Highlighting the importance of CTF for heavy cotton harvest machinery

John McLean BENNETT[1,*], Diogenes L. ANTILLE[1], Troy A. JENSEN[1]
[1]*University of Southern Queensland, National Centre for Engineering in Agriculture, 4350 Toowoomba, QLD, Australia*
[*]*John.Bennett@USQ.edu.au; Dio.Antille@USQ.edu.au; Troy.Jensen@USQ.edu.au*
Institution website: http://www.usq.edu.au/ncea

The cotton industry has recently undergone a revolution in harvesting technology whereby the requirement for multiple operations such as harvesting, chaser bins (boll buggies) and module building (compression of cotton for transport to processing plant) has been decreased to a single operation using an on-board-module-building (OBMB) system. Both Case IH and John Deere (JD) have produced cotton harvesters that pick, accumulate and compress cotton into modules on-the-go; this work will focus on the JD 7760 OBMB. With the addition of the OBMB, the machine weight of the JD7760 ranges from 32 Mg (field ready starting weight) to 36.5 Mg (fully laden; i.e. carrying two modules), which is approximately a 50% increase in weight from the previous cotton harvest system. Additionally, as the machine creates a module on board, the weight over the rear axle increases from 10.6 to 12.8 Mg, and then from 14.5 to 16.5 Mg as it creates a second module and carries the first module in a basket at the rear of the machine. The front axle weight remains close to constant at approximately 21.5 Mg. The front axle load is spread over four wheels in a dual wheel configuration, whilst the rear axle is spread over only two wheels that are slightly offset to the inner dual wheel of the front axle. This increase in machine weight and large traffic footprint present concerns for soil compaction, as well as subsequent yield penalty and tillage energy costs.

The JD 7760 has a 2 m centre (distance between the centres of the wheels on an axle) with 1 m between the centres of each dual wheel on the left and right; this is standard JD production configuration. However, some Australian farmers have modified these machines to have a 3 m centre and run on controlled traffic farming (CTF) tram-tracks, removing a left/right front axle wheel. Due to the centre of gravity and the width of the harvest front, converting the JD 7760 to CTF requires a more stable base. Thus, 3 m centres are considered the minimum for such conversion. The Australian cotton farming system is predominately irrigated on 1 m furrow/bed spacing with planting and harvesting occurring at 12 m and 6 m frontages, respectively (1 m system). Such a system is not compatible with the standard 3 m centres of the CTF JD 7760, thus, 1.5 m furrow/bed spacing is used (1.5 m system). We compared a standard JD7760 and a CTF JD 7760 at an Auscott farm near Warren, New South Wales, Australia. The soil is a medium to heavy clay, with shrink-swell capacity (Vertisol). As the field needed to be planted using existing equipment, planting occurred for both systems on 12 rows. Hence, to ensure true CTF without modifying the machine frontage, the CTF JD7760 harvested 4×1.5 m system rows (6 m), whilst the standard JD 7760 harvested 6×1 m system rows (6 m). We measured soil bulk density (SBD) and strength (as cone penetrometer) to a depth of 0.8 m. It was found that both harvest systems caused a similar increase in SBD, by depth, for all depths in traffic furrows (Figure 1). Traffic furrow increase in SBD, as compared to guess furrows, was 22%, 13%, 4% and 5% at depths 0-0.1, 0.1-0.2, 0.2-0.3 and 0.3-0.4 m, respectively. Given the standard JD 7760 has a dual wheel configuration, it traffics 67% of the furrow surface, whilst the CTF JD7760 50% of furrow surface. Hence, 17% more of the field furrow surface is compacted between 22%-25% through the 0-0.4 m depth. This translates to less plant available soil water in the standard JD 7760 system (decreased soil porosity with increased compaction), as can be seen in Figure 2 (blue regions). Additionally, whilst SBD at 0.4-0.8 m is statistically similar under traffic compared to non-traffic furrows, variance of the data is decreased by an order of magnitude in the traffic furrows. Thus, the heterogeneity of the soil pore network has been decreased by application of the machine load, and most importantly, it indicates that both systems have effect on soil porosity to a depth of 0.8 m. Soil strength increases to a depth of 0.8 m under wheels (Figure 2), which supports the reduction in variance observed in traffic furrow bulk density. There is a 37% increase in blue zones (soil strength <1500 kPa), which indicates greater water storage per unit of cotton produced. This is both a function of the reduced traffic and expansion of the furrow system from 1 m to 1.5 m spacing. However, if the CTF JD7760 was modified to pick 6×1.5 m rows, then traffic could be reduced to 33%, providing further savings. Of importance, whilst there are less cotton plants grown per unit area in the 1.5 m system, the gross margin is equal between the two systems. There is scope to increase yield production in the 1.5 m system. This work therefore highlights that there will likely be long-term gains from a CTF JD 7760 system, as well as short-term reduction in soil compaction.

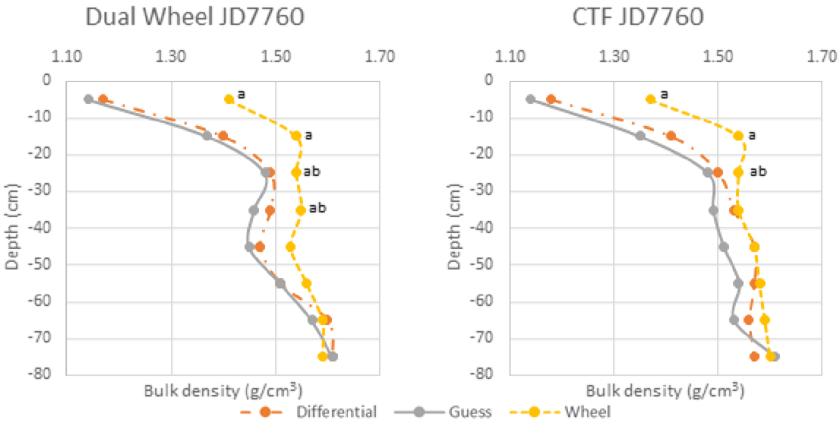

Figure 1: SBD for the dual wheels (standard) JD 7760 and the CTF-compatible JD 7760 measured in the centre of the furrow. Guess and differential denote the furrow between two system fronts, and the furrow directly below in the centre of the machine, respectively. Wheel denotes trafficked furrows. N.B.: for the dual wheel JD 7760 , 'Wheel' is 4× traffic furrows, while for the CTF JD 7760 it is 2× traffic furrows. Lower case 'a' indicates significant difference to Guess and Differential, while 'ab' indicates significant difference to only Guess. No letter means no statistical difference.

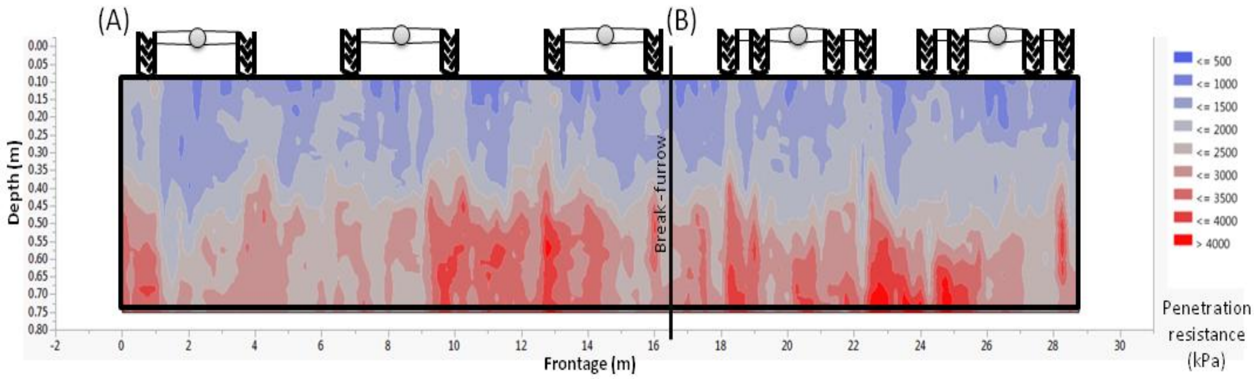

Figure 2: Comparison of cone penetration resistance (soil strength) for (A) CTF JD7760; and, (B) Standard JD7760 on dual wheeled front-end, as they appear in the field. Zero on the x-axis denotes the top of a hill, while "break-furrow" denotes the furrow between the two systems.

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