Farmer experiences in achieving productivity gains through GPS

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Abstract
GPS (Global Positioning Systems) have considerable potential to assist pastoral farmers in coping with pressures they will face in future. These include managing resource use, environmental constraints and controlling farm input costs. In the first case study, the farmer was able to cost effectively prepare his own farm map which in turn enabled detailed planning of farm infrastructure in preparation for a new dairy conversion. Case study 2 highlights the benefits of using GPS when applying fertiliser. Benefits included: accurate placement, more even spread with reduced double application areas leading to more efficient use of machinery and labour. In case study 3, the farmer had clear objectives of increasing the efficiency of his K-line irrigation system. Using GPS resulted in improved placement of the pods, a more uniform pattern of water distribution and reduced potential for runoff of surplus water, nutrients and sediment. In the final case study, the farmer used GPS to solve some of the problems associated with long lateral irrigation systems. Optimised placement of the sprinklers increased the evenness of water application, reduced water use and enabled better use of labour.
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Introduction
Until recent times, widespread use of GPS technology in agriculture has primarily been limited to broadacre cropping (for accurate planting, fertiliser application, spraying and traceability of agri-chemicals), and to precision engineering (earthworks for irrigation, layout of orchards and vineyards). On pastoral farms GPS use has historically been limited to use by contractors and service providers (Techno Systems fencing layout, repeatable soil test transects by fertiliser companies, farm mapping and fertiliser spreading). As hardware costs have come down, pastoral farmers have found uses for the lower precision consumer-type GPS systems to achieve on-farm productivity gains.

The Global Positioning System, originally developed by the United States Department of Defence as a military project, is now considered a dual-use technology as it has significant applications for other industries. In brief, GPS is one of the Global Navigation Satellite Systems (GNSS). GPS utilises a constellation of 24 satellites that transmit precise microwave signals. The time difference between when the GPS satellite transmits a signal to when it is received by the GPS receiver allows a GPS to triangulate its location and calculate speed, direction and elevation. These are the attributes used in the technologies that are applied on-farm.

The tools readily available for farmers range from hand-held GPS to more sophisticated vehicle guidance systems. The more expensive hand-held GPS and low end vehicle guidance systems typically provide sub 2 m accuracy, which the farmers find adequate for their purpose. Several commercial entities have utilised this technology and offer the ability for farmers to map their own farms using GPS and geo referenced mapping software, either off the shelf or specifically designed for farmers, as an alternative to having to engage a professional mapping firm (www.garmin.com, www.wheresmycows.com, www.tracmap.co.nz, www.tumonz.co.nz).

This paper reports the experiences of four pastoral farmers who have used GPS based methods to achieve productivity gains and reduce the environmental impact for their farming systems.

Case Study 1: Duncan Johnston – Using handheld GPS to map his farm
Waverley, South Taranaki: a 350 ha dairy farm milking 1000 cows on a 300 ha milking platform.

Duncan is in the process of a new dairy conversion and had experience of having a previous farm mapped by GPS. This farm is a rolling property with some steep gullies and even includes the New Plymouth rail line.

An accurate farm map was determined to be the first priority. He decided that the easiest and cheapest option was to map the property himself before planning the conversion.

- Using a two wheeled motorbike and a handheld GPS it took him about 2 days to map the main and internal fence lines on the property.
- This enabled him to have a close look at the property at the same time and get a feel for the place very quickly.
- He was able to go around the 'old' farm with the owner and mark existing water lines and taps which

gave him very good information prior to making changes.

Once this base map was completed he was able to use the farm map software for planning and moving fence lines to create the desired conversion layout.

His objective was to design a layout that enabled the property to efficiently milk the 1000 cows as two herds, one of 450 and one of 550 cows. Three ha paddocks were required for the smaller mob while the larger one needed 4 ha paddocks. Duncan then employed professionals who used the more accurate Real Time Kinematic (RTK) GPS to lay out the paddocks to the planned design.

He was also able to accurately determine how far the cows would travel at milking and include this in the decisions made on the final layout. This also provided the information on how many kilometres of races/lanes were needed which was used when obtaining the quotes for the earthworks. His handheld GPS was also used in designing the new water system and layout of water lines, troughs and sheds.

Advantages

- Provision of an accurate farm map.
- The GPS was easy to use and very cost effective especially in comparison to paying to have the farm mapped. A do it yourself farm mapping kit, including a GPS, software and instructions can be purchased for as little as $650 + GST while a quote for having a property mapped professionally is likely to start at $1500 + GST depending on the size of the farm and complexity of the job.
- Simple mapping software to use.
- Carryover of information which was used to inform contractors of the location of waterlines etc. during the conversion.
- On the rolling country, the GPS was used to work out the gradient to ensure that the races/lanes were not too steep for the cows. The top of the range hand-held GPS include a barometric altimeter which enables accurate height measurements (±10m compared to ±30m for a GPS altimeter) which are adequate for this type of use.
- Once you have the programme and the hand-held GPS you can update the farm map to include any changes very easily.

Disadvantages

- When mapping a new farm you do not have the spatial relationships between the different parts of the farm established (a visual picture). This can create some confusion when you transfer the GPS data to the mapping programme and it may not look as you expected. This is more difficult if only the corners of fences were marked when mapping a paddock rather than the fence lines.

Duncan will continue to use the technology in the future to maintain an accurate farm map and gain the benefits from having current farm information readily available. He was surprised how often the hand-held GPS had matched the more accurate RTK GPS when it came to laying out the new paddocks. He will be looking for the future opportunities with the technology such as the linking of pasture cover measurements and GPS.

Case Study 2: Barry Pannett – Using GPS to apply fertiliser accurately

Clinton, South Otago: 485 ha which includes a dairy farm (191 ha milking platform milking 625 cows), drystock and cropping on the balance of the area.

This is a large property with a mix of farming operations which includes growing 40 ha of barley and 160 ha of silage as well as the dairy platform. Barry has always had an interest in new technology and its place on farm and this is reflected in the systems already in place in the dairy shed. It has been his role to apply the fertiliser on the dairy farm and the cropping area. More recently he has moved off the farm and away from direct operational involvement and was concerned at leaving the job of applying fertiliser accurately in the hands of other staff.

The installation of a GPS system on the tractor has enabled efficient fertiliser application to continue. It allows the fertiliser spreader to operate at an 18 m spacing (prior to this spacing was 15 m which was the limit for visual estimation) as the driver simply follows the tracks on the GPS screen. The GPS helps to minimise missed or overlapping bands of fertiliser, especially important on the rolling hill country.

The fertiliser spreader used on the farm has scales and a laser system to control the release valve. When combined with the GPS, this allows the driver to operate at an appropriate speed which suits the land conditions, yet still apply the desired rate of fertiliser.

Advantages

- Provides accurate track spacing.
- Evenness of spread of the fertiliser.
- Wider spacing allows efficient use of equipment and time, provided the fertiliser spreader is capable of achieving wider bout widths.
- Provides confidence that the fertiliser will be applied evenly, irrespective of operator. One staff member can complete a job that has been started by another by following the on-screen GPS map.
- The potential for printouts of the maps i.e. proof of placement and traceability. This also provides for staff accountability in the future, something that is not required with the present staff.

- The GPS system was easy to learn to use and takes less than 5 minutes to set up for each paddock.

Disadvantages

- Barry has not found any disadvantages to using GPS technology.

In summary, Barry has found that using a GPS system has improved the fertiliser application practices on his farm through improvements in accuracy, efficiency and evenness of spread. The result is less fertiliser applied across the farm with no losses in productivity although the farmer has not yet quantified this accurately. However recent research has measured the variation in field application of fertiliser and shown that the biggest improvements are to be gained from improved driver accuracy and driver method (Lawrence and Yule 2007). Further economic analysis by these authors indicated that poor spreading could be costing between $52-72/ha/yr for a typical New Zealand dairy farm (Yule and Lawrence 2007).

He has also used the GPS on the tractor during cultivation to find the centre of the paddock when ploughing. In the future the system will enable him to locate the tiles on the property and to provide maps where traceability is required.

Case Study 3: Matt Murney – Using GPS to shift K-line irrigation more accurately

Ikawai: 326 ha dairy farm, rolling South Canterbury downlands. This property is part of a larger dairy development that has been divided into two farms, one of which is this equity partnership.

The farm has a K-line system that can irrigate 200 ha of rolling hill country. Currently a labour unit is employed full time to shift the pods. K-line systems potentially have the lowest distribution uniformity and these inefficiencies are highlighted with inaccurate placement of the pods (Thomas *et al*. 2006).

Matt identified a need for a system that could help him and his staff to effectively shift the K-lines around the hill country using a motorbike. He chose a system which integrated a bike mounted GPS with associated software (TracMap) that allowed accurate repositioning of the K-line at each shift. A primary objective was to remove the element of human judgement to enable the lines to be shifted accurately on the hill country for effective and consistent coverage, especially with no line of sight.

A second important issue was to reduce any potential runoff of surplus water on hill country. Matt does not want to waste water through mismanagement as he values the water resource he has. He is also sensitive to potential issues that can arise where surplus surface water runs off on a dairy farm removing sediment, nitrates and bacteria. Therefore he wants to minimise runoff and also harvest and reuse water through the use of dams. Environmental pressure on dairy farms is increasing in all regions and he wants to stay one step ahead of the regional council's requirements.

The third reason is the practical aspect of managing his labour resource. The GPS system allows all staff members to shift the K-line efficiently once they are trained. This will allow shifting to be less reliant on the one staff member. It will also allow Matt to check whether the K-line has been shifted and to track any problems that may occur.

Advantages

- The ability to accurately shift K-line on hill country.
- Minimise potential runoff from the irrigation and better use of available water.
- Better use of labour (more rapid placement of lines) and reducing the potential for mistakes.

Disadvantages

- The set-up time for the system was longer than expected.
- There is a requirement for some level of technological experience to utilise the system.

In summary, Matt sees the TracMap system as a valuable tool for the irrigation within his dairy operation. The TracMap system enables him to provide proof of placement maps if there are issues that arise around traceability or accountability. He will be looking to use the farm map option that is planned for the future as well.

Case Study 4: Tom Lambie – Using GPS in a long lateral irrigation system

Pleasant Point, South Canterbury: 310 ha organic dairy farm milking 600 cows, 280 ha irrigated.

The long lateral irrigation system has been in place on this property since 1999. These systems consist of hydrants connected to underground main lines with sprinklers then connected to the hydrants by a flexible 60 m pipe (the laterals). The sprinklers are shifted daily by the operator. Technically, the system on this property allows 18 positions around each hydrant, and there are 320 hydrants on the farm. It is a low infiltration rate system (3 mm/h) and over 65% of the water is able to be applied at night.

To obtain good uniformity, the sprinklers should be moved in a regular pattern and therefore performance is directly affected by where sprinklers are placed (McIndoe 2001). It is difficult to expect someone to shift and position sprinklers accurately by eye. This is exacerbated when there is more than one worker required to shift sprinklers. One misgiving of placing sprinklers "by eye" is the potential for both over and under watering.

Tom has been searching for a solution to this problem for 5 to 6 years and reached the conclusion that, because of the difficulties using a physical marker, the logical answer was some type of GPS. He already had experience, using GPS from having the farm mapped and the position of each hydrant marked.

GPS has been used to determine the best placement of the sprinklers for the most efficient water use. The TracMap system has a map identifying the hydrants and associated sprinkler positions and is mounted on a motorbike. Staff are able to locate a hydrant and move the sprinkler to the next identified position.

Advantages

- Accuracy of sprinkler placement.
- More even application of water.
- Potentially use less water as a result of the more consistent application depth resulting in less run off (Thomas *et al.* 2006).
- Better use of staff.

Disadvantages

- The system would be improved with better mapping on screen as it currently only shows reference points on the screen.

In summary, Tom has an efficient low application rate irrigation system that uses less energy (up to 20%) than travelling gun irrigators with similar capacity. Wells (2001) reported that low pressure systems such as long line laterals have a lower energy requirement than big guns or travelling irrigators. Barber & Pellow (2005) highlighted the potential savings from the use of night rate electricity tariffs. It is suited to rolling country or paddocks with irregular shapes. The main disadvantage is the high labour input to shift laterals and sprinklers and the difficulty of judging this accurately "by eye". The GPS system allows the sprinklers to be placed in the most desirable pattern with a high degree of repeatability, thus improving the efficiency of the system.

Discussion

Farmers are subjected to increasing pressure to improve the sustainability of their farm systems. Sustainable development can best be defined as a resource or system that meets the needs of the present without compromising the ability of future generations to meet their needs (WCED 1987). It is unlikely that current 'best farm practice' will deliver either the productivity gains that farmers, the industry and economy need, or that policy makers are seeking in areas such as water use and nutrient management. To this we can also add the 'traceability' requirements for chemicals and fertilisers as well as consumers desire to know that the food they are eating is safe.

It is therefore likely that farmers and researchers will look to developing and delivering new systems that can help maintain productivity levels while reducing the potential impacts of intensive farming. Precision farming is about applying all the inputs at the correct time, in the correct amount to the right location with the main objective to optimise resource use. Many researchers have shown that there are significant economic gains for crop production from the adoption of precision agriculture (Yule 1999).

Agricultural technology advances will be similar to other technology revolutions and there will be very rapid developments in the next few years. Agriculture needs to be positioned to benefit from these changes in the future. GPS will be one of the tools that farmers may use to meet both production and environmental targets in future. Technology will provide an opportunity for farmers to improve agricultural production with less resource. The case studies outlined in this paper show several opportunities realised by farmers adopting GPS technology on their farms.

Conclusion

As GPS technology has improved in accuracy and features, and the cost has reduced, pastoral farmers are finding applications where there are sufficient benefits to justify the capital and time investment of adopting their use on farm.

Improvements in the efficiency of their resource use, along with reductions in environmental impact, are areas where GPS devices may provide an effective tool for farmers to use. Examples of worthwhile gains are in:

- Water use efficiency.
- Fertiliser inputs.
- Vehicle navigation.
- Nutrient leaching.
- Farm planning and data recording.
- Labour utilisation.
- Environmental compliance.

As environmental constraints, traceability and sustainability of farm operations become greater issues in both growing and marketing agricultural product, then we can expect increased adoption of precision technology (including GPS) and more aligned research. As the technology continues to evolve, and farmer experience grows, more innovative and widespread use is likely to follow, resulting in GPS technology being an important tool on many pastoral farms in future.

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