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# TEST PROCEDURES FOR GRANULAR APPLICATOR PERFORMANCE TESTING

by

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**SUMMARY:**

The test procedures for performance testing of pneumatic granular herbicide applicators are explained. Test result comparisons are given for different approaches of determing distribution pattern uniformity. Where applicable, test results are used to explain test methods and procedures.

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## INTRODUCTION

The application of granular pesticides is becoming more common as the number of products available in granular form increases. There are basically two types of granular herbicide applicators available; gravity or dribble type applicators, which have boxes across the entire width of the machine from which material is metered and allowed to fall onto the ground, and pneumatic or air applicators, which have centrally located hoppers from which material is metered and delivered by air across the width of the machine and spread by the airborne granules being impinged onto deflector plates.

Pneumatic applicators appear to offer several advantages over conventional dribble type applicators. Advantages include central tank filling, easier installation on tillage implements, improved material distribution and easier transporting of trailer mounted applicators. In response to these advantages, pneumatic granular applicators appear to be replacing the dribble type applicators.

This paper expands on the test procedures outlined by Drever and Wiens[1], particularly in the area of pneumatic granular applicator testing. Methods of analysing distribution uniformity are discussed, as well as the variables that affect the distribution of granules.

## LABORATORY EVALUATION

### Calibration

Metering system calibration for pneumatic applicators was determined over a range of application rates, including the recommended application rates, for a variety of granular herbicides presently available on the market. Since bulk densities of available granular herbicides differ considerably, separate calibration charts or curves must be established for each material. It was also necessary to use active herbicide as opposed to blank or non-active carrier material, since in some instances the calibration rate of the two were different.

Calibration of metering devices was determined under stationary laboratory conditions. The material delivered from each outlet was collected in containers (FIGURE 1) equipped with a screen in the lid to allow air to escape, while retaining the granular material. Collection of material from individual outlets permitted determination of the variation in delivery rate across the entire machine as well as total material delivered. The variation in delivery rates among individual outlets was expressed by the

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[1] Drever, K.W. and Wiens, E.H. 1979. Granular Herbicide Applicator Testing, ASAE/CSAE Paper No. 79-1006.

coefficient of variation[2]. A coefficient of variation of less than 10% was considered desirable for acceptable metering accuracy. Although accurate metering of each outlet does not necessarily guarantee uniform distribution, it is a desirable prerequisite.

For the calibration of ground driven metering devices, the effective wheel circumference of the drive wheel under typical field conditions was determined. The drive wheel was then driven in the laboratory at the proper ground speed with a variable speed drive. Non-ground driven metering devices were rotated in the laboratory tests at the manufacturer's recommended speed.

## Ground Speed

A calibration check was performed in the laboratory at a nominal application rate for ground speeds of 4, 8 and 12 km/h to determine if ground speed had an effect on application rate.

## Field Slope, Field Vibrations, Compaction and Pulverization

The effect on metering calibration of field slope was determined by checking the delivery rate at simulated fore and aft field slopes of 10% and side slopes of 5%. The delivery rates obtained were compared to those obtained on level ground.

The effect of field vibrations on metering calibration was determined by bouncing the applicator at a vertical amplitude of 15 mm and a frequency of 2.3 hz. These simulated vibrations were based on field measurements in a rough field at 9 km/h. The delivery rates at simulated field vibrations were compared to those obtained with the applicator stationary.

Compaction of granular material and its effect on delivery rate was established by vibrating the applicator at the above amplitude and frequency for 20 minutes and measuring any change from that obtained prior to bouncing. In addition, effect of the amount of material in the hopper was determined by measuring delivery rates with the hopper full, 3/4 full, 1/2 full, 1/4 full and nearly empty. Pulverization of granular material by the applicator was determined by subjecting i00 g samples, obtained at the above various depths of material in the hopper, to a sieve analysis. The sieve stack consisted of number 30, 40, 50, 70, 100 and 140 sieves and pan. The amount of material retained on each sieve after 10 minutes shaking on a Ro-Tap sieve shaker was compared to bagged granules to determine granular pulverization.

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[2] The coefficient of variation (CV) is the standard deviation of delivery rates frcm individual outlets, expressed as a percent of the mean delivery rate. A low CV represents uniform delivery across the machine, while a high CV indicates non-uniform delivery.

All the above tests were conducted with blank non-active carrier material, to reduce the health risk to test personnel. Although the application rate for blank material was slightly different from active product, the tests were based on a comparison to a stationary, level machine and therefore the results were relative and indicative of the results that would be obtained when using active product.

Distribution Uniformity

Variables: There are a number of variables that affect the distribution pattern uniformity of pneumatic granular applicators. These include: air volume and velocity at each outlet, type of deflector used, height of deflector, deflector spacing, material density and uniformity of delivery rate from each outlet.

Test Methods: To determine the effect of the above variables on the distribution pattern, two different test methods and apparatus were used. One method used was to measure the distribution pattern by collecting the material delivered in 150 mm wide intervals across the entire width of spread. The 150 mm intervals were established by securing 19 x 19 mm angles, 1219 mm long to the floor (FIGURE 2), using silicone caulking. The material collected in each 150 mm wide interval was collected using the vacuum cleaner-cyclone collection apparatus described in an earlier paper by Drever and Wiens[1]. Each sample collected was weighed, the application rate calculated and the value plotted to determine the distribution pattern across the width of spread. The coefficient of variation was used as a measure of distribution pattern uniformity.

This collecton method was time consuming since the distribution pattern across the entire width had to be obtained. Determing the effect of variables such as deflector height, deflector spacing and material bulk density did not always require obtaining the entire pattern. Consequently a narrower patternator, 1840 mm wide, which collected the material from only a few applicator outlets, was developed (FIGURE 3). This patternator collected material in 16 mm wide intervals. The patternator was calibrated for each granular material used so that the height of material in each interval, electrically measured by the position indicator (FIGURE 4), could be converted to an application rate. Data was recorded on an Analogic ANDS 5400 series data acquisition system and processed with an ANDS 7000 series microprocessor. An example printout and plot of the distribution pattern across the width of the patternator are shown in APPENDIX I. This method of distribution pattern determination allowed for faster assessment of some applicator variables, giving both quantitative as well as quick visual results.

Due to the different width of collection intervals (i.e. 150 mm and 16 mm) of the two test methods, it was necessary to determine the correlation between the two methods. FIGURE 5 shows the distribution patterns of one outlet, overlapped on each side by adjacent outlets, for both the floor vacuum (150 mm intervals) and patternator (16 mm intervals) methods when outlet deflectors on the applicator were spaced 762 mm apart. At this wide outlet deflector spacing, the two methods correlated very well, with a CV of 14.7% for the pattern using the 16 mm intervals and a CV of 12.1% when using the 150 mm collection intervals.

FIGURE 6 shows distribution patterns when outlet deflectors were spaced at 381 mm. At this narrower deflector spacing, correlation between the two collection methods deteriorated. Due to the fewer readings between outlet deflectors using the 150 mm interval collection method, the high and low application rates across the width of spread were not as pronounced as when using 16 mm collection intervals. This has a significant effect on the distribution pattern, resulting in a CV of 7.9% using the 16 mm intervals and 13.0% using the 150 mm intervals. Therefore, for more precise distribution pattern information, narrower collection intervals should be used.

Air Volume: Air volume measurements were made at each outlet to determine variation of air volume across the width of the machine. Air measurements were made with an orifice meter and manometer. FIGURE 7 shows the actual air distribution across the width of two different granular applicators. As noted, air volume decreased for outlets at the outer ends of both applicators. This points out the need to obtain the full pattern width when determining the effect of air volume on distribution pattern.

This requirement for obtaining the full pattern is further demonstrated in FIGURE 8 which shows an actual distribution pattern obtained for the right hand side of an applicator when applying limestone blank carrier material. Where air flow was adequate (i.e. the first 4 outlets right of the applicator centreline) the distribution pattern was good with a CV of 2.9%. Towards the outer extremity the pattern deteriorated as air volume decreased, resulting in inadequate material overlap between outlets and a CV of 11.2%.
The CV of the overall pattern was 8.7%. This change in pattern over the full width of spread would not become apparent if the narrower patternator with 16 mm intervals had been used.

Deflector Height: The effect of deflector height on distribution patterns could be analyzed using the narrower patternator, by collecting material from one outlet overlapped by the material from two adjacent outlets. FIGURE 9 is an example of distribution patterns showing the effect of height. At a deflector height of 546 mm the CV was 7.3%, while at a deflector height of 394 mm the pattern deteriorated, due to inadequate material overlap, with a resulting CV of 19.2%.

Deflector spacing: The effect of deflector spacing on distribution pattern could also be determined using the narrower patternator. FIGURE 10 shows distribution patterns of one overlapped outlet at deflector spacings of 610 and 762 mm, resulting in CV of 5.9 and 16.7% respectively. The difference in patterns was due to incomplete overlap at the 762 mm spacing.

Bulk Density: The bulk densities of the granular herbicides presently available on the market vary from approximately 700 kg/m³ to 1600 kg/m³. Additionally, bulk densities of active and non-active or carrier material also differ. Although the use of active product should be kept to a minimum to limit test staff exposure, it is necessary to check the effect of material bulk density by obtaining at least one distribution pattern with active product. One pattern, within the recommended application rate range, with both active and inactive material should be obtained to determine this effect.

FIGURE 11 compares distribution patterns obtained when using limestone, with a CV of 10.1%, to Treflan QR5, with a CV of 12.4%. The inactive limestone material had a higher bulk density and produced the best pattern. In addition to bulk density, particle size and flowability of the product may also contribute to differences in distribution patterns.

## FIELD EVALUATION

The applicators were operated in a variety of field conditions while assessing ease of operation and adjustment, rate of work, quality of work and operator safety. Performance on rolling topography and rough fields was assessed and suitable operating speeds on various field surfaces were determined.

Calibration of the metering system was checked in the field and compared to laboratory results to determine the effect of such factors as field bounce and material compaction.

The effect of wind was observed and an estimate of the maximum wind speed that the applicator could effectively operate in was determined.

The hoppers were assessed for weather tightness and ease of filling.

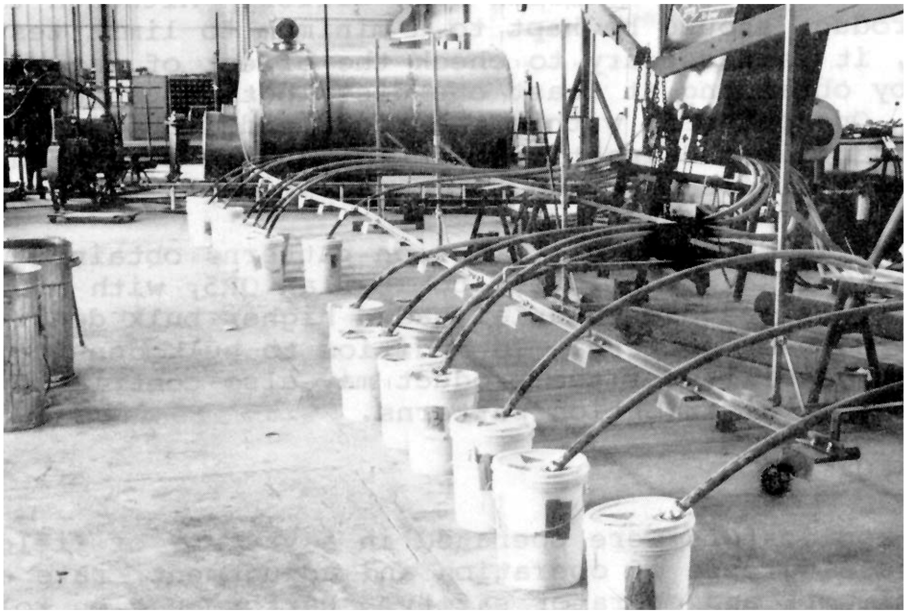

**FIGURE 1.** Metering Calibration.

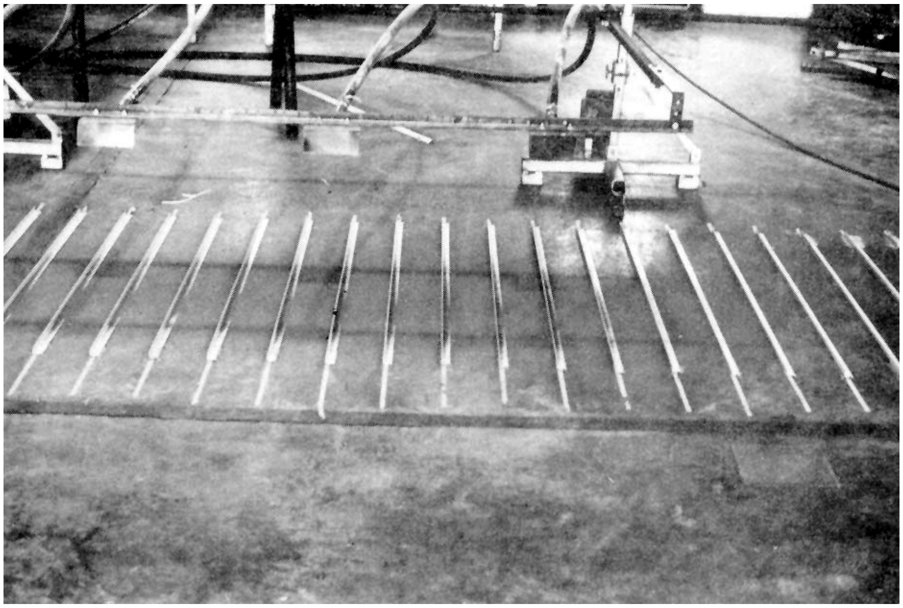

**FIGURE 2.** Distribution Pattern Determination using 150 mm Wide Intervals.

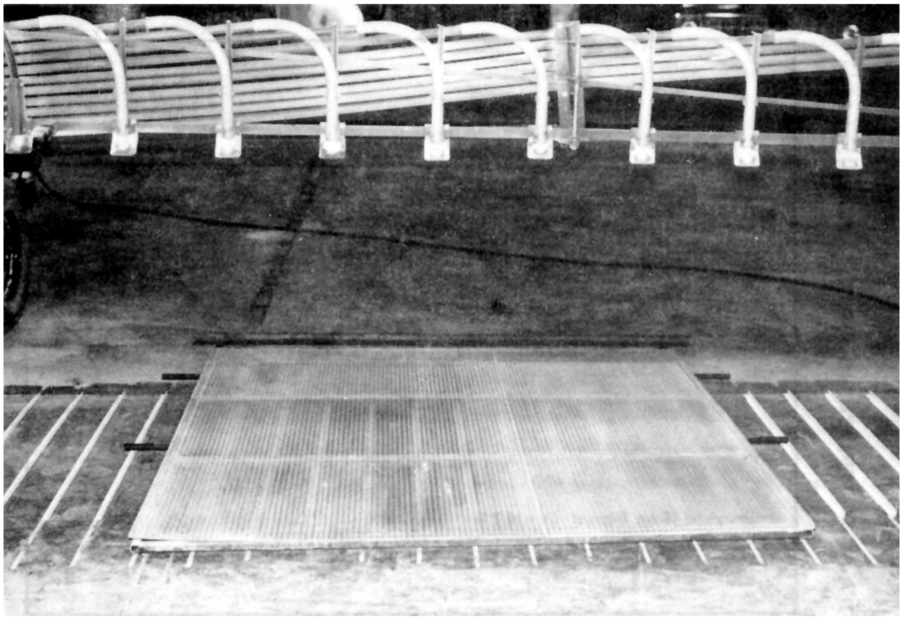

**FIGURE 3.** Distribution Pattern Determination using 16 mm Wide Intervals.

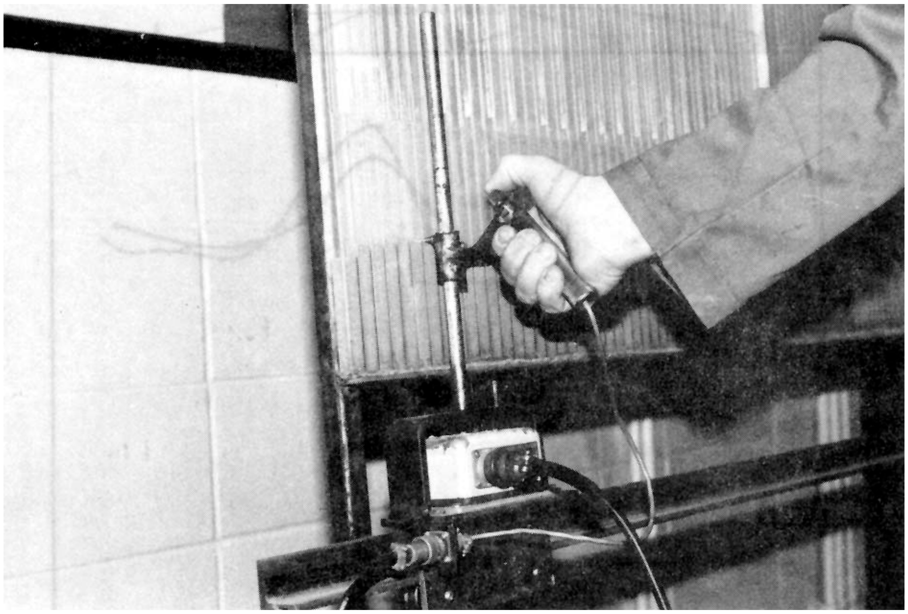

**FIGURE 4.** Electrical Position Indicator for Measuring Height of Material in Patternator.

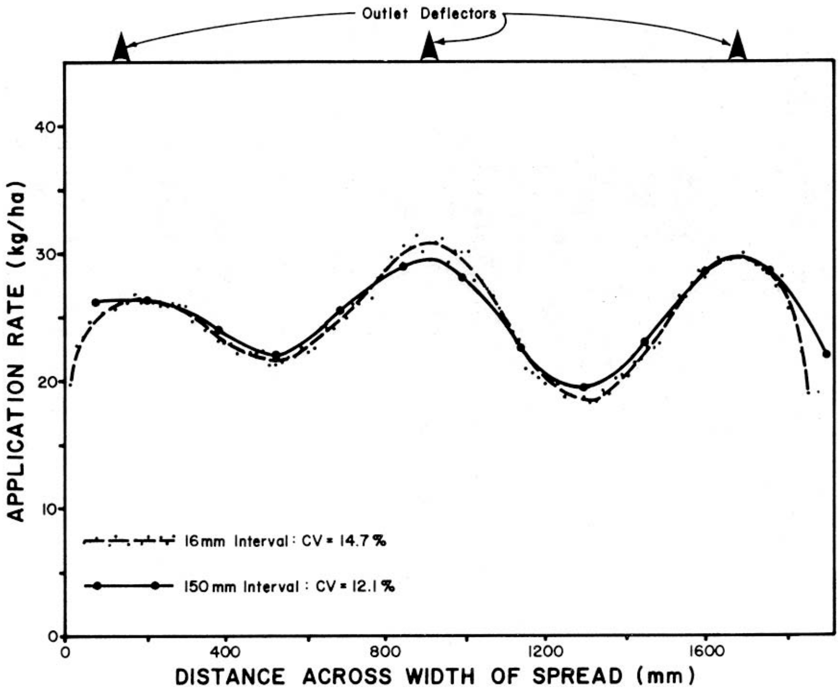

**FIGURE 5.** Distribution Pattern Comparison using 150 mm and 16 mm Wide Collecting Intervals with Outlet Deflectors Spaced at 762 mm.

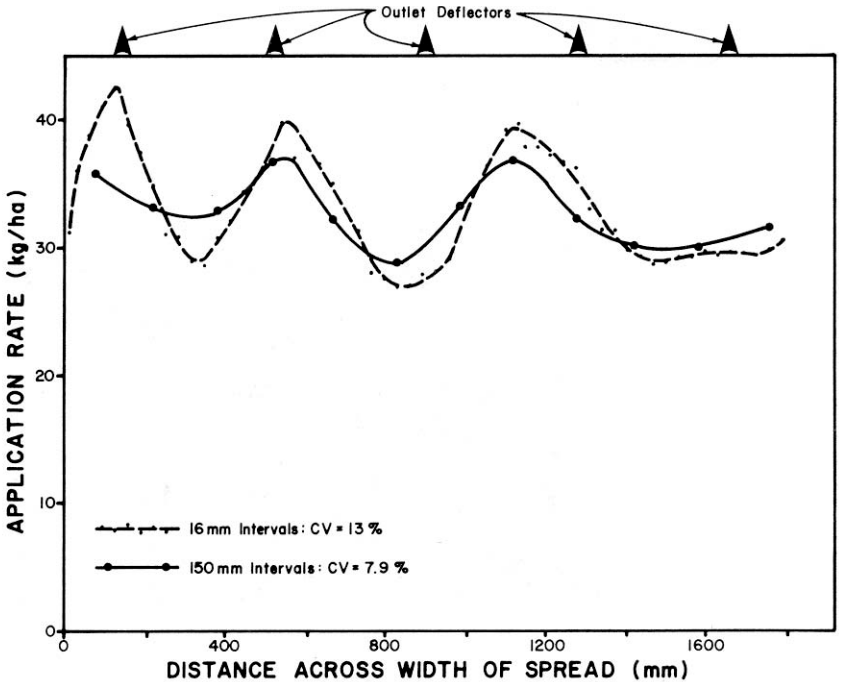

**FIGURE 6.** Distribution Pattern Comparison using 150 mm and 16 mm Wide Collecting Intervals with Outlet Deflectors Spaced at 381 mm.

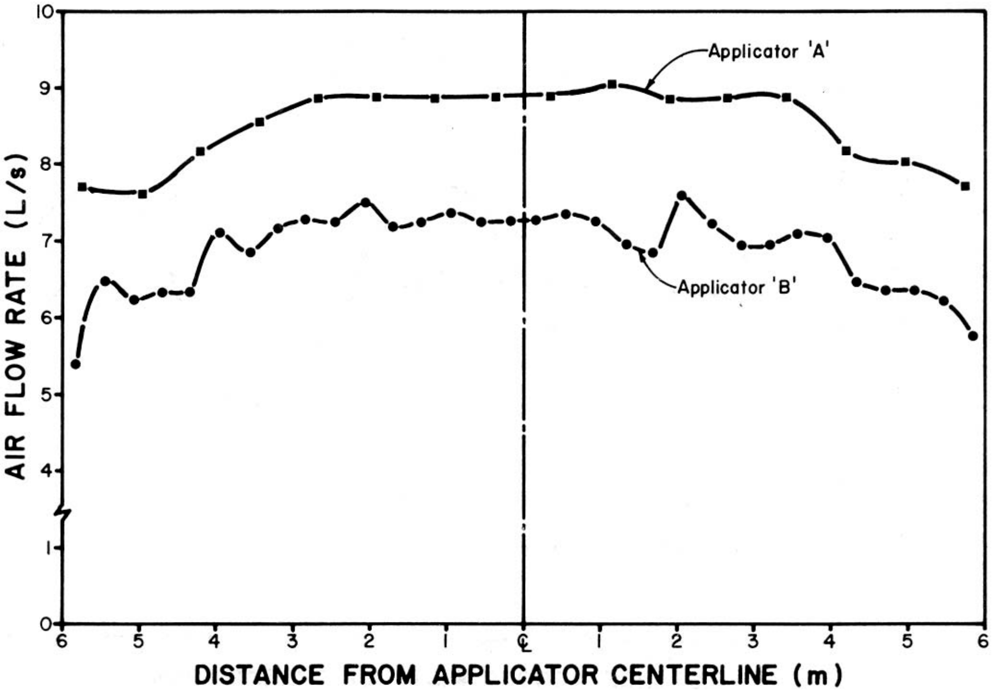

**FIGURE 7.** Typical Air Flow Volume from Outlets across the Width of Two Granular Applicators.

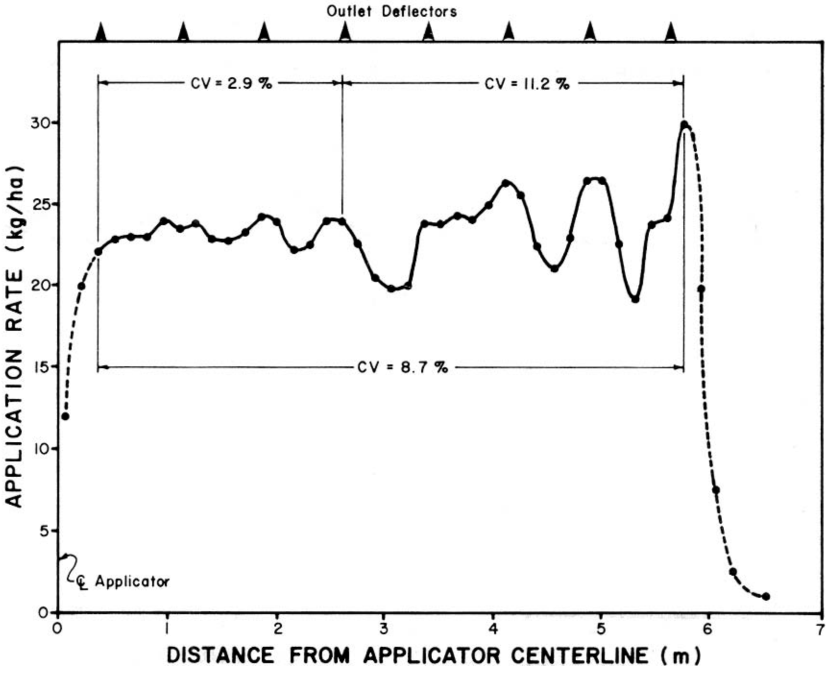

**FIGURE 8.** Distribution Pattern Variation, when Applying Limestone Carrier, for the Right Hand Side of an Applicator, Showing the Effect of Decreasing Air Volume across the Width.

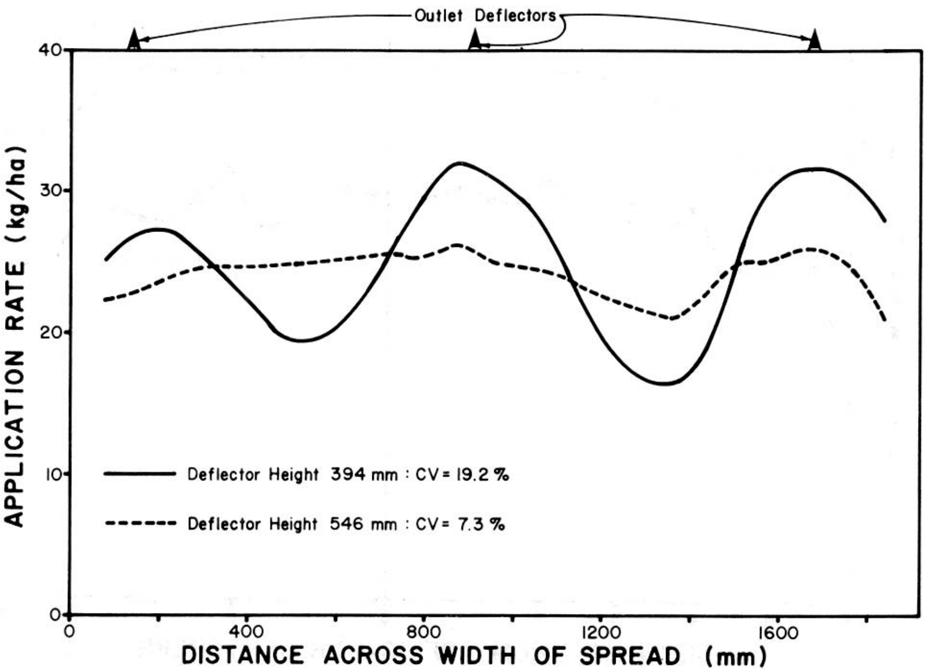

**FIGURE 9.** Distribution Patterns Showingthe Effect of Deflector Height.

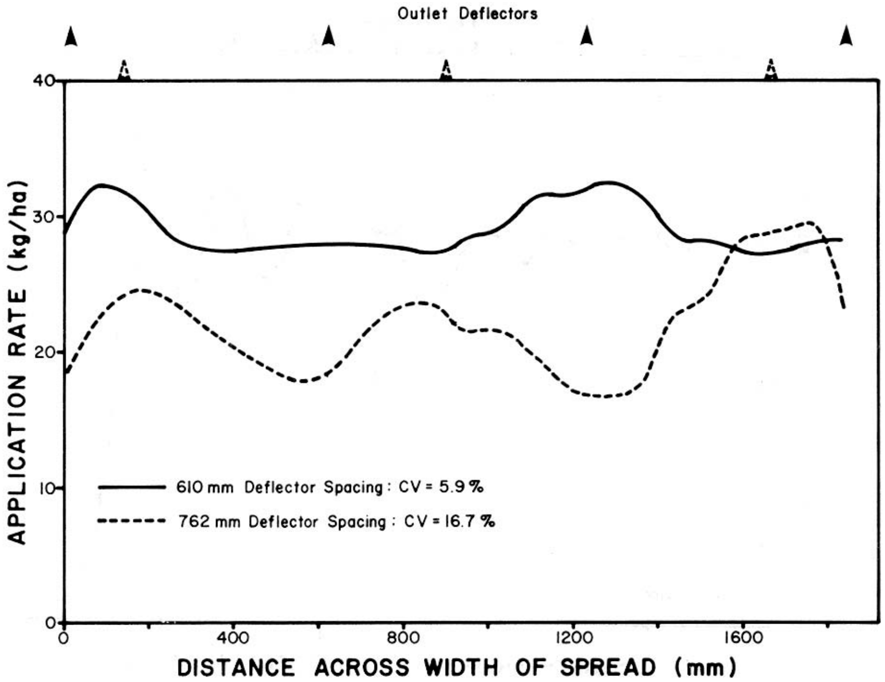

**FIGURE 10.** Distribution Patterns Showing the Effect of Deflector Spacing.

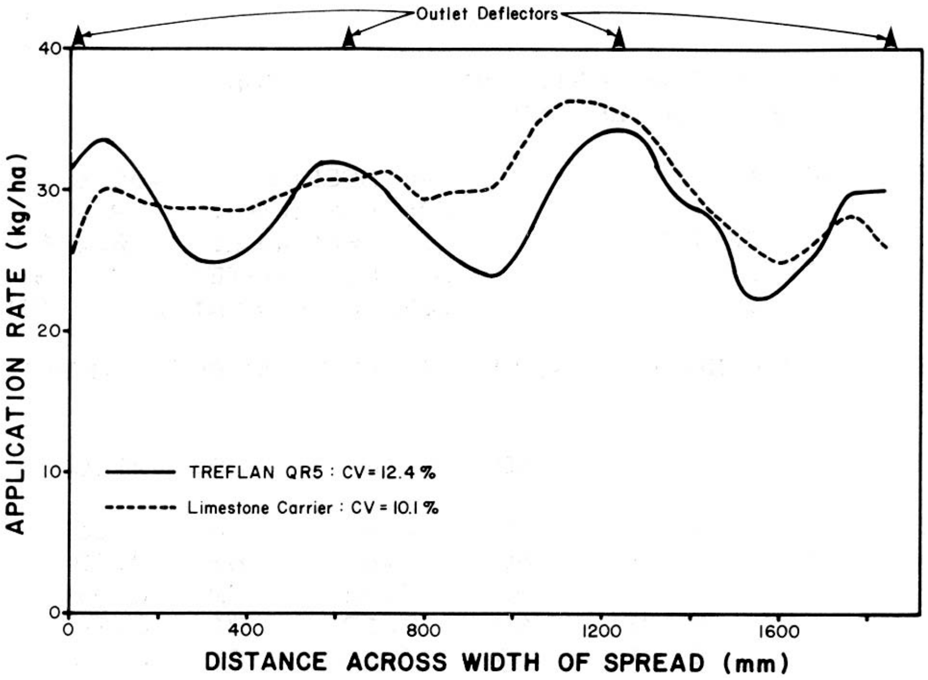

**FIGURE 11.** Distribution Patterns Showing the Effect of Material Bulk Density.

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## APPENDIX I

DATE: AUG 17 /83
PROJECT #E1983A

### DISTRIBUTION TEST:PAMI PATTERNATOR
### RUN NUMBER: A27

MATERIAL METERED: AVADEX
METER SETTING: 30.0
ROTOR SPEED: L 0.0 R 22.7 RPM
DEFLECTOR SPACING: 30 IN
DEFLECTOR HEIGHT: 19.5 IN

FAN SPEED: 405.6 RPM
FAN PRESSURE: 9.0 OZ.
OIL PRESSURE: 800.0 PSI
OIL FLOW RATE: 7.7 GPM
LENGTH OF RUN: 2.999 MIN

DEFLECTOR NUMBER 10 IS DIRECTLY ABOVE PATTERNATOR SLOT NUMBER 9

| NO. | WT(G) | NO. | WT(G) | NO. | WT(G) | NO. | WT(G) |
|---|---|---|---|---|---|---|---|
| 1 | 7.72 | 30 | 8.86 | 59 | 7.92 | 88 | 9.26 |
| 2 | 7.85 | 31 | 8.59 | 60 | 7.60 | 89 | 8.78 |
| 3 | 8.39 | 32 | 8.46 | 61 | 7.98 | 90 | 8.99 |
| 4 | 8.46 | 33 | 8.25 | 62 | 8.12 | 91 | 8.84 |
| 5 | 8.52 | 34 | 8.12 | 63 | 8.06 | 92 | 8.78 |
| 6 | 8.65 | 35 | 8.38 | 64 | 7.86 | 93 | 9.06 |
| 7 | 8.59 | 36 | 8.25 | 65 | 8.46 | 94 | 9. b5 |
| 8 | 8.46 | 37 | 8.39 | 66 | 8.39 | 95 | 9.10 |
| 9 | 8.66 | 38 | 7.91 | 67 | 8.79 | 96 | 8.79 |
| 10 | 8.59 | 39 | 8.12 | 68 | 8.32 | 97 | 8.65 |
| 11 | 9.14 | 40 | 8.05 | 69 | 8.72 | 98 | 8.86 |
| 12 | 8.72 | 41 | 8.11 | 70 | 8.65 | 99 | 8.72 |
| 13 | 9.07 | 42 | 7.78 | 71 | 8.91 | 100 | 8.59 |
| 14 | 8.86 | 43 | 7.97 | 72 | 8.38 | 101 | 8.59 |
| 15 | 8.93 | 44 | 7.64 | 73 | 8.66 | 102 | 8.66 |
| 16 | 9.07 | 45 | 7.96 | 74 | 8.66 | 103 | 8.99 |
| 17 | 9.06 | 46 | 7.91 | 75 | 9.05 | 104 | 8.25 |
| 18 | 9.34 | 47 | 7.80 | 76 | 8.52 | 105 | 8.26 |
| 19 | 9.20 | 48 | 7.27 | 77 | 8.46 | 106 | 8.39 |
| 20 | 9.14 | 49 | 7.40 | 78 | 8.71 | 107 | 8.06 |
| 21 | 9.35 | 50 | 7.34 | 79 | 8.66 | 108 | 8.32 |
| 22 | 9.21 | 51 | 7.72 | 80 | 8.59 | 109 | 8.12 |
| 23 | 9.00 | 52 | 7.32 | 81 | 9.18 | 110 | 8.52 |
| 24 | 9.14 | 53 | 7.78 | 82 | 9.05 | 111 | 8.32 |
| 25 | 9.07 | 54 | 7.40 | 83 | 8.98 | 112 | 9.07 |
| 26 | 8.80 | 55 | 7.58 | 84 | 8.99 | 113 | 7.99 |
| 27 | 8.93 | 56 | 7.19 | 85 | 8.45 | 114 | 8.23 |
| 28 | 8.86 | 57 | 7.71 | 86 | 8.96 | 115 | 7.78 |
| 29 | 8.52 | 58 | 7.40 | 87 | 9.04 | 116 | 7.21 |

| | | |
|---|---|---|
| MEAN | 8.46 | (G) |
| STD. DEV. | 0.55 | (G) |
| C.V. | 6.49 | (%) |
| MAXIMUM | 9.65 | (8) |
| MINIMUM | 7.19 | (G) |
| | | |
| FLOW RATE | 0.008 | (KG/MIN) |

RUN NUMBER A27

THESE VALUES ARE FOR APPLICATION RATE IN kg/ha FOR EACH SLOT AT A SPEED OF 8 km/hr.

| NO. | RATE | NO. | RATE | NO. | RATE | NO. | RATE |
|---|---|---|---|---|---|---|---|
| 1 | 12.16 | 30 | 13.96 | 59 | 12.48 | 88 | 14.59 |
| 2 | 12.36 | 31 | 13.53 | 60 | 11.97 | 89 | 13.84 |
| 3 | 13.21 | 32 | 13.32 | 61 | 12.57 | 90 | 14.16 |
| 4 | 13.32 | 33 | 12.99 | 62 | 12.80 | 91 | 13.93 |
| 5 | 13.43 | 34 | 12.79 | 63 | 12.70 | 92 | 13.84 |
| 6 | 13.63 | 35 | 13.20 | 64 | 12.38 | 93 | 14.28 |
| 7 | 13.53 | 36 | 13.00 | 65 | 13.32 | 94 | 15.20 |
| 8 | 13.32 | 37 | 13.21 | 66 | 13.22 | 95 | 14.34 |
| 9 | 13.64 | 38 | 12.47 | 67 | 13.85 | 96 | 13.85 |
| 10 | 13.53 | 39 | 12.79 | 68 | 13.11 | 97 | 13.63 |
| 11 | 14.39 | 40 | 12.68 | 69 | 13.74 | 98 | 13.95 |
| 12 | 13.74 | 41 | 12.77 | 70 | 13.63 | 99 | 13.74 |
| 13 | 14.28 | 42 | 12.26 | 71 | 14.04 | 100 | 13.53 |
| 14 | 13.96 | 43 | 12.55 | 72 | 13.21 | 101 | 13.53 |
| 15 | 14.06 | 44 | 12.04 | 73 | 13.64 | 102 | 13.64 |
| 16 | 14.28 | 45 | 12.54 | 74 | 13.63 | 103 | 14.16 |
| 17 | 14.28 | 46 | 12.47 | 75 | 14.25 | 104 | 13.00 |
| 18 | 14.71 | 47 | 12.29 | 76 | 13.43 | 105 | 13.01 |
| 19 | 14.50 | 48 | 11.46 | 77 | 13.32 | 106 | 13.22 |
| 20 | 14.39 | 49 | 11.65 | 78 | 13.72 | 107 | 12.70 |
| 21 | 14.73 | 50 | 11.57 | 79 | 13.64 | 108 | 13.10 |
| 22 | 14.51 | 51 | 12.17 | 80 | 13.53 | 109 | 12.79 |
| 23 | 14.17 | 52 | 11.54 | 81 | 14.47 | 110 | 13.42 |
| 24 | 14.39 | 53 | 12.26 | 82 | 14.26 | 111 | 13.11 |
| 25 | 14.28 | 54 | 11.66 | 83 | 14.15 | 112 | 14.29 |
| 26 | 13.86 | 55 | 11.95 | 84 | 14.16 | 113 | 12.58 |
| 27 | 14.07 | 56 | 11.33 | 85 | 13.31 | 114 | 12.97 |
| 28 | 13.96 | 57 | 12.15 | 86 | 14.12 | 115 | 12.26 |
| 29 | 13.43 | 58 | 11.66 | 87 | 14.24 | 116 | 11.36 |

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            APPLICATION RATE (kg/ha) OF RUN  NUMBER:  A27
    0         5         10        15        20        25        30        35
#   1---------1---------1---------1---------1---------1---------1---------1---
  1 1************************
  3 1**************************
  5 1**************************
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