COMPUTERIZED FERTILIZER APPLICATION BY SOIL TYPE

M.A. SCHMITT, W.G. WALKER, D. FAIRCHILD

As a farmers looks out over a field during the growing season, he usually wants to see a very homogeneous appearance of crop growth. However, he often observes a very heterogeneous appearance of soils and crop yields associated with these soils in this same field while preparing the seed bed and harvesting the crop. Visual observations show that high spots in the field are lighter in color and often yield less than low spots in the field, which are often darker and higher yielding.

Several factors are important in soil formation: these include soil age, parent material, vegetation, time, and relief or slope of the soil. In most crop producers' fields, these factors are constant except for soil slope, with a slope of as little as 0.5 percent actually causing visual differences. In addition, fields are usually not organized by soil type, but rather, are laid out on the basis of either convenience to the producer or a predesigned grid arrangement.

The result of having several soil types within one field is that, unless farmers manage the soils individually in a field, resources and yields will not be optimized. Several soil properties vary within a field that could influence a producer's management scheme. Obviously, a soil's fertility status can vary with it's location within a field. Table 1 shows soil properties, including nutrient content, for three areas within three different fields.

Herbicide rates and effectiveness can also vary as the soils change both chemically and physically. Factors such as organic matter content, soil pH, and soil texture influence a majority of the herbicides that are used today (Table 2). If a producer uses an average field organic matter content for a herbicide recommendation, the rate could be too low on the darker, lowland soils and too high for the lighter, eroded soils.

The selection of yield goals is another management practice that can be affected by differing soil properties within a field because uniform yields are not achieved across a field. Table 3 shows yield variations within some fields due to differing soil type. If yields vary, then practices such as fertilizer rate, planting populations and possibly, varieties should be changed accordingly.

Agronomists for CENEX, Inver Grove Heights, Minnesota.

The need and awareness for technology to handle different soils within a field has been growing steadily in recent years. While some researchers have predicted this technology will not be implemented for 5 - 15 years, several fertilizer applicators are currently being used which utilize modern technology to treat soils individually within a field. Soil Teq Incorporated, the company developing this technology under the trade name of "Soilection System", is a joint venture of three Minnesota-based companies. Soil scientists from CENEX and the University of Minnesota have provided the technical expertise to make this project agronomically sound.

The fertilizer applicator, the first application of the Soilection System, has the capability to change fertilizer blends and the rate of material application as soil types change in a field. By using a computer, the system incorporates both soil information from a memory board and electronic sensors to regulate flow of fertilizer material from bins on the unit to individual soil bodies in the field.

The first step in the operation of the fertilizer unit is making a digitized map of each field. During the early spring of the year, before the vegetation is present, infrared photographs are taken of the fields. These photographs depict varying shades, primarily due to soil color. Color is influenced by soil organic matter and soil moisture, which can reflect soil texture.

The infrared photographs are then enhanced using a computer to produce a digitized soil map. The enhancement delineates the shades of color into any number of divisions. Currently, the computer program delineates three soils, with a capacity for eight soils. In the enhancement process, the concurrent use of a recent soil survey for the area has been beneficial. Even if an aerial photograph is not available, a digitized map can be made solely from a soil survey. Once this digitized map has been produced, it can potentially be used for many years since soil properties do not change very readily.

The digitized maps are being stored on a programmable read-only memory (PROM), which is inserted in a microprocessor in the cab of the vehicle. The digitized map is displayed on a computer monitor that also is mounted in the cab. As the vehicle moves across the field, a cursor blinks to designate its location. This is accomplished with a radio signal navigation system that interacts with the microprocessor. By using PROMs and the navigation system in a soil sampling vehicle, samples can be taken and tested from each of the different soil types and recommendations can be made for each soil.

When one is ready to spread fertilizer, the operator must enter the recommendation rates for each soil type into the microprocessor, along with some other, general application information. The application rig has six bins for carrying dry fertilizer and four compartments for herbicides that can be impregnated on the fertilizer. As the applicator passes over different soils, the microprocessor sends signals to the different fertilizer bins on the back of the rig. This signal regulates the dispensing rate of the bin by hydraulically controlling the rotation rate of the starwheel at the bottom of the bins, thus dispensing the correct amount of each product to produce the required blend. As the soils change according to the PROM, the fertilizer blend changes.

The economics of this system are somewhat difficult to assess. Naturally, more money is invested in this unit, and almost inevitably, the per-acre application charge will increase. Another cost to be dealt with is soil sampling and testing fees. If a crop producer currently takes only one sample per entire field, the sampling and testing fees will increase. However, if an intensive soil sampling system or multiple samples are being taken presently from a field, costs should not change. In addition, there is an added initial cost to have the PROMS made. However, this is a one-time charge, and some local dealers are buying and keeping the PROMs as a customer service for crop producers.

While the economic liability of this system may be easy to determine, the system also promises monetary returns, although they are difficult to measure. When a crop producer treats a field as an entity, whether 20 or 200 acres, an average is used that will undoubtedly apply too many inputs in some areas and too little in others. But, looking at this from the positive side, the phenomenon also would enable producers to set different yield goals for different areas of a field, based upon soil type. Then, the producer can apply ample fertilizer in good soil areas of the fields, while applying less fertilizer on the poorer areas where lower yields are common.

Additionally, this system can correct micronutrient deficiencies that generally occur in the small portions of a field. A producer would probably not treat an entire field because of prohibitive costs and, thereby, would suffer some yield decreases on those deficient soils. Economic gains should also be seen with precision application of herbicides. Depending on the acreages of the different soil types within a field, a large savings can be realized by treating the soils separately.

This technology is currently being used only with soil sampling trucks and with dry fertilizer spreaders. However, the principles of digitized soil maps and the related technology have other applications as well. Work is presently being done to apply this technology to liquid spreaders, both for fertilizer and pesticides. This concept could also be used on anhydrous ammonia applicators to control the flow rates on various soil types and to apply nitrogen stabilizers on appropriate soils. This technology could also be included on irrigation systems to control water flow and fertilizer and chemical slows based on soil types and their respective water holding capacities.

The technology that reconizes and treats fields as a composite of soils has arrived. To an agronomist, soils scientist, or crop producer, this provides a sound application of the principles of efficient input of resources. The goals of the developers should reflect the goals of the crop producer: to enhance profitability through the efficient use of resources.

Table 1. Soil Property Variations in Three Minnesota Fields as Affected by Soils Within Each Field

Field	Soil	Texture	pH	O.M. (%)	P (lb/A)	K (lb/A)	S (ppm)	Zn (ppm)
1	A	CL	8.0	6.1	29	357	50	1.4
	B	CL	6.8	3.4	46	462	5	1.3
	C	CL	7.8	1.8	34	260	12	0.7
2	A		7.3	10.7	57	280	42	2.8
	B		7.6	3.9	90	432	50	2.2
	C		6.9	1.7	34	294	6	0.6
3	A	SiCL	7.4	4.2	29	243	...	0.8
	B	SL	7.3	3.3	20	170	...	0.4
	C	SL	7.9	1.5	11	164	...	0.3

Table 2. Some Selected Herbicides that are Affected by Soil Physical and Chemical Properties

Soil pH	Organic Matter	Soil Texture
Sencor	Lasso	Treflan
Lexone	Dual	Aatrex
Aatrex	Princep	Bladex
Bladex	Lorox	Lasso
Glean	Bladex	Dual
	Banvel	Sonolan
	Prowl	Prowl
	Sencor	
	Lexone	
	Aatrex	

Table 3. Grain Yield Variations in Four Field as Affected by Soil Types within Each Field, Montana State University

Field	Soil	Yield (bu/A)
1	A (Telstad)	33.7
	B (Joplis)	32.6
	C (Hilton)	29.6
2	A (Bearpaw)	58.7
	B (Vida)	58.1
	C (Fahill)	33.4
3	A (Scobey)	33.2
	B (Kevin)	28.2
	C (Hilton)	23.9
4	A (Kobar)	39.5
	B (Marvan)	11.9