ACCURATE METERING OF SEED AND FERTILIZER

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Introduction
Over the years the AFMRC and PAMI have been frequently asked whether air seeders meter and distribute as accurately as conventional drills. In the early development years this was a valid concern. Today it is not a factor as long as the equipment is well maintained. Air seeders made after 1987 compare favorably with conventional drills as far as metering and distributing is concerned. The following will address trends and identify some of the factors that influence metering and distribution.

Metering System

There are two distinct types of metering systems:

Variable Displacement System - A system in which the application rate is adjusted by varying the length that the meter is exposed or the position of a cut-off gate. There are several variations of this design. Most common is an externally fluted meter operating on a feed cup. This is really just an oversized metering cup used on most hoe and disc drills. The other type consists of an adjustable gate operating over a conveyor belt or chain. Both of these systems are reasonably accurate but the main limitation is metering small amounts of small seed. To compensate, manufacturers may offer a slow speed kit. Another solution is a multi-stage fluted meter. The first stage allows for small seeds/low rates to be metered. The second stage allows for larger seeds/higher rates to be metered.

Variable Speed Metering System

This system relies on some mechanism to change the speed to vary the rate. The speed can be changed through a gear box, chain and sprocket combinations, variable length crank arm, variable speed drives or combinations of the above. These systems may have either distinct speed settings or be infinitely variable within a given range. The stepped or distinct speed control systems may dictate specific application rates. The actual meters themselves come in several different forms. They may be metering auger, fluted feed roll, smooth double roll system or pegged roller system. Each of these types operate in a metering box or seed cup. Several manufacturers offer optional roller configurations for different types of materials.

Metering Accuracy

We have tested twenty air seeders in last ten years. To date, every system has had a linear relationship between setting and application rate. Several manufacturers have actually used our test results as their calibration charts for their machines. When we compare the manufacturers' settings to what we have found in the lab the results have been very good for cereal crops. For example, in wheat, over 70% of the manufacturers have calibration charts within 10% of what we have found in our tests.

The machines with calibration charts which differ from our test results by more than 10% typically were made before 1987. Application rates within 10% may sound unreasonable but variations in seed size and densities usually account for this variance.

The real test for metering accuracy comes when either canola or fertilizer is applied. The problem with canola is that it is a very small seed applied at very low rates. The meters used are really designed for applying much larger volumes of material. For canola only 30% of the units tested have calibration charts within 20% of what we found in the lab. Again, the trend is much better over the last few years because the manufacturers have recognized the problem with metering small seeds. This has lead to manufacturers supplying such items as optional feed rolls especially designed for canola.

Fertilizer is difficult to meter for several masons. First, it is not a uniform size. It consists of large and small particles of varying densities. It also tends to clod and bridge under certain situations. And lastly, application rates are higher than cereal crop seeding rates. At rates below 55 kg/ac nearly all the manufacturers have accurate calibration charts. At rates over 55 kg/ac there is a greater discrepancy between our results and the manufacturers. The central metering systems used on air seeders today are as accurate as the multiple metering systems used on conventional seed drills. Inaccuracies are primarily due to calibration charts rather than the meter itself.

Factors That Influence Metering Accuracy

1. Material size and density

Material size and material density may account for most of the variations we find in calibration charts. For example, in wheat the variation in seed size between spring wheat and durum is quite apparent. Density variations within a variety and among varieties may vary as much as 15%. With fertilizer, for a given blend, the density may vary by as much as 10%. Between blends the density may vary as much as 20% depending on its composition. This makes it difficult for farmers to set their meters. One solution to this problem has been to supply charts that not only include all different types of materials but different densities as well. This greatly simplifies initial settings and calibrations in the field.

2. Application rates

The meter may or may not be the limiting factor in determining the maximum application rate of a given material. Ideally, the size of the meter or meters should be matched to the air distribution system. This will ensure the system is not overloaded, preventing plugging. The flow characteristics of the material largely determines how efficiently the meter handles high application rates. At fertilizer application rates greater than 90 kg/ac or high seeding rates of specialty crops the metering accuracy is extremely variable. This requires field calibrations to ensure the proper application rate.

3. **Field slope** - slope from side to side or fore and aft usually had no effect on metering accuracy. Less than 10% of the units were affected. There was no one type of meter that was especially susceptible to field slope.

4. **Ground speed -** all air seeders rely on a ground wheel to drive the meter. Metering accuracy on the majority of machines is not affected by changes in ground speed. Units affected (i.e., less than 10%) were usually variable displacement type meters.

5. **Field bounce -** the naturally occurring pitching and rolling in the field does not have any effect on metering accuracy.

The metering devices used in today's air seeders are affected by the same factors that affect conventional seed drills. Farmers have accepted these limitations.

Calibration and Adjustment

As mentioned previously, field calibration is a necessary procedure to ensure accurate metering settings. A variety of methods are used to accomplish this task.

1. **Traditional method -** an operator fills the seeder, drives a known distance, determines the area covered, measures the amount of material to refill the seeder and then calculates the application rate.

2. **Application rate device method -** is based on the amount of material collected in a special cup from a single run. The seeder is driven a set distance. Based on run spacing and the amount of material collected, the application rate can be calculated or determined from a chart supplied by the manufacturer.

3. **Sample collector -** this feature is available on several makes. It consists of a collection device mounted below the metering box or attached to the primary distribution system. The operator manually turns the meter a specified number of turns. The material collected is weighed and the value is entered into an equation to convert it to application rate.

The calibration of the meter is an important aspect in the operation of an air seeder. It doesn't matter which method of calibration is used as long as the system is calibrated.

The ease of operation and adjustment of the meter is a feature that is still under consideration by most manufacturers. Before 1987, machines were not as convenient to operate or adjust as compared to the more recent machines. There is still room for improvement in the following areas:

1. **Access -** Meters are located at the bottom of hopper-shaped tanks. This makes operator access difficult.

2. **Scale divisions -** most manufacturers rely on some sort of unitless scale divided into divisions. Often the increments are too large for any degree of accuracy. This is especially true for low application rates.

3. **Repeatability -** Returning to a desired rate is often a trial and error process. This is because of the lack of refinement in scale settings and because meter settings usually rely on some type of mechanical linkage or device. Operational techniques such as always setting the meter the same way will eliminate some

of this error. For example, variable displacement meters should be adjusted from smaller to larger application rates. The reason for this is when there is material in the meter it is extremely difficult to make the volume smaller. This also ensures that any slack in the adjustment linkage will always be the same. This guideline also applies to variable speed drives. Always setting the speed from the same direction will minimize errors.

Gear boxes and chain/sprocket type speed adjustments do not result in problems with settings and repeatability. However, these systems have to be well thought out in order for operators to access and use them conveniently.

The perfect system of operating and adjusting meters has yet to be developed. There have been many improvements in the last few years and the systems used on air seeders are on par with those on conventional drills. A key advantage of air seeders over conventional drills is that a central meter or meters is far easier to maintain than a complete set of meters as used on the conventional drill.

Distribution System

Types

Distribution systems can be classified into three main types (FIGURE 1) according to how the material being conveyed is divided. Type A is a system that uses one metering device for each tank and divides the material at the primary and secondary header locations before delivering the material to the individual openers. The variation among the amounts of material delivered to each opener depends on the division accuracy of the primary and secondary headers.

The Type B system uses a metering device for each primary distribution tube with pneumatic material division at each secondary header before being delivered to each opener. The variation to each opener depends on the accuracy of the metering system and the accuracy of the division at the secondary headers.

The Type C system uses individual tubes running from the metering system to each opener. Division occurs at the metering system as material falls into seed cups attached to each distribution tube. Variation to each opener depends only on division of material at the meter.

The majority of machines on the market use either a type A or B distribution system. Only a few manufacturers use the type C system. Early models of air seeders had very bulky and cluttered arrangements of hoses on the cultivator. Recent designs are low profile and can be adapted to any make of cultivator.

Distribution Uniformity

Air seeders have always been reasonably accurate in metering material. A more important factor has been how uniformly the material is delivered to the individual openers. With a central meter the material has to be divided in some manner. The more times the material is divided the greater the chance for variations in uniformity. Consequently, going from a Type A to a Type B to a Type C distribution system, reduces the source of variation in distribution uniformity. Machines made before 1987 normally support this conclusion. Today the technology is available to manufacture metering distribution systems with similar distribution uniformity.

Table 1 shows how manufacturers have fine tuned their machines in the last few years. The table shows the average uniformities of air seeders tested before 1987. It then compares them to conventional drills and air seeders made after 1987. The term of comparison is the coefficient of variation 1. This term is used extensively throughout our reports to indicate acceptable levels of uniformity. Values over 15% are considered unacceptable, under 15% acceptable and under 10% very good. The materials in comparison are wheat, barley, canola and two application rates of fertilizer.

Table 1. Distribution uniformity at normal seeding rates based on coefficient of variation.

Implement	Material				
	wheat	barley	canola	11-51-00 23 kg/ac	11-51-00 68 kg/ac
			cv[1]		
Early Air Seeder	7.9	8.1	16.3	11.7	19.3
Hoe and Disc Drills	1-4	1-4	1-6	2-7	2-7
1987 Model Trend	5	5	8	6	7

Many of the design problems have been overcome in recent years. The air seeder of today is a viable option to the conventional drill based on distribution uniformity.

Factors that Influence Uniformity

1. Material and Application Rate

TABLE 1 shows how the type of material influences the distribution uniformity. Canola and fertilizer consistently have higher CV'ss than cereal grains. This is due to two factors. First, the size, shape and lack of uniformity among particles determines how efficiently the distribution system can divide the material. Secondly, most distribution systems are designed for a certain range of application rates of cereal grains. This corresponds to a certain range of application rates. Canola seed rates are well below this range and fertilizer is applied at rates above this range. Based on our results, the CV typically gets better at rates over 4.5 kg/ac for canola. This is also true for fertilizer when the rates are below 90 kg/ac.

2. Field Slope

In most cases, field slope had no effect on distribution uniformity. As long as the meter itself was not affected by slope the distribution uniformity was not affected.

3. Ground Speed

In nearly all cases ground speed affected distribution uniformity. This is related to the material load in the system. As ground speed increases, metering rate increases to maintain the same application rate. The greater the load on the system the more difficult it is to divide uniformly. As long as the speed is maintained, (approximately 8 km/h for our tests,) there will be a minimal affect on uniformity.

[1] The coefficient of variation (CV) is the standard deviation of the application rates from the individual runs, expressed as a percent of the mean application rate.

4. Field Bounce

The naturally occurring pitching and rolling in the field does not have any affect on distribution uniformity.

5. Fan Speed

Fan speed has a significant effect on distribution uniformity. In order for material to remain suspended in the air flow, air velocities of 1200 to 1800 rpm are required. As the amount of material in the air stream increases, the pressure or resistance to flow increases. To maintain this balance the fan speed has to be properly selected and maintained. Any variations in this speed can result in reduced uniformity. Velocities that are too high can also result in seed damage. This is a concern with seeds that split easily, such as canola and peas. At very high application rates, fan speed or air velocities may be the limiting factor. At air velocities below 1200 rpm the material may not remain in suspension and result in plugging of the distribution system. In the past, not enough emphasis has been placed on fan speed recommendations. This variable is as important as the meter setting.

CONCLUSIONS

Individual manufacturers have approached the development of air seeders in many different ways. The result has been machines with metering and distribution systems that compare favorably with conventional seed drills. The added benefit has been that farmers have a variety of machines to choose from to suit their individual needs. Because of the competitive nature of the industry, further fine tuning of air seeders will occur in the future. The winners will be the farmers who are able to take advantage of the benefits of using the air seeder system.