

Site-specific management of in-field spatial and temporal variability of soils

By Prof ME Moshia, specialist researcher ARC-ISCW

Agricultural production has traditionally been optimised for profit. Nevertheless, this has been changing gradually due to increasing pressure for agribusiness practices to meet certain environmental standards.

With the adoption of precision agriculture or site-specific farming practices, every part of the field is treated individually as opposed to treating the whole farm as one unit with homogeneous soil type, slope, texture, pH, and more.

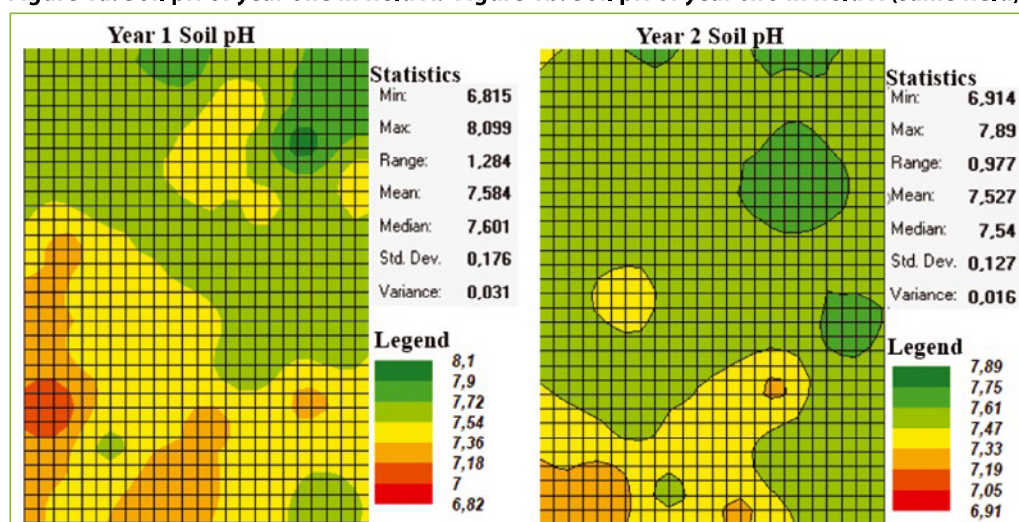
The eventual goal of precision agriculture is to manage spatial and temporal variability associated with all aspects of agricultural production for optimum profitability, sustainability, and protection of wildlife and the environment. Spatial variability is when one part of the field produces more, while another part of the same field produces a decreased yield in the same year/season.

Variability must be managed

Temporal variability is when an agricultural field produced 17 ton/ha in 2016, 13 ton/ha in 2017, and suddenly 10 ton/ha in 2018. Yield varies over the years. Both spatial and temporal variability in an agricultural field must be managed, and the causes of variability must be established through soil surveys.

Figure 1a and 1b show a change in soil pH from year one to year two; that is temporal variability – changes over time or across years. In the same picture we can see different soil pH levels in year one ranging from acidic soils (pH = 6,82) to alkaline soils (pH = 8,09). When you have

Figure 1a: Soil pH of year one in field A. Figure 1b: Soil pH of year two in field A (same field).



acidic and alkaline soils in the same field, lime must be applied variably with the use of a navigation system such as a differential global positioning system (DGPS).

DGPS is a GPS system that communicates with satellites and have sources of GPS errors removed (Figure 2), as opposed to a

Figure 2: Differential global positioning system (DGPS).



handheld Garmin GPS (Figure 3) that has an accuracy of around 15 metres or more. With DGPS, there is an annual subscription with private companies; handheld GPS units do not have a differential correction and there is no annual subscription fee.

Precision agricultural technology attempts to answer profoundly debated global issues of concern such as soil erosion, increasing demand for food due to the increasing world population, the unstable world economy, and the environment.

Figure 3: Handheld Garmin GPS (no differential correction).



Comparable to many other inventive developments in the sciences, precision agriculture is, for the most part, a byproduct of the amalgamation of massive investments in science, a productive intellectual culture, and global socio-political conditions.

Traditional farm management

The reported adoption of precision agricultural technology globally has been slower than estimated, because proper decision-support systems that will aid the implementation of decisions based on precision agricultural technology are lacking.

This whole-field traditional farm management ignores spatial variability and assumes that 'average' conditions are the same everywhere in the field. Whole-field uniform management is based on broad averages of field data with management actions directed by 'typical' conditions.

Suppose a farmer relied on an average soil pH. It means the farmer would treat the field as having slightly alkaline soils and entirely ignore the fact that some areas of the field have a soil pH of 8, where availability of essential maize nutrients such as zinc, manganese, copper, and iron could be affected (Figure 4).

Unlike precision agriculture, traditional farm management systems lack the technology to understand in-field variability to manage crop production systems accordingly. Instead, farmers apply lime, fertilisers, pesticides, water, and other agricultural production inputs uniformly across the field.

In a field with spatial variability of soil properties it was reported that uniform application of lime, or fertilisers such as nitrogen (N) and phosphorus (P), often results in various areas of the field receiving greater farming inputs than is necessary.

Phosphorus runoff and N leachate from over-fertilised areas may contaminate the ground and surface water supplies, while crop yield may be restricted in under-fertilised areas. In one of the studies conducted with N fertilisers and animal manure, it was observed that precision agricultural techniques have the potential to reduce environmentally sensitive nutrient loads into the environment.

Who can adopt precision agriculture?

Any farmer with a field that has a spatial variability of soil properties or yield limiting factors, meaning that soil properties change as a farmer moves from one part of the field to another. The field's spatial variability has to be significant enough to affect yield and farm economics; however, the size of the field does not matter.

Some of the methods to determine the existence of spatial variability and yield limiting factors are soil surveys and mapping, which determine all soil types occurring on the farm. Soil depth, soil texture across the field, and subsoil clay content are essential to determine, especially on irrigated fields.

Previous yield maps can show variability in yield. Topography/slope maps can give a hint because it is a fact that different soils

occur at different landscape positions, or across slopes.

Free satellite images of agricultural fields are available on the Internet. Scan the images you have selected back into the computer and convert them to greyscale (not black and white) – areas that appear lighter are said to have more sandy soil

and low organic matter content, while areas appearing darker could have more clay soil and organic matter content.

Draw/zone out those areas with pencil on a paper map and, using a GPS, navigate to those areas in the field to check/verify soil texture, soil depth, and other soil characteristics.

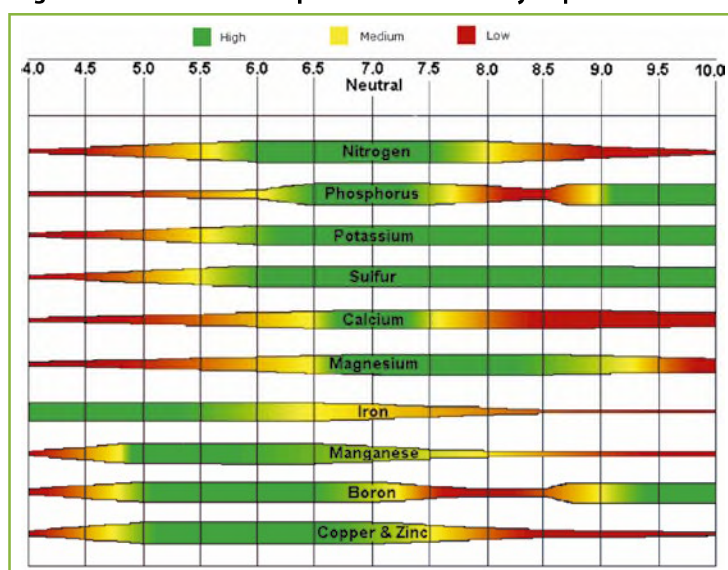
Myths about precision agriculture

The following myths about precision agriculture are not true:

- Precision agriculture uses expensive and complicated equipment that is not easy to operate.
- Implementing precision agriculture is expensive.
- You need a bigger field to implement precision agriculture.
- Precision agriculture is for American and European farmers.
- It is not easy to implement precision agriculture in Africa.
- There are no people in South Africa who are educated enough to help farmers.

At ARC-ISCW we conduct training on soil surveys, GPS/GIS applications and precision agriculture, and offer services related to data management. We can help farmers determine the degree of spatial variability, acquisition and manipulation of satellite images to understand in-field spatial variability, land suitability assessment, soil analysis, mapping of agricultural fields, implementation of precision agriculture, and delineation of management zones. 🌱

Figure 4: The effect of soil pH on the availability of plant nutrients.



Prof ME Moshia is a specialist researcher in soil information systems at the Agricultural Research Council – Institute for Soil, Climate, and Water in Pretoria. He holds a PhD in soil sciences, specialising in precision agriculture, from Colorado State University, US. He was a Fulbright Research Scholar in environmental soil sciences at the University of Florida, US. He is a rated researcher by NRF and represented South Africa at the International Society of Precision Agriculture for five years. He currently represents Africa at the FAO-Intergovernmental Technical Panel on Soils (2018-2021).

For more information, contact him on 012 310 2603 or email MoshiaM@arc.agric.za.