Assessing the whole-farm benefits of Controlled Traffic technology

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Abstract

Controlled Traffic (CT) technology confines traffic-induced compaction to permanently defined tramlines within a farm's cropping area. This technology improves trafficability whilst simultaneously supporting soil-structure improvement between tramlines, thereby raising crop yields and offering other advantages such as reduced overlap to save on crop inputs. This study uses whole-farm modelling to assess the profitability and role of CT technology in different farming systems. The whole-farm bioeconomic model, MIDAS (Model of an Integrated Dryland Agricultural System) is used to compare various farming systems that employ or do not employ CT technology. Stepwise analysis, combined with sensitivity analysis, is used to reveal the characteristics of CT technology that most affect its value. Results indicate that the most valuable aspect of the technology is its beneficial impact on the yield and quality of crops grown on soils most subject to compaction. Hence, on farms dominated by these soils and where the faming system emphasizes cropping, then CT technology forms an especially valuable role. For a typical farm in the study region, steady-state farm profit increases remarkably by over 50 percent through use of this technology. Hence, not surprisingly, this technology in various forms is beginning to be widely adopted.

Key Words

Controlled Traffic technology, farm modelling, farm profitability, innovation

Introduction

Studies of CT technology (Jochinke et al. 2007; Li et al. 2007;, Robertson et al. 2007b; Tullberg et al. 2007) indicate a range of benefits are generated. These benefits include:

(i) Reduced soil compaction and surface pooling that improves plant available water and facilitates root and crop production, while potentially decreasing erosion, waterlogging, run off and displacement of nutrients and agricultural chemicals (Raper 2005; Tullberg et al. 2007).

(ii) Compacted tramlines improve the timeliness of sowing and reduce tillage draft requirements (Rainbow 2004).

(iii) Reduced driver fatigue and an opportunity to employ less skilled drivers at lower cost.

(iv) Diminished overlap or underlap to generate input cost savings (Robertson et al. 2007a; Webb et al. 2004).Growers moving to CT report steady improvements in crop yields as the effects of compaction are reduced season by season (Lorimer 2008). Grain quality improvements have also been recognised, with less screenings in cereals and higher oil content in canola (Webb et al. 2004). The combination of these benefits may have whole-farm implications such as increasing the profitability of cropping relative to livestock enterprises which in turn leads to changes in the composition and management of a farming system. Most studies on CT, however, focus on paddock-level rather than whole-farm implications and often they mainly consider scientific or technical outcomes rather than economic ramifications (McBratney et al. 2005). Moreover, applying the results of CT studies from other regions such as Europe, North America or China to Australian broadacre dryland cropping conditions is a process that is fraught with difficulty (Tullberg 2008). The impacts of CT often have very different outcomes in Australian farming systems with their different soils, climate and farm size. For example, the impacts of CT may be different for Western Australian broadacre farms, which typically are large and contain less productive sandy soils.

Accordingly, for Western Australia where adoption of CT remains in its early stages, this study seeks to assess the profitability and potential role of CT in a whole-farm setting.

Methods

Farm modelling

MIDAS (Model of an Integrated Dryland Agricultural System) is a mathematical programming model of a representative farm. The version of MIDAS used in this study describes a 2000 hectare broadacre farm in the central grainbelt of Western Australia (Gibson et al 2008; Doole et al. 2009) that experiences a Mediterranean climate with an annual average rainfall of 350-400 mm. The model assumes a steady-state environment of average climatic conditions for the region and assumes the main motivation of farmer behaviour is profit maximisation. Other management preferences involving animal welfare, soil conservation and leisure are imbedded in the model's structure. The several hundred farming activities in MIDAS include alternative rotations on each of eight land management units (LMU) (see Table 1), crop sowing opportunities, livestock options, yield penalties for delays to sowing, cash-flow recording, machinery use and overhead expenditures. Constraints on activities include resource restrictions such as availability of land, labour and capital. MIDAS is described in a 60MB Excel? file linked through VBA routines to the solver Lindo?.

Table 1. Land management units (LMU) in the MIDAS model.

			LMU area (ha) in each farm type		
LMU	Name	Dominant soil type	Light land farm	Standard farm	Heavy land farm
S1	Poor sands	Deep pale sand	240	140	40
S2	Average sandplain	Deep yellow sand	310	210	110
S3	Good sandplain	Yellow gradational loamy sand	450	350	250
S4	Shallow duplex soil	Sandy loam over clay	210	210	210
S5	Medium heavy	Rocky red/brown loamy sand/sandy loam; Brownish grey granitic loamy sand	200	200	200
S6	Heavy valley floors	Red/brown sandy loam over clay; Red and grey clay valley floor	50	200	350
S7	Sandy surfaced valley	Deep sandy surfaced valley; shallow sandy-surfaced valley floor	150	300	450

S8	Deep duplex soils	Loamy sand over clay	390	390	390

CT in MIDAS

Costs of adopting a CT system generally lie under $40,000 (Tullberg et al. 2007;, Webb et al. 2004). Guidance costs can vary depending on suppliers and developments in technology so to ensure a conservative approach, a $35,000 investment was assumed which is at the more expensive end of the scale for a 2000 hectare farm. This cost included a 2 cm accuracy GPS system ($18,000), a 10 cm accuracy autosteer for the tractor ($10,000) (Webb et al. 2004), an annual subscription cost ($2000) to a satellite service (Knight and Malcolm 2007; Robertson et al. 2007a) and machinery modification costs to match axle widths.

Drawing on a range of data sources on the impact of CT in different settings, a conservative approach was adopted whereby use of CT was assumed to lift yields by 5 % on sandy soils (S1, S2, S3 & S7), 7 % on duplex soils (S4) and 9 % on clay soils (S5, S6 & S8). Improvements in grain quality, attributable to CT, have also been identified (Webb et al. 2004), with a reduction in screenings for wheat and higher oil contents in canola. Accordingly the chance of producing feed wheat was decreased by 2.5 %, with offsetting probability changes in other grades and the oil content of canola was increased by 1 % with resulting price increases for canola production. As several studies show input savings from more precise application average to be 10 % for fuel, seed, fertiliser and chemicals (Rainbow 2004; Robertson 2008; Robertson et al. 2007a; Stone 2004; Webb et al. 2004) this level of saving was assumed. Lastly, casual labour costs for seeding were decreased from $24/h to $20/h to represent the advantage of being able to hire less-skilled farm labour.

Results

The optimal cropping size for the standard farm with no CT was 1571 ha (shown by the thin vertical dotted line in Figure 1). This was compared to the same farm with CT at the same cropping size to determine what characterises the profitability of the CT system. The main revenue and cost items of the farm plans are compared in Table 2 and show the adoption of CT leads to additional revenue of $49,188, a $24,366 reduction in costs that together cause a gain in net revenue of $73,554 (or $46.82/ha of cropped area).

The key source of profit from adoption of CT is the increase in grain revenue, from increased yields and improved grain quality, particularly in wheat, followed closely by canola. Results are similar for farms with different LMU mixes. Sensitivity analyses on these factors found CT remains a profitable inclusion in farming systems. Despite decreases of up to 50 per cent in all the anticipated benefits, CT remained profitable, generating $35,568 additional profit compared to a farming system without CT.

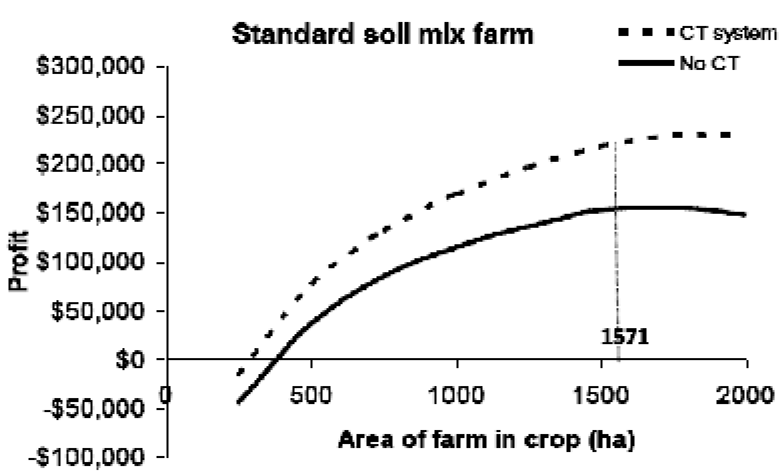

Figure 1. Profitability of a standard farm using CT compared to one without CT.

CT technology increases the overall profitability of cropping relative to livestock enterprises (Figure 1). Because cropping becomes more profitable to a greater degree on the heavier S8 and S5 soils than on lighter soils like S3 (where the benefits of CT are less) the heavy-land farm (Table 1) benefits more from adopting CT. Optimal use of CT involves a shift in the location of pasture on the farm; being taken off the heavy soils and concentrated more on the lighter soils that are less responsive to CT. Overall CT encourages farming systems to become slightly more crop dominant and thereby more profitable.

Table 2. Differences in revenue and costs per hectare for a farm using CT compared to one without CT.

	CT	**No CT**	**Difference in gross margins**
Grain Sale REVENUE	**($/ha)**	**($/ha)**	
Premium wheat	294	274	$ 19.41
Canola	16	0	$ 15.64
Malt 1 barley	18	9	$ 8.63
Malt 2 barley	6	3	$ 2.77
Field Peas	46	43	$ 2.29
GP wheat	15	14	$ 1.01
Lupins	27	32	-$ 5.27
Feed wheat	7	13	-$ 6.00
Feed barley	6	13	-$ 7.17
TOTAL REVENUE	$ 433	$ 402	$ 31.31
Crop & Pasture COSTS			
Fertiliser	87	93	-$ 5.92
Labour at seeding & harvest	34	40	-$ 5.91

Machinery operating costs	25	27	-$ 2.08
Herbicides	53	54	-$ 1.57
TOTAL COSTS	$ 198	$ 213	-$ 15.51
		Total Gain (per ha)	$ 46.82

Conclusion

In the broadacre farming systems of Western Australia CT is found to boost farm profit considerably, particularly in crop dominant farming systems. Annual profits are found to increase remarkably by over 50 per cent across a range of farm types. The key source of profit from CT is the increase in grain revenue (by $31/ha) generated by increased yields and improved grain quality, particularly in wheat, then canola. Almost two thirds of the profits attributable to CT are due to these revenue increases. Input cost savings were also important but not as significant. Sensitivity analyses on these factors found CT to remain a profitable inclusion in farming systems. Despite decreases of up to 50 per cent in all the anticipated benefits, CT remained a profitable inclusion in farm management.

CT causes cropping enterprises to become more valuable. Hence, the greater the size of the cropping enterprise, the larger the profit increases. The shift in the relative profitability of cropping causes whole-farm effects regarding enterprise selection and rotation choice on various soil types. Pasture becomes allocated on the sandier soils less responsive to CT. Cash crops such as cereals and canola become more profitable with CT and more of these crops are grown on clay soils that are more responsive to CT.

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