Saskatchewan
Soil Conservation
Association

Soil Facts

Variable Rate Nitrogen

Precision Farming (PF) and Site Specific Management (SSM) are terms that have been used since the early 1990's. PF can be defined as the management of variability to improve economic benefit and reduce environmental impact. It is the integration of many different technologies utilizing Global Positioning Systems (GPS) and Geographic Information Systems (GIS). GIS is software that makes managing, viewing, and analyzing data possible. Integrating GPS, GIS and agronomy is proving to be a challenge.

PF is a systems approach to managing crops and land site specifically, according to their needs. It integrates the latest technology with agronomy to enable farmers to get a better understanding of their fields. Farmers should identify strategies that allow them to manage the variability found on their farm. There are different types of field variability such as spatial variability, the term used to describe changes across a field. An example would be one part of a field out yielding other areas. The reasons could be related to different soil physical properties i.e. horizon depth, organic matter content or slope position. Slope position or topography is an important aspect because slope characteristics tend to define many soil and crop production drivers.

One use for SSM is variable nitrogen (N) fertilization, because it is usually the highest input in crop production. Nitrogen content and a soil's nitrogen supplying power can dramatically change through out the landscape. The first stage in developing a program for variable rate N fertilization is to develop different management zones. Understanding the variability allows fields to be divided into relatively uniform areas, which can be managed using variable-rate fertilization.

Assessing variability in the field can be accomplished by examining yield maps or looking at soil parameters. Yield mapping history is a start to understanding different areas of the field. A management zone or unit map based only on historical data such as yield maps may not reveal the reason for the yield recorded. For instance, if a section of a field shows a low yielding area, adding more nitrogen may not be the solution to the problem. The low yields for the area in question could be due to some other reason such as lodged crop, flooding, soil salinity, or a coarse textured soil where moisture is a problem. It is critical to assess what is causing the depressed yield. Adding less nitrogen may be the answer to achieving the highest net return in that management zone.

Using soil parameters along with historical yield data can help generate useful information when defining different management zones. Soil sampling can be expensive but it can identify many soil parameters such as texture and horizon which do not change over time. When measuring soil nutrient status, sampling must be treated with care as repeatability and accuracy are difficult to achieve. There are many different methods of sampling soil.

Traditional soil sampling involves randomly taking soil cores at midslope positions throughout a field, trying to avoid saline areas and other problem areas in order to get the best representative field sample. The cores are then mixed together and tested as a single field sample. Some limitations to traditional sampling are that it does not provide any indication of field variability and it does not give any information that is of use in SSM. It is also possible that 1 or 2 samples in a field, which are excessively high in nutrients, will skew the test, resulting in under-fertilization of the entire field.

Benchmark soil sampling is another method of testing. It samples the same location in the field year after year. The benchmark sites are located in a representative area of a given management zone. The site is a 20 foot diameter circle and 15-20 samples are taken from the area and consolidated into one. This area is treated as a reference area and will track year-to-year changes in nutrient status. Benchmark samples may provide information that is applicable in variable rate fertilization. A problem with this type of sampling is that it does not provide a full indication of field variability. It is critical the sampling location is representative of the whole management zone. This method is not very expensive and can be very effective in tracking nutrient changes but it is critical to have a proper benchmark location. Field history and understanding of soil is crucial so one can avoid problem areas such as old yard sites.

Grid sampling is another method of sampling with a goal to reveal fertility status. It assumes no logical reason, such as topography, for the fertility changes. The field is divided into smaller cells of equal distance apart. The greater the sampling intensity, the greater the likelihood of finding a fertility pattern. It is recommended a sampling intensity of at least one sample per acre be required to obtain useful data. Grid sampling is well-integrated into GPS and variable rate fertilization (VRF) but the sampling is very expensive.

Landscape Direct soil sampling integrates some of the previous systems into one. The field is divided into management zones then each area is randomly sampled just like traditional sampling - treating each management zone as a separate field. This type of sampling is based on spatial patterns that are defined by some prior knowledge or observation in a field. The knowledge is gained from many different sources such as soil survey information, aerial photographs, yields maps and satellite imagery. Landscape direct sampling has the potential for use in variable rate fertilization.

Using topographic maps from digital elevation models or aerial photography can be helpful for identifying management zones based on slope position. This approach typically divides the landscape into lower (depressions), mid and upper slopes (knolls). These different zones are tested (landscape direct soil sampling) to validate that the zones are all of the same potential productivity status. If a field is divided into 3 management zones the field has many different areas (polygons) distributed throughout the field. Each polygon is designated as one of the three management zones. To effectively manage these polygons in a field, it is important that they all have similar productivity characteristics. Usually same slope positions are the same management units, i.e. depressions all one management unit, mid slopes another, and knolls another although there are exceptions. Using information from soil samples and yield maps helps to pick out areas in a zone that should be high in productivity but for some reason are not. For example, if a depression is diagnosed with salinity as the reason for low yield, adding a high amount of nitrogen will not be the answer.

These zones need to have a nitrogen regime plan. The technology is available to deliver whatever amount of fertilizer is desired. The problem is that it is difficult to know the proper amounts of nitrogen to add to the respective zones or polygons. Basing the amount of nitrogen added to a system on the current amount of available N is not accurate. The current nutrient status is not the only factor affecting crop production. Soil nutrient supplying power and moisture play major roles in the amount of nitrogen fertilizer required. Nitrification and mineralization are major factors in the nutrient dynamics of soil. Variable rate nitrogen recommendations based only on current nutrient status have been shown to be generally unsuccessful. Yield mapping helps, once management units are defined, to analyze the response to the added nitrogen. In most cases, more nitrogen fertilizer is allocated to the depressions because they are more productive. The yield map can be overlaid with the fertilizer-input map and the net profit can be evaluated. When starting a program leave a representative check area of the conventional practice so that net profits may be compared. The net returns will take into account only those years' weather conditions, crop input prices, and commodity prices. This type of data is valuable and should be taken every year because results may vary year to year. The right prescription is often dependent on the weather conditions. Data should be taken every year with the goal of understanding the productivity of each management unit on every field.

Determining the amount of nitrate N in the soil is easily obtained. Knowing the amount of organic N and inorganic N helps describe the system a bit better. Conventional soil test recommendations for nitrogen take into account the current nutrient status of available N and then use an area nutrient supply curve to estimate the nitrification/mineralization for the field. The actual nitrate supply of a soil can drastically change over a given region; it even changes drastically over a few hundred meters in the same field. The problem is that mineralization rates are dependent on many different factors and a season's weather conditions. Saskatchewan soils typically contain 2000-7000 lbs./acre of total nitrogen in the top 24 inches of the soil profile. The soil's mineralization rate per year can range from .05% to 0.3%. So the amount of available nitrogen can range from 10 to 200 lbs./acre per year. Using a regional supply curve poses a problem as far as accuracy is concerned. This is where years of data obtained from each management unit of each field is useful. Knowing the actual nutrient supplying power of selected soils helps in making the best fertilizer prescription.

There are many potential benefits to precision farming but there is still much to learn and consider. Precision farming involves more intensive management and more intensive information gathering practices. SSM will continue to advance and eventually producers will be able to easily track profits on their land.

For more information contact

Saskatchewan Soil Conservation Association
Box 1360
Indian Head, SK S0G 2K0
(306) 695-4233
E-mail: info@ssca.usask.ca
Website: www.ssca.ca

Greenhouse Gas Mitigation Program for Canadian Agriculture

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