Development of Controlled Traffic in WA and Future Directions Integrated with Precision Agriculture

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DEFINITIONS

In this discussion paper, 'precision technology' includes the equipment and systems considered in 'Tramline farming' (TLF), 'Controlled Traffic farming (CTF), 'Raised Bed farming (RBF) and 'Precision Agriculture' (PA), especially 'Variable Rate Technology' (VRT).

INTRODUCTION

For many growers and consultants there is a wide and bewildering choice of for precision technology, competing strongly with other current concerns of finance for machinery replacement, adequate farm size and the attraction of suitable staff. The choices some growers have already made may not have been the best, in hindsight. Costs of yield monitors, remote sensed images and variable rate equipment are also relatively less than many modifications and guidance systems required for controlled traffic or tramline farming. This has encouraged some growers to move into variable rate technology first; not necessarily the best choice for early improvement of farm profitability and efficiency. It is important to estimate the possible priority and sequence of the best purchases and changes. Grain growing in Australia is also challenged by an increasing frequency of dry seasons; assessment of the role of precision technology to best manage these circumstances is important to minimise financial risk for those considering adopting the improved cropping systems offered by precision technology.

BENEFITS OF CTF/TRAMLINE FARMING IN WA

Research in WA since 1997 has identified the following benefits to grain growing from CTF/Tramline farming :- (1) A more robust grain growing system; better grain yield and quality. (2) Less wastage of inputs by more precise driving. (3) shielded spraying option.
The size of these benefits and their relative contribution to net farm income for medium rainfall sandplain farming systems are summarised in tables 1 and 2; from Blackwell et al. (2003). **About 70% of net financial benefit comes from traffic control after deep ripping.**

Table 1. The grain yield and value from 9m wide harvester cuts for normal or controlled traffic after initial deep cultivation in 1997 at Mullewa, Western Australia

Crop (year)	Lupins(1998)	Wheat(1999)	Canola(2000)
Measured yield (Normal Traffic)	1.10	2.43	0.94
Measured yield (Controlled Traffic)	1.21	2.75	1.04
Benefit of CT over NT (%)	10	13	11
Benefit kg/ha	110	316	103
Average grain price at farm gate	170	172	313
Benefit $/ha (average = $35/ha)	18.7	54.3	32.4

Table 2. Potential net financial benefits of CTF, on a whole farm basis for WA, with 2000 ha of sandy soils and lupin/wheat/canola/wheat rotation in medium rainfall; 2003 prices

Source of benefit ($/ha)	Area applied to	Gross benefit Benefit x Area	Estimated cost $/ha	Net benefit $/ha/yr (%)
Traffic control (40)	100%	40 x 1 = 40	3.3#	37 (**69**)
Input saving (15)	100%	15 x 1 = 15	7.5 *	7.5 (**14**)
Fuel saving (3)	100%	3 x 1 = 3	Nil extra***	3 (**6**)
Weed control in lupins (30)	25%	30 x 0.25 = 7.5	1.5**	6 (**11**)
Total $/ha		65.5	12	53

average costs/ha of machinery track modifications from five case studies in WA.
* $15,000 p.a. for four years for dGPS autosteer on the 2000 ha property; minor cost to match widths.
** shielded sprayer worth $30,000 for 2000 ha of lupins over 4 years; autosteer already purchased..
*** machinery modifications already done for compaction control covers this cost.

Similar estimated gross margin benefits from the first year of CTF adoption have been calculated for other soils with clay or gravel dominated textures (Blackwell et al 2004a)
(4) Firm permanent tramlines and weaker soil between tramlines reduce power requirements for traction and cultivation. The measurements and records from paddock experiments and farm records showed **about 20% less fuel use by use of tramlines in No-Till** (Blackwell et al. 2004b). Figure 1 shows an example of the fuel savings from in-paddock monitoring of tractor fuel consumption.

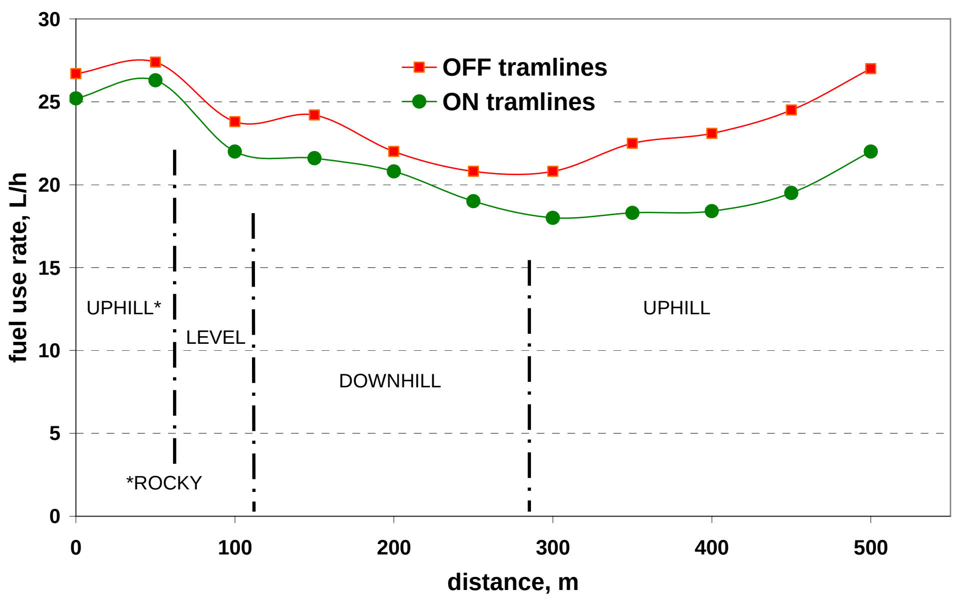

Figure 1. An example of fuel use with or without tramlines for a herbicide spraying operation at Minninnooka farm near Geraldton. The effect of slope on tractor movement is indicated, as well as the surface condition. Tramlines reduce fuel use by reducing rolling resistance.

Technical details on how to apply the principles of controlled traffic within a tramline farming systems and capture some of the benefits are described in a technical manual available from http://www.agric.wa.gov.au/pls/portal30/docs/FOLDER/IKMP/LWE/LAND/CULT/BULLETIN4607_PART1.PDF

Possible downsides of using such precision technologies may be:

- poor compatibility of tramline based field traffic layouts with surface water control structures and revegetation patterns in the landscape

- increased soil erosion risk when surface cover is low and the topsoil is compacted by grazing; especially gully development, when tramlines are across slope
- satellite dependence, risks of serious interruptions from downtime of navigation systems.

To capture these possible benefits and avoid possible downsides we need a broad understanding of the technical opportunities and costs of the new technologies and strategies to reduce risks and capture the best net benefits for each situation and in the best sequence.

An integrated view

This paper offers an INTEGRATED VIEW of all the new technologies by considering which ones offer the best early benefits, and which rely more on others to provide later benefits. Cropping area drives many of these total benefits from new technologies thus it easier for larger programs to repay higher costs of autosteer and smaller programs (often those who do not use hired drivers) to cover the costs of marker arms. Despite this, the benefits of better soil management and new ways of sowing or spraying between or in rows can still be captured, whatever the guidance technology chosen. Precision agriculture's benefits from farming zones differently with variable rate technology come from accumulated knowledge of paddocks; thus it is more sensible to plan that technology as a later development. A farmer in New South Wales was quoted in a meeting in 2003 as follows: "We started with yield monitoring, then went to variable rate technology then to controlled traffic. **With hindsight we should have reversed the order!**" This is a good indication that those in WA who move into the new technologies, or who are already partly involved, need to get the adoption sequence sorted out to ensure the best benefits. Peter Stone in "Do the sums to check precision pays it's way" Farming Ahead No 148 May 2004 pp 18-20 also concluded "When the benefits of reduced compaction and greater traction are added, tramlining is a more certain investment than the use of precision agriculture for fertiliser zone management".

The Figure 5 is a flowchart that proposes a pattern of adoption of precision technology for cropping in a beneficial time sequence. The proposed sequence begins at "apply to the whole farm" in the flowchart. A yield monitor and suitable steering guidance technology are the first purchases. The monitor allows an early start to collecting as much annual yield data as possible for multiple growing seasons; this will help later choices of where and when to apply soil amelioration and variation of inputs. The appropriate guidance technology is the foundation for the traffic control system and the 'platform' from which to apply novel agronomic techniques for appropriate benefits. Benefits of reduced driver fatigue, reduced wastage of fertiliser seed and fuel will be gained from this first stage.
Progress to investment in swath and wheel track matching will enable traffic control and with the guidance system provide the basis for the majority of technical benefits to crop production (from yield improvement, through greenhouse gas reduction to offset running benefits). Somewhere in this part of the sequence decisions may occur on specialist tools, such as bed formers and shielded sprayers, according to the relative importance of waterlogging control and reduction of weed control costs for each individual farm.

The yield variation data, as well as biomass data, acquired over the seasons since purchase of the yield monitor will then allow more precise identification of zones of poorer yield within paddocks. Visual Soil Analysis (VSA) and analysis for subsoil constraints (SSC) may then diagnose the cause of poorer yield and proscribe a suitable economic remedy; e.g. deep cultivation with some chemical stabilisation. When the major economically rectifiable constraints have been corrected, the remaining variation in productivity and gross margins will be largely due to differences in soil fertility and leaching potential. Then a sequence of paddock based trials will help identify how variation of inputs by VRT may better match the nutrient requirements of different zones, as well as accommodate the needs of different weed populations and disease risks. At that stage there will be no further challenges and there will be more time to relax!

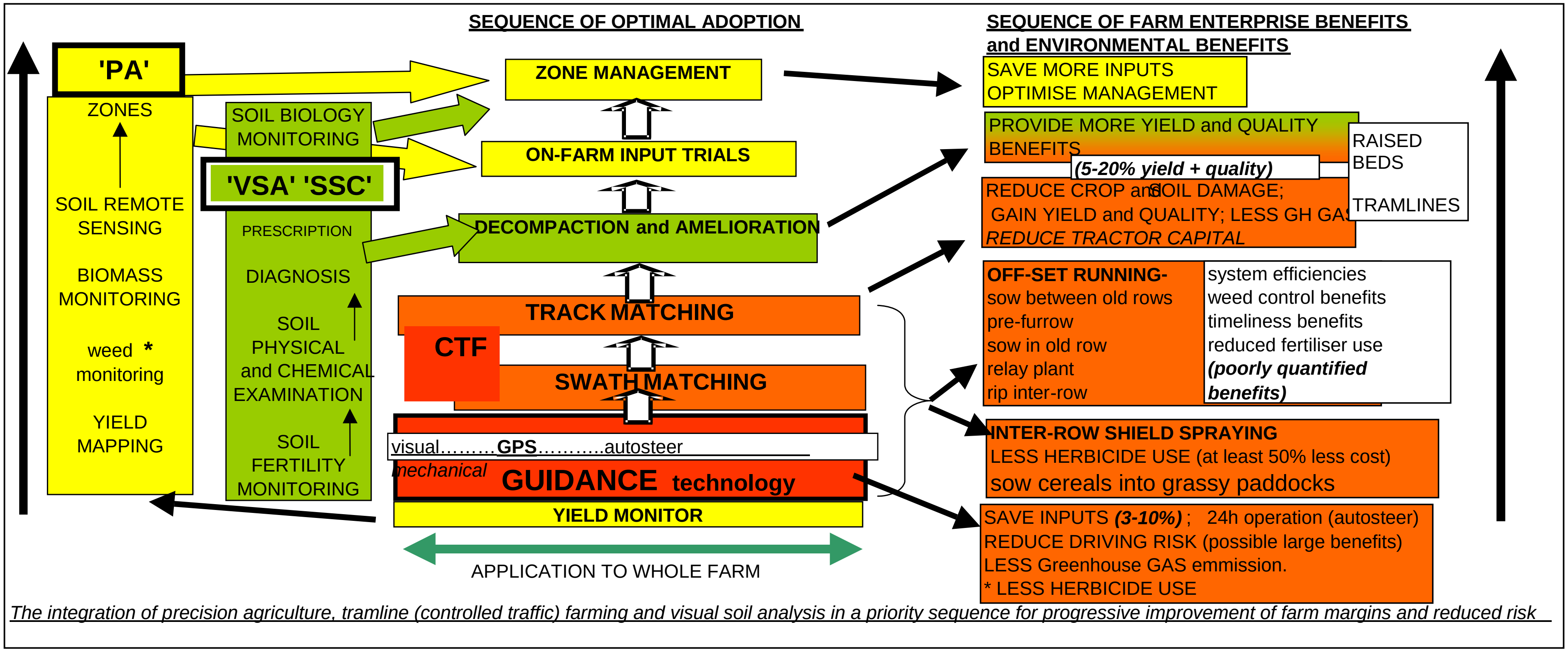

Figure 5. A flowchart showing the integration of Controlled Traffic Farming, Precision Agriculture and subsoil improvement

Better husbandry of the environment and carbon trading

Controlled traffic/tramline farming, precision agriculture and soil examination offers more than financial and risk management to the farm enterprise. More precise operations and the segregation into different zones (tramline, row, inter-row, 'soil type') allow the farm and regional environment to benefit from the following.

- Generally less herbicide and fertiliser use from managing paddocks in 'zones' of approximate soil types, as well as treating patches of weeds instead of the whole paddock with a herbicide; thus less opportunity for herbicide to drift into remnant vegetation and waterways.
- Less greenhouse gas production (CO_2 from fuel burning and N_2O from nitrogenous fertiliser losses in wet conditions) due to less fertiliser application with little overlap. Blackwell et al. (2004b) showed there was also a potential of 200 tonnes of CO_2-equivalent saved annually for every tonne of extra grain production by CTF (assuming an estimated 10% yield benefit on 2.5t/ha). These savings in emissions may attract carbon credit trading from other emitters of greenhouse gas to benefit the farm budget.
- Easier integration with in-paddock tree planting; with compatible matching between swath widths, especially odd ratio fits of sprayer to seeder.
- Possible integration with surface water control structures when broad-based banks are used with downhill tramline patterns; especially for raised beds. The downhill tramlines and furrows minimise overland flow concentration and the rollover banks (with good surface cover) minimise risks of high surface water flow rates.

Controlled Traffic for dry seasons

There is growing evidence that there is a shift in rainfall and evapotranspiration patterns in the northern agricultural region of WA towards less frequent and lighter winter rains combined with increased rates of evapotranspiration rates. We now have some evidence that the soils with low clay content can retain more plant available water for dry conditions when they are not as loose as possible, but firmed by a process such as rolling before seeding (Blackwell, 2005). A trial at East Binnu, NE of Geraldton, investigated the effect of pre or post seeding traffic on grain yield from a sandy soil in a dry growing season; 170 mm of winter rain in 2004. The results, in figure 3, confirmed the suspicions of some observant farmers that light compaction, or 'firming' can be beneficial to yield in a dry season for deep ripped sandy soils.

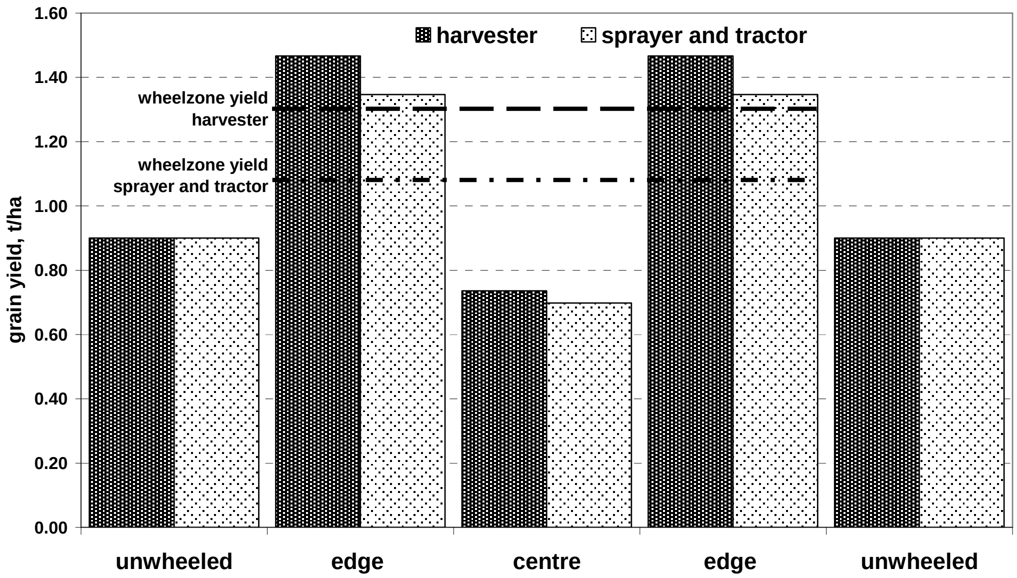

Figure 3. Effects on yield by traffic on deep ripped sand in a dry season. The harvester was used in the previous season, the sprayer before seeding. The 'wheel zone' is twice the wheel width and 'edge' measurements came from the unwheeled crop next to the wheelmark and half the width of the wheelmark. 'Centre' is the central 50% of the wheelmark

Compaction under the centre of cropping traffic wheelmarks, after deep ripping, reduced yield; even in dry seasons. 'Firming' from lateral forces alongside wheelmarks improved yield. Post seeding traffic and intense traffic from seeding plant was more detrimental and produced net negative effects on yield. Appropriate firming a loaded roller after deep ripping sandy soils and pre-seeding should help to improve yields from deep ripping and reduce yield loss in dry seasons. Coil packers may be too light to achieve this firming effect.

The most important current consideration of many farms in WA considering conversion to CTF is 'Will the investment in CTF be more profitable than the equivalent expenditure on improving work rates at seeding to help adapt to a drying climate?'

The number of days when soil is adequately moist for seeding declines as rainfall becomes less frequent and of smaller amount; especially when higher temperatures and stronger winds induce faster evaporation of available soil moisture. A cropping program faced with fewer seeding days needs a higher work rate to enable the same area to be cropped within the same calendar period and maintain the planned income potential. Higher work rates at seeding can be achieved by widening the seeding bar and increasing row spacing without increasing tine number; this enables the same tractor power to be used. Wider row spacing will also enable higher forward speed to improve work rate. If a work rate is increased by 20% then the grain production from each planting opportunity will be more than the increase from conversion to CTF (approx 10% at best in the first year). If the increased work rate also allows earlier planting of each paddock, there will be corresponding increases of yield from earlier time of sowing which may not be available from conversion to CTF. This analysis needs quantification in more detail, but is most likely to be a net benefit for investment in improved work rate, compared to investment in CTF, when rain events are fewer and the whole cropping program is difficult to achieve without improvements to work rate.

CONCLUSIONS AND FUTURE DIRECTIONS

To gain earlier financial benefit from precision agriculture and tramline farming, purchase guidance first (GPS autosteer or one marker arm), as well as a yield monitor, then finance machinery modifications to capture benefits of compaction control. Later, after some management of subsoil constraints and input trials, variable rate technology may be worthwhile to gain the most from 'precision technology'.

Environmental benefits may include potential for carbon credit trading.

Penalties from 'over loosening' sand by deep ripping in dry seasons in a CT system can be reduced by firming with appropriate rollers after deep ripping.

Caution is advised for investment into CTF for the drying climate of the WA wheatbelt; the same investment in improved work rate at seeding may be more profitable.

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