TRAFFIC AND COST REDUCTIONS UNDER BROADACRE CONTROLLED TRAFFIC

B.G. ROBOTHAM, Senior Research Officer, BSES, Bundaberg
P.A. WALSH, Senior Agricultural Engineer, QDPI, Toowoomba.

ABSTRACT

Two dryland farming systems, using reduced tillage and zero tillage practices, were examined to determine the potential benefits of broadacre controlled traffic. Wheel-track locations were calculated using computer simulations of the existing machinery and cropping practices.

Wheel-tracks accounted for 28% of the paddock area under large scale zero tillage and 40% under the smaller cropping system. Even at these low levels, potential benefit exist in converting to controlled traffic. Practical difficulties, particularly with respect to harvesting, do exist but the economic analysis indicates controlled traffic to be a viable option.

INTRODUCTION

Controlled traffic is a farming method that aims to separate the wheeled areas and the root-beds. This can lead to benefits in soil conditions for moisture storage and crop growth within the root-beds as well as for traction and trafficability within the wheeled areas (Marchenko, 1989). This paper looks at the potential benefits of controlled traffic in the context of two existing farming systems on farms on the Darling Downs and in Central Queensland in Northern Australia.

The benefits of controlled traffic that are of most importance to the farmers are the potential yield increases where compaction is eliminated and the possible reduction in energy and machinery costs when tyres consistently work on prepared traffic lanes.

Researchers have generally found yield increases when compaction due to wheel traffic has been eliminated. In reviewing research on crop yields under controlled traffic, Murray (1993) concluded from recent research that crop yield increases under controlled traffic were more than sufficient to compensate for loss of root-bed area to permanent wheel-tracks. Yield increases of between 0-10% could be expected under controlled traffic systems.

When compared to random traffic systems, researchers have consistently reported reduced implement draft. In summarising European controlled traffic research, Chamen et al (1992) reported implement draft reductions in all experiments. Tullberg (1988) reported reduced draft for tillage tools in soil that had not been wheeled compared to those working in wheel-tracks. Draft reduction ranged from 15% for firm soil to 55% for soft (previously tilled) soil conditions. He also reported chisel plough and cultivator draft reductions averaging 27% for replicated trials. Tullberg and Lahey (1990) reported reductions in machine draft averaging 40%. They also noted that greater draft savings were possible because it was not necessary to till so deeply in the controlled traffic plots.

The reduction in implement draft in controlled traffic systems is accompanied by an improvement in tractive performance for tractors operating on the compacted wheel-tracks. Murray and Tullberg (1988) and Lamers et al (1986) reported 8% and 13% improvement in tractive efficiency respectively when comparing tractors working on rolled traffic lanes to random traffic systems.

A third aspect of confining the wheel traffic to designated traffic lanes is a possible reduction in the frequency and depth of tillage required. Walsh (1994) showed evidence of disturbance and reduced porosity to a depth of approximately 500 mm below the existing soil surface for a single pass of a loaded grain harvester tyre. This work was conducted at soil moistures near the plastic limit for an alluvial silt loam, not unlike the conditions that may be encountered during a wet harvest in the Northern grain areas. It is readily apparent that such compaction is below the depth where it would be alleviated by ploughing under normal tillage operations. Additional tillage passes at increased depths may be the only alternative to accepting the deleterious effect of such wheelings on subsequent crops.

For the two example farms, this paper aims to clarify the potential benefits of controlled traffic by :-

- Identifying the machinery configuration and sequence of operations for example crops.

- Quantifying the wheel traffic involved in terms of numbers and locations of passes as well as the tyre pressures involved.

An attempt to quantify the possible benefits and costs involved in moving to a full controlled traffic system was undertaken for Farm One. Farm machinery was accurately measured and tyre sizes recorded. Tyre inflation pressures were recorded in an attempt to quantify ground pressures. Some inflation pressures recorded were considered excessive causing the tyres to be overly rigid. This information should be considered with the work of Smith et al (1994) where soil-tyre interface pressures many time the inflation pressure of rubber tyres were recorded. This notwithstanding, documentation of tyre inflation pressures allows some comparison of the relative ground pressure of the different machinery.

Implement width overlap was assumed to be 10% for the slasher and the harvester. Overlap of other machinery was reduced depending on the width and use of markers and guidance aids.

CURRENT FARMING SYSTEMS

It is important to note that the example farms and crops chosen for this exercise were not selected to be representative of farming systems and machinery currently in use. The selected farmers are considered leaders in adopting improved farming systems and machinery. The two farming systems have independently evolved to zero tillage or reduced tillage operation. The Central Queensland operation has a history of high initial energy usage, including a 391 kW four wheel drive tractor, but now both tractor size and operating hours per year have reduced. The Darling Downs farm was initially based around smaller machinery. The adoption of zero tillage and the benefit of increased cropping frequency have resulted in the original tractors being able to satisfy current cropping requirements.

The potential benefits of a full controlled traffic system may not be large for these farmers as, it can be argued, they have already progressed a considerable way towards this goal. However, and more importantly, it will be farmers such as these who are most likely to move to controlled traffic systems. Therefore it is important to quantify the potential benefits and problems which will drive and hinder this process.

Farm One

Tables 1 and 2 contain a broad summary of the cropping systems and the machinery employed for the two example crops on Farm One.

Table 1 Details of Farm One

Location	Central Queensland
Crop Area (Ha)	2000
Crop Type	Wheat
Preceding Crop	Wheat
Operation Sequence 1 (Reduced till)*	Spray -18m boom on truck
	Cultivate -16m cultivator (Steiger ST350)
	Cultivate
	Spray
	Plant 16.6m planter (D8 crawler)
	Harvest
Operation Sequence 2 (Zero till)	Spray -18m boom on truck
	Spray
	Spray
	Spray
	Plant 16.6m planter (D8 crawler)
	Harvest

* For this example crop only: the fallow was a very dry period and the number of cultivations and sprays during the fallow was reduced compared to "normal" conditions

Table 2 Farm machinery details for Farm One

IMPLEMENT	WIDTH	TRACTOR	TYRE SIZE	PRESSURE (kPa) for tyres or track
Heavy cultivator	16m	Steiger ST350	40x14 Compactor	200
Boomspray	18m	Truck mounted	9.00x20 Truck	350
Planter	16.6m	Cat D8	10.00x20 Truck	300
-	-	Steiger ST350	30.5LR32 Singles	105
-	-	Cat D8	Tracks 559mm wide	87 (Average)
Harvester			30.5x32	

Figure 1 Wheel-track pattern for Farm One, reduced tillage

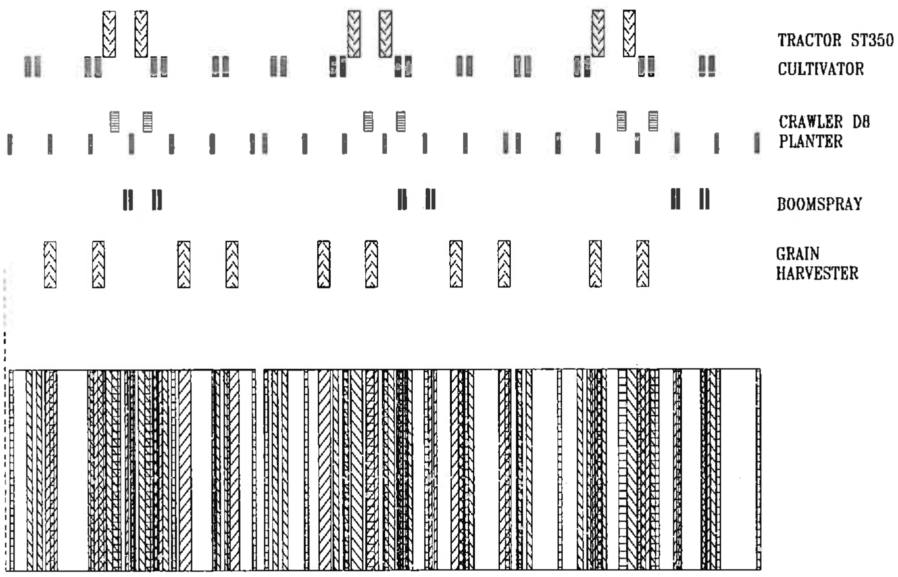
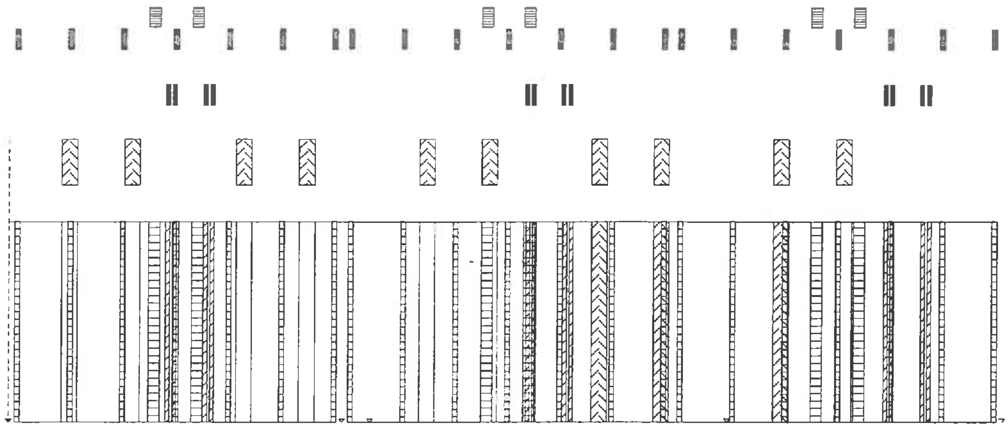


Figure 2 Wheel-track pattern for Farm One, zero tillage



Farm Two

The property is situated near Chinchilla on a brigalow cracking clay loam. The current owners moved onto the property in 1978 and were concerned with the high level of soil erosion. Strip cropping was introduced in 1984 and parallel contour banks introduced to control excess water flows. Zero tillage trialed in 1989 and the whole farm was converted to a zero tillage system two years later.

Table 3 Details of Farm Two

Location	Darling Downs
Crop Area (ha)	340
Crop Types	Wheat, sorghum or dryland cotton
Preceding Crop	Cotton
Operation Sequence (wheat)	Slash - after cotton only, 2 passes Plant - Multi-planter Spray - post-emergent herbicide 2 passes Harvest - New Holland 8080 harvester
Operation Sequence (cotton)	Plant - 3 point linkage, twin disk planter Spray - herbicide 2 passes (spray rig 1) Spray - insecticide 7 to 10 passes (spray rig 2) Harvest - 2-row International Harvester cotton harvester
Operation Sequence (sorghum)	Spray - herbicide 2 passes Plant - Multi-planter Harvest - New Holland 8080 harvester

A front wheel assisted tractor, John Deere 4450 (Tractor 1), is used for tillage and slashing operations. A small two wheel drive tractor, Fiat 750 (Tractor 2), is used for all spraying operations. Both tractors use similar width tyres at the same spacing. Current tractor usage is approximately 120 hours per year for the larger tractor and 220 hours per year for the smaller tractor..

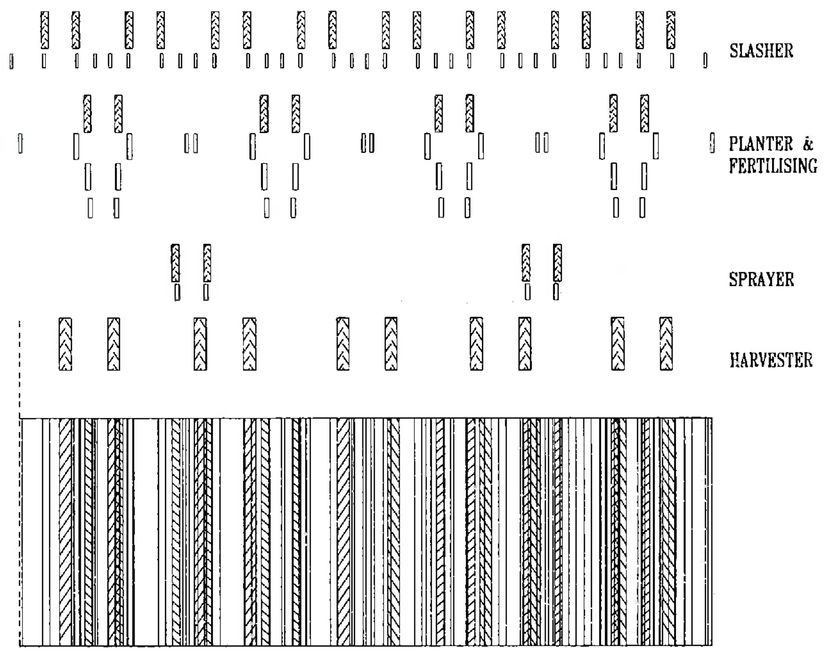
TABLE 4 Farm machinery details Farm Two

IMPLEMENT	WIDTH (m)	TRACTOR	TYRE SIZE	PRESSURE (kPa)
Planter	10.6	FWA	12.00R20 (inner)	275
			7.50x16 (outer)	200
Airseeder			12.4x24	200
AA Trailer			10.00x16	310
Slasher	6.1	FWA	6.95x14	210
Spray rig (1)	8.5	2WD	7.60x15	180
Spray rig (2)	21.2	2WD	10R15	200
Tractor (1)		FWA	18.4x38	100
Tractor (2)		2 WD	18.4x32	100
Harvester (grain)	9.14		30.5x32	180
Harvester (cotton)	2 row		18.4x38	200

The wheat and sorghum planting system has evolved into a one pass operation which places seed and the full fertiliser requirements of the crop. The planter comprises of the planter frame with planting tines and presswheels, a trailed seed and solid fertiliser airseeder and a one tonne trailed anhydrous ammonia (AA) tank. The N-jector tine developed by Robotham (1994) and Strong enables fertiliser placement during sowing occur without causing seedling mortality.

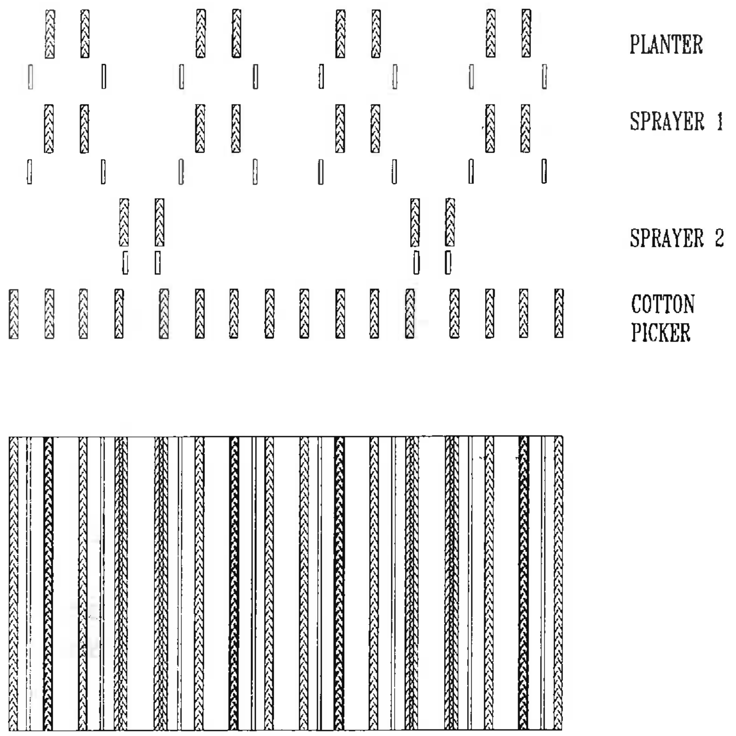
As sorghum is planted with the same planter configuration as wheat, only the wheat wheel-track pattern is shown. The wheel-tracks of the slasher could be deducted to determine the area wheeled during the sorghum crop.

Figure 3 Wheel-track pattern for Farm Two, zero tillage wheat



The cotton crop was grown under a twin row skip configuration with two rows of cotton being separated by a one metre gap. Each paired row is separated by a three metre gap enabling the insecticide rig to clear the fully grown crop. Cotton crop wheel-tracks, Figure 4, has been included to contrast the broadacre wheat cropping systems with a intensive but zero tillage row crop.

Figure 4 Wheel-track pattern for Farm Two, zero tillage cotton



RESULTS

Farm One

For farm one the two farming systems resulted in 55% of the area wheeled for reduced till and 28% for zero till. This assumed a consistent 5% overlap for all operations, as well as a single set of wheel-tracks for repeat operations such as spraying, and is therefore a conservative estimate of the area covered by wheel-tracks. By comparison, the controlled traffic system considered most achievable is based on wheel-tracks at 4 m centres. It would reduce wheeled area to 11.8% for the same sequence of operations for reduced till and for zero till. It is notable that the zero till wheelings are identical to the reduced till system in terms of the percent of the area wheeled for the example crop. Although the reduced till would have more passes on the wheel-tracks, the actual area of wheel-tracks would be the same.

A preliminary economic analysis of the long term benefit of a controlled traffic system for continuous wheat production on farm one was undertaken. The analysis used a spreadsheet based technique developed by Page and Walsh (1991). This analysis estimated cash flows to develop and set up a new system and produced yearly cash flows over the life of the project. Return or cost of the project is summarised as the Net Present Value (NPV) or the Internal Rate of Return (IRR) of the project. Straight line depreciation was used to estimate the cost of machine ownership.

Assumptions used in the economic analysis were as follows :-

1. The average (35%) of the estimates for draft reduction provided by Tullberg (1988) and Tullberg and Lahey (1990) can be achieved. The added possibility of shallower working should make this conservative.
2. Tractive performance will be improved by 10% or the average of the available estimates.
3. This will allow the Steiger tractor to pull a 32 m cultivator and planter as opposed to the current 18 m.
4. A 12 m grain harvester could be employed.
5. This wheel spacing could be matched to a 32 m boom spray, cultivator and planter, such that all wheeling were at 4 m centres.
6. Accurate marking out and tracking could be achieved.

The analysis indicated that cost of ownership and operation of machinery would be reduced by $19 per hectare for each crop. This only accounts for the reduced implement draft and improved tractive efficiency assumed above. No account is taken of the potential to increase yield due to reduced area compacted or other benefits of improved precision in controlled traffic systems.

For the 1 000 ha of wheat cropped on the example farm, the potential benefits translates to a Net Present Value of around $100 000 over ten years. Such a benefit would only be realised if the machinery required could be purchased as part of the normal machinery replacement program on the farm. Where this expenditure was required to be brought forward to the first year to initiate the controlled traffic program, the analysis indicates that the break-even point for such expenditure could be as high as $100 000. In other words, for 1 000 ha of wheat in Central Queensland, expenditure of $100 000 to convert to controlled traffic would be returned within ten years due to savings in reduced implement draft and improved traction only.

A similar analysis for the zero till area showed reductions in cost of around $7 per hectare due mainly to the use of a wider planter with the same tractor. This translates to a Net Present Value of $35 000 for 1 000 ha of wheat over ten years, based on machinery replacement as part of the normal on farm replacement system.

Farm Two

The wheat cropping system resulted in 51% of the paddock surface being wheeled. If the 6.1 m slasher, used twice to reduce the cotton trash, was not required the wheeled area would have reduced to 40%. Under cotton, 32% of the ground was wheeled. Cotton planting was the first and only tillage operation, therefore no tillage of wheel tracks was undertaken. Only 17.5% of the wheeled area was trafficked once and the wheel-tracks used for insecticide spraying received multiple passes plus one pass of the harvester. There is potential to better match the tyre spacings of the insecticide spray rig and tractor and the harvester.

The grower is quite happy with his current cropping system. Both the 10.6 metre planter and Spray Rig (2) were purchased in the last 12 months. With this purchase has come the potential for income through limited contract sowing and spraying. Purchase of a cotton mulcher would save one machine operation compared to the current slasher but a mulcher is considered an item which cannot be economically justified. The grower concedes that the planter and new spray rig are not compatible in terms of wheel-tracks but questions the cost and mechanical reliability of a 31.8 metre spray boom. As all crops are harvested by contractors, the grower has little input into harvester width, tyre sizes and wheel spacing. He believes the harvester to be the weak link in his cropping systems but sees no real solution in the foreseeable future. The grower did not consider the use of a gantry as probable solution for his farm.

CONCLUSIONS

The two example farms illustrate the importance of using realistic situations when comparing controlled traffic systems to current farming practices. The methodology used has enabled the potential benefits of broadacre controlled traffic systems to be identified and a dollar value placed on these gains. Because the data is based on real farm situation, further economic evaluation may assist farmers and researchers to develop economically viable controlled traffic systems.

The importance of using realistic cropping system data is clearly indicated by the crop rotation currently practiced on farm two. The common usage of planter and spray rig indicates a wheat and sorghum rotation would assist in the development of a controlled traffic system. But as the current returns of an average cotton crop are approximately four times that of a sorghum crop, economics determine that a row crop and a swath crop are often grown in rotation.

The use of low cost computer-aid-drafting (CAD) packages enables growers and researchers to examine wheel-tracks in real cropping situations and superimpose many what-if scenarios in a clear visible manner. Different levels of implement overlap or poor tracking of implement passes can be easily simulated. An additional examination of the cropping systems used on these two farms in 5 to 10 years time may show significant advancement towards the appropriate broadacre controlled traffic systems.

REFERENCES

Chamen, W.C.T., Vermeulen, D.J., Campbell, D.J. and Sommer, C. (1992). Reduction of traffic-induced soil compaction : A Synthesis. Soil and Tillage Research, 24 (1992) 303-318.

Lamer, J.G., Derdok, U.P., Lumkes, L.M. and Dlooster, J.J. (1986). Controlled traffic farming systems in the Netherlands. Soil and Tillage Research, 8 (1986) 65-76.

Marchenko, O.S., 1989. Optimising soil cultivation and seedbed parameters referring to soil conditions. In 'Land and Water Use'. Vol. 3. Agricultural Mechanisation. Edited by V.A. Dodd and P.M. Grace. Balkema Rotterdam pp 1507-1516.

Murray, J.R. (1994). Controlled traffic; a sustainable approach to agricultural land management. Dept. of Management Studies Research Series. Vol. 2 No. 1. University of Queensland, Gatton College.

Page, J.R. and Walsh, P.A. (1991). The economic evaluation of crop research proposals. Proc. Conf. Australian Economics Society, Armidale.

Robotham, B.G. (1994). Placement of Nitrogen Fertiliser at Sowing for Reduced Tillage Cropping nin Northern Australia. Masters Thesis, University of Southern Queensland.

Smith, B.E., Burcham, T.N., To, F.S., VanDevender K.W. and Matthes R.K. (1994). Mobile Soil-Tyre Interface Measurement System. Trans of ASAE, Vol 37(5)

Tullberg, J.N. (1988). Controlled traffic in sub-tropical grain production. Proceedings 11th Conference International Society Soil Tillage Research Organisation, Germany.

Tullberg, J.N. and Lahey, G.V. (1990). Controlled Traffic Cropping. Final Report to The National Energy Research, Development and Demonstration Program

Walsh, P.A. (1994). An Improved Soil Displacement Assessment System for Compaction Studies. Proceedings of the Conference on Engineering in Agriculture, Christchurch, Paper No. SEAg 94/050.