Making Controlled Traffic Work In Non-Parallel Contour Banks.

R.M. Mason [A], G.W Titmarsh [B], M.M. Sallaway [C].

[A] Dept. Primary Industries, PO Box 23 Kingaroy, Qld 4610.
[B] Dept. Primary Industries, PO Box 102, Toowoomba, Qld 4350.
[C] Dept. Primary Industries, PO Box 910, Bundaberg, Qld 4670.

Introduction

Permanent wide-bed systems are now common in the major cotton areas of the Darling Downs and Northern NSW (Lucy, 1993). This cropping area is well suited to permanent beds as the crops are grown on low sloping flood plains and in straight rows for flood irrigation. However, large areas of rain-grown crops are planted on sloping land where non-parallel contour banks have been constructed to control run-off water. The established benefits of permanent beds / controlled traffic in the irrigated cotton areas could also be true in other cropping areas if there was a system of managing parallel permanent wheel tracks in non-parallel contour bank layouts.

In the Burnett region of Southern Queensland, row crops have been grown within non-parallel contour banks for the past fifty years. Crops are planted in multiples of 4, 6 or 8 rows (3.6m, 5.4m, 7.2m) then managed until harvest in this same pattern. The introduction of single-spaced contour banks (this means on slopes greater than 6% there is a contour bank every 30m) produced some problems for producers who once prided themselves on straight rows. However, producers in the Burnett now successfully grow row-crop in non-parallel contour bank layouts using modified row layouts as explained later. A logical development for cropping in the Burnett is to leave permanent wheel tracks in multiples of 4, 6 or 8 rows as part of a controlled traffic program.

Row layouts are usually based on one of the following three layouts.

1. Traditional method. Up until the last ten years this was the standard technique of row cropping with non-parallel contour banks was to plant parallel to the top contour bank for most of the bay. It is then finished by planting parallel to the bottom bank. As the banks are not parallel there will be a number of short rows (or point rows) in the middle of the bay. The aim is to have most of the machinery turning above the contour bay channel so the tractors do not become bogged in wet periods (Figure 1).

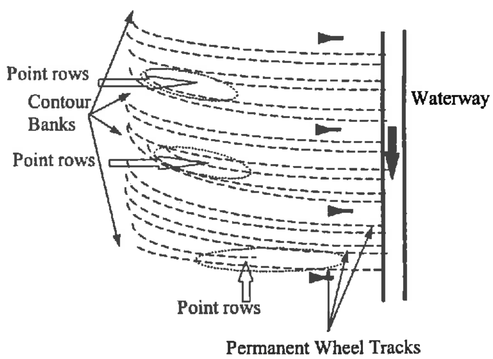

Figure 1 Traditional method of managing row crops in non-parallel contour banks.

In paddocks with steep slopes (greater than 6%) where there are narrow based contour banks this is the only option to plant a row crop. This layout has the disadvantages that up to 30 percent of the area is taken up with point rows. Weed control in the point rows is difficult and these areas act as a weed seed source for the following crop. When there is a run-off event the furrows tend to run in both directions and discharge at a low spot (which is often a rill from previous run-off).

2. Plant parallel to a paddock boundary ignoring the non-parallel contour banks. This method is only suitable on lower slopes where broad-based contour banks are constructed. The aim is to maximise row length and eliminate point rows. Row direction is determined by a paddock boundary and the contour banks are ignored and crossed at any angle.

This system has the major disadvantages of high contour bank maintenance (tillage machinery drags the contour banks down), and there is minimal surface detention as the furrows discharge directly to a contour bank channel. Modifications to machinery are required to allow adequate depth control of planting and tillage equipment and it may not be possible to direct harvest low growing crops, such as soybeans and navy beans because of the angle the rows cross the contour banks. There is also a risk in this system of high harvest losses in some years as the wet channel may delay planting or harvesting operations.

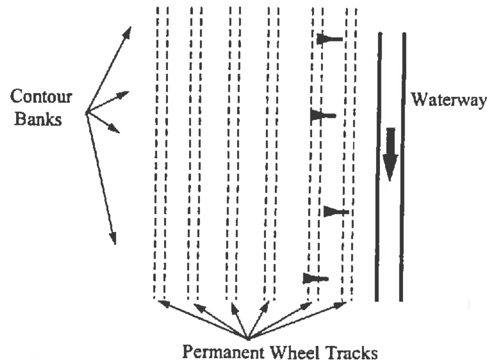

Figure 2 Choosing the longest row and planting the paddock parallel to this ignoring the contour banks.

3. Parallel furrows. In this system a key furrow is chosen across the slope so that it discharges directly to a contour bank channel or waterway. The paddock is planted parallel to the key furrow. The aim is to minimise the grade on the furrows but ensure they all discharge to the same end. The direction of water flow in the furrow may be the reverse of the flow direction in the contour bank and the furrows may be either straight or curved depending on the topography of the paddock. This has the advantage over the traditional method in that furrows have a continuous fall to contour banks and discharge into waterways. Similar to the previous system this parallel furrows system requires extensive machinery modifications, and restricts the harvesting of some crops. There is also a higher contour bank maintenance requirement but it eliminates point rows.

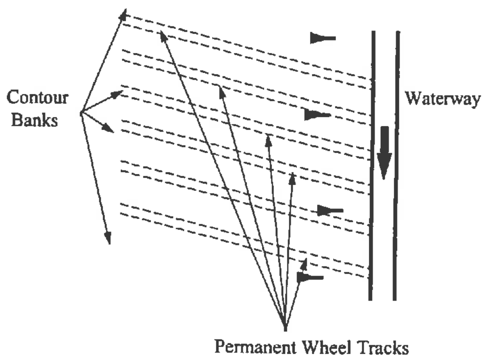

Figure 3 The rows and wheel tracks are designed to discharge directly to a contour bank channel or waterway.

Implementing controlled traffic using the three possible layouts

To maintain permanent wheel tracks through a fallow period and minimise the compacted area, sunken wheel tracks appear to be the most suitable solution. There is some concern that these sunken, compacted wheel tracks will channel water and lead to an increase in run-off and soil erosion.

This paper will look at the estimated run-off and soil movement from the three layout types for a range of land slopes, furrow gradients and furrow lengths.

Methodology

The effects of the three layouts on run-off and soil loss were simulated for a range of furrow length and gradients. Run-off was estimated using KINCON, a kinematic wave type model (Connolly et al., 1988). Soil loss was estimated using results from studies on a similar soil.(Sallaway et al. ,1994).

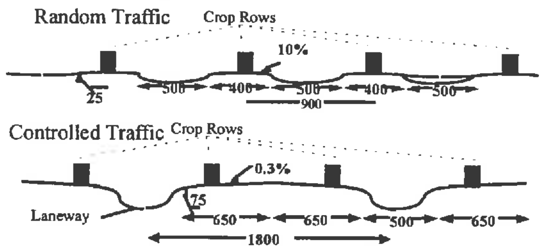

Figure 4 Cross-section and dimensions (mm) of beds in the traditional and controlled traffic systems.

Furrow shapes and dimensions differed between random and controlled traffic (Figure 4). For the traditional layout (Figure 1) furrow gradient was set at 0.3% (the same as contour banks) and furrow lengths used ranged from 30 to 150m. For second layout (Figure 2) furrow gradients are the same as the land slope. Here the furrow length is determined by land slope. Furrow gradient used were: 1%, 2%, 60m; 4% 40m; and 6%,30m. In the parallel furrow layout (Figure 3) furrow gradients ranged from 0.3% to 6% and furrow lengths from 30 to 150m. A range of land slopes up to 6% were also considered.

KINCON is suitable for evaluating the effect of alternative surface conditions on design of soil conservation structures. In the model different surface conditions can be allowed for in two ways: firstly, by alteration of infiltration properties; and secondly, by modifying flow retardance. Here only infiltration properties were obtained for the different conditions- a bare smooth surface was used in all cases (Manning retardance co-efficient of 0.035). The rainfall loss model used is based on a three layer Green and Ampt infiltration model (Brakensiek and Rawls, 1983; Moore and Larson, 1980). Some values of the parameters used in the simulations were obtained from Bridge and Bell, (1994) and are in Table 1.

Table 1. Parameters used in Green and Ampt Equation.

Parameter	Treatments		
	Conventional	CT furrow	CT bed
Ki	100	30	100
Kf	5	1	20
Za	150	150	1000
Ma	0.1	0.05	0.1
Mb	0.1	0.05	0.1
Md	0.1	0.05	0.1
B	0.95	0.95	0.95
Sa	250	100	200
Sb	100	100	200
RR	0.5	0.5	1
EO	250	750	750

In all cases the 1 in 10 storm of 25 minutes duration and 37mm was used. Stream power (units of Kg/s^3) was calculated from KINCON output on a minute by minute basis. Sediment generation rates for each minute were calculated using equations 1 or 2 as appropriate and summed to give a total sediment moved of the storm.

Random Traffic

$$\text{Sediment Transport Rate (g/s)} = 5.37 * \text{Stream power}^{1.66} \quad (1)$$

Controlled Traffic

$$\text{Sediment Transport Rate (g/s)} = 1.35 * \text{Stream power}^{1.86} \quad (2)$$

Results

Traditional and Parallel Furrow Layouts

Total Run-off. KINCON predicted only small differences in total run-off for the parallel furrow layouts (Figure 5). Furrow gradients had minimal impact on the amount of run-off above approximately 1%. There was a noticeable increase in run-off as furrow gradient increased from the lowest value (0.3%) to 1% for the longest rows. Generally, the controlled traffic (CT) treatments yielded less run-off. This was despite the wheel track area shedding 90% of the rainfall occurring on it. However this high run-off rate was compensated for by the higher infiltration(84%) in the bed area, which comprised the larger part of the field. If there was less area of compacted tracks throughout the

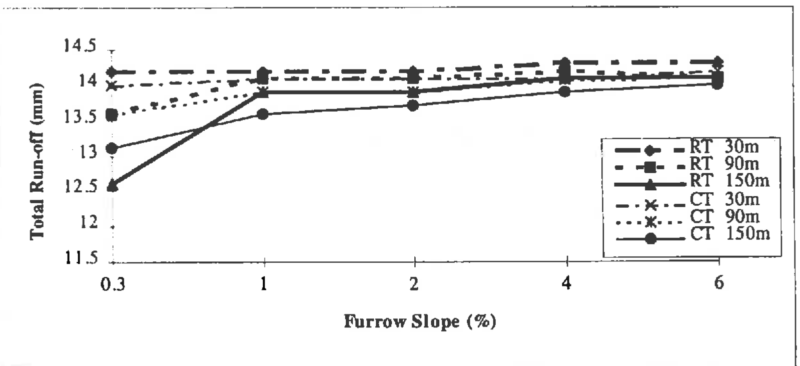

Figure 5 Simulated total discharge from furrows following a rainfall event of 37mm in 25 minutes.

paddock compared to bed area through wider wheel spacing there would have been less run-off from the controlled traffic treatments. The effect of row length is minimal for all furrow gradients above 1%.

Soil Loss As furrow gradient increased the amount of soil loss increased (Figure 6). The lowest soil loss was achieved when all furrows had a gradient of 0.3% (the traditional method). There was a higher rate of soil loss in the random traffic treatments at all furrow gradients and lengths. The length of the furrow also impacted on the estimated soil loss as the longer the furrow the greater the soil loss.

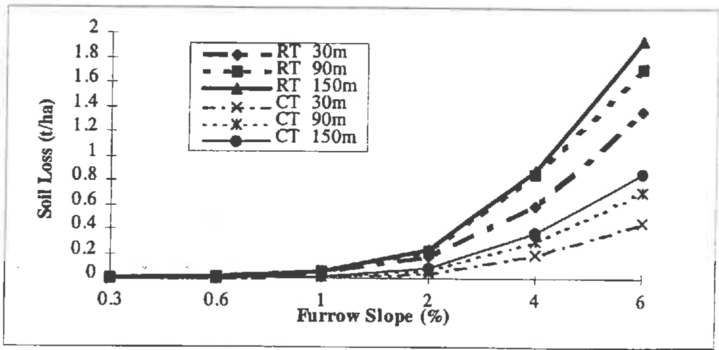

Figure 6 Total soil loss from a range of furrow gradients and lengths under random traffic(RT) and controlled traffic treatments (CT).

For furrows above 2% there is a rapid increase in the rate of soil loss from both the controlled traffic and random traffic treatments.

When Furrows run Parallel to Boundary Layouts.

If the furrows were positioned at right-angles to the contour bank (Figure 2) the furrow gradient is controlled by the land slope and the furrow length by the predetermined bank spacing. For both farming systems, as the slope of the furrow and the corresponding land surface increased the amount of run-off and soil loss also increased (Figure 7). This occurs despite the length of the furrow decreasing. as the slope increases. However for both run-off and soil loss the increase was less under controlled traffic situations than for random tillage.

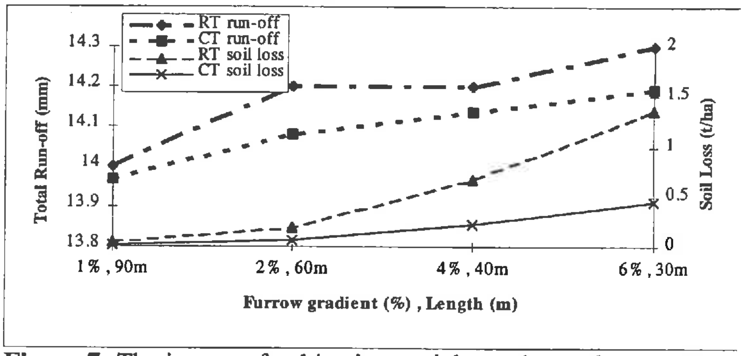

Figure 7 The impact of cultivating at right-angles to the contour bank in terms of run-off and soil loss.

Discussion

It is possible to implement controlled traffic using the layouts described in Figures 1, 2 and 3. The simulations show run-off and soil erosion would be minimised if all furrows had a gradient the same as contour banks at 0.3%. Reconstructing the contour banks to a parallel layout is an unacceptable cost to many producers and in many cases is not possible due to the topography of the land surface. Therefore they must use one of the 3 options and realise the limitations of each.

The case for CT using the traditional row-cropping layout

There is little option but to use this method on slopes greater than 6% or where contour banks are constructed in such a way that they can not be crossed with tractors and machinery. This system requires the least change to the current method of growing crops. By implementing controlled traffic the point rows will be identified before the crops is planted. The results from the simulations show that there will be less soil erosion (Figure 7) and run-off will not be increased (Figure 6) over the current system.

The limitation of this system is there is still the problem of furrows over-topping before they reach a safe disposal area (contour bank channel or waterway). This occurs because of reverse grades caused by previous wash lines, and changes in topography between contour banks. In most cases, the furrows themselves have sufficient capacity. On the red soils in the Burnett this appears to be the major cause of soil movement between contour banks. This may be improved by land leveling between contour banks or changing the gradient on the furrow so there are no reverse grades.

The case for crossing contour banks parallel to a paddock boundary.

This is the simplest method of implementing parallel furrows within non-parallel contour banks. As long as the cultivating and planting equipment have some flotation ability and the contour banks are large enough to have no steep batters it appears possible to "climb" over the contour banks.

The problems with this approach is that all though furrows may begin by crossing at right-angles at some part of the paddock the furrows are going to cross at an angle other than at a right angle. This poses problems for harvesting low crops such as soybeans and requires more complex depth control on the machinery.

Of more concern is that by adopting this type of layout there is an increase in run-off and soil loss (Figure 7). On lower sloping land (less than 2%) this system may be considered an acceptable compromise. However, in dry years yields may be reduced through less stored water. In the long-term concern of higher soil erosion under this layout which leads to a decline in productivity and higher contour bank maintenance. On the land slopes considered in this series of simulations controlled traffic again provided a significant reduction in soil loss and total run-off.

The case for parallel furrows

The concept of parallel furrows within non-parallel contour banks is not new. It was suggested in the 1950's as a method of reducing erosion in paddocks where the construction of contour banks would make row-cropping too difficult to manage. However, it was only recommended on land slopes less than 5% and where the soil had moderate to high permeability (Jones et al, 1959). Dickenson and Faulkner (1988) showed that parallel furrows could reduce soil erosion in a random traffic system. This study shows how controlled traffic combined with parallel furrows would reduce the soil loss even further.

Figure 7 shows a significant increase in the rate of soil loss as the furrow gradient exceeded 2%. At this slope furrow length had minimal impact on the rate of soil loss but as the slope increased the length became more important. In all cases the furrow gradient controlled the rate of soil loss rather than the land slope. This suggests that furrow gradients of less than two percent on paddocks with a land slope of 6% would provide an acceptable compromise between a parallel system of laneways within a non-parallel contour banks. If these furrows drain directly to the contour bank channel or a waterway there is potential to reduce soil erosion over the current traditional point rows. However, to achieve this planning is required to ensure the furrow gradients do not exceed 2% and there are no reverse grades within the furrow.

The system of parallel furrows requires more machinery adaptations to allow constant depth while crossing contour banks at an angle. In the Burnett there are no harvesting fronts that will allow the harvesting of low growing crops such as soybeans in the system.

Further work.

In all simulations it was assumed there was a bare fallow. The next step would be to examine the impact of cover on run-off and soil loss. In the controlled traffic layout used here it was assumed that there was a permanent wheel track/furrow at a maximum spacing of 1.8m. The results suggest that if there were less wheel tracks there would be less overall run-off but the furrow size may have to increase in capacity to safely convey the larger area contributing to the furrow. The shape of furrow may also impact on the rate of run-off and the total soil loss.

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