CONCLUSIONS FROM AN EROSION STUDY
RAINFALL EVENT - FEBRUARY 1997

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Introduction

Controlled Traffic Farming (CTF) might be expected to reduce soil erosion because:

- Permanent wheeltracks and implement furrows can be used to prevent concentration of overland flow, and to channel runoff rapidly to safe disposal areas, and
- Soil infiltration capacity will be improved, and runoff reduced with zero compaction and zero tillage.

The first of these mechanisms has aroused substantially controversy because it entails "downslope" rather than "contour " orientation of all farming operations. Disagreement occurs largely because the contour bank/contour operation philosophy applied in soil conservation extension for the past 50 years is apparently in conflict with the "downslope" systems used in CTF, where permanent wheeltracks and all farming operations are oriented generally parallel to the slope direction.

Severe storm activity occurred in February 1997 in areas of the Central Highlands of Queensland where some farmers were using CTF. The aerial survey and followup ground work reported here were carried out following discussion of interesting land management system effects on erosion in the Bauhinia/Moura and Biloela districts of the Dawson Callide, and in the Kilcummin/Clermont areas after these events.

Methods

During the aerial survey, large numbers of still photographs were taken of obvious erosion damage and management system response, and over 2 hours of video footage was recorded. Team members completed the subsequent on-ground measurements at several sites identified from the air, in order to quantify soil movement in relation to the photographic record. A snapshot of farmer rainfall records was obtained to supplement results from official gauging stations.

Soil movement was estimated using 100 m horizontal transects, recording width and depth for each rill. Early in the investigation soil loss calculations were based on a triangular rill shape, but rills were observed to be rectangular in most situations, so soil loss calculation was subsequently carried out on this basis, using transects midway down the slope length.

Results and Discussion

The aerial survey technique enabled rapid inspection of large areas of farm and pasture lands, and identification of major damage. The photographic record was particularly useful, although we also studied specific sites on the advice of growers. The record assisted in discussion of causal relationships between erosion damage and processes involved. This damage, which was observed on paddock after paddock, and on many farms, was caused largely by rilling, contour bank breakage and watercourse problems. Some of the results are summarized in Table 1.

Table 1: Summary of results -- rainfall events and return periods, management systems and soil movement:

RAINFALL	SITE	DISTRICT	ESTIMATED SOIL MOVED	
>400mm/ 6hrs 1:100 = 75mm/hr	Alluvial Stripping	Bauhinia	2000 ton/ha	up to 2500 ha
	Conventional	Bauhinia	<30% stubble cover	196 ton/ha 35 000ha
	Zero Till	Bauhinia	>70% stubble cover	80 ton/ha
>150 mm/1.1hr 1:100 = 75mm/hr 1:10 = 40mm/hr	Conventional	Kilcummin	>30% cover	60 ton/ha
	Controlled Traffic	Kilcummin	>30% cover	< 5 ton/ha
100 mm	Zero Till	Jambin	>70% cover	< no evidence of loss
	Controlled Traffic	Jambin	>70% cover	< 5 ton/ha

Rilling

This was clearly identified as the dominant process of in-paddock soil loss. Rilling occurred on all conventional (ie non-CTF) farming properties which received more than 100 mm rain, regardless of cover level. Rill frequency and width was probably greater on bare cultivated paddocks than on uncultivated paddocks (eg. 1996 wheat paddocks with over 70% cover), but rilling was severe even on these paddocks. Of the paddocks surveyed, 60% included contour banks which did not stop rilling, but prevented rills accumulating into gullies.

Rills are caused by runoff following implement marks or wheeltracks, and moving across slope to concentrate in the rill line. This process was clearly encouraged by contour cultivation, planting and harvesting. Contributing area is the key parameter. Most rills were shallow, occurring only to the depth of an apparent compacted layer. They were wider in bare cultivated soils, but strict comparisons were not possible due to the lack of rainfall data. Zero tillage appeared to have removed the compacted layer in the case of one paddock which had been in zero till for three years, and helped to convert overland flow into stream flow. Although the rills in this paddock were infrequent, they were up to 450 mm deep and more than 1m wide, making it almost unfarmable. In C.T.F. paddocks, no runoff concentrations occurred.

Broken Contour Banks

Contour breakage creates major gullies in paddocks which usually cannot be fully removed, particularly where the cascade effect of a broken top bank causes failures on an increasing scale down the slope. Bank failure often occurred at the point where the contour channel was restricted by the silt fan introduced by a rill. Where banks didn't break, the silt fans and their attendant pondage areas caused continuing difficulties with timeliness of subsequent operations.

The following considerations, and critical values of contour bank design parameters, have been written to incorporate the lessons learnt from this observation of bank performance in a situation where the rainfall event substantially exceeded those used in contour bank system design:

1. Water/Silt must be delivered uniformly along the full length of the bank - not by concentrated rills.
2. Contour banks need to be resurveyed and maintained to remove zero and reverse grades.
3. Contour banks must be up to specification and compacted to full design height.
4. Contour banks discharge ends must be clear of obstruction and have positive grade.
5. Systems must be protected from run on water, including that from houses, sheds, yards etc..
6. All system elements must drain positively, ie. rows to a safe discharge, contour banks to a waterway.
7. Bank maximum spacing (for rain fed systems)
   0 - 0.5% banks at landscape faults
   0.5- 1% banks at less than 1000 metres
   1 - 1.5% banks at 600 metres or less

1.5 - 2% banks at 400 meters or less
2.0+ % banks at major slope changes or less than 200m

It should again be noted that the Bauhinia rainfall event exceeded the one in a hundred return period every hour for 6 hours and the Kilcummin event was twice the one in a hundred return period.

Ineffective Waterways:

Constructed Waterways:
Waterways must have adequate depth. Seasonal events leading up to the event meant that shallow waterways were carrying large bodies of grass. This along with silt deposition and flows exceeding the one-in-ten design capacity caused many waterways to overtop and prevented contour banks being able to discharge freely. Soil loss from this process was very large, but impossible to quantify using this survey method.

Natural Waterways:
Follow up surveys found that natural depressions used for waterways were often not adequate to run water at design depth and this effect was compounded by grass and vegetation. In the Bauhinia area particularly, natural water course capacity was often exceeded, and alluvial topsoil stripping was estimated to have occurred on over 2,500 ha. at a rate of 2,000 tons per hectare. Landholders have seen this occur 5 times in the last 20 years (*McDonald per comm*) and are now questioning the sustainability of cropping on these highly productive areas.

C.T.F. and Down Slope System Performance:

The survey covered a number of CTF and conventional properties using downslope systems, allowing comparisons between neighbouring properties with the full support of most producers.

The results and differences were clear, unambiguous and observed repeatedly across all CTF properties. There was no accumulation of rills into gullies, contour channels were clear and there was no restriction to access or other effect on operational timeliness where CTF was used. Contour bank overtopping and breakages did occur along with ineffective waterways, but timeliness was affected only on small areas.

The outcome in three CTF paddocks is described here to provide compelling evidence for use of this system in erosion control. Where sites were recorded from producers working downslope:

1 Birch - With paddocks furrowed downslope, runoff was delivered to contour banks from defined elements (ie each furrow). The contour banks ran at or near capacity, but silt deposition occurred only at the leading edge of the channel leaving the full depth of the channel available to carry water. Soil movement was < 12t/ha.

2 Sanderson - Downslope layout, with no defined elements, but water moved downslope between crop rows and a little deeper in the wheel tracks. Soil movement was not measurable.

3 Durkin - Downslope lengths up to 650 m showed no significant soil loss - cover levels exceeded 70 percent.

4 Swifts - Downslope system; soil movement was less than 10 tons per hectare and contour bank channels free of silt fans, cover less than 30 percent.

5 Mathieson - This was an across the slope (contour) layout. Wheeltracks and rows carried water for about 300 m until these were over-topped, but soil loss was less than 10 tons on a per bay basis.

The conclusion that a design that prevents surface water concentration, particularly where furrows behave like a corrugated roof, appears to be sound. The CTF system was effective in preventing rill development and delivereed very little soil to contour structures, while maintaining trafficability.

Erosion Measurement:

The aerial survey technique is effective in the rapid assessment of damage from severe (over-design) rainfall events, where rilling is the major mechanism of damage in paddocks with adequate residue cover. In the Central Highlands of Queensland, these infrequent but catastrophic erosion events are arguably responsible for the major proportion of damage to crop lands. In this environment rilling is likely to become a key performance indicator for erosion control programmes, and of the downstream effects of agriculture.

We propose the use of aerial photographs to allow measurement of rill frequency and broken/silted contour banks, followed by ground truthing for rill depth and width as the basis for realistic performance indicators to explain the problems and potential solutions to individuals and groups of growers.

This aerial survey technique does not take account of all erosion processes, because sheet erosion, for instance, cannot be seen from the air. Soil deposition is also not easily detected from the air or from quick land traverses, and no attempt has been made to assess movement in terms of suspended and bedloads. The repeatability of soil loss estimation from ground traverses might be questionable, but the alternative estimation process of scaling-up soil loss measurement from instrumented bays to real life also involves many assumptions.

Conclusions:

The aerial survey technique was highly effective in providing a rapid assessment of erosion damage caused by over-design rainfall events in terms of data and photographic evidence that would be difficult to observe from the ground. The visual impression of erosion damage has also had a substantial and long-lasting impact on the work ethic of those involved. Data from the survey has demonstrated that:

1) The installation of CTF across the affected areas would have reduced in-paddock soil movement by at least 90 percent.

2) Contour bank damage would have been less of a problem in CTF. The other major benefits of better channel performance include access, trafficability and timeliness of operations.

The support of other team members, Don and Wayne, plus other Soil Conservation Officers is gratefully acknowledged. The support of landholders who helped with the survey despite recent experience of catastrophic damage to their properties and enterprises, was particularly gratifying.

A more extensive report on this material is contained in "Performance of Controlled Traffic Farming Systems in an Episodic Rainfall Event February 1997" (in print).