Does the Direction of In-field Controlled Traffic Affect Runoff, Erosion and Crop Yield?

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Controlled traffic farming is increasingly being adopted by agricultural industries to improve farming efficiency and manage the risk of soil compaction, runoff and erosion. Quite often to maximise field efficiency the longest run coincides with being parallel with the slope and this goes against the historical recommendation of farming on the contour to reduce runoff and erosion. This paper presents results from a long term field trial on a self mulching cracking clay soil (2000 to 2004) to examine the effect of a down slope and across slope controlled traffic layout on runoff, soil loss and crop yield. Runoff and soil loss was higher from the down slope layout compared with the across slope layout (40 v 30 mm/yr and 0.9 v 0.7 t/ha/yr). Crop yield was not affected by traffic layout.

Key words Controlled traffic, zero tillage, down slope, across slope, layout

INTRODUCTION

Controlled traffic farming is a system where traffic lanes are kept separate from plant growth zones. This enables soil compaction to be restricted in extent and managed and soil conditions for crop growth to be optimised. To maximise in-field efficiency the longest run is selected, which usually coincides with the longest fence-line. This results in traffic layouts occurring at varying angles across slopes and, if present, crossing contour banks at oblique angles.

To simplify layout it has been suggested that traffic direction should be down slope, which is a major constraint to adoption since previous advice has been to farm on the contour on sloping areas, to minimise runoff and erosion. Runoff will naturally flow down the wheel tracks, along cultivated sowing lines and crop rows. To manage runoff and erosion, in down slope layouts, all water must drain with no reverse flow or be retained in low spots and directed to a safe disposal area, such as a contour bank or grassed waterway, and all runoff within the traffic lanes, tillage furrows and crop rows must remain contained within these zones with cross flow being prevented (Yule, 1995).

Studies have shown that wheel tracks contribute to runoff and erosion on sloping land, with the amount varying depending on slope, rainfall intensity, surface cover and surface management (Reed, 1986; Basher and Ross, 2001). To reduce runoff and erosion it has been suggested that traffic layouts should go across the slope or that traffic lanes be cultivated to slow water movement (Reed, 1986). These practices may be impractical to implement and to some extent compromise the benefit of controlled traffic in the first instance; field access at appropriate times for weed or insect control.
This work was undertaken to provide further insight on the direction of controlled traffic on sloping ground to enable informed decisions with respect to layouts and the potential for runoff and erosion.

MATERIALS AND METHODS

A long term trial was established north of Emerald in central Queensland on the property Moonggoo (S23.15763^0, E148.05545^0). The site consisted of a 230 ha paddock which was divided into two cropping frequency treatments (opportunity cropped outside traditional planting window, south paddock and conservative cropped within traditional planting window, north paddock), each of which was divided into two direction of traffic treatments: 1). controlled traffic down slope (DTS) and 2), controlled traffic across slope (ATS) with both treatments being zero tilled. The average slope within the DTS treatment was 1 - 2 % while that for ATS treatment was 1 %. The cropping sequence for the trial is shown in Figure 1.

The soil at the site is a self mulching black vertisol (Isbell, 1996) with some typical properties shown in Table 1. Runoff was measured through flumes installed at the outlet of each contour bay, with water height being recorded using a data logger. Pump samplers were used to automatically collect water samples for sediment analysis. Pluviometers were located adjacent to each treatment with data being logged on a daily basis. Greater detail is provided by Rohde et al (2000).
No statistical analysis is possible since treatments were not replicated as only one bay for each treatment was instrumented. Data was collected from 2000 to 2004.

Table 1. Typical soil properties for the soil at Moonggoo (after Irvine 1998).

Parameter	Surface	Subsurface
pH	8.0	8.4
Exchangeable Na (%)	0.6	1.7
Electrical conductivity (mS/cm)	0.06	0.1
Clay content (%)	67	74
Plant available water (mm) (0-0.9 m)	170	

RESULTS AND DISCUSSION

Total annual rainfall exceeded the long term average in 2000 (946 mm v 579 mm) with all other years being below the long term average. There was no runoff or soil loss from any treatment in 2002 or 2003. With one exception runoff and soil loss from the DTS treatment was greater than that from the ATS treatment in all years (Figures 2, 3, 4 and 5). This is consistent with the findings of other research (Reed, 1986; Basher and Ross, 2001; Titmarsh pers. comm.., 2006). The exception occurred in 2004 where extensive rilling occurred resulting in greater runoff and soil loss from the ATS treatment (Figures 3 and 5). However, in contrast Rohde et al (2000) and Stevens and Collins (2000) found that, on a duplex soil, across the slope layouts produced greater runoff and greater soil loss compared with a down slope layout. For all years of measurement the conservatively cropped treatment (Figure 2 and 4, north paddock) resulted in less runoff, which is contrary to previous work (Carroll et al, 1997), and soil loss compared with the opportunity cropped treatment (Figure 3 and 5, south paddock), with the exception of 2000 where the reverse was the case. Also, in 2004 for the opportunity cropped area greater runoff and soil loss occurred from the ATS than from the DTS area (Figure 3 and 5), which is similar to the findings of Stevens and Collins (2000). This result needs to be put into context in that the preceding crop was chickpea, which provides very little stubble to protect the soil surface. The effect of stubble cover can be inferred from runoff and soil loss. When wheat was a preceding crop the amount of runoff and erosion was reduced in the following year, compared with say sorghum or chickpea, where stubble levels were not as great and losses were larger. Mean soil loss was greater from DTS compared with ATS for all years with the exception of 2000 where the reverse was true (data not shown). The results show the variable nature of runoff and soil loss events, with greater losses occurring during periods of high rainfall. The mean annual runoff was 40 and 30 mm per year and mean annual soil loss was 0.9 and 0.7 tonnes per hectare per year for DTS and ATS. The greatest soil loss of 2.9 t/ha, occurred from DTS in a year of high rainfall (Figure 4). We speculate that the majority of runoff was generated from the wheel tracks, but it was not possible to differentiate runoff from particular zones in this trial. This is something that needs to be addressed in future work, as it should be easier to control runoff from the tracks compared with the whole paddock.

Crop yield was not adversely affected by the direction of layout (Figure 1). There was a slight depression in yield for the ATS compared with DTS for both conservatively cropped and opportunity cropped areas. However, yield tended to be lower under opportunity cropping than under conservative cropping, but it should be noted that different crops were grown in each area (Figure 1).

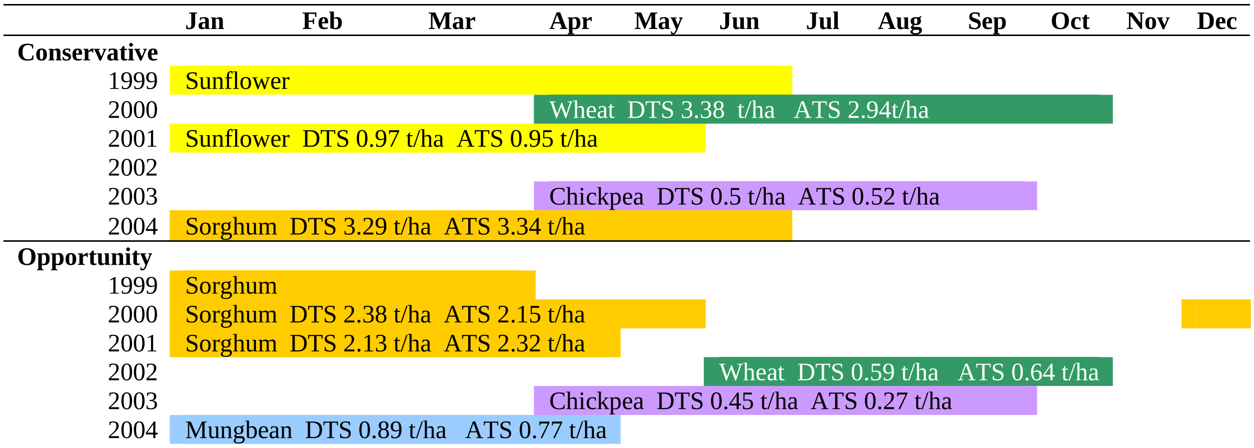

Figure 1. Cropping sequence and yield (t/ha) for the trial from 1999 to 2004

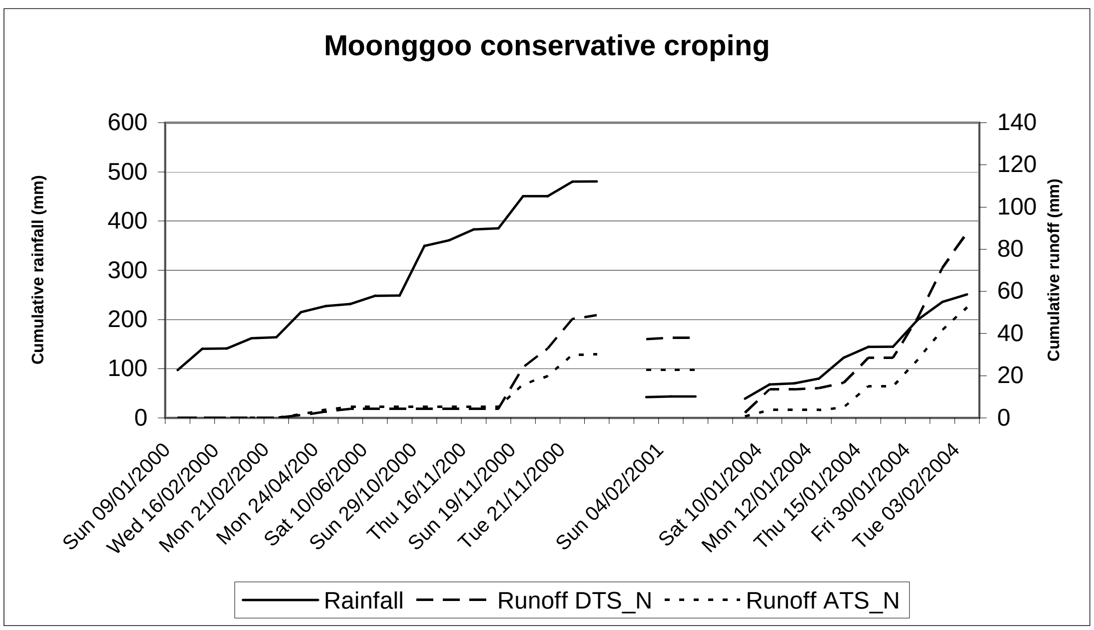

Figure 2. Cumulative runoff (mm) from conservative cropped DTS and ATS from 2000 to 2004

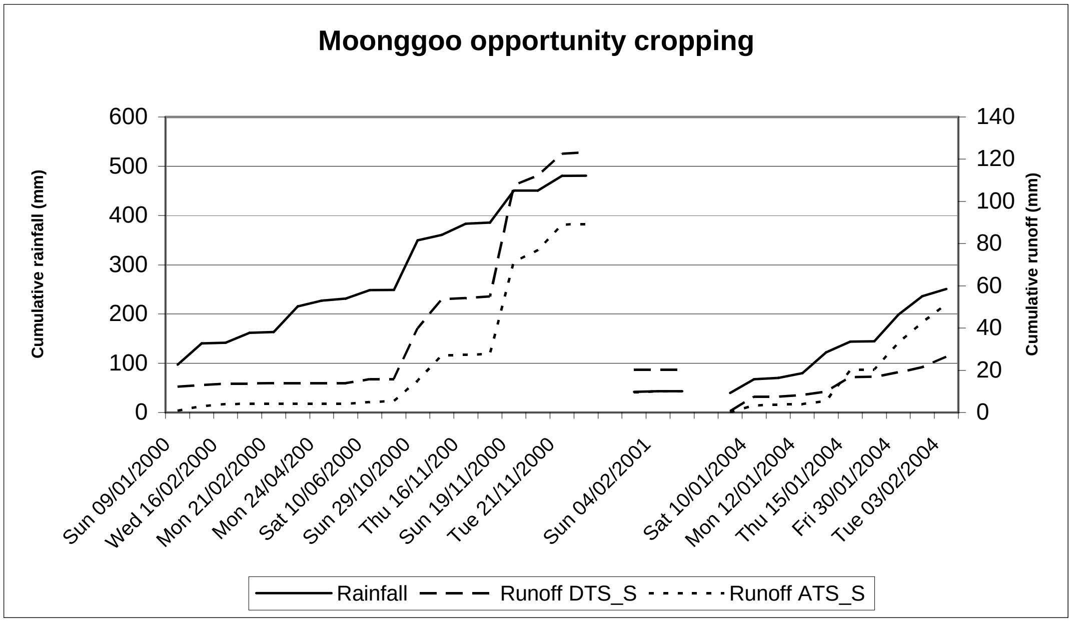

Figure 3. Cumulative runoff (mm) from the opportunity cropped DTS and ATS from 2000 to 2004

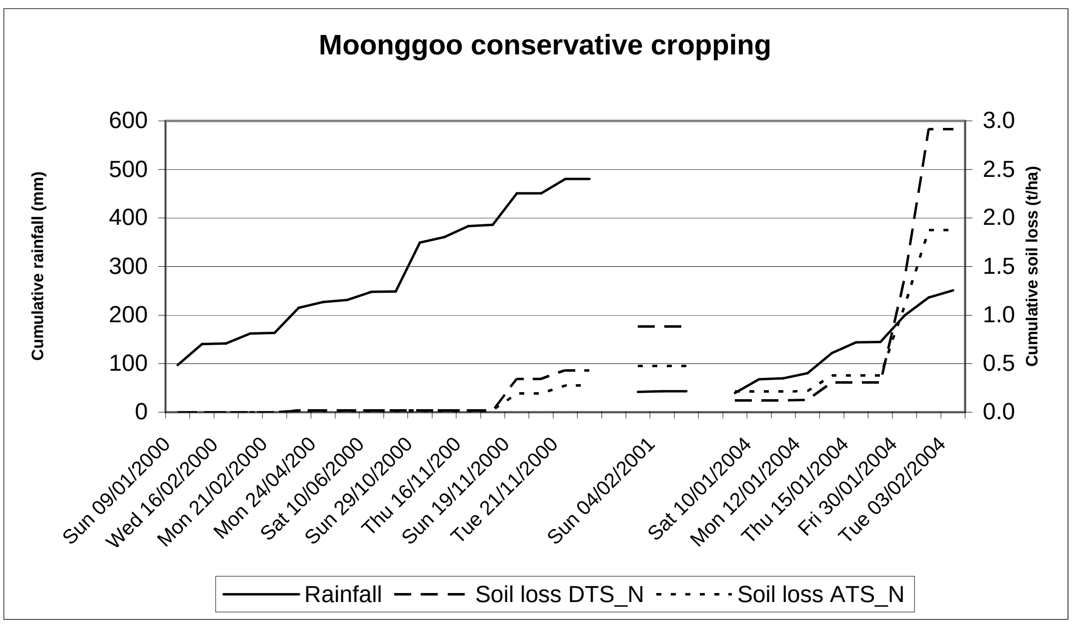

Figure 4. Cumulative soil loss (t/ha) from conservative cropped DTS and ATS from 2000 to 2004

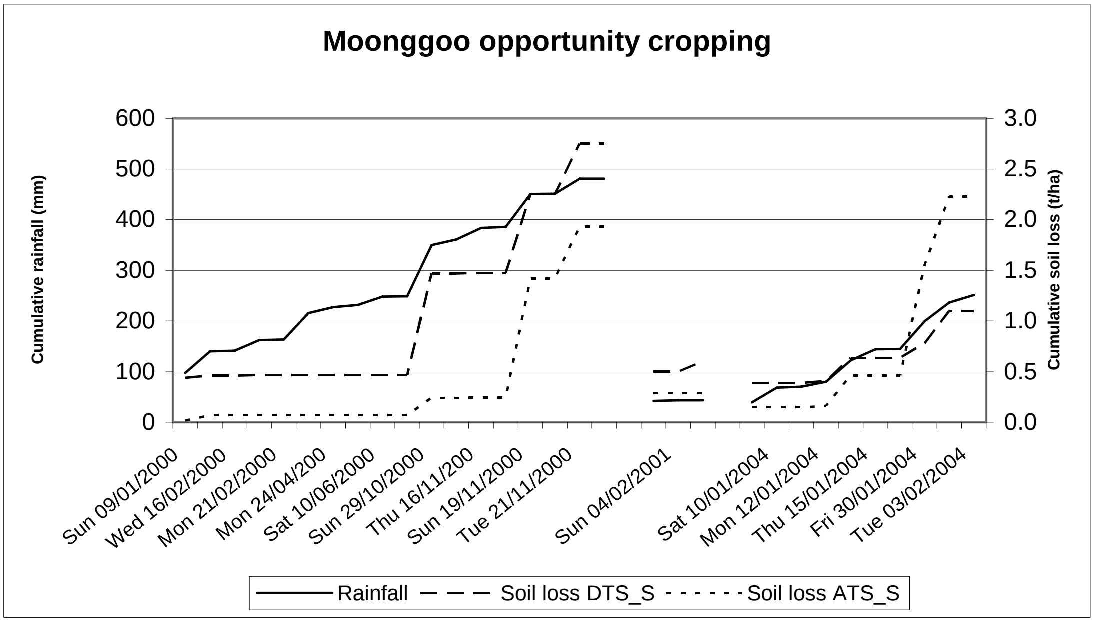

Figure 5. Cumulative soil loss (t/ha) from opportunity cropped DTS and ATS from 2000 to 2004

The amount of runoff and erosion will depend on many factors such as rain intensity, antecedent soil moisture, slope, length of slope and amount of stubble cover. Each factor needs to be considered in deciding a direction of traffic and perhaps a compromise taking all into account will be the longest run notwithstanding that this may be down slope.

It should be remembered that the monitoring occurred during a dry period compared with the long-term average rainfall, which contributed to the low runoff and soil loss. However, even under these circumstances the direction of controlled traffic had an effect on runoff and soil loss, with more runoff (40 v 30 mm) and soil loss (0.9 v 0.7 t/ha) occurring with down slope orientation compared with across slope layout. Runoff and soil loss was greater in higher rainfall years. Direction of traffic layout had little effect on crop yield. Further work should be undertaken to identify where runoff and erosion originate from within controlled traffic systems to aid in remedial measures.

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