Variable rate technologies

Precision agriculture in vegetable systems

R&D FARM-READY
ADOPTION READINESS

What is variable rate technology?

Variable rate (VR) technology enables growers to vary the rate of crop inputs such as fertiliser, soil amendments, irrigation and agricultural chemicals.

The use of VR technology is based on recognising that fields are not uniform, and therefore should not be managed uniformly. Soil mapping or crop imagery (with ground-truthing) generally provides the data to generate variable rate prescriptions. VR technology essentially provides the right input, in the right amount, in the right place.

VR technology combines GNSS (GPS) technology with variable input controllers on farm equipment to adjust the application rate of crop inputs based on crop or field variability. In most cases, fields are split into 'management classes' or 'zones' based on soil and nutrient maps.

Application rates are assigned to each zone to form a prescription map and the VR controller adjusts product output according to a prescription map. Inputs can be any product used to enhance crop production, although most VR technologies have been developed for irrigation, fertiliser, lime/gypsum and herbicides.

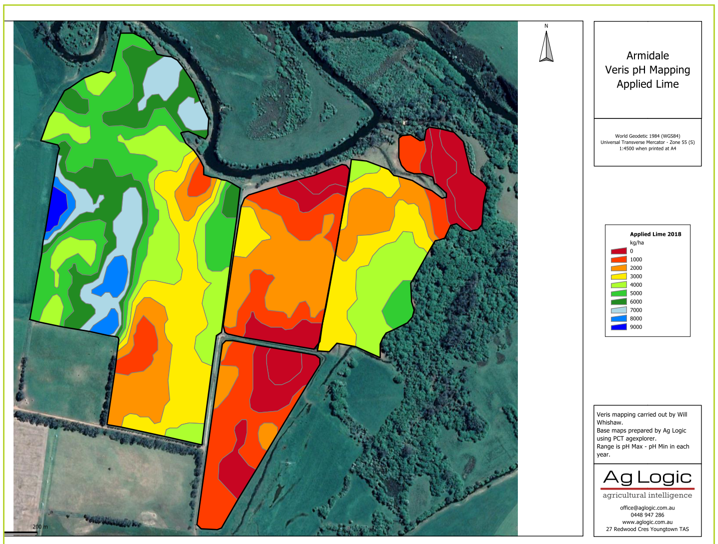

Figure 1. *Lime prescription map developed from Veris® soil pH mapping and targeting a soil pH of 7.*

Key considerations

- Magnitude of variability – is the variability of a magnitude that is of economic concern?
- Type of variability – is the variation spatial and/or temporal i.e. is it spread across the field, does it change through the season or is it consistent across subsequent crops?
- Cause of the variability – is the variation caused by something that can be managed using VRT, such as nutrient deficiency or pH?
- Distribution – can the variability be clustered into zones of manageable size, or is it made up of many small areas within the paddock that are beyond the capacity of VR technology?

VARIABLE RATE SOIL APPLICATIONS

Variable rate application of soil amendments or fertiliser are generally based on soil mapping data. Ground-truthing of the soil map usually identifies the input required, e.g. lime to amend low pH, fertiliser to increase nutrient levels, or gypsum to improve water infiltration.

The soil mapping layer can then be converted to a prescription map with each 'zone' on the map assigned a rate to be applied (Figure 1).

The total area of each management class is used to calculate the total amount of product required. Prescription maps are uploaded into the VR controller on the spreading equipment. These maps can vary in their level of precision (Figure 2).

VR spreading equipment

VR controllers can often be retrofitted to existing spreaders. This can usually be achieved at a cost of $5000 to $6000, plus installation.

An increasing number of spreading contractors have VR capability (Figure 3). VR contract spreading is usually similar in cost to broadcast spreading.

Hort Innovation
Strategic levy investment
VEGETABLE FUND
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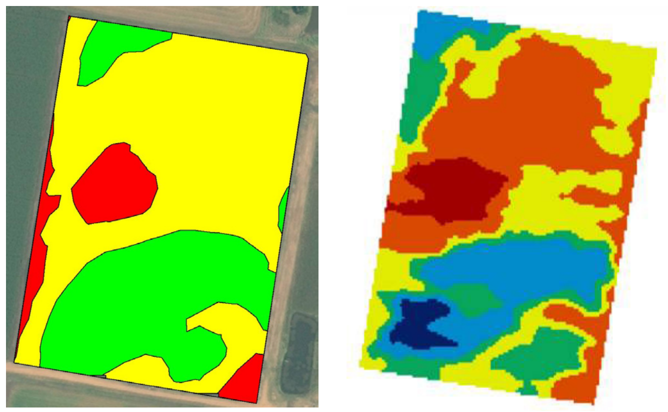

Figure 2. *Difference in the level of detail in two prescription maps with four potassium application rates (left) and nine lime application rates (right).*

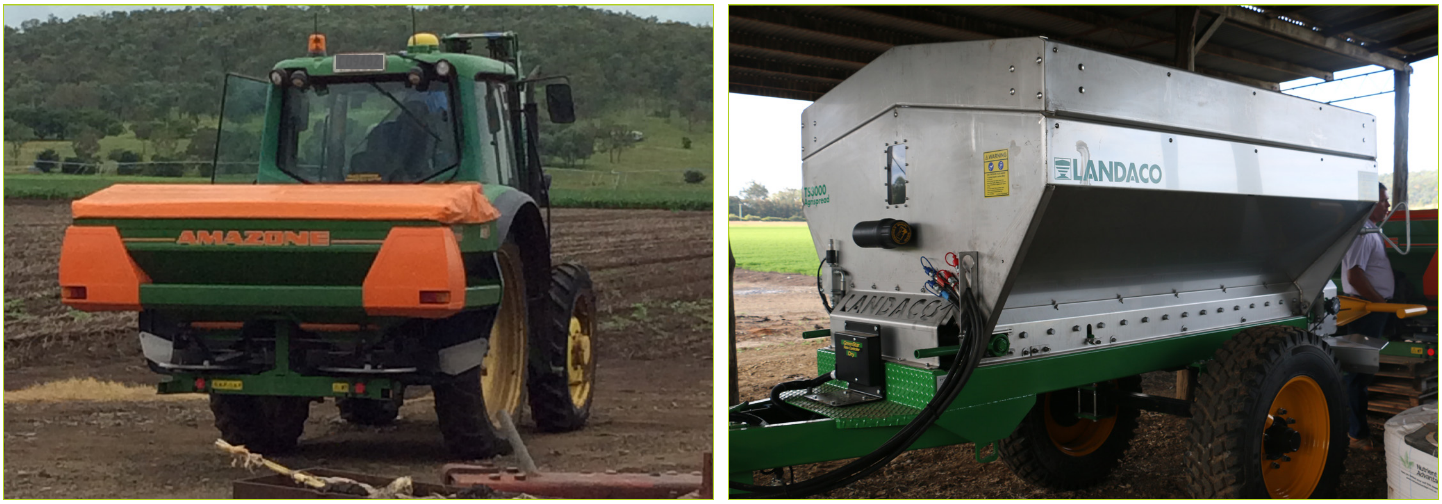

Figure 3. *Variable rate granular spreader (left) and VR bulk spreader (right).*

Costs

Costs associated with VR soil applications include soil mapping and ground-truthing, which varies depending on the soil mapping technology. Other costs include data processing for map development and inputs costs. Input costs may increase, decrease or remain similar to conventionally applied product.

There are examples of all these scenarios with VR applications in vegetables. Savings of over 40 per cent in lime and up to 25 per cent in fertiliser have been achieved with VR applications. In many instances the same or similar total amounts of product are applied with targeted distribution based on where it is most needed. However, there have also been cases where the VR application required significantly more product (up to 4 fold) to improve uniformity across the field.

Remapping the treated area post-VR application can help qualitify whether the VR application has improved uniformity.

Challenges

There are some challenges with VR soil applications, such as:

- Variable rate controllers do have limits to the breadth of application rates that can be applied. If the rate changes are outside the capacity of the spreader gate adjustment, the only way to vary the rate is by varying the ground speed.
- Having numerous, finely defined zones can be challenging for speed adjustments.
- In many cases multiple VR applications over time may be required to achieve the desired change in uniformity of a particular soil characteristic.

VARIABLE RATE IRRIGATION

The objective of VR irrigation is to optimise inputs (water and pumping energy) and crop performance by matching application rates to soil type and crop requirements. VR irrigation is a practical option with linear and centre pivot irrigators.

The precise management of water in vegetable cropping systems underpins efficient use of a limited resource and high crop productivity. Interest in VR irrigation is usually driven by soil variability, water availability, energy costs and crop variability.

The soil's ability to store water for crop use is a function of soil texture and management. For this reason, EM38 mapping and in-field ground-truthing is often the starting point for informing the development of VR irrigation prescription maps. Topography and crop

Figure 4. *Variable rate irrigation prescription map for a Rienke centre pivot irrigator. The VRI map shows lighter rates (orange and green) over wetter areas and water off completely over a swampy area at the top. Source: James Addison.*

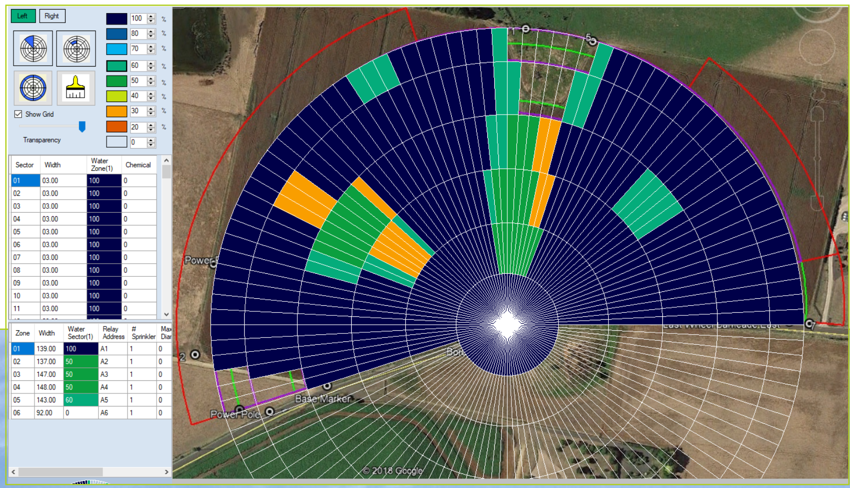

Figure 5. *Retrofitting of VRI capability to a centre pivot irrigator for vegetable production.*

growth factors during the season also need to be considered when developing the prescription map.

Generally, more than one prescription map is required per field to accommodate the changing irrigation requirements throughout the growing season.

Costs

All major manufacturers of centre pivot and linear irrigation systems market VR controllers that can either be supplied at installation or retrofitted to irrigators. The cost of VR irrigation varies depending on the level of control required along the spans of the irrigator.

Future developments

The future of precision irrigation will be the ability to vary irrigation applications based on real-time water demand data. Current research in this area includes the use of real-time data capture, active weather monitoring and forecasts using crop models to predict and control water application rates.

VARIABLE RATE AGRICULTURAL CHEMICAL APPLICATIONS

The variable rate application of agricultural chemicals for pest, disease and weed control are limited mainly by the lack of adequate sensors.

Weed sensors are most advanced, with optical sprayers such as Weedseeker® and WEED-IT in use for over 20 years. The optical sprayer technology has been primarily used for variable application of herbicides in fallow situations. The on-board sensors detect the presence of green plants and activate the relevant nozzles to apply herbicide to those plants.

This is known as green-on-brown optical spraying. There is currently rapid progress in vision systems and in-crop weed identification, that are expected to result in new options for VR herbicide applications in-crop. This is termed green-on-green optical spraying.

The technological capability to achieve variable rate application of agricultural chemicals for disease and pest control is commercially available, but there are currently no sensors available that can accurately detect and identify specific pest and disease outbreaks from remotely sensed imagery.

Consequently, identifying those areas requiring chemical control to develop an appropriate prescription map is currently a limitation. While NDVI or other vegetation indices can be used to identify areas of lower crop performance, field inspections are needed to diagnose any specific pest or disease issues.

The time taken to collect the vegetation data and conduct the necessary and detailed field inspections would potentially delay the spray operation, resulting in additional crop damage. VR application of agricultural chemicals in these circumstances requires either a knowledge of the disease risk (for preventative sprays), or on-ground disease identification (for curative sprays).

There is increasing interest in drone technology for detecting (Figure 6) and spot spraying weeds and pest or disease incursions. As with on-ground sprayers, this is reliant on accurate identification of targets to prepare a VR application map.

For more information on weed sensing in agriculture go to https://spaa.com.au/portfolio-item/factsheet-2-weed-sensing/

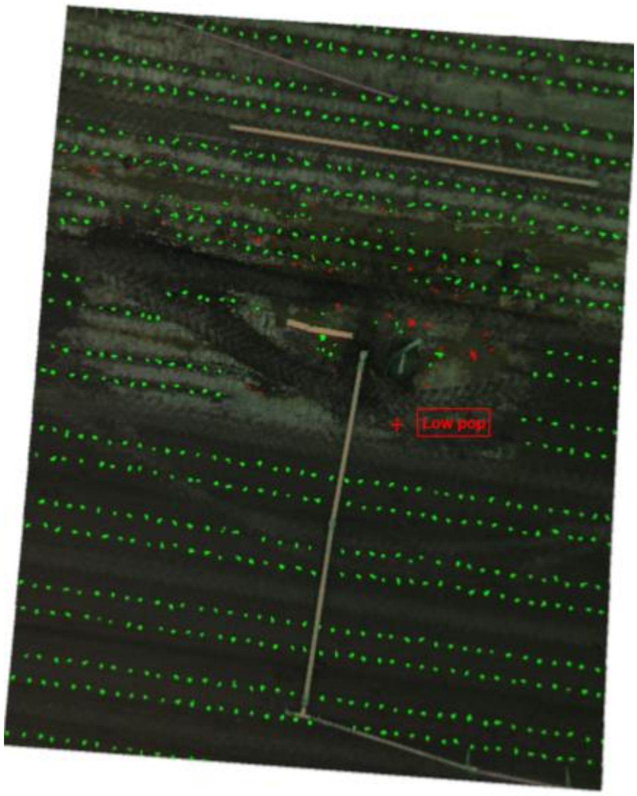

Figure 6. *Weed detection analysis from drone imagery in sweet corn. Weeds appear as red and the sweet corn plants green. Source: Airborn Insight.*

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Funding and Project Partners

This project has been funded by Hort Innovation using the vegetable research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au