Soil compaction under cotton pickers: preliminary results

Michael Braunack, Jo Price and Darin Hodgson
CSIRO, Plant Industry, Cotton Community Catchments CRC, Locked Bag 59, Narrabri, NSW 2390. michael.braunack@csiro.au, jo.price@csiro.au and darin.hodgson@csiro.au

Abstract
New round bale cotton pickers offer significant benefits in timeliness and efficiency of harvest. However they weigh more than twice as much (33 t v 16 t) than current basket pickers, so although the cotton industry is aware of soil compaction and strategies to manage it, there is considerable risk of subsoil compaction. High soil strength (>2000kPa) at depth may impede root growth and limit water and nutrient uptake, which may limit productivity for the following crop. Opportunistic measurements of soil cone resistance and soil moisture profiles were taken before and after traffic by a round bale picker, both empty and laden, during the 2011 harvest. Results indicate an increase in soil compaction after traffic by the picker both empty and loaded. The effect was greater when loaded compared with that empty. High soil strength occurred closer to the soil surface and under crop rows due to picker passage. Soil conditions for the harvest season resulted only in a tyre imprint on the surface. This paper highlights the invisible soil changes that can occur during cotton harvest as caused by the new round bale pickers being widely adopted by the cotton industry compared to the basket pickers.

Key Words
Subsoil, soil strength, harvest compaction

Introduction
There are many benefits with the round bale picker compared to the basket picker; it can pick 6 rows compared to 4, there is a reduction in required labour from 6 to 2 persons, resulting in cost savings. It well known that crop yield is reduced by soil compaction (Soane and van Ouwerkerk, 1994) and subsoil compaction is of concern due to the increase in size and weight of agricultural equipment (Horn et al. 2000). Cone penetrometers are often used to assess soil strength in relation to soil compaction and root growth (Bengough et al. 2001). Resistance to penetration is affected by soil type; soil texture, organic matter content and clay mineralogy (Stitt et al. 1982), while within a soil type it is affected by soil water content, bulk density and structure.

Soil resistance greater than 2000 kPa is considered to limit root growth (Hamza and Anderson, 2005). However, soils with a resistance even less than 2000 kPa have been shown to reduce cotton yield (Carter and Tavernetti, 1968). In contrast Kulkarni et al. (2010) indicated no yield penalty despite reduced plant growth to soil resistance of 1600 kPa..

Much research was undertaken by the cotton industry during the period from 1981 to 2002 in response to planting and harvesting on wet soils and the amelioration of soil degradation (McGarry and Chan, 1984, Daniells, 1989, Stewart et al. 2002). No assessment was undertaken to determine the effect of soil compaction on yield loss or the time taken for recovery of soil structure.

Cotton growers have expressed concern about the effect of the new round bale pickers on soil compaction, especially under wet harvest situations. This preliminary survey was undertaken to determine if soil strength greater than 2000 kPa occurs after traffic by the new round bale pickers.

Methods
Three cotton fields were selected during the 2011 cotton harvest to cover a range of soil types and soil moisture conditions; one in the Namoi valley (grey-cracking clay), one at Hillston (red-brown clay) and one at Boggabilla (cracking clay). Soil cone resistance was measured, to depth of 0.6 m at intervals of 0.02 m, with a recording penetrometer (12.3 mm dia. cone, 30^{o} included angle) across trafficked and un-trafficked furrows and crop rows before and after the passage of a round bale or basket cotton picker (Table 1). Soil samples were collected at the same time from 0-0.1, 0.1-0.2, 0.2-0.3, 0.3-0.4, 0.4-0.5 and 0.5-0.6 m depths for gravimetric water content. Soil bulk density profiles were estimated from the cores. Three transects five metres apart were measured 20 m in from the tail drain end of the field perpendicular to the direction of picker travel. Soil resistance data were plotted using the contour function in SigmaPlot 11.0.

Results
It should be noted that since soil strength is dependent on soil moisture the strength profiles shown will change as soils become drier, through extraction by a rotation crop, or wetter, through rainfall or irrigation. At the sites sampled soil strength profiles changed after traffic compared with before traffic with greater

changes being measured under fully laden pickers compared with empty pickers. Comparisons can only be made between before and after picker traffic at any one site since soil strength is dependent on soil moisture. Soil water content did not change before and after traffic by the pickers (Table 1).

Table 1 Details of sites, soil type and equipment measured.

Site	Soil	Equipment	Weight (t)		Soil moisture (%)
			Empty	Loaded	
Narrabri	Grey cracking clay	Round bale+trailer	38	47	24
Hillston	Red brown clay	Round bale	32	34	19
Boggabilla	Cracking clay	Basket picker	16	18	22

The colours in the profiles in figure 1 a, b and c indicate soil strength; with the blue colours representing soil with low strength of less than 2000 kPa; where roots will grow. The change in soil strength from 2000 to 5000 kPa indicates increasing soil compaction, and where roots will experience difficulty in penetrating the soil. The literature suggests that roots stop growing at strengths above 2000 kPa (290 psi).

At all sites there was a degree of compaction before harvest. Soil strength profiles before traffic are the result of previous operations; such as listing, fertiliser application, sowing and other operations and exhibit a degree of variability reflecting the variation in soils and soil water at the time of trafficking. Zones of higher soil strength were deeper before traffic and shallower after traffic at all sites.

On the grey cracking clay the after traffic profiles for a round bale picker plus trailer (Figure 1a) showed that the area of soil of low strength (1000 kPa) was reduced and the area of high strength (3000 -5000 kPa) was increased. At this site soil strength was measured to a depth of 0.7 m and showed that the area of 3000 to 5000 kPa is closer to the soil surface compared with before traffic (0.1 m compared to 0.3 m) and has become more uniform across the rows. Also note that the strength at depth has increased.

On the red brown clay in southern NSW, the effect of traffic by a round bale picker is again evident (Figure 1b). At this site it was only possible to measure soil strength to 0.5 m. Soil strength was increased closer to the surface (0.05 m) after traffic by the picker. Below 0.3 m soil strength becomes more uniform after traffic.

At the round bale picker sites lateral movement of soil has resulted in an increase in soil strength under the crop row (the vertical green zones spreading out from wheel tracks) (Figure 1a, b).

On the cracking clay at Boggabilla after traffic by a basket picker, soil strength less than 2000 kPa occurred between 0-0.3 m while high strength occurred below 0.4 m (Figure 1c). Also, high soil strength did not encroach under the crop row. The vertical blue zones before traffic correspond to cracks along wheel furrows. These have closed after traffic.

Discussion

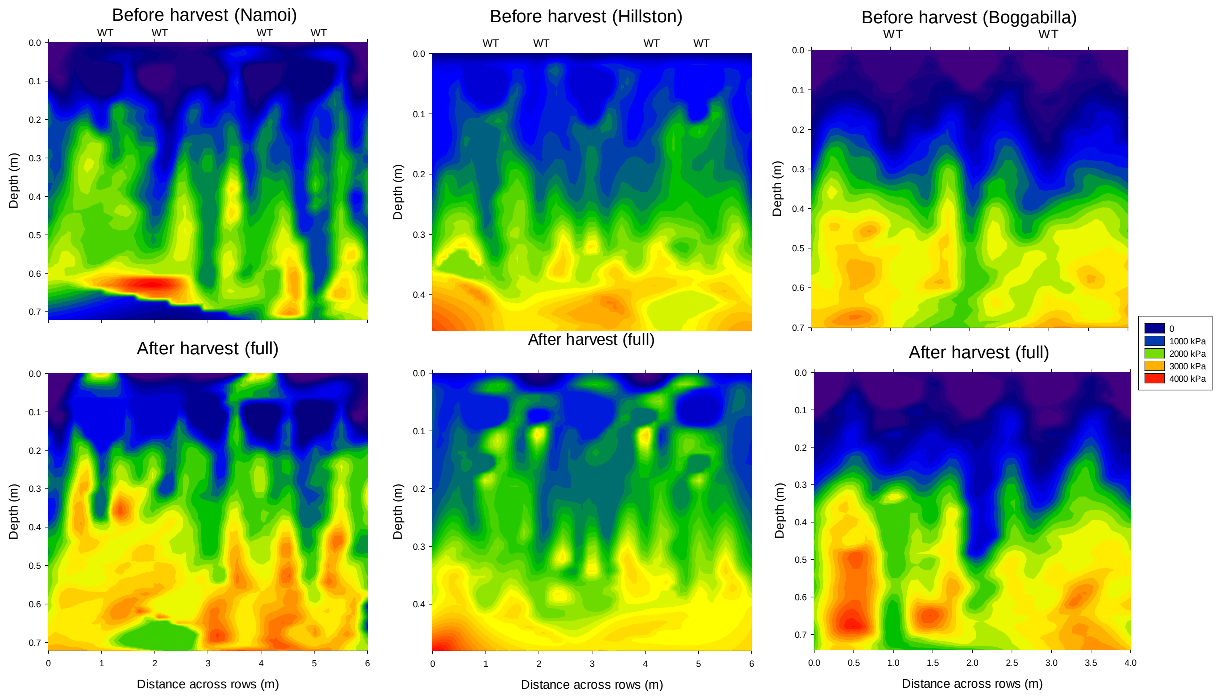
Of concern are the changes in soil strength being detected between 0.2 and 0.6 m under the round bale picker while it only occurs between 0.4 and 0.6 m under the basket picker. Problems will eventuate if soil strength remains above 2000 kPa after the soil wets, which will restrict root growth, water and nutrient uptake. Restrictions on root growth, water and nutrient uptake will eventuate if soil strength remains above 2000 kPa after the soil wets. Roots will grow through high strength soils if there are cracks and bio-pores through the profile, but not if compaction has reduced pores to smaller than the diameter of the root.

Another issue is the proximity of wheels to the crop row due to spacing between dual wheels and track widths of round bale pickers. This results in soil compaction beneath the row due to lateral soil movement.

Change in soil strength is substantial under the round bale picker after traffic irrespective of grey cracking clay or red brown clay. There is a need to investigate and substantiate the compaction and test if it occurs over a wider range of soil types and soil moisture profiles. The potential for subsoil compaction is higher under round bale pickers compared to with basket pickers, so options for reducing the risk (eg managing last irrigation more carefully) or amelioration need to be assessed.

Conclusion

The round bale pickers contribute to significant compaction of grey cracking and red brown clays.



(a) (b) (c)

Figure 1 Change in soil cone resistance due (a) round bale picker+trailer on a black-cracking clay (Namoi Valley 2011), (b) round bale picker on a red-brown clay (Southern NSW 2011) and (c) a basket picker on a cracking clay (Boggabilla 2011); the larger (kPa) the number the greater the soil strength.

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