Potential Uses of Pneumatic Applicators in Alfalfa Production

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Abstract: Pneumatic, or air stream, applicators have many uses in alfalfa production. They are being used for application of fertilizers, seed, granular pesticides, and chemically impregnated granules. The principles of operation are similar across all brands and uses. Key components are described, along with their role in product distribution. Measures of performance are detailed, as a guide to prospective purchasers of either a unit itself or its services. Potential future uses and roles of pneumatic applicators are outlined.

Keywords: granular, pesticide, fertilizer, pneumatic, seed, application equipment, air stream

Introduction

The use of pneumatic, or air stream, applicators has grown in recent years. These devices are designed to apply granular pesticides, fertilizers, and seeds. They may apply the materials either in a broadcast application or in a directed application. Pneumatic applicators use moving air to entrain the particles of fertilizer, seed, or pesticides and transport them from the metering point to the release point. Most have a boom attachment, although equipment set up for a directed application may use air hoses tied directly to an implement.

Several firms are producing and selling these units in California and elsewhere. The principles of operation are the same regardless of the manufacturer, as are measures of performance of concern to the applicator, PCA, and grower. The choice of which machine to use should be based upon the requirements of the application and may change depending upon those requirements.

Components

The basic components of a pneumatic applicator are: a hopper, box, or bin; metering system; air supply; distribution system; and transport tubes. Each will be discussed briefly.

Hopper: The hopper is the component into which the material to be spread is loaded. Capacity should be large enough to offer a reasonable field efficiency, within the boundaries of acceptable loading to avoid soil compaction problems, based upon the field conditions and tire surface area. Materials for the hopper may be steel, galvanized, stainless steel, or a coated steel Corrosion could be a problem with some types of construction when used with particular products. Note any particular corrosive properties of the products to be spread and check for compatibility with the components of the spreader.

A cover which can be rapidly deployed for road travel or to protect the load against the elements is an advantage. It should also be easily removed for quick loading of the hopper.

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Metering System: The metering system is used to regulate the delivery of material to the distribution system. It is sometimes a gate placed into a moving stream of the granular material, allowing only a limited amount to pass through the opening. Other schemes may block portions of the opening. Bridging or plugging can be a problem here, particularly at low flow rates and thus small opening sizes. The metering system may also employ wheels or disks with openings or slots in them. Material falls into the slots and is carried past the unit housing, which allows only material inside the wheel to pass. With all systems, the size and flow characteristics of the material can significantly change the flow rate for a given size orifice or opening. Each material should be recalibrated to ensure that the desired rate is being achieved.

Distribution System: This process divides the metered granular or dry material into portions which are fed, along with air, to each of the air discharge tubes. Devices used here should be corrosion resistant for the chemicals to be used and should be of sufficient size for the flow rates anticipated. Air and material should be divided equally, so that each tube receives the same amount of product and air. This process, along with the metering process, should be carried out without grinding or excessive mechanical contact between the material to be spread and machine components. Air is supplied by a fan, which is an integral part of the system and is sized by the manufacturer according to the size and number of discharge tubes on the unit. This point is crucial and determines the uniformity of the application.

Transport Tubes: These are the tubes which transport the air and entrained material to the emission point. They should be of sufficient diameter to avoid plugging at the highest flow rates, but yet not too large for the fan. Air velocity must be sufficient to keep all material suspended, or at least moving without interruption. The tubes should also be of a design that avoids sharp bends and changes of direction, which can cause plugging.

Performance Measures

Calibration: All applicators must be calibrated. This is simply the process of matching the speed and swath width (area covered per unit time), flow rate, and desired application rate. To perform a calibration, the swath width must be measured or determined from the formula:

Swath width = # of discharge tubes X tube spacing

Travel speed should be measured in the field upon which the application is to be made and should be obtained with the hopper approximately half full. A course of at least a couple of hundred feet should be marked, and the applicator driven through the course and the time measured. The applicator should be at speed before entering the marked course and should pass through the entire course before reducing speed. This procedure should be performed three times and the average of the three used as the travel speed.

Flow rate can be determined by capturing the output from each discharge tube for a period of time, such as 30 seconds or 1 minute. The material should all be weighed and the process repeated three times. The average is the flow rate, expressed in pounds per minute.

The application rate is then determined by using standard calibration and rate formulas as found in handbooks and owner's manuals.

Accuracy: This is a measure of how closely the application rate matches the desired rate. The rate (lbs./acre) should be selected at the beginning of the application to a field and should remain constant over the entire plot. (The exception to this is if a prescription farming system or site specific crop management system is employed.) The equipment should compensate for changes in application speed, either through a radar unit or an undriven metering wheel in contact with the ground. Sensing of changes in speed causes a change in the metering system to either increase or decrease the flow rate per time.

The implementation of the metering, distribution, and transport system will have an effect on the time delay between the sensing of travel speed changes and the resulting change in output at the point of placement. Long hoses or tubes with a relatively low air velocity can result in a significant delay before rate changes become apparent. At this point, the travel speed may have changed again, resulting in the actual application rate being different than the intended rate, This factor is more important at higher travel speeds and with a wider boom or implement.

To measure accuracy, a course can be laid out over terrain typical of that to be covered. Catch basins such as cans or troughs (padded to avoid material bouncing out and long dimension in the direction of travel) should be placed at uniform intervals along the direction of travel. One or more passes (in the same direction each time) should be made over the course, and the material from each trough collected and weighed. Coefficient of variation should be calculated from the formulas:

$$\text{Mean} = \overline{X} = \frac{\sum X_i}{n}$$

$$\text{Standard Deviation} = \sigma = \frac{n\left(\sum X_i^2\right) - \left(\sum X_i\right)^2}{n(n-1)}^{(1/2)}$$

$$\text{Coefficient of Variation} = CV = \frac{\sigma * 100}{\overline{X}}$$

Where X_i is the weight of material from each of the "i th" trough. All troughs must be included in this calculation.

The mean application rate over the course should be very close to the desired rate. Values of ± 5 % are usually thought of as acceptable. A difference of more than 5% from desired rate should indicate that the spreader needs to be recalibrated for the material being spread.

Each PCA, grower, and applicator must decide upon an acceptable value for CV. Most applications should have a CV of less than 10% if at all possible.

Uniformity: The uniformity of an application is a measure of how evenly the material is spread across the boom or application width. If there is any overlap from one pass to the next, this must be incorporated before uniformity is measured. Uniformity is influenced by distribution system design, air tube design, and boom design, particularly the boom suspension. On long booms and uneven ground, boom height varies across the width of the boom. As boom height changes, the dispersion below each outlet will change as a function of the height from the release point to the ground.

The procedure to measure uniformity is similar to that for accuracy, except the cans or troughs are laid out perpendicular to the direction of travel with their long dimension parallel to the boom. Again, one or more passes are made across the samplers, in the same direction. Material is collected and weighed again, and the calculations as described above are once more completed.

Sometimes this performance characteristic is measured by placing bags on the outlets of the air tubes. This will measure how evenly material is divided among the air tubes, but may or may not represent the ground deposits. If the distance between air tubes is large, or more precise measurements of distribution patterns as they occur on the ground is desired, catch tray, pans, or cans must be used, rather than bags.

Potential Future Uses

The continuing development of site specific crop management systems, or prescription farming systems offers a great potential for pneumatic applicators. By their very design and use, they can conceivably alter the amount of granular material delivered to each small unit of field surface. Variability in one dimension, the direction of travel, is already in place and could be extended to the other dimension through the use of individual metering gates on each air tube. This capability could allow application of continuously varying amounts of fertilizer, pesticide, seed, or other dry or granular product over an entire field and be a significant advancement toward optimizing inputs for each unit area of an entire farm.

In addition, impregnation of granules or blank granular material could also be done in real time in the field. A variety of liquids could be used, as nutrients, pesticides, or soil amendments. The rate on each liquid could be varied according to the needs of each unit area of the field, thus truly customizing and optimizing the application process according to the needs and capacity of the field.