PRECISION AGRICULTURE

Implementing Site-Specific Management: Liquid Manure Application

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Introduction

Site-specific management (SSM) practices are being used to control and document traditional inputs in crop production such as fertilizer, seed, and crop chemicals. The principle of tailoring crop production inputs to the site-specific needs of crops and soils is far from new. However, the actual practice of SSM developed only recently, aided by technologies such as the Global Positioning System (GPS) and Geographic Information Systems (GIS). Another application for these new technologies is the monitoring and control of manure application. Often overlooked as a nutrient resource, the value of manure in crop production is directly related to how it is managed. There is now the ability to document the amount of manure applied, to document where and when it was applied, and to avoid application in areas that might be environmentally sensitive.

There are several reasons why site-specific manure management should be considered:

- more accurate **nutrient credit** may be given for manure, thereby saving on commercial fertilizer costs;
- **documentation** will be useful for developing and following manure management plans;
- **records** will be readily available to document the timing and amount of application, to develop a nutrient history of the field, and for legal defense in the event of alleged improper application.

Implementing Site-Specific Manure Management

The keys to integrating manure into a site-specific nutrient management plan are ***measurement, control,*** and ***documentation***. Although there is ongoing research and development in this area, four basic principles for site-specific management have emerged: measure nutrient content, determine application rates needed, control the rate applied, and produce a record of where and when that application occurs.

Measuring Nutrient Content

Nutrient content can be measured by a number of methods, both in the laboratory and in the field. In either case, it is important that the sample or samples that are tested accurately represent the material that is actually being land applied. If nitrogen is of primary concern, a “nitrogen meter” (also referred to as an “N-meter”) can be used to provide a relatively accurate, direct estimate of the plant-available nitrogen. These meters can be

purchased or contact the Purdue Extension office in your county to see if they are available for loan. Laboratory analysis methods can provide information on other nutrients and manure properties of interest. Sampling in storage/treatment facilities and, preferably, from individual applicator loads, should be performed when the manure is in the same condition as it is when it is land applied. In other words, if a storage pit is being agitated prior to loading manure into an applicator, sampling should be done at or near the time of loading. The more accurate the sample, the more effectively manure can become part of an overall nutrient management program.

Determining Application Rate

Once in the field, it is necessary to have an accurate means of estimating application rates. Application rates can be determined if material discharge rate, applicator travel speed, and application swath width are measured or known. The calculation would look something like this:

$$\text{Application Rate} \sim \frac{\text{Discharge Rate}}{\text{Width of Application x Travel Speed}}$$

There are two basic methods for measuring discharge rate of material onto/into soil: ***weighing*** and ***flow sensing***. Weighing systems typically consist of load cells mounted under the manure "container" on an applicator (Figure 1). Load cells can provide static weight data or they can be used to provide a continuous stream of weight data during applicator discharge. Measured weight differences during unloading can be used to determine applicator discharge rate. Such systems can work with liquid or solid material application equipment. Load cells have accuracy ratings of 99.5 percent when used in static conditions. Ground surface roughness and movement of liquid manure within a tank can cause weighing errors when an applicator is in motion. Such weighing errors are in the range of 2 – 8 percent and depend upon the liquid level in a tank and travel speed.

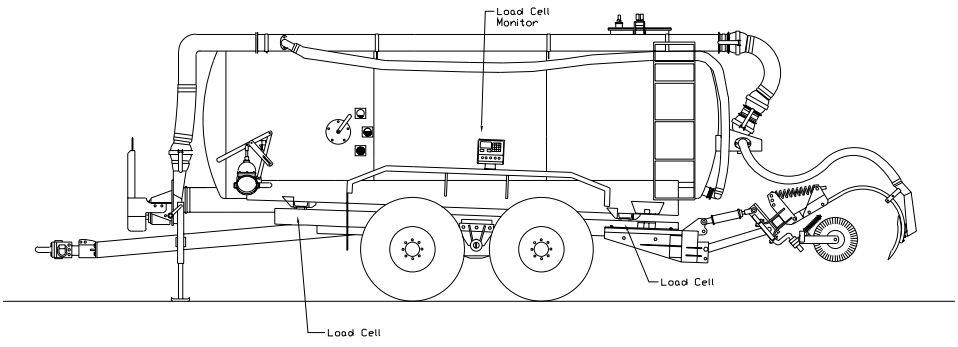

Figure 1. A manure applicator equipped with load cells.

Flow sensing systems are used with liquid applicators including tankers and towed-hose or umbilical cord units. The systems typically use electromagnetic flow meters. While expensive, such meters have no moving parts and can handle liquids with a wide range and type of solids content. Electromagnetic flow meters are capable of measuring with errors of less than half a percent. Their accuracy also appears to be less affected by travel through the field than that of load cells. Electromagnetic flow meters are often flange-mounted into transfer tubes on tanker applicators that use slurry pumps, as illustrated in Figure 2.

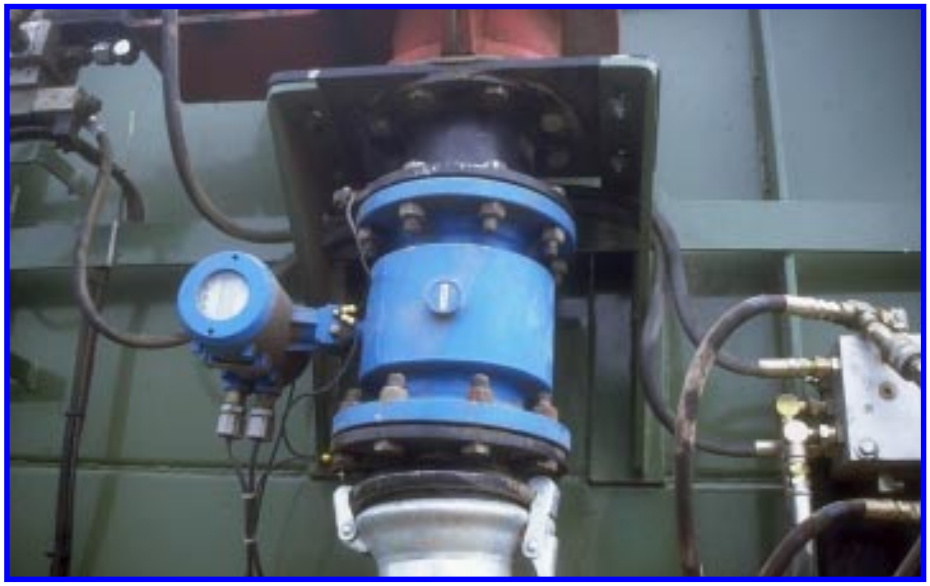

Figure 2. Electromagnetic flowmeter installed on a manure applicator.

As with all land-based site-specific farming operations, it is important to have an accurate measure of travel speed during manure application. Radar and ultrasonic speed sensors have proven successful in operations such as fertilizer application and crop yield monitoring. Both radar and ultrasonic sensors are preferable to wheel- or transmission-mounted sensors because neither is affected by changing vehicle weight or wheel slip. A GPS receiver can also provide travel speed data if the applicator is so equipped.

In addition to travel speed, it is important to have an accurate estimate of effective application width. With injection, determining effective application width is relatively straightforward (i.e., number of shanks *times* shank spacing) if the applicator maintains a precise distance equal to shank spacing between adjacent passes. However, with surface application, there can be variation in application width due to inconsistency in material, flow rate, and/or topography. Such variation can lead to errors in estimating actual application rates.

Producing an Application Record

In order to be most useful in a comprehensive nutrient management program, manure application data must be placed in a format that is compatible with other types of site-specific data, especially soil fertility, fertilizer application, and crop yield data. Site-specific data are georeferenced, meaning that each dataline collected during application contains a geographic reference such as latitude and longitude in addition to other measured or fixed values (Table 1).

Table 1. An example of datalines from a file containing georeferenced data.

Latitude (degrees)	**Longitude** (degrees)	**Time*** (week)	**Time*** (seconds)	**Travel Speed** (mi/hr)	**Working Width** (feet)	**Flow Rate** (gal/min)
40.253706	-85.150187	1083	136813	2.31	10	385
40.253702	-85.150176	1083	136814	2.33	10	391

* GPS receivers produce messages that allow time data to be converted to Universal Time Coordinated (UTC) or to the time in any time zone. "GPS Time" is reported in weeks (starting from January 6, 1980) and second-of-week. The time in line 1 of Table 1 would convert from week 1083, second-of-week 136813 to a UTC of October 9, 2000, 2:00 p.m.

Site-specific application location can be determined using GPS hardware and software. Site-specific manure application systems can be assembled to collect position, travel speed, and flow rate data on a continuous basis. Such systems include a GPS receiver, flow sensor, and travel speed sensor connected to an in-cab display unit through an electronic application controller (Figure 3).

Figure 3. Site-specific application system display unit (on the left) and an electronic application controller.

The electronic application controller can serve a number of different functions. The controller can be used to maintain a constant application rate even as travel speed varies. Some can also be used to apply manure at variable rates using previously defined application maps. Variable-rate application is accomplished by varying applicator discharge rates with flow control devices such as pinch valves.

In some fields, there may be areas in which manure application should not occur. Often, setbacks specified by regulatory agencies will define "no-apply zones." Figure 4 shows an example of an "as-applied" map created from data collected during the operation of a manure applicator. The applicator was equipped with a controller that closed a gate valve to shut off application whenever the unit entered a predetermined "no-apply zone." The map includes areas in which application occurred and rates were recorded. It also includes a setback area in which no manure was applied, even though the applicator passed through this area.

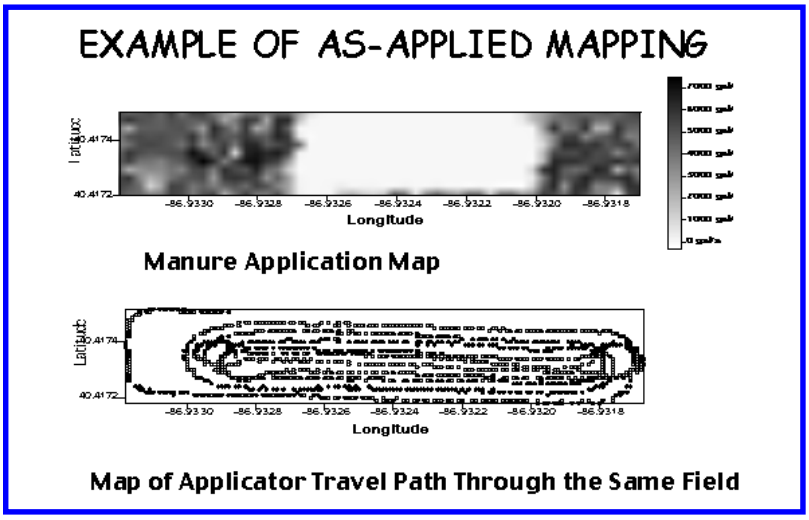

Figure 4. An as-applied map that provides a record of manure application rates and locations.

Of course, manure application rate and location data are only part of the story of site-specific manure management. Nutrient content data must be integrated into the application record in order to make manure a meaningful part of a site-specific nutrient management program. Maps such as those in Figure 4 are generated from data that can normally be read by common spreadsheet software. Nutrient content data can be incorporated into the application record with a spreadsheet even if the data become available after application has occurred. This helps ensure that proper credit will be assigned for the nutrients provided for crop production by manure.

It is possible to include not only position, but time and date information in an application record as well. Such documentation could be used for accurate record keeping for nutrient application and machine operation and, potentially, for regulatory and legal defense purposes.

Options for Implementing Site-Specific Manure Management

At least two manufacturers offer systems that can be used for site-specific manure application. The applicatior shown in Figure 5 is manufactured and marketed by Balzer, Inc. (Mountain Lake, MN). The unit is equipped with an electromagnetic flow meter (KROHNE, Inc., Peabody, MA), a pinch valve to control manure output (Red Valve Company, Inc., Pittsburgh, PA), a tank-mounted GPS antenna, a tractor-cab-mounted Raven controller (Raven Industries, Inc., Sioux Falls, SD), and an AgLeader® monitor (Ag Leader Technology, Inc., Ames, IA). The system is capable of producing as-applied maps.

Ag-Chem Equipment Co., Inc. (Minnetonka, MN) manufactures and markets the Terra-Gator 2505 Nutrient Management System. The applicator utilizes the Falcon® CD controller to produce map-based, variable-rate liquid product application and as-applied records.

Figure 5. An applicator used for site-specific manure management.

Issues to Consider

Flow meters, speed sensors, and GPS units are capable of producing large amounts of data. It is important to consider how much data is necessary to accurately represent field operations such as manure applications. While some data collection systems can update and log data at a rate of one line per second, operators limit the amount of data collected by reducing the rate to one line per three or even five seconds. Much will depend upon how other data (e.g. soil property and crop yield) are currently being managed in a site-specific crop production operation.

Related Publications

The following Purdue University Cooperative Extension Service publications provide information about other aspects of manure application and management.

A detailed discussion of manure sampling and management can be found in the following Purdue Extension publications:

ID-101, "Animal Manure As a Plant Nutrient Resource"
ID-205, "Swine Manure Management Planning"
ID-206, "Poultry Manure Management Planning"
ID-208, "Dairy Manure Management Planning"

The following Purdue Extension publications provide additional information on ensuring accurate land application rates:

AY-277, "Calculating Manure and Manure Nutrient Application Rates"

AY-278, "Estimating Manure Spreader Capacity"

Contact your local county Purdue Extension office, or call 1-888-EXT-INFO to obtain these or other publications.

Source of Products Mentioned in the Publication

"Nitrogen Meter" – Sylvette Corporation, 5100 Eden Avenue, Suite 208A, Edina, MN 55436. Phone: (800) 788-7218.

Ag-Chem Equipment Co., Inc., 5720 Smetana Drive, Minnetonka MN 55343. Phone: (612) 933-9006.

Ag Leader Technology, Inc., P.O. Box 2348, 2202 South Riverside Drive, Ames, IA 50010. Phone: (515) 232-5363.

Balzer, Inc., County Road 27, Box 458, Mountain Lake, MN 56159. Phone: (800) 795-8551.

KROHNE, Inc., 7 Dearborn Road, Peabody, MA 01960. Phone: (800) 356-9464.

Raven Industries, Inc., 205 East 6th Street, Sioux Falls, SD 57104. Phone: (605) 336-2750.

Red Valve Company, Inc., 700 North Bell Avenue, Pittsburgh, PA 15106. (412) 279-0044.

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