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Machinery Management

Impact of Improved Global Positioning System Satellite Accuracy on Precision Agriculture

Ronald Schuler, Wisconsin Extension Engineer

On May 1, 2000, Selective Availability (SA) was discontinued by the United States Department of Defense for Global Positioning System (GPS) satellites. SA was the government system that created errors in satellite data available to the public by introducing clock errors. These errors were deliberately created because position data was needed for secure military purposes, especially during the Gulf War, and the Department of Defense didn't want enemies to have accurate data. As a result, a GPS unit without differential correction had errors greater than 30 feet. With SA turned off, the errors became 30 feet or less. Since SA has been discontinued, there have been many reports in the public press describing great improvements in GPS accuracy. What is the impact on precision agriculture?

For those who have handheld GPS units, there is a tremendous improvement in positioning accuracy. But there isn't a comparable change in GPS systems using differential correction (DGPS). The primary purpose of DGPS was to correct the errors created by SA.

For those using DPS systems on combines, planters, and fertilizer applicators, there will be very little change in the accuracy, which is about three feet. DGPS also corrects some of the errors created by the atmosphere between your receiver and the satellites. But operators will find that they are less likely to lose their signal during operation. And there will be a lesser tendency to see the location of yield data wander or drift. Multi-path errors and satellite signals reflecting from nearby buildings or other structures will still exist.

Eliminating SA is the first step for improving the accuracy of GPS. Other improvements coming include a national differential correction system (National Differential Correction GPS or NDGPS) and other steps to redesign the satellites to insure improved accuracy. More improvements will be added during the next ten years.

GPS was the major development to make precision agriculture a reality. Improved accuracy should have little impact on the future adoption of precision agriculture because the three-foot accuracy available with DGPS is adequate for most applications. The improved accuracy will have a greater impact on guidance system development for tractors and self-propelled farm equipment.

In This Issue

Manure Managment

Early Separation of Fresh Swine Manure May Enhance Separation Efficiency

Jun Zhu, Minnesota Extension Engineer

Fresh swine manure contains high levels of suspended solids and low levels of dissolved solids (Evans et al., 1978). Once excreted from animals and stored anaerobically, the manure will naturally undergo decomposition. Dissolved solids are easily degradable organic materials and suspended solids are more difficult to degrade. Bacteria first consume the dissolved solids and, at the same time, hydrolyze and convert the suspended solids into dissolved solids to obtain a continuous food supply for their growth. This decomposition process leads to an increase of total dissolved solids (TDS) and a decrease of total suspended solids (TSS). Since manure separation only affects TSS with little effect on TDS (TDS are usually removed by biological treatment or coagulation), use of separation is not effective for removing solids from liquid manure after bacteria convert TSS to TDS. Therefore, the maximum separation efficiency is achieved if separation is performed before the bacteria in manure become fully established. An experiment was carried out to show the changes in TSS and TDS of fresh swine manure with different particle size ranges during 30 days of storage. The most effective separation time after manure is excreted may be inferred based on the data collected from this study.

Experimental procedure

Fresh liquid manure was divided into three different portions with particle size ranges of < 2.0 mm, < 1.4 mm, and < 1.0 mm. The particle size ranges were created by successive sieving of the fresh swine manure through a series of three ASTM standard wire screen sieves with openings of 2.0 mm, 1.4 mm, and 1.0 mm (ColeParmer Company, Chicago, Illinois). Two 35-gallon containers were used to transfer manure back and forth for each sieving. After each stage of separation, a sump pump was used to mix the sieved manure to keep solids suspended and, at the same time, one of three 91.62-cm tall Plexiglas columns (15.27 cm in diameter) was filled with manure of that specific particle size range, leaving approximately 10.18 cm of headspace. Once all the columns had been filled, each column was thoroughly stirred using a motorized paddle-stirrer and a sample was drawn from the homogenized slurry. This sampling technique was used every five days during the 30-day test period. The columns were placed in a dark room to simulate the conditions in storage pits and the room temperature was maintained between 18 and 22^{o}C. For each sampling, total solids (TS), total suspended solids (TSS), and total dissolved solids (TDS) were measured.

Results and discussion

The concentrations of TSS and TDS for all the particle size ranges during the 30-day storage period are presented in Figure 1. The reduction of TSS and the increase in TDS were relatively small within the first 10 days of the test and there appeared to be increasing decomposition of TSS thereafter. This observation implies that the breakdown and liquefaction of TSS by microbes may not proceed at an appreciable rate for manure less than 10 days old in these particle size ranges. It is therefore recommended, that solid-liquid separation treatment should be performed within the first 10 days of manure storage to improve the separation efficiency.

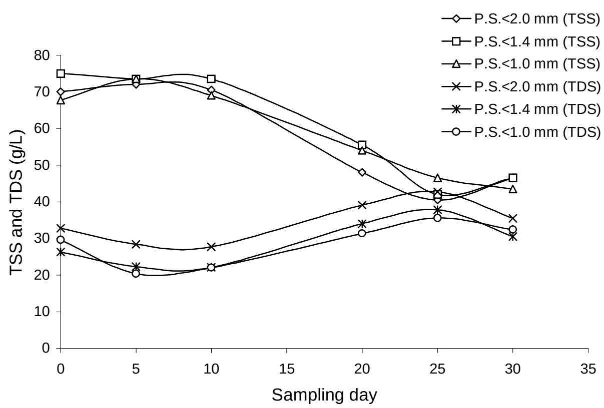


Figure 1. The TSS and TDS concentration during the first 30-days of storage of fresh manure.

Also from Figure 1, the TSS concentrations started to decrease at a higher rate after 10 days of storage accompanied by increases in TDS for all particle size ranges. On day 25, the amount of TSS was almost equal to the amount of TDS for the manure with particle size < 2.0 mm. For the other two size ranges, the difference between the quantities of TSS and TDS also reached a minimum. A simple calculation based on the data presented in Figure 1 indicates that approximately 42%, 44%, and 31% of TSS in the manure for the three particle sizes of <2.0 mm, <1.4 mm, and <1.0 mm, respectively, were dissolved after 25 days of storage (Table 1).

Table 1. Percentage reduction in TSS during storage.

Sampling day	Particle size < 2.0 mm	Particle size < 1.4 mm	Particle size < 1.0 mm
0	0	0	0
5	-2.9	2.0	-8.6
10	-0.7	2.0	-1.9
20	31.4	26.0	20.2
25	42.1	44.0	31.3
30	33.6	38.0	35.8

According to Table 1, the concentrations of TSS did not vary much during the first 10 days, but increased tremendously on day 20 and 25. Thus, it is likely to be more efficient and economical to conduct separation on manure less than 10 days old to remove as much of TSS as possible.

Summary

According to results from this study, the solid-liquid separation technique, if applied to the treatment of liquid swine manure with solid particle sizes equal to or greater than 1.0 mm, should be performed within the first ten days after the manure is excreted in order to improve separation efficiency.

In the first 25 days of storage, about 31 to 42% of total suspended solids were biologically degraded and no longer available for mechanical separation. Therefore, use of separation techniques to treat manure that is older than 25 days may not be a cost effective practice in terms of removing organic solids that have potential for producing odors during storage.

Reference

Evans, M. R., R. Hissett, M. P. W. Smith, and D. F. Ellam. 1978. Characteristics of slurry from fattening pigs, and comparison with slurry from laying hens. Agriculture and Environment 4(1):77-83.

Crop Handling and Storage

Forage Harvest and Storage Questions?

Brian Holmes, Wisconsin Extension Engineer

University of Wisconsin county extension agents and state specialists have been working as a team to develop an information resource concerning forage production and management. The TEAM FORAGE has created a web site:

http://www.uwex.edu/ces/crops/uwforage/uwforage.htm

to make this information available to those who can access the Internet. This home page allows a person to search amongst 13 forage-related subject matter areas. The Harvest and Storage Workgroup of the TEAM FORAGE has created a page within the web site which is dedicated to harvesting and storage issues. This Harvesting and Storage web page is located at:

http://www.uwex.edu/ces/crops/uwforage/storage.htm

The following headings categorize information within this web page:

- Silage Harvesting and Equipment
- Bale Harvesting and Equipment
- Custom Field Operations/Equipment Sharing
- Storage Sizing and Management (Silages)
- Hay and Silage Additives
- Storage Economics
- Storage Types
- Safety

Within each of these categories you can find articles, software, and presentation slides. These materials were developed by University of Wisconsin faculty to enhance understanding of forage harvest and storage management. Plans are to continue to build the site by adding more information as it is developed. Keep checking back to see new information.

Planning Grain Drying, Handling, and Storage Facilities

Bill Wilcke, Minnesota Extension Engineer

The USDA Farm Service Agency's farm storage loan program has stimulated lots of interest in upgrading grain drying, handling, and storage facilities. Here are some things to think about as you plan new or renovated facilities. Consider both your immediate needs and your long-term needs. Keep in mind that life expectancy is probably 5 to 10 years for fans and some types of conveyors, 10 to 20 years for dryers, and 15 to 30 years for storage bins.

Do you really need your own facility?

- Do you have a grain marketing plan and do you need a grain drying, handling, and storage facility to make that plan work?
- How far are you from the nearest commercial facility?
- Do you think you can dry and store grain at a lower cost than the commercial facility would charge?
- Are you a good storage manager and are you willing to bear the risk of possible quality loss in storage?
- Do you raise livestock? Are you planning to add or to drop livestock in the future? (Livestock production and the type of livestock raised can have a big impact on grain facility planning.)
- If you are a livestock feeder, is it important to use the grain that you produced on your farm? Would you get your own grain back from a commercial storage facility?
- If you're a livestock feeder, could you be using more forages, silage, or high-moisture grain and less dry grain?
- Would your marketing options be too limited if you used a commercial storage facility?
- How long would you have wait in line to unload grain at a commercial facility during the busy harvest season?
- Could you share drying and storage facilities with a neighbor or partner?
- How close are you to retirement? Would your investment in these facilities be valuable to the next generation that operates the farm?

Where should the drying, handling, and storage facility be located?

- Do you have a good, well-drained, accessible site that is somewhat protected from wind and snow? (High water tables can limit use of below-ground pits.)
- Is there room for large vehicles to move through the facility without having to back up? (Semi-trailers need about a 55-ft turning radius.)

- Is there room for future expansion?
- Does it make sense to improve existing facilities, or would you be better off starting with a bare site? (Don't forget that existing bins can be moved and that concrete foundations are relatively cheap compared to the cost of ending up with a poorly laid-out facility.)
- How close is the facility to your house or a neighbor's house? Would vehicle traffic, noise, dust, and chaff be a problem?

If the site you currently have in mind has some serious limitations (not enough space, drainage problems, too close to residences, too far from a good road, poor utility service), you might be better off starting over at a new site.

What total storage capacity and what size bins do you need?

- How many bushels per year are you storing now and how many are you likely to be storing in the future? Consider possible increases in both acreage and yield per acre.
- How many different crops or different varieties of crops that need to be separated are you growing now or will you be growing in the future? Consider the possibility that some day you might be growing varieties that have special characteristics (for example, high-oil, organically produced, or non-genetically modified) and need to be handled separately with their identity preserved.
- Are you willing to consider storing grain for neighbors, partners, or landlords?

Note that you have more marketing and storage flexibility, and probably lower risk of spoilage if you have a number of medium-sized bins rather than a few large ones.

What drying and grain receiving capacity do you need?

- How many total bushels of each crop will you be harvesting per year?
- What is your harvest capacity in bushels per hour and bushels per day now, and what is it likely to be in the future? (Many farmers have traded combines several times since they last upgraded their grain handling facilities and now their harvest capacity greatly exceeds their drying and handling capacity.)
- How many field working days can you count on for harvest? Consider precipitation, combine availability, days off, time needed for other farm operations.
- What size and how many vehicles do you use for hauling grain from the field?
- Are you willing to run the dryer more hours per day and more days per week than you run the combine? (If you install a large wet-holding bin, your dryer doesn't need to keep up with your combine. If you choose in-storage drying, you can combine as fast as you want without worrying about the dryer keeping up.)
- What is your typical harvest moisture and how many points of moisture do you generally remove?
- For high-temperature drying systems, are you willing to consider unloading grain hot and cooling it in storage or in a cooling bin? (This can boost dryer capacity, improve grain quality, and save energy.)
- Are you interested in doing some custom drying for neighbors, partners, or landlords?

What type of dryer do you prefer?

- Is grain quality (for example, low stress cracks or high test weight) important to you or your buyer? (Natural-air drying provides much better grain quality than does high-temperature drying.)
- How expensive is electricity relative to gas on your farm? (Low electricity cost and high gas cost make natural-air drying more attractive, and high electricity cost and low gas cost make high-temperature drying more attractive.)
- Would electrical service to your farm need to be upgraded if you installed a number of large electric motors? (Work with your electric power supplier to see what it would cost to get three-phase power and larger transformers – if you need them.)
- Is it important to have all of your grain dry before winter? (With some in-storage drying systems, you might need to finish drying in spring.)
- Do you need to add drying and storage capacity, or just drying capacity? (In-storage drying is more feasible if you need to increase both drying and storage capacity.)

How much automation would you like to install?

- How much labor is available during harvest? What about five years from now?
- Do you have plenty of labor, or would you be better off spending more money on extra equipment and automatic controls to reduce labor requirements?
- Would you like to have your drying and handling system operate around the clock?

What kind of grain conveying equipment makes the most sense for your operation?

- Bucket elevators are convenient, handle grain gently, and provide high capacity with relatively low power requirements, but they can be quite expensive, they require careful bin layout, grain can be damaged from long drops, they require either a tower or guy wire support system, and once installed, they're hard to move.
- Pneumatic conveying systems have limited capacity and relatively high power requirements, and they can damage grain if they are not laid out and operated properly, but they are quite flexible and can be easily adapted to fit into existing systems.

- Augers can be hazardous and can cause grain damage if not operated carefully, but they are more flexible and less expensive than other types of conveyors. Newer, large-diameter augers have fairly high capacity.
- Large grain receiving pits are very convenient and allow for rapid grain unloading, but they can be expensive and difficult to install where water tables are high.
- Will you be producing a crop that must be handled separately and kept free of contamination from other crops (for example, non-genetically modified crops)? If so, it will be important to use pits, conveyors, and hopper bins that are self-cleaning or that can be easily cleaned when you switch crops.
- Will grain be hauled from the farm by semis or other large vehicles? If so, it might be important to design for high-speed load out to minimize the amount of time that it takes to fill vehicles.

Safety is an important consideration in planning grain, drying, and storage facilities.

- Consider installing stairs, rather than ladders on bins that are frequently climbed.
- Make sure vehicles can load and unload without having to back into position.
- Install plenty of lighting for night work.
- Try to avoid using equipment that has exposed, rotating power shafts.
- Bury powerlines, if possible.

Install equipment for monitoring and aerating stored grain.

- Install aeration equipment on all storage and wet-holding bins.
- Consider installing automatic controls on grain aeration equipment, but carefully evaluate the reliability and cost per bushel of controllers.
- Consider installing temperature cables that can be used to monitor grain temperature in storage bins.
- Provide a shed or trailer at the facility for moisture meters, grain probes, grain moisture and temperature records, and for workers to rest and escape the noise, dirt, and weather.

Before ordering equipment:

- Study references like *Grain Drying, Handling, and Storage Handbook, MWPS-13.* (You can order this handbook from either the U of MN BioAg Eng Department or the U of WI BioSysEng Department.)
- Visit several other systems and ask operators what they like about their facility and what they would do differently next time.
- Estimate cost per bushel to own and operate a grain drying, handling, and storage system and compare that cost with alternatives.

Water Management

Daily Crop Evapo-Transpiration Values Available on the World Wide Web

Jerry Wright, Minnesota Extension Engineer

Daily crop evapo-transpiration (ET) values are available on the World Wide Web at the following address:

Minnesota and Wisconsin (potential ETs only):

http://bob.soils.wisc.edu/wimnext/water.html

The map presents the daily ET estimates across the state via color contours. Information is updated seven days a week and continues through September. Each daily map remains stored on the web page and is accessible any time. **The daily values for a given field site within the map area can also be sent directly to a user by e-mail each day, if requested.**

Each map displays a reasonable estimate of the potential daily ET value across the area based on the weather conditions of that day. The displayed daily ET value is very similar to the estimated daily crop ET from a full cover alfalfa crop of 6 to 10 inches in height.

For crops that have less than full canopy closure or that are nearing maturity, the daily potential ET value must be multiplied by a crop stage correction factor that ranges from 0.2 to over 1.0, dependent on the growth stage of the specific crop. Generally, once a plant's canopy has nearly closed, the correction factor is equal to one. For some crops, however, this factor can increase to 1.10 to 1.15 during the crops' critical growth period, as with corn between pollination and early dough stages.

The daily ET maps are created and managed by University of Wisconsin Extension Soils Scientist, Bill Bland. These potential ET daily contour maps are generated using data from local airport automatic temperature recording stations across the state and solar radiation estimates calculated from a GOES satellite. The satellite takes a picture about every ten minutes to estimate the daily solar radiation for a given location.

A comparison of the last two years' actual ET values with ET estimates made using data from local weather stations at Staples has shown that the two values are similar, but actual values are about 10 percent greater than estimates reported by local ET hotline services from Staples.

For more information on how to use daily crop ET information, contact Jerry Wright, Extension Engineer at the West Central Research and Outreach Center at Morris, Minnesota, by e-mail at jwright@tc.umn.edu or by phone at (320) 589-1711.

Irrigation Scheduling Software Available

Jerry Wright, Minnesota Extension Engineer

New software is available to assist Minnesota farmers and crop advisors with irrigation scheduling and with recording in-field soil water status and precipitation amounts. Irrigation engineers Tom Scherer and Dean Steele from North Dakota State University and Jerry Wright from the University of Minnesota developed a spreadsheet software program that estimates daily soil water status for individual irrigated fields for several conventional crops. The software was field tested with about a dozen farmers and crop consultants in Minnesota during the summer of 1999. Users were surveyed at the end of the year and their suggestions for improvements were incorporated into the current version of the software.

The software creates a spreadsheet-like work document for each irrigated field that reflects soil types, available water holding capacity, crop-type, and emergence date. The user is required to input the maximum daily air temperature for each day after emergence, daily rainfall amounts, and irrigation depths for each irrigation. If the daily air temperature is not entered, a historical average maximum temperature is assigned based on the nearest historical weather site that is incorporated into the software. The software lists several regional weather stations from around Minnesota and North Dakota.

From these daily inputs, a field's soil-water depletion status (expressed in inches of water depleted and also percent deficit) is estimated for each day. This estimate should be cross-checked every five to ten days with an in-field soil water assessment by the operator, and if differences are found, a correction can be made to the spreadsheet estimate.

The software generates soil-water depletion maps (example below) that are printable for taking to the field or for filing with other information on the specific field's performance and inputs.

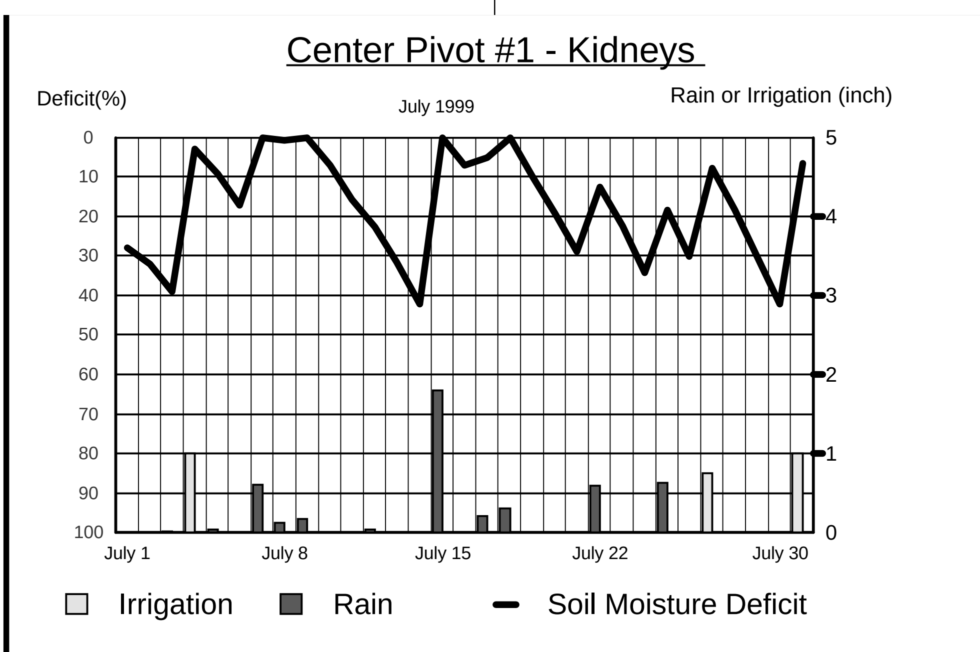
The software includes daily crop water use evapo-transpiration (ET) estimates for alfalfa, corn, soybeans, potatoes, dry beans, wheat, and sugar beets.

The program is designed to run on IBM-compatible computers with Windows 3.1 or higher operating systems. The software requires 5 MB of memory and 5 MB of free hard drive space. The program works better on faster processors and operating systems.

A copy of the software and operating manual can be obtained by sending a $30 check made payable to University of Minnesota to:

West Central Research and Outreach Center
University of Minnesota
Attn: Jerry Wright, Extension Engineer
PO Box 471
Morris, Minnesota 56267

For more information, contact Jerry Wright, Extension Engineer at the West Central Research and Outreach Center in Morris, MN (320) 589-1711 or jwright@tc.umn.edu.



Calendar of Events

July 11-12, 2000, **Four-State Professional Dairy Management Seminar,** Dubuque Five Flags Center, Dubuque, IA. In Minnesota, contact Jeff Reneau (612) 624-9791 and in Wisconsin contact Paul Fricke (608) 263-4596.

July 11-12, 2000, **Minnesota Forage and Grassland Council Forage Expo 2000,** University of Minnesota West Central Research and Outreach Center, Morris, MN. Contact Betty Schiefelbein (651) 436-3930.

July 13, 2000, **Summer Field Day,** University of Minnesota West Central Research and Outreach Center, Morris, MN. For information, call (320) 589-1711.

July 27, 2000, **Organic Field Day,** University of Minnesota Southwest Research and Outreach Center, Lamberton, MN. For information, call (507) 752-7372.

July 27, 2000, **Horticulture Night,** University of Minnesota West Central Research and Outreach Center, Morris, MN. For information, call (320) 589-1711.

July 28, 2000, **Pasture Walk and Farm Tour,** CRGraziers, Todd County, MN. Features New Zealand style swing parlor. For information, call (218) 924-2134.

August 17, 2000, **Summer Field Day,** Central Lakes Ag Center, Staples, MN. For information, call (218) 894-5161.

September 13, 2000, **Fall Field Day,** University of Minnesota Southwest Research and Outreach Center, Lamberton, MN. For iinformation, call (507) 752-7372.

September 14, 2000, **Farm Tour,** Mike Larson Dairy-Grazing Farm, Long Prairie, MN. Features self-designed milking parlor. Contact Lynda Converse (320) 594-2456.

October 9-11, 2000, **Eighth International Symposium on Animal, Agricultural and Food Processing Waste (ISAAFPW 2000),** Des Moines, IA. Contact Brenda West (800) 371-2723 or west@asae.org

October 9-11, 2000, **Swine Housing Conference,** Des Moines, IA. Contact Brenda West (800) 371-2723 or west@asae.org

October 9-11, 2000, **2nd International Conference on Air Pollution from Agricultural Operations,** Des Moines, IA. Contact Brenda West (800) 371-2723 or west@asae.org

October 15-19, 2000, **Bioenergy 2000: Moving Technology into the Marketplace,** Adams Mark Hotel, Buffalo, NY. See website at www.nrpb.org

November 14-16, 2000, **4th Decennial National Irrigation Symposium,** Phoenix, AZ. Contact Brenda West (800) 371-2723 or west@asae.org

December 5-8, 2000, **National Conference on Grazing Lands,** Bally's Las Vegas, Nevada. See website at www.glci.org

December 14, 2000, **Central Minnesota Dairy Expo,** Holiday Inn, St. Cloud, MN. Contact Jim Salfer (320) 255-6169.

Minnesota/Wisconsin

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Our mission is to conduct research and educate people to solve engineering problems in agricultural and biological environments.

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University of Minnesota, United States Department of Agriculture, and Minnesota Counties Cooperating

University of Minnesota Newsletter Team: Bill Wilcke and Andrea Jahn. This publication is available in alternative formats upon request.

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Minnesota Extension Engineer

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