Integration of GPS technologies into cropping practices

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LandWISE

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LandWISE Agmardt Project; Summary of NZCPA involvement

Powerpoint presentations made at LandWISE Seminar May 2003

Ian Yule; NZCPA: EM soil mapping and precision ag applications

Callum Eastwood; NZCPA: Integration of GPS technologies into cropping practices

John Ahearn; Trimble: How farmers in the USA are making money from Precision Ag

Introduction:

LandWISE is a landcare group principally run by members of the farming community, associated industry and regulatory organisations. Its primary aim is to foster the development and implementation of sustainable farming techniques. LandWISE is currently supported by MAF Sustainable Farming Fund and Hawke's Bay Regional Council.

The project 'Integration of GPS technologies into cropping practices' was borne out of LandWISE members needs to investigate the new and varied GPS technologies available to them in a real-farm environment. The aim of the project was to provide a forum whereby interested parties could learn, assess and adjudge the implications of these technologies.

GPS technologies identified for investigation were soil mapping using a GPS linked EM38™ and self steer tractor systems.

It was anticipated that some of the benefits of these applications would be the creation of management zones within fields, and hence the economic and environmental impacts of more efficient use of fertiliser, seed and agrichemicals. Also predicted were applications to strip tillage and mechanical weeding practices.

LandWISE organised a series of trials, seminars and field events to demonstrate and assess the anticipated benefits. Included in the series of events were:

- EM38™ mapping
- Trimble® Autopilot accuracy demonstration
- Mechanical weeding demonstration
- Strip tillage demonstration

The events also provided a valuable forum for networking of interested parties and a focal point for discussion.

For this project LandWISE worked collaboratively with Apatu Farming Group, Crop and Food Research, New Zealand Centre for Precision Agriculture and Trimble Navigation Ltd..

LandWISE would like to gratefully acknowledge the financial contribution of AGMARDT to this project.

Project Objectives

To demonstrate the benefits of Precision Agriculture, using two GPS based technologies, to the New Zealand cropping sector. Using the Trimble GPS AutoPilot and New Zealand Centre for Precision Agriculture EM38 Soil mapping technology LandWISE will facilitate information flow between service providers and farmers while demonstrating the relevant applications. Key demonstrations will include mechanical weeding, strip tillage and multi layer farm mapping.

GPS technologies employed

LandWISE members identified soil mapping based on measurements using 'EM38™' technology as employed by the New Zealand Centre for Precision Agriculture (NZCPA) and the self-steering Trimble® Autopilot system as the key technologies they wished to investigate.

EM38™: Soil electromagnetic conductivity mapping

New Zealand Centre for Precision Agriculture operates a commercial EC/GPS soil mapping service utilising Geonics EM38™ and Trimble® Ag214 Equipment.

The EM38™ sends electromagnetic energy into the soil. A sensor in the EM38™ measures the resulting electromagnetic field, the strength of which is proportional to the electrical conductivity of the soil. A soils electrical conductivity reading provides an indication of several important soil properties including clay content, moisture content, salinity, and bulk density.

Trimble® Ag214 GPS

The Trimble® Ag214 provides highly accurate positioning (centimetre level precision) through an RTK, or real-time kinematics, receiver. The use of a local base-station permits correction to overcome inherent and designed inaccuracies of satellite only positioning. This enables highly accurate topographical maps to be generated using Geographical Information Systems (GIS) software.

EM 38™ - Trimble® Ag214 combination

Using GIS to link EM38™ measurements to simultaneous Trimble® Ag214 positioning data enables soil measurements to be plotted. The result is a topographic map of soil electrical conductivity (EC) .This highlights changes in soil electromagnetic conductivity across a site.

For more information www.nzcpa.co.nz

Trimble® Autopilot

Trimble® provided a Trimble® Autopilot. The Trimble® Autopilot uses the same Ag214 RTK receiver employed in NZCPA's EM38™ with the addition of Autopilot capacity. Self-steer systems provide the ability to drive in straight lines and maintain the exact position within a paddock. The Trimble® Autopilot achieves this to an accuracy of +/- 2cm.

The Trimble® Autopilot was placed in a John Deere 6280 and used in everyday farming practice at Apatu Farming Group.

More information on GPS and Trimble is available on their website: www.trimble.com

Demonstrations

Demonstration events were organised by LandWISE to facilitate the flow of knowledge about the applications of the above technologies. Key areas of interest acknowledged by LandWISE members prior to the events were:

- GPS assisted soil mapping and management zone creation
- Self steering system's accuracy
- Applications to strip tillage and mechanical weeding practices

GPS assisted soil mapping and management zone creation

The inner Hastings racecourse was used for demonstrating soil mapping and management zone creation. Apatu Farming Group currently leases this paddock and its rotation for the 2002-03 season was process tomatoes.

To demonstrate soil mapping and zoning LandWISE organised:

- NZCPA to survey the soil using GPS guided EM38™ and map the results
- Crop and Food to assess the soils fertility from the resulting 'management' zones
- Crop and Food to assess the yields from the resulting 'management' zones
- NZCPA to assess the data and create an appropriate multi-layer map

Attached in the resulting report:

LandWISE AGMARDT Project

Summary of NZCPA involvement

Callum Eastwood

NZCPA; Massey University

Self Steering systems accuracy demonstration

LandWISE, in conjunction with Trimble Navigation Ltd, organised a seminar/field day the Hastings Racecourse in November 2002. It served to introduce interested parties to the GPS technologies under investigation (EM38™ and Trimble® Autopilot) and provided a forum for networking for those who attended.

Dr Ian Yule of New Zealand Centre for Precision Agriculture spoke about the EM38™ system and its uses and also on the concept of multi-layer mapping and its implications. John Ahearn from Trimble Navigation Ltd spoke about the applications of the Trimble® Autopilot.

A demonstration of the accuracy of the Trimble® Autopilot was then held. This was achieved by performing "bed-raising" operations for the process tomato paddock. (Fig 1)

Fig 1 Bed raising under GPS guidance

Applications to strip tillage and mechanical weeding practices

GPS and auto-steer technologies were presented at the annual LandWISE Autumn Seminar held on 7th and 8th of May in Havelock North. The theme for the 2003 seminar was “Sustainable Farming, Sustainable Profits” and included both theatre sessions and field events.

Presentations given included:

- EM soil mapping and precision ag applications I Yule; NZCPA: Massey University
- Integration of GPS into cropping practices C. Eastwood; NZCPA: Massey University
- How farmers in the USA are making money from Precision Ag J Ahearn; Trimble Navigation Ltd

Field events included:

- Trimble Autopilot – simulated mechanical weeding demonstration
- Strip tillage and maize planting demonstration

Fig 2 Mechanical Weeding Demonstration

Fig 3 Strip tillage machine

Fig 4 Strip tillage maize (emerging)

Benefits of GPS EM38 soil mapping and multi layer mapping

Demonstrating the concepts and applications of soil mapping and multi-layer mapping was a key objective of this project.

Soil mapping appears to have many applications. Soil Mapping provides a base from which to start assessing the soils within specific sites. While the EM38 does not identify the actual causes of variation it measures in the field, it can identify areas where further investigation may be worthwhile.

Layering soil maps with fertility maps over yield maps could provide the farmer with good information from which to base decisions. Similarly, the creation of management zones, appears on the surface to be of great benefit to the farmer with the potential for cost savings.

Our demonstration did not show any correlation between EM38™ measurement and fertility or yield. As stated in NZCPA's report (attached) that it is believed that this was due to the narrow band of EM readings obtained from the site. The demonstration did however fulfil its objective of showcasing this technology and it implications to interested parties.

Benefits of high accuracy self-steer systems

Self-steer demonstrations were very successful. They underlined the accuracy of the Trimble® Autopilot system, highlighted a number of applications for this technology.

The feature offering most immediate and easily measured benefits from using these technologies is the ability to drive straight lines, to place those lines with great accuracy across a field, and to return to them exactly. Many benefits of GPS technologies can be attributed to this as outlined below.

Economic and environmental benefits offered by auto-steer

- Reduction in pass to pass overlaps
- Saves time and labour, allows use of lesser skilled labour
- Saves diesel, fertiliser, seed and agrichemical usage etc (lower inputs, better for the environment)
- Saves soils from unnecessary cultivation
- Allows machinery to cover a greater area each day and season
- Knowing your exact location within a paddock
- Ability to form rows 'out of sequence' (Attachment)
- Ability to avoid buried objects e.g. irrigation tape, drainage systems
- Ability to relocate problem soil regions
- Ability to return to the same spot within a paddock
- Ability to adopt Controlled Traffic Farming techniques
- Ability to plant accurately into strip tilled zones
- Ability to adopt high accuracy mechanical weeding practices
- Shorter headland turning time (Attachment 1)
- Less time spent filling tractors, seeders etc
- Better utilisation of available time
- Ability to work throughout the night or in difficult conditions such as fog.
- Accurate row placement
- Increasing utilisation of cropping space
- No variability between runs (no "guess rows")
- Can utilise different width/row number machinery without crop damage
- Aids in subsequent operations such as harvesting
- Reduce driver fatigue by not having to concentrate on driving straight lines
- Ability to assess other operations more accurately with the tractor still working

Discussion

The high accuracy self-steer system increases efficiency in a number of ways. Of considerable importance is reduction of overlapping during field operations. Under conventional marking practices, marker arms or foam markers are used to guide drivers within a paddock. Using this technique, overlap has been estimated to be commonly 10% and up to 20%.

Overlap occurs in all operations, including cultivation, planting, agrichemical and fertiliser applications. With multiple passes typical for most cropping systems, there are considerable cost savings to be made.

The amount by which automatic guidance systems reduce overlap depends on their accuracy. With high accuracy systems (+/- 2cm) overlap is virtually eliminated.

Soils benefit considerably too. In effect, up to one fifth of the paddock is cultivated twice as often as the rest. Again, this is all but eliminated under high accuracy self steer systems

Time savings

Shorter turn around time at the end of each run is made possible by using the five:three row forming process as opposed to the traditional sequential row forming process. (Figs 5 & 6) The time savings are made in the reduction in amount of time it takes to start working another row. Sequential row working requires tight headland turning that is not always achievable in a single movement

The following diagrams illustrate the process.

Fig 5 Traditional sequential side by side row forming operation.

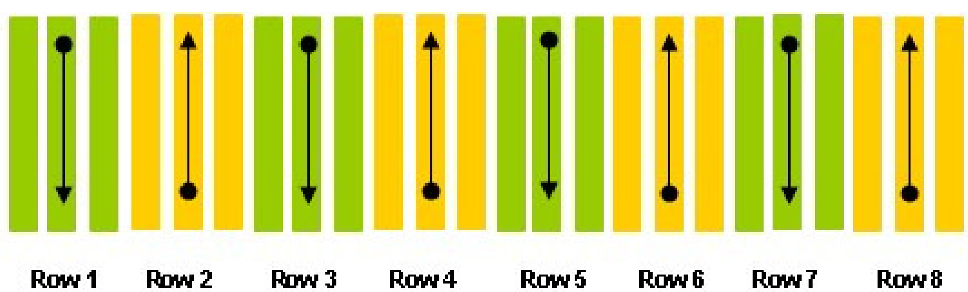
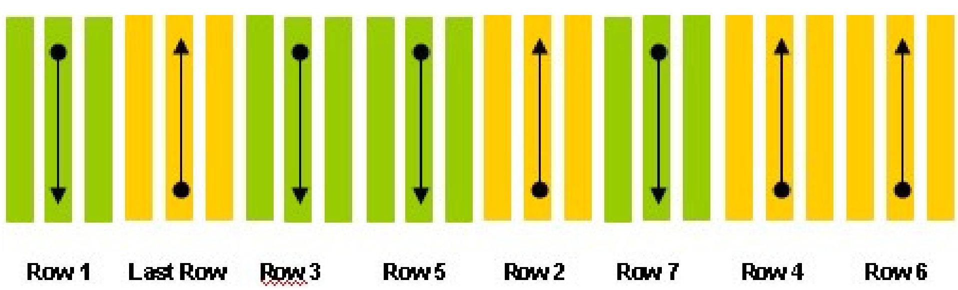


Fig 6 GPS achievable "five: three" row forming sequence.



se in the coming near future.

However many have expressed reservations about the capital outlay required.

The current retail price for a system with the accuracy used for this project is approximately $100,000.

Indications are that other brands of self-steer systems will be in the New Zealand market by the end of 2003 and that these will be competitively priced. The accuracy of these systems has yet to be determined.

Conclusion

This project investigated the application of two GPS technologies to the field cropping industry.

The GPS technologies investigated were soil mapping using a GPS linked EM38™ and self steer tractor systems. It was anticipated that some of the benefits of these applications would be the creation of management zones within fields, and hence the economic and environmental impacts of more efficient use of fertiliser, seed and agrichemicals.

Generation of field maps

The project demonstrated this process.

High accuracy topographical maps of the field were generated.

Data from EM38 scanning were processed and presented as a map layer.

Several "zones" were identified within the field. However, the factors that gave rise to the variations were not able to be determined.

Yield maps based on hand harvest yield data could be generated but were not able to be correlated with the EM38 maps.

Self-steer tractor systems.

The ability to drive straight lines appears to offer greatest and most readily demonstrable benefit to the farmer.

The system assessed under this project worked well, although satellite shadows were noted and at times field operations were restricted.

The ability to undertake very accurate mechanical weeding operation of row crops was demonstrated.

It appears many economic and environmental benefits are to be derived from the uptake of this technology and that over time they will become an integral part of the cropping environment.

Farmers are continually assessing the cost benefit of buying into the various systems available and though the reason for doing so may be different the benefits derived are mostly due to the ability of the tractor to drive in straight lines independent of the driver.

Milestone Table

Milestone	Description	Date expected	Completed date
1	EM 38 Soil differential map prepared by NZCPA	Oct 02	Oct 02
2	In field soil assessments and analyses completed by Crop & Food	Nov 02	Nov 02
3	Soil type management zone maps produced by NZCPA	Nov 02	Nov 02
4	Mechanical weeding demonstration presented	Dec 02	May 03
5	Strip tillage demonstration presented	Dec 02	May 03
6	Hand harvested yield analyses completed by Crop & Food	Feb 03	Mar 03
7	Multi-layer map produced by NZCPA	Apr 03	see Appendix
8	Reports presented at LandWISE annual seminar	May 03	May 03

Milestone 7:

We generated topographical maps and overlaid the results from EM38 scanning.

We were unable to generate a satisfactory yield map as the hand harvested data points were not sufficient for adequate “kriging”, the process by which data is interpolated and processed to allow analysis between layers.

In a normal farming situation a machine based yield monitor would be used, allowing the collection of multitudinous data points providing the database needed.

The concept of multi-layer mapping using various integrated technologies was showcased at the Precision Agriculture seminar and at the annual LandWISE Autumn seminar.

While a usable (valid) yield map was not produced for our demonstration site we consider interested parties now have a good understanding the applications of multi-layer mapping, how they are achieved and knowledge of the various key contacts within the industry for further support in this area.