Abstract: The popularity of spinner spreaders for application of granular fertilizers and agricultural lime, along with increased interests in variable–rate technology (VRT), has raised concern about application accuracy and distribution of these spreaders. This investigation was undertaken to assess the application distribution of a VRT spinner fertilizer spreader. Application distribution was assessed using a matrix of collection pans and following test procedures outlined in ASAE Standard S341.2. Uniform and variable–rate tests were performed to characterize the application variability of the spreader and to test the effect of rate changes via GPS control. Uniform and variable–rate application models were developed from the collected data. A sigmoidal function was used to describe increasing application rate changes, while a linear function described decreasing rate changes. Average transverse distribution patterns were used to model both high and low application rates. The resulting models were then compared to the actual distributions. The model was found to do a good job of characterizing uniform and variable–rate application patterns and therefore may be suitable for simulating variable–rate application errors.

Keywords: Precision agriculture, Variable–rate technology, Modeling.

Current commodity prices and pressure from environmental regulations are causing the agricultural production sector to seek more competitive methods of producing food and fiber products. With the development of the global positioning system (GPS) and VRT, precision farming is now a common practice on many U.S. farms. GPS and VRT have the potential to improve productivity and profitability while conserving and protecting our natural resource base.

Traditional methods of fertilizer and chemical application tend to treat all areas of a field the same, regardless of variability in soil and landscape features. With this approach, soil cores are pulled at random throughout a field and mixed into a single composite sample. These samples are then analyzed and fertility recommendations made for nutrient application levels. Nutrients (phosphorus, potash, and nitrogen) or agricultural lime are then applied in broadcast or banded fashion to the entire field. Prior to precision agriculture, the variability within many fields was accepted as a factor that producers could do little to manage. In fact, this variability was quantified and used as justification for modifying recommended fertilizer applications rates to insure crop yields are not limited.

Searcy (1995) defined Site–Specific Crop Management as “the use of local soil and crop parameters to make precise application of production inputs to small areas with similar characteristics.” Spatial variability occurs with respect to many parameters, such as soil type, fertility, and slope, that affect crop production. Therefore, the potential exists to vary production inputs (fertilizer, seed, and chemicals) as a function of field location.

Linsley and Bauer (1929) outlined a practice to intensively sample and map soil pH variation for determining areas for lime application at various levels. This demonstration predates today’s efforts, in which technology makes site–specific management a reality. Concerns still exist with regard to whether site–specific management is profitable when compared with traditional field–average application practices. Application uniformity and accuracy are important elements of this assessment. Therefore, tests were conducted to assess and characterize spread pattern variability of a spinner spreader, and then mathematically model uniform and variable–rate application of granular materials. This model can then be used to predict overall application efficiency and estimate the deviation from the desired spread patterns. This approach can also be used to investigate and specify appropriate management grid resolution for precision agricultural practices based on equipment limitations.

Specific objectives for this investigation were: (1) to conduct uniform and variable–rate distribution tests to characterize the discharge pattern of a spinner–disc variable–rate fertilizer applicator, and (2) to model variable–rate application of muriate of potash fertilizer.

Background

Site–specific management allows farmers to manage fields on a much finer resolution when compared with “whole...
field” basis. This approach to managing nutrients has agronomic, economic, and environmental advantages over traditional approaches. One of the more visible precision farming tools is the variable-rate controller. As with any equipment, the question always arises about the accuracy of nutrient application. With variable-rate equipment, more complexity is introduced with continuously changing application rates. Therefore, a methodology is needed to quantify the application accuracy of variable-rate equipment.

Schuenel (1989) described liquid fertilizer mixing and flow control to minimize material transport lag times. He concluded that rate and mixture variations are improved by: (1) controlling flow to each system component, (2) decreasing the response times of the pumps and valves involved, (3) minimizing the volume of connecting hoses, (4) adequate mixing, and (5) mixing as close as possible to the nozzles. It was also found that varying the pump speed or re-circulation flows were viable options for flow control.

Reichenberger and Russnogle (1989) described a system that simplifies precision fertilizer application. The system utilized a laptop computer and a fifth wheel to determine location. An application rate map was stored in the computer’s memory, and machine application rates were controlled with feedback from the fifth wheel. The unit was reported to be ready for modifications that would allow application of liquid fertilizer, chemical injection, planting, and the development of yield maps.

Application accuracy is an important property to quantify when assessing variable-rate spinner spreaders. The coefficient of variation (CV) is typically used to characterize the quality of spread distribution. Lower CVs tend to be indicative of more uniform distribution patterns. Typically, the CV varies from 5% to 10% for spinner spreader patterns. However, this variation may be much higher with terrain irregularities; Parish (1991) observed CVs in the upper 20s to 40s for spinner spreader patterns. It was also found that varying the pump speed or re-circulation flows were viable options for flow control.

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An ASAE standard (S341.2, 1997) describes a uniform method of determining performance data from broadcast spreaders for comparison of distribution patterns. Specifications for test setup, collection devices, test procedures, effective swath width, and application rate determination are clearly defined in this standard.

Olieslagers et al. (1996) described the fertilizer distribution of a spinning disc spreader. Many parameters, including orifice position and angular speed of the discs, affect the distribution pattern of disc spreaders. VRT application, accomplished by changing the mass deposition rate on spinner discs, leads to a fluctuating spreader pattern, which results in large deviations from intended application rates. Olieslagers et al. (1997) suggested that continuous change in various spreader adjustments might be needed to maintain a uniform distribution pattern when changing rates on the go. They also stated that future work should be concentrated on the particle dynamics of granular materials and spread pattern when varying material deposition rates on the go.

Chaplin et al. (1995) investigated the distribution of dry material application in the field. They described a methodology based on ASAE standard S341.2 (ASAE Standards, 1997) and performed tests for a single-disc mounted fertilizer spreader. Pettersen et al. (1991) investigated how the distribution pattern of a twin-disc spreader was influenced by fertilizer particle size. Their results showed that different particle sizes produce varying spatial distributions. They provided a detailed test method for collecting fertilizer samples and used interpolation techniques to generate continuous distribution patterns.

**Overview of Spreader and Control System**

The Biosystems and Agricultural Engineering Department at the University of Kentucky maintains a custom-built variable-rate fertilizer truck that uses two spinner discs to apply granular products. The spreader box was modeled after a Newton Crouch (Model 54) spreader. Granular material was supplied to the twin spinners using a traditional apron chain. A Gerotor motor (Model DT9906223DZ1) was used to power the apron chain drive. Flow to this motor was controlled using a Source Fluid Power motorized control valve along with additional pressure-compensated valves (Model MFC16–20–12V–7) to control the fluid bypassed for speed control. The truck was equipped with a Midwest Technologies, Inc., TASC 6200 controller to vary the speed of the apron chain, thereby controlling the rate of material deposition onto the spinners.

The TASC 6200 was interfaced to a laptop computer through an RS–232 serial data link. The apron chain drive motor was equipped with a magnetic speed sensor as part of the feedback control for the system. An Omnistar 7000 receiver with C–band differential correction was mounted on top of the truck and linked to the laptop via a second RS–232 serial port. Agris’s FieldLink version 2.15 was used to acquire GPS positioning information and communicate the requisite application rate to the TASC 6200 controller. FieldLink was used to record the test site boundary and establish a rate change line or two polygons for testing rate changes from low to high or high to low.

**Field Data Collection**

Field tests were conducted at the Animal Research Center in Woodford County, Kentucky, to evaluate the deposition from the variable-rate spinner disc spreader while applying granular potash fertilizer. Application rate, distribution, and the effect of rate changes via DGPS were evaluated by modifying ASAE standard S341.2 to include a two-dimensional array of collection pans. Test cases investigated included: (1) fixed-rate application at a low rate, (2) fixed-rate application at a high rate, (3) variable-rate application from a low to high rate, and (4) variable-rate application from a high to low rate. Single-pass tests were performed for each of these cases to assess application accuracy and characterize rate changes. The effect of overlap on spread uniformity was evaluated by performing multiple parallel passes for only the high and low fixed applications rates. Therefore, a total of six tests were performed.

Tests were conducted in situ at uniform and variable application rates to assess the application accuracy. All field tests were conducted on days when sustained wind speeds
were less than 8.0 km/hr (5.0 mph) at a height of 1.5 m (5 ft) above the ground, and the slope of the test site was less than 2% (ASAE Standards, 1997). All tests were run with the hopper filled to approximately 40% to 50% capacity, as defined by ASAE standard S341.2.

ASAE standard S341.2 was followed to fabricate aluminum collection pans for testing the spreader. The pans measured 40.6 cm (16 in.) wide, 50.8 cm (20 in.) long, and 10.2 cm (4 in.) in height. An aluminum divider with a 10.2 cm (4.0 in.) × 10.2 cm (4.0 in.) grid and 5.1 cm (2 in.) height was also fabricated to place inside each tray to minimize material movement out of the tray. Pans were placed uniformly in a two-dimensional array for collection of discharged granular materials for both single and multiple passes. The size of the array normal to the direction of travel included 13 collection pans, spaced evenly across the anticipated distribution width. Parallel to the axis of travel, there were 13 evenly spaced rows of collection trays. Figures 1 and 2 show the two different pan arrays used for testing the applicator. Spacing in the direction of travel was determined as a function of controller response and ground speed of the applicator to ensure complete rate change patterns were captured. The narrow array spacing of the multiple-pass tests required the omission of two longitudinal rows of trays to allow room for the wheels of the spinner spreader truck within the collection matrix (fig. 2).

Many factors directly affect fertilizer distribution and application accuracy, such as systematic errors associated with machine calibration and metering efficiency. To minimize the combined effect of these factors and achieve accurate fertilizer distribution, the spreader truck was calibrated prior to performing the tests. The best distribution was achieved by adjusting the position of the rear divider until a uniform Gaussian transverse distribution was achieved for an average application rate of potash (fig. 3). A one-dimensional array of 13 pans was used during this process. Spinner speeds were set at 550 rpm, with the gate opening positioned at 4.4 cm (1.75 in) above the floor of the bed. The truck was operated in second gear and at 1800 rpm, which resulted in a ground speed of 20.4 km/hr (12.7 mph).

Test application rates were made at 25% and 75% (ASAE Standards, 1997) of the maximum application rate, as recommended by the University of Kentucky’s Lime and Fertilizer Recommendations for muriate of potash (AGR–1, 1998). AGR–1 recommends a maximum application of 134 kg/ha (120 lb/ac) of potash (K₂O) for corn production. Muriate of potash is 60% K₂O (0–0–60), and therefore an application rate of 58.0 kg/ha (50 lb/ac) was selected for the low rate and 168.1 kg/ha (150 lb/ac) was selected for the high rate. For these particular tests, the potash used had a density
of 1041 kg/m³ (65 lb/ft³) and moisture content less than 1% (wet basis).

The center of each swath was flagged so that the driver had a visual guide when traversing the test site. Potash was collected within the swath width of the spreader using the collection pans. Collection pan contents were collected, bagged, and labeled for each of the field tests. All samples were then weighed and recorded to the nearest hundredth of a gram. Surface plots were generated in Surfer Version 6.04 (Surfer, 1996) for a visual verification of data collection.

**ANALYSIS AND MODELING**

Figures 4 and 5 present the fixed–rate single application surfaces for the 56.0 and 168.1 kg/ha application rates. The 56.0 kg/ha application surface appears somewhat uniform with minimal irregularities. Irregularities are expected from a spinner spreader. These irregularities can be attributed to particle dynamics and shearing of the material mass at the apron chain–spinner interface. Figures 4 and 5 show evidence of these irregularities when looking at longitudinal cross–sections. The surface plot in figure 4 hints that an M–shaped pattern (less material than desired at the center of the pattern) is occurring. In fact, the plot of the mean transverse application rate for the uniform 56.0 kg/ha, presented in figure 6, shows a slight decrease in material at the center of the pattern. For the most part, the spreader does an acceptable application job at the low rate.

Figure 5 shows similar irregularities as figure 4 and the resulting pattern shift from the desired Gaussian pattern. The W–shaped pattern results when more material is applied at the pattern’s center than on either side of the center. Figure 7 is a plot of the mean transverse application pattern and demonstrates this W–shaped pattern. Both the high and low rate tests were performed with identical truck settings. The shift in pattern coincides with the conclusions of Olieslagers et al. (1997) that concurrent changes in the spreader settings (divider position, spinner speed, adjustable fins, etc.) are needed to maintain a Gaussian distribution.

The mean transverse distribution application patterns for the 56.0 and 168.1 kg/ha uniform single passes are presented in table 1 along with standard deviations and coefficients of variation (CV). The CV is low at the center of the pattern and increases towards the edges. This increase can be attributed to the small amount of material collected in the outside pans. Typically, these pans accumulate few particles, so an additional particle or two results in higher CVs. This explains the high CV in the low–rate tests in comparison to the high–rate tests. Looking at only the center seven pans (representing the effective swath width), the CV appears acceptable, with the majority of the CVs for each test around 20%. The test area was a hay field with some topographic relief. Sogaard and Kierkegaard (1994) stated that the CV would definitely increase under actual field tests from the desired 5–10% to 15–20%.

The mean transverse application rates for the uniform low and high rates were used to model the application of both and are presented in figures 8 and 9. The strength of the relationship for uniform rates will be discussed later.

The uniform application test plots for multiple passes are presented in figures 10 and 11. These surfaces show a wide variation in application distribution, with the center and outer pans receiving more material that the others. Table 2 summarizes the target application rate along with the statistical parameters for each test. The actual application rate is slightly larger than the desired rate. Both tests show a range in application rates with a coefficient of variation of 21% for
the 56.0 kg/ha rate test and 20% for the 168.1 kg/ha rate test. While the spreader is applying at or near the target rate, the quality of distribution is less than desirable but typical for spinner spreaders.

Figures 12 and 13 present the application surfaces for rate changes from 56.0 kg/ha to 168.1 kg/ha and from 168.1 to 56.0 kg/ha, respectively. The zero longitudinal distance denotes the desired transition in the rate change. For these particular tests, the look-ahead time in the FieldLink control software was set at zero so that the system latency could be characterized using the test–pan data.

The rate change surface for an application rate–change from 56.0 to 168.1 kg/ha (fig. 12) demonstrates what was

Table 1. Average transverse spread pattern statistical results for single–pass tests.

<table>
<thead>
<tr>
<th>Test</th>
<th>Transverse location (m)</th>
<th>Mean application rate (kg/ha)</th>
<th>Standard deviation (kg/ha)</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.0 kg/ha</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>13.35</td>
<td>0.5</td>
<td>1.7</td>
<td>360.6</td>
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<td></td>
<td>10.68</td>
<td>5.4</td>
<td>4.8</td>
<td>89.4</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>29.9</td>
<td>7.8</td>
<td>26.2</td>
</tr>
<tr>
<td></td>
<td>5.34</td>
<td>46.3</td>
<td>9.1</td>
<td>19.7</td>
</tr>
<tr>
<td></td>
<td>2.67</td>
<td>54.0</td>
<td>12.0</td>
<td>22.3</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>50.2</td>
<td>7.5</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>–2.67</td>
<td>55.3</td>
<td>10.5</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>–5.34</td>
<td>48.0</td>
<td>6.8</td>
<td>14.1</td>
</tr>
<tr>
<td></td>
<td>–8</td>
<td>27.0</td>
<td>7.7</td>
<td>28.4</td>
</tr>
<tr>
<td></td>
<td>–10.68</td>
<td>5.1</td>
<td>3.7</td>
<td>71.9</td>
</tr>
<tr>
<td></td>
<td>–13.35</td>
<td>0.8</td>
<td>2.0</td>
<td>245.3</td>
</tr>
<tr>
<td></td>
<td>–16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>168.1 kg/ha</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>13.35</td>
<td>3.1</td>
<td>3.7</td>
<td>119.9</td>
</tr>
<tr>
<td></td>
<td>10.68</td>
<td>27.5</td>
<td>12.6</td>
<td>45.9</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>129.4</td>
<td>17.2</td>
<td>13.3</td>
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<td>19.0</td>
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<td>131.5</td>
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<tr>
<td></td>
<td>–16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
seen in the uniform tests. The spreader does a good job of distributing potash at 56.0 kg/ha, but as the rate change occurs, the pattern shifts from Gaussian to W–shaped. The same type of pattern shift occurred when adjusting the rate from 168.1 to 56.0 kg/ha (fig. 13). The results portrayed in both of these figures provide insight into one of several problems of variable–rate application with disc spinner spreader. Additionally, the rate change characteristics were different in each of these tests. The difference in the rate change from high to low and low to high was probably due to the characteristics of the controller.

The next step was to model the variable–rate application process shown in figures 12 and 13. Symmetry with respect to the center of the pattern was assumed for transverse distribution. Correspondingly, equidistant longitudinal rows from the center pans were averaged to create seven longitudinal data sets to represent the rate change dynamics. The center row was used as is and not averaged with any of the other rows. Pans in the last longitudinal row collected little or no material and were set to zero application rate for both tests. Only nine of the 52 outside collection pans in both of the rate change tests contained any material. An important facet for modeling the application rate change was to utilize
the same regression function on each particular test to simplify the process.

Sigma Plot 4.0 (Sigma Plot, 1997) was used to fit a sigmoidal curve to each of the data sets for the rate change from 56.0 to 168.1 kg/ha. The basic function used was:

\[
\hat{y} = y_0 + \frac{a}{1 + e^{-\frac{(x - \delta)}{b}}}
\]  

where

\(\hat{y}\) = predicted application rate

\(a\), \(b\), and \(\delta\) are constants fit to the data.
Table 2. Desired uniform application rate along with statistical information for actual applied rate for multiple-pass tests.

<table>
<thead>
<tr>
<th>Desired rate (kg/ha)</th>
<th>% Difference</th>
<th>Mean (kg/ha)</th>
<th>Min. (kg/ha)</th>
<th>Max. (kg/ha)</th>
<th>Std dev. (kg/ha)</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.0</td>
<td>9.8</td>
<td>62.1</td>
<td>30.5</td>
<td>99.7</td>
<td>13.2</td>
<td>21.3</td>
</tr>
<tr>
<td>168.1</td>
<td>2.7</td>
<td>172.7</td>
<td>86.2</td>
<td>253.7</td>
<td>34.6</td>
<td>20.0</td>
</tr>
</tbody>
</table>

\( y_o \) = minimum predicted application rate  
\( a \) = range of the predicted application rate  
\( x \) = longitudinal position  
\( x_o \) and \( b \) = constants calibrated based on the \( x \) values.

Figure 14 shows the results of fitting the rate change dynamics to the average of the ±2.67 m data points along with the 95% regression confidence interval for the initial sigmoidal function using the original parameters in table 3. The curve has an \( R^2 \) of 0.98, suggesting a good model fit. Table 3 presents the results for all six data sets along with the equation coefficients and \( R^2 \) values. Zero application rate values in the average data, representing the transverse pan position ±13.35, were set equal to 0.01 so that Sigma Plot could perform the analysis. The ±13.35 data resulted in a less than desirable fit (\( R^2 \) of 0.64). Similar to the outside pans, these pans collected very few particles and an addition of one or two potash granules produced more variation from pan to pan, unlike those pans located nearer the center of distribution, which received more potash.

Constants were calculated for parameters \( b \) and \( x_o \), by averaging these parameters, since these values were fairly consistent, thereby simplifying the family of equations. Figure 14 presents the new simplified function and is labeled “predicted.” The new function differs slightly but is contained within the 95% regression confidence interval and has an \( R^2 \) value of 0.97. The simplified equations for each of the data sets do a good job of predicting the “actual” application rate. Each equation was then applied to the six longitudinal rows to calculate a predicted application rate for each pan.
The same procedure was employed to model the rate change from 168.1 to 56.0 kg/ha. However, a simple linear model was used to describe the rate change as opposed to the sigmoidal function. Figure 15 presents the rate change dynamics for the average longitudinal applications rate for the ±2.67 m pan position along with the 95% regression confidence interval for the linear fit. The results for each linear fit are summarized in Table 4. Although a linear prediction equation did a better job than the sigmoidal, the overall fit was not as good as the results for the rate change from 56.0 to 168.1 kg/ha, as shown by the lower \( R^2 \) values. This could be seen with more distribution irregularities, as shown in Figure 13 and Figure 12. Similar to the low to high rate change results, the fit of the ±13.35 data was questionable at best (\( R^2 = 0.29 \)). Two outlier data points were deleted for this analysis. Each occurred at 44 meters for the 10.68 and 13.35 transverse position. These points were extremely high, skewing the fit of the linear regression model (\( R^2 = 0.23 \) for the ±10.68 data, and \( R^2 = 0.01 \) for the ±13.35 data) for these two data sets. Several elements could have contributed to the high values at this location, such as larger, denser fertilizer particles, which traveled farther.

The predicted values were then used to create surface plots, which model the rate changes. Figures 16 and 17 contain the modeled surfaces for the rate change from 56.0 to 168.1 kg/ha and from 168.1 to 56.0 kg/ha, respectively. At first glance, figures 12 and 16 are very similar, except that many of the irregularities seen in Figure 12 are smoothed out in figure 16. The same results can be seen when comparing figures 13 and 17. Using the coefficient of correlation to compare the actual data used to generate the models to the predicted data shows a good fit for both models. Table 5 contains the coefficient of correlation for each of the rate changes, as well as the data for each of the single-pass uniform application tests. The high correlations coefficients are expected since the original collected data used to develop the models were used for the comparison. The high correlation coefficient for the 168.1 to 56.0 kg/ha rate change (0.96) may not have been anticipated due to the low \( R^2 \) values seen in Table 4, but it can be explained because a majority of the product was distributed within 8.0 m of the center pans.

Figures 18 and 19 contain plots of the predicted versus observed data points for all of the 169 pans in each test. In both cases, a high percentage of the data points are along the one–to–one line. From these results, it appears that a model can be developed that does a good job of approximating the actual variable–rate and uniform distribution for this spreader truck.

**SUMMARY**

This investigation was conducted to assess the accuracy of a variable–rate fertilizer applicator and to determine whether uniform and variable–rate application of potash could be modeled. Uniform and variable–rate tests were performed using a 13 × 13 matrix of collection pans to gather material spread by a spinner spreader truck. The results of these tests showed the spread variability existing with spinner spreaders. Coefficient of variations above 20% were
Figure 16. Modeled rate change application surface (56.0 to 168.1 kg/ha).

Figure 17. Modeled rate change application surface (168.1 to 56.0 kg/ha).

Figure 18. Predicted vs. observed collection pan contents for 56.0 to 168.1 kg/ha application rate change.

Figure 19. Predicted vs. observed collection pan contents for 168.1 to 56.0 kg/ha application rate change.
calculated for the average transverse spread patterns for both the 56.0 and 168.1 kg/ha uniform tests.

Uniform and variable–rate applications were mathematically modeled from the collected data. A sigmoidal function was used to describe rate change from 56.0 to 168.1 kg/ha, while a linear function described the rate change from 168.1 to 56.0 kg/ha. The average transverse spread pattern was used to model uniform application at 56.0 and 168.1 kg/ha. Comparing the modeled application surface to the actual collected material for each test showed that the modeled application at uniform rates of 56.0 and 168.1 kg/ha, the modeled rate change from 56.0 to 168.1 kg/ha, and the modeled rate change from 168.1 to 56.0 kg/ha did a good job of projecting the actual distribution. Further, the comparison between 56.0 and 168.1 kg/ha distribution patterns showed that there existed a need to change the spreader adjustments to maintain a uniform pattern. The spinner spreader did a good job of applying material at 56.0 kg/ha (with only a slight M–shaped pattern), but at the higher rate of 168.1 kg/ha, the distribution pattern shifted from the desirable Gaussian shape to the less desirable W–shaped pattern. The shift to a W–shaped pattern at the 168.1 kg/ha application rate was also observed in the rate change tests. Therefore, adjustable fins on the spinners or concurrent movement of the rear divider during rate changes might improve pattern shifts at different rates, and thereby improve application accuracies.

Further field–testing will enable the development of a simulation model for predicting application accuracy by use of the recorded truck’s DGPS application traverse. In return, the field investigation will allow for characterization and modeling of variable–rate application of granular materials with the ability to assess deviation from the desired application. This will help determine and refine the acceptable management grid resolution based on the spreader truck’s limitations for precision agriculture. Determining the spread pattern variability of such equipment may illustrate limitations, thereby allowing producers to select the optimal economic sampling and management grid resolution.

The actual spread model and the calculated application error can also be used to assess operator and equipment performance. Overlap and under–lap can be determined to see if driver error seriously affects application accuracy. Alternately, users may choose to look at the sensitivity of spinner spreaders to perform adjustments.

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