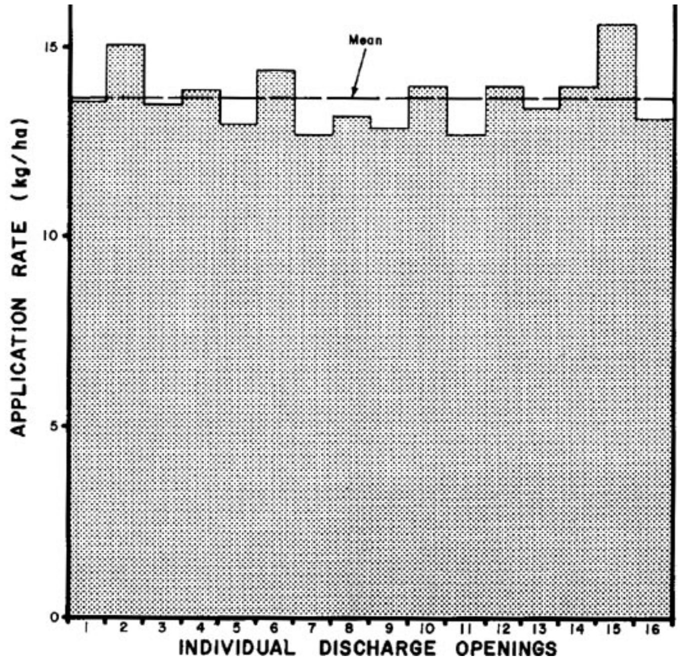

FIGURE 13. Variation in Delivery Rates From Adjacent Discharge Openings when Applying 13.7 kg/ha of Avadex BW at 9 km/h.

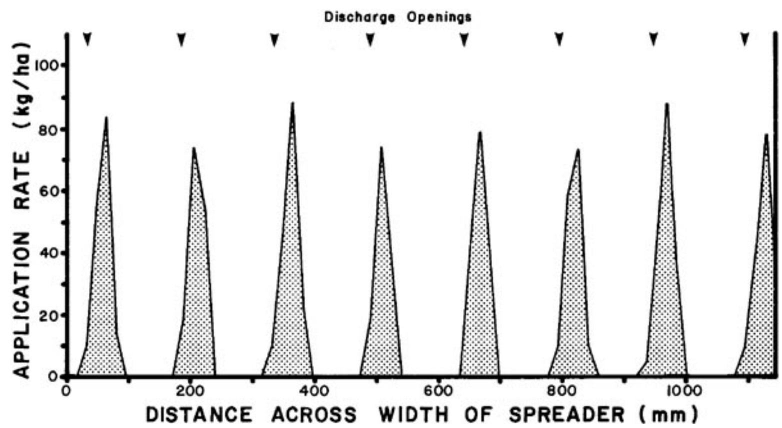

FIGURE 14. Typical Distribution of Avadex BW Granules on the Ground under a 1.14 m Wide Section of the Barber Applicator when Applying 17 kg/ha.

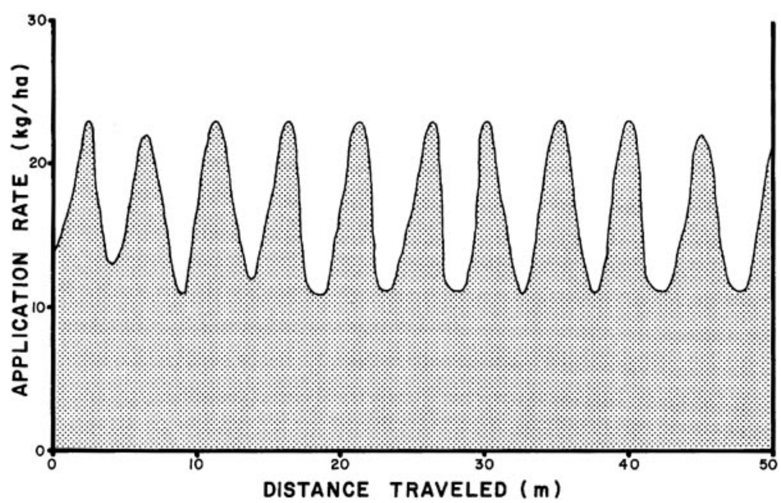

FIGURE 15. Typical Distribution of Avadex BW Granules in the Direction of Travel with the Barber Applicator.

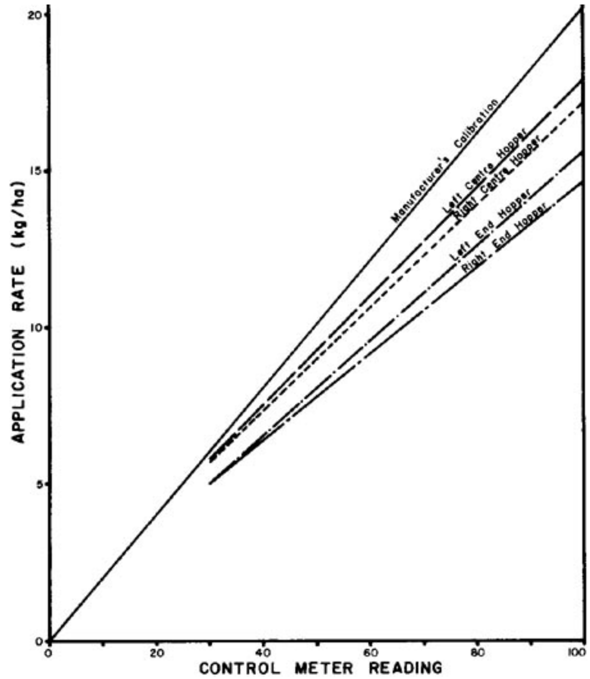

FIGURE 16. Calibration Curves for Avadex BW in a Simulated Smooth Field at 9 km/h for the Beline Applicator.

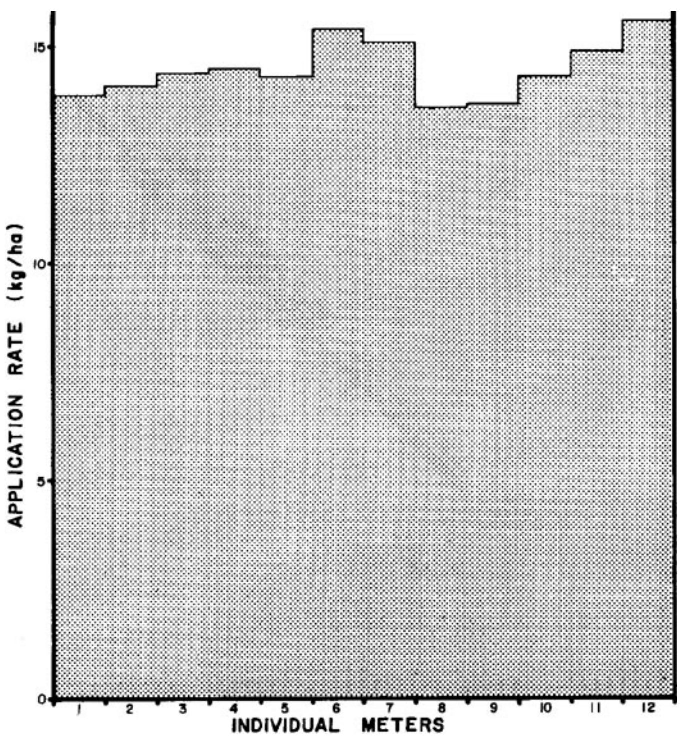

FIGURE 17. Variation in Delivery Rates from Adjacent Meters when Applying Approximately 14 kg/ha of Avadex BW at 9 km/h.

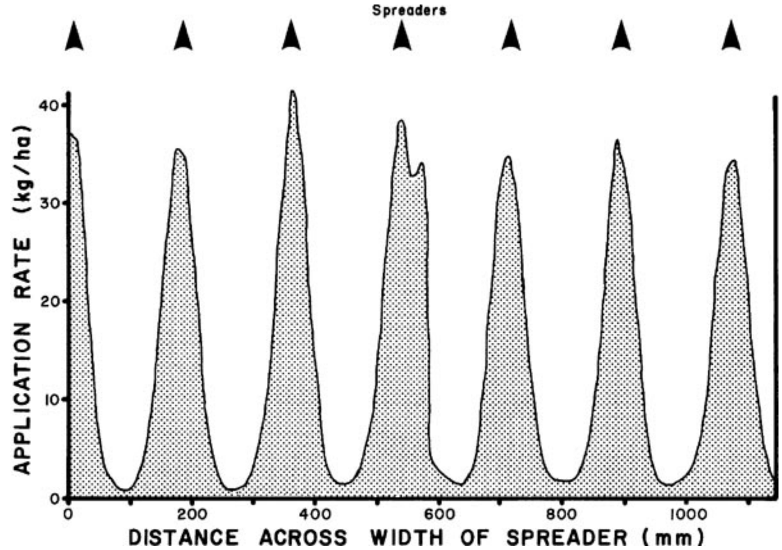

FIGURE 18. Typical Distribution of Avadex BW Granules on the Ground under a 1.14 m Wide Section of the Beline Applicator when Applying 14 kg/ha at 9 km/h.

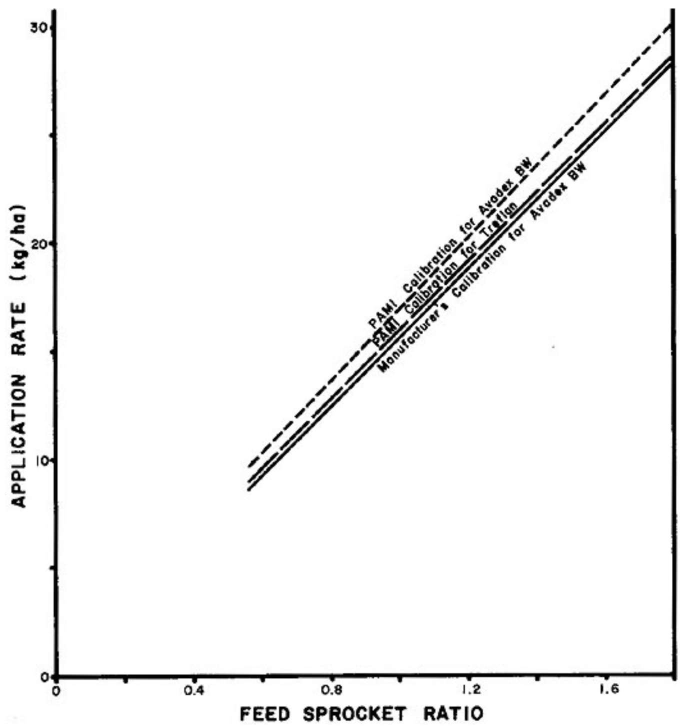

FIGURE 19. Calibration Curves for Avadex BW and Treflan at 540 rpm Power Take-off Speed at 9 km/h with the Horstine Applicator.

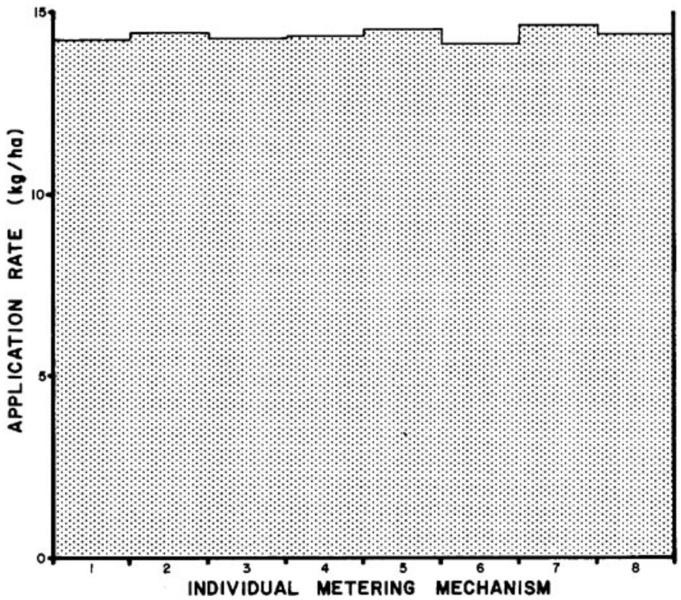

FIGURE 20. Variation in Delivery Rates from Adjacent Metering Mechanisms when Applying Approximately 14 kg/ha of Avadex BW at 9 km/h.

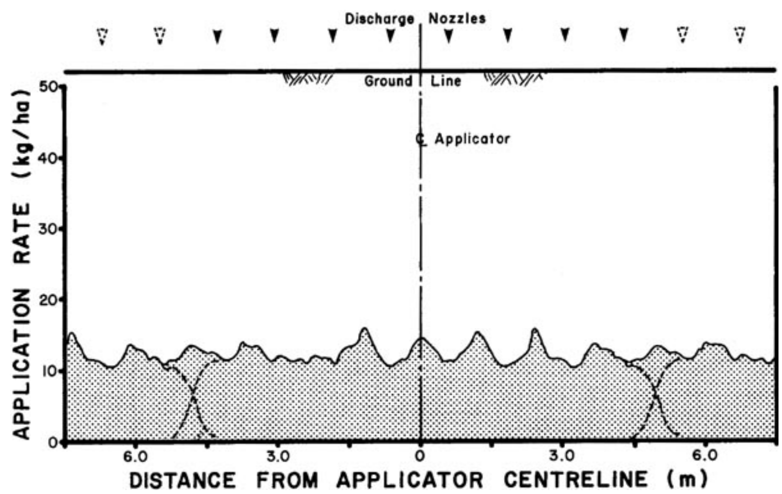

FIGURE 21. Typical Distribution Pattern when Applying 12 kg/ha of Avadex BW at 540 rpm Power Takeoff Speed and 9 km/h with the Horstine Applicator.

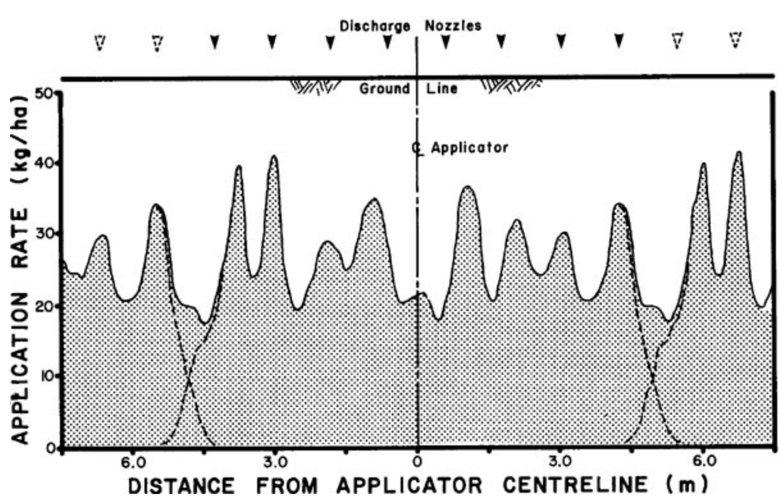

FIGURE 22. Typical Distribution Pattern when Applying 26 kg/ha of Treflan at 540 rpm Power Take-off Speed and 9 km/h.

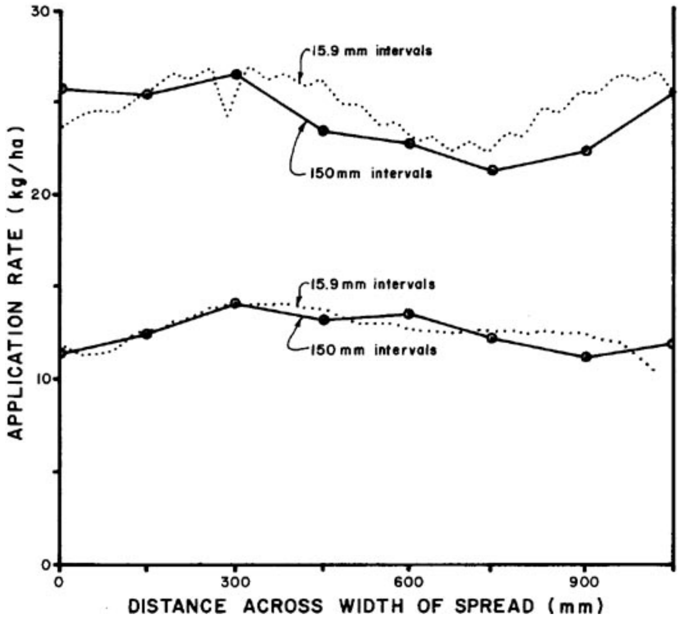

FIGURE 23. Distribution Patterns Obtained using 150 mm and 15.9 mm Collection Intervals Across a Section of the Horstine Applicator when Applying Avadex BW.

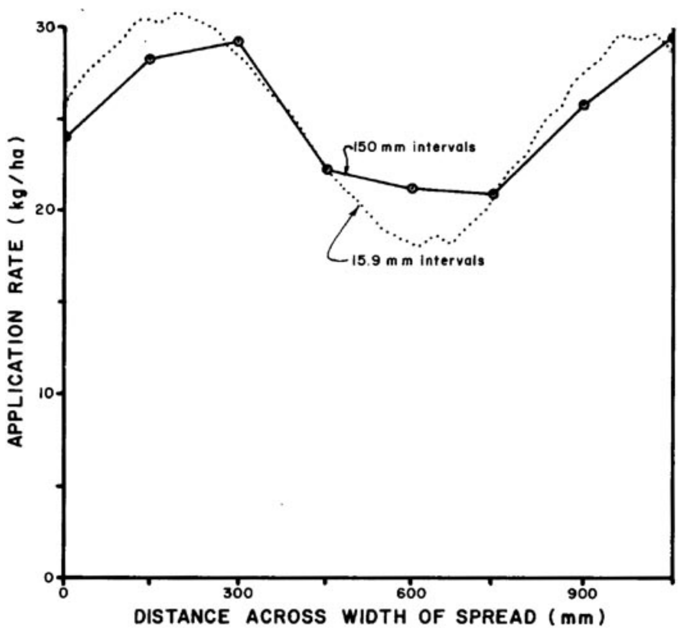

FIGURE 24. Distribution Patterns Obtained using 150 mm and 15.9 mm Collection Intervals Across a Section of the Horstine Applicator when Applying Treflan.