Wheeltrack Compaction Effects on Runoff ,Infiltration and Crop Yield

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1. INTRODUCTION

In Queensland, conservation tillage practices have been widely used in an attempt to optimise sustainable rainfed grain production in an environment where soil degradation is a problem, and moisture is limiting.

Conservation cropping with reduced tillage and maintainance of surface mulch has beem shown to reduce runoff and erosion. However, under zero tillage some of the positive effects of conservation practices have, to some extent been negated by the harmful effects of compaction caused by random wheel traffic. In traditional cropping systems, these effects are removed in the surface layers by regular tillage. This is not the case in many conservation tillage systems.

A recent major review of soil compaction in crop production concluded that amongst soil properties affected by soil compaction and related tillage, perhaps least is known about soil hydraulic properties(Horton et al. 1994). Young and Voohees(1982)demonstrated that wheel traffic influenced a number of soil properties which in turn affect runoff and erosion. Tullberg and Lahey(1990)provided some evidence of controlled traffic effects on infiltration, and the results of a pilot trial by Tullberg and Ziebarth(1994), demonstrated that traffic had a major effect on infiltration and runoff rates under irrigation.

The object of this trial was to investigate the effect of wheel traffic on runoff, infiltration and crop yields in a rainfed grain production system with different tillage and trash management practices.

2. MATERIALS AND METHODS.

Statistical design included four complete randomised plots of three tillage/residue treatments (zero till, mechanical minimum till and conventional or stubble mulch tillage) each split into compacted and controlled traffic plots. All plots were worked with a tractor (J.D. 4040) modified to give a track width of 3m, so providing a non compacted 2.5m 'bed'and a highly compacted 0.5m 'wheeltrack'. Furrowers positioned behind the tractor front wheels were used to move soil out of the wheeltrack, and ensure these were depressed 100mm below the level of the beds.

Plots were 30m long, positioned diagonally across a 10% slope so that the runoff from each plot was channelled via the depressed wheel track to 6L tipping bucket runoff gauges(Ciesiolka and Coughlan 1995).

The soil was black earth, a self -mulching Lawes series clay overlying a friable B horizon with sand lenses at 1.2-1.5m. Before installation the plot area was ripped to a depth of 0.45m. Compaction treatments were applied four days after the application of 50mm of irrigation in June 1994.

Compaction was carried out by three runs of a working 100 kW tractor with a rear axle mass of 60kN on single 18.4 x 42 tyres at 100 kP pressure. 'Work' was a drawbar load of 25kN provided by the 3m tractor travelling in the wheel tracks. This operation served to simulate the normal and shear loads applied to the soil by a working medium weight tractor, so the complete 'bed' area of each compacted plot (approximately 2.5m wide) experienced compaction treatment by a 30kN wheel applying a 12kN horizontal force . This appears to be more uniform, but otherwise similar treatment applied to fields in stubble mulch opportunity cropping system, where an area exceeding that of the crop is trafficed by tractors after rain ,each year.

Simular treatments were applied to all plots to allow planting of the initial winter crop. Planting was carried out using a 2.4m 'agroplough' tine planter for winter crops. Summer crops were direct planted into zero till plots with an experimental planter using 'Jahnke' knife tines. The same planter was used in other plots after the minimum mechanical till plots received one tillage treatment with a spring tine scarifier, and stubble mulch plots received three such treatments.

Wheat was planted in July 94 and harvested in November, strategic irrigation only being used to ensure establishment in very dry condition. No further compaction treatments were undertaken before sorghum was planted in January 1995, again after irrigation to allow planting. At this stage wheat residue levels were approximately 2t/ha in zero till plots and 1t/ha in mechanical till plots. Sorghum was harvested in June. The runoff measuring system was installed by October 94 on all plots. Neutron probe tubes were installed prior to the sorghum being planted and were read on a weekly basis until after harvest.

3. RESULTS AND DISCUSSION

a) Runoff and Infiltration

No natural runoff events occurred between September 1994 and February 1995, when sorghum was planted in the plots after the completion of tillage treatments, and a light irrigation of 20mm was applied. In the absence of natural rainfall, irrigation was applied on the 9th February to simulate rainfall and produce a runoff event. A number of natural runoff events occurred between 12 February and 9 March, providing a range of rainfall intensities on the plots at different levels of soil moisture content. These results are summarised in Table 1.

The same information is illustrated in Figure 1 ,but the tabulated data includes corrections made for a number of errors in the original data, occurring as either blockages to tipping bucket units, or overland flow breaking through the diversion bank at the top of one set of plots during one high intensity event. Figure 1 illustrates one instance of this where the runoff from the compacted MT treatment with (1T/ha of residue) was 20% greater than any other treatment.

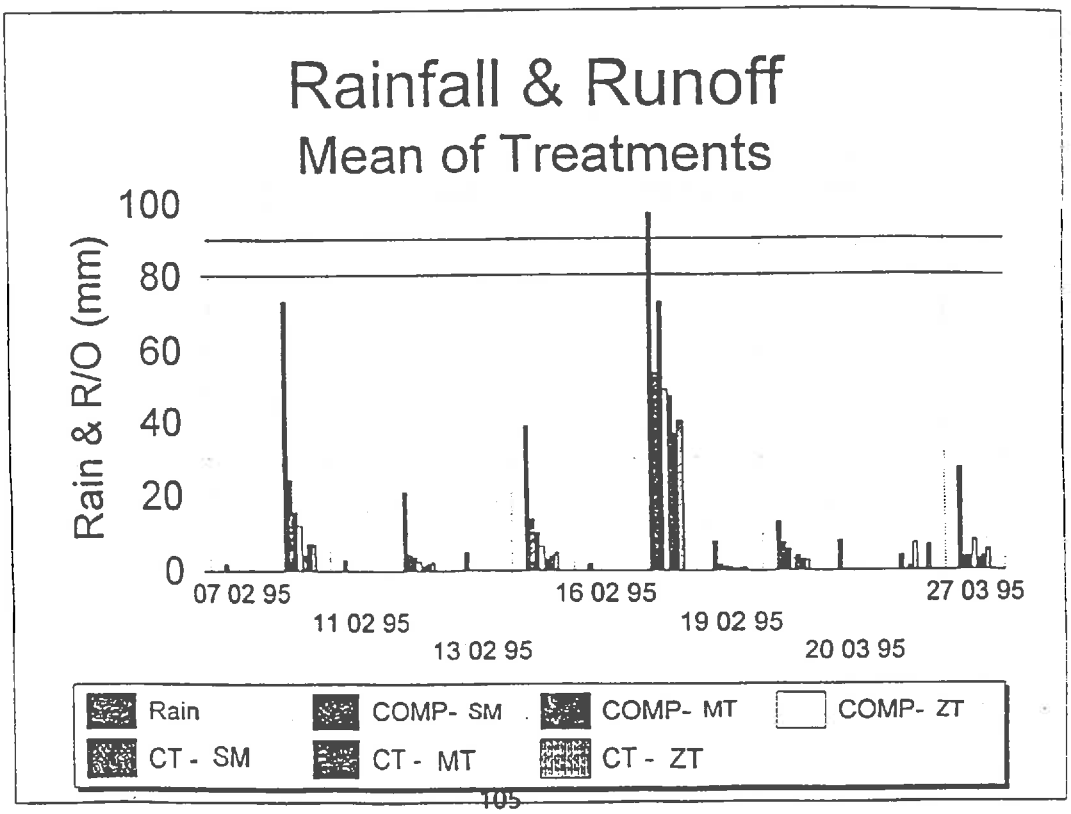
Table 1 **Rainfall and runoff on compacted and controlled traffic plots under different tillage systems (corrected figures) SM - Stubble Mulch MT - Minimum Tillage ZT - Zero Tillage**

			Runoff in mm												
			Compacted Plots						Controlled Traffic Plots						
			SM		MT		ZT		SM		MT		ZT	
Date	Rainfall														
	Event	Total	Event	Total	Event	Total	Event	Total	Event	Total	Event	Total	Event	Total
7/2	2	2	0	0	0	0	0	0	0	0	0	0	0	0
9/2	73	75	19	19	21	21	12	12	4	4	10	10	7	7
11/2	3	78	0	19	0	21	0	12	0	4	0	10	0	7
12/2	21	99	5	24	4	25	3	15	1	5	2	12	2	9
13/2	5	104	0	24	0	25	0	15	0	5	0	12	0	9
15/	39	143	14	38	10	35	7	22	3	8	5	17	5	14
16/2	2	145	0	38	0	35	0	22	0	8	0	17	0	14
17/2	97	242	67	115	65	100	55	77	47	55	37	54	33	47
18/2	8	250	2	117	1	101	1	78	0	55	1	55	1	48
19/2	13	263	8	125	6	107	3	81	4	59	3	58	3	51
9/3	8	271	0	125	0	107	0	81	0	59	0	58	0	51
Total Infiltration			146 mm		164 mm		190 mm		212 mm		213 mm		220 mm	

All totals are cumulative

The data in Table 1 demonstrates clearly that the wheel traffic treatment imposed on these plots had a very large effect on runoff, and the traffic effect was substantially greater than the tillage treatment effect . the effect might be illustrated by the cumulative mean runoff of 104 mm from the wheeled treatments whereas 56mm ranoff from the controlled traffic treatments. In other words, out of the total precipitation of 271mm, an additional 48mm infiltrated into the controlled traffic plots

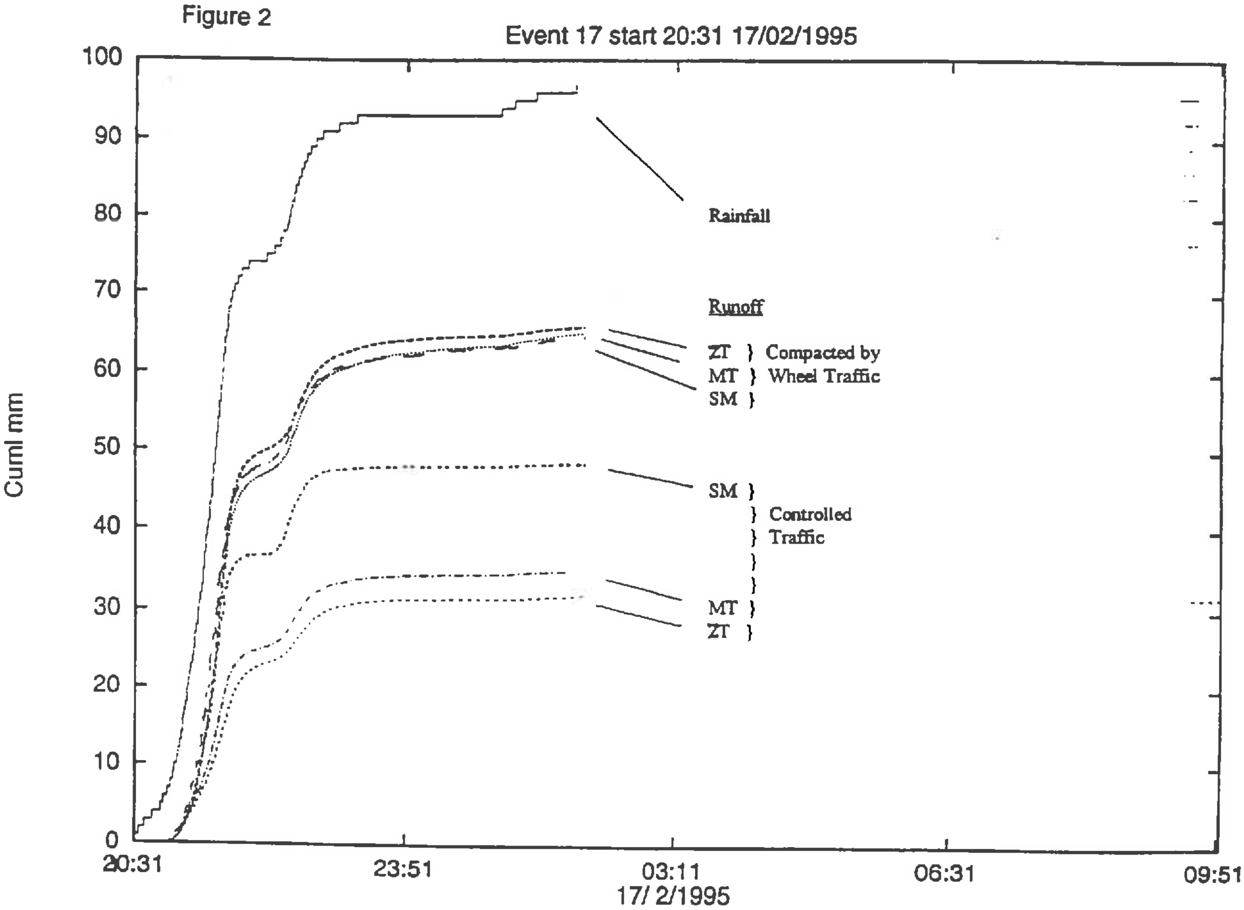
Figure 1



Tillage treatments had the expected effect, with gross mean runoff from zero till being 66mm, from minimal mechanical till 83mm and from stubble mulching 92 mm. Zero tillage thus provided an increase in infiltration of 26 mm.

Statical analysis of these results is not complete, however the quality of the data can be illustrated with reference to figure 2, which shows the cumulative runoff from block 1 during the high intensity rainfall event that began on the 17 February. The corresponding hydrograph demonstrates that maximum short term rainfall intensities exceeded 100 mm an hour on two occasions during that event. Under this high intensity rainfall, the difference between different tillage systems was almost negligible when soil was compacted, but the tillage treatments had a large effect on the controlled traffic plots. this is consistent with the notion of a compaction 'throttle' to infiltration.

Figure 2



b) Crop Performance

Yield was assessed using 3 quadrats taken from the middle of each bed - thus avoiding edge effects. Total plot yield was subsequently recorded after harvesting with a modified Harvester front and using a stationary thresher. Results are presented in Table 2.

Although the mean population was substantially greater in controlled traffic plots, this difference was not significant at the 5% level. According to Keys and Younger (1988), and Colwell(1963) wheat yield is relatively insensitive to plant population over a range from .5 million to 2 million plants per ha, so population appears unlikely to be affecting yield in this case.

Table 2. Wheat Yield

		C	CT	
Plant population	M/ha^{-1}	.79	.95	NS
Tiller length	mm	459	503	*
Tillers/plant		3.54	3.18	**
Grain yield	t/ha	2.23	2.44	**
Total biomass	t/ha	7.33	8.19	**
Whole plot (corrected yields)	t/ha	1.37	1.68	**

Grain yield as assessed by quadrats was approximately 10% greater in controlled traffic plots, at 2.44 t/ha, and simular ratios apply to total biomass. Whole plot yield on the other hand , was greater by 22% in controlled traffic. The difference between these two must be due to a greater edge row effect in controlled traffic plots.

Preliminary quadrat data from the 1995 grain sorghum crop showed a slightly greater mean yield of controlled traffic sorghum but did not prove to be statistically significant. Following the hand harvesting of the whole plots ,controlled traffic treatments proved to have significantly higher yields, and these results are presented in Table 3.

Table 3 . Sorghum Yield. t/ha.

Tillage treatment	Wheeled	Controlled Traffic	
stubble mulched	5.38	6.57	**
minimum mechanical	5.13	5.56	*
zero till	5.17	5.46	*
Average	5.22	5.86	**

The 1994 wheat crop was grown on limited moisture, with a strategic irrigation of less than 40mm to establish the crop , followed by a total of less than 120mm during it's growing period. It appears likely the yield of this crop was limited by moisture availability, particularly towards the later stages of growth.In these conditions the greater soil volume potentially available to control traffic wheat could account for the greater yield

The sorghum crop on the other hand, was well supplied with water. A preplant irrigation, was followed by the rainfall events reported in Table1, providing a total of more than 330 mm. The crop appeared water stressed only briefly in late March at which point infra-red temperature measurements indicated that the mean leaf temperature of sorghum growing in compacted soil was 1.5 degrees greater than that of controlled traffic sorghum at noon when relative humidity was 25%. This indicates greater water stress in the contacted plots despite the greater neutron probe readings at the time showing the compacted plots had approximately a 10% greater water content than the controlled treatments. It is evident that water in the compacted plots was being held at tensions that made it unavailable to the crop. Unfortunately 25 mm of rain fell 2 days after this observation preventing any longer term measurements. Subsequent disc-permeameter increase in very small pores in the compacted plots.Soil strength and bulk-density measurements were also higher in the compacted plots

4. CONCLUSION

This work has demonstrated

1. A large consistent and important difference in runoff due to wheel traffic effects under a range of natural rainfall and irrigation intensities.

2. These differences occurred almost 9 months after the compaction treatment was installed using a relatively light tractor, subject to normal drawbar loads.

3. Compaction treatments had a significant effect on the yield of a wheat crop grown under moisture limiting conditions. This effect was repeated in a sorghum crop where the conditions were more liberal and water supply less limiting

5. REFERENCES

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