CONTROLLED TRAFFIC DEVELOPMENT ON DRYLAND BROADACRE FARMS IN CENTRAL QUEENSLAND.

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INTRODUCTION

The Queensland British Food Corporation (QBFC) pioneered large scale cropping (26000 ha) in Central Queensland from 1948 till 1952 when operations ceased due to financial losses. QBFC land was broken up, balloted and many successful applicants were experienced farmers from southern Queensland and New South Wales. They facilitated the commencement of successful grain production in the Central Highlands (Spackman and Garside 1995, Gillies 1978). In the adjoining Dawson-Callide area development occurred during the Fitzroy Basin Land Development Scheme (Brigalow Scheme) in the 1960s. Across Central Queensland the area cultivated has increased dramatically from 350 000 ha in 1970 to more than 800 000 ha in 1990. Major expansions during the 1950's and 1970's were associated with decades of generally above average rainfall and the collapse in beef prices during the 1970's. In 1995, crops are grown on 510 000 ha in the Central Highlands and 124 000 ha in the Dawson-Callide. The main planting windows and principal crops are December to March for sorghum, sunflowers and mung beans, and March to June for wheat and chickpeas. Dryland cotton is planted October to December. Spring planted grain and fodder crops are generally unreliable due to high temperatures at flowering and low probability of in-crop rain.

The region receives an average of 600-700 mm of predominantly summer rainfall, but falls greater than 75 mm have been recorded in every month. There is a high degree of variability, within and between seasons (Willcocks 1993). Sixty percent of daily rainfall occurs in falls under 10 mm, while annual pan evaporation is 2.5 times the annual rainfall (Willcocks 1993). Pan evaporation exceeds rainfall in all months and averages 4 mm/day in winter and 8 mm/day in summer. Soil water storage efficiency during fallows is typically less than 20% (Carroll *et al.* 1994). Soil evaporation is the dominant loss mechanism and can account for 70% of rainfall in a normal year. During a 9 month fallow in 1991, 299 mm of rain was received and 267 mm lost as soil evaporation. Runoff can be significant (up to 15% of annual rainfall) and in wet periods, usually associated with cyclonic influences, drainage losses can also be as high as 10% (Carroll *et al.* 1994).

The major threat to long term sustainability is soil erosion from the sloping (up to 3%), highly erodible, cracking clay soils. Contour banks have been installed on 60% of the erosion prone cultivation in the Central Highlands (G. Bourne pers. comm.), but inter bank erosion is still high. Peak rainfall intensities (I_5) up to 170 mm/hr have been recorded within storms (K. Rohde pers. comm.), but the average intensity (I_{60}) is 35 mm/hr. 1 in 10 storms reach 75 mm/hr (Willcocks, 1993). Residue retention (>30% cover) and a reduction in tillage will reduce runoff and , more particularly, erosion (Carroll *et al.* 1994). Runoff reduction can be important at planting time when, due to surface sealing, runoff can occur from finely mulched soils without fully wetting the seedbed. Judicious use of fallow herbicides is the key to effective soil management. However, efficient herbicide application has been limited on large areas by ineffective marker systems.

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CENTRAL QUEENSLAND FARMING SYSTEMS

Broadacre grain farmers in Central Queensland have traditionally conducted machinery operations within contour bays. However, parallel runs, generally across the slope, are now more popular following the development of broad based contour banks which can be traversed at any angle with contour-flexing machinery up to 20m wide. This practice improves the efficiency of operations with large machinery. Where herbicides are commonly used, "tram-lines" for subsequent spraying operations are made using unplanted wheel tracks or missed rows.

Minimum tillage practices of chemical weed control with blade and chisel plough cultivation are typical. Some farmers are loathe to use chemical fallow due to concern about chemicals, limited knowledge of herbicides, higher cost than cultivation, increased requirements for specialised equipment and marking difficulties. Treatments at planting range from full cultivation to zero tillage. The only set rule for these systems is their flexibility. The decision to spray or cultivate is usually made on the basis of soil water stored, the cost of spraying, density of weeds and time of year.

Tractors used in the Central Highlands range from 230 to 460 kW for 4WD, and 150 to 300 kW for tracked type machines. Typically these machines weigh 14000 kg to 28000 kg for 4WD, and 14000 to 36500 kg for tracked machines. Common tyres are dual 30.5 X 32 loggers. Area under cultivation varies between farms, with 2500 hectares or more, common.

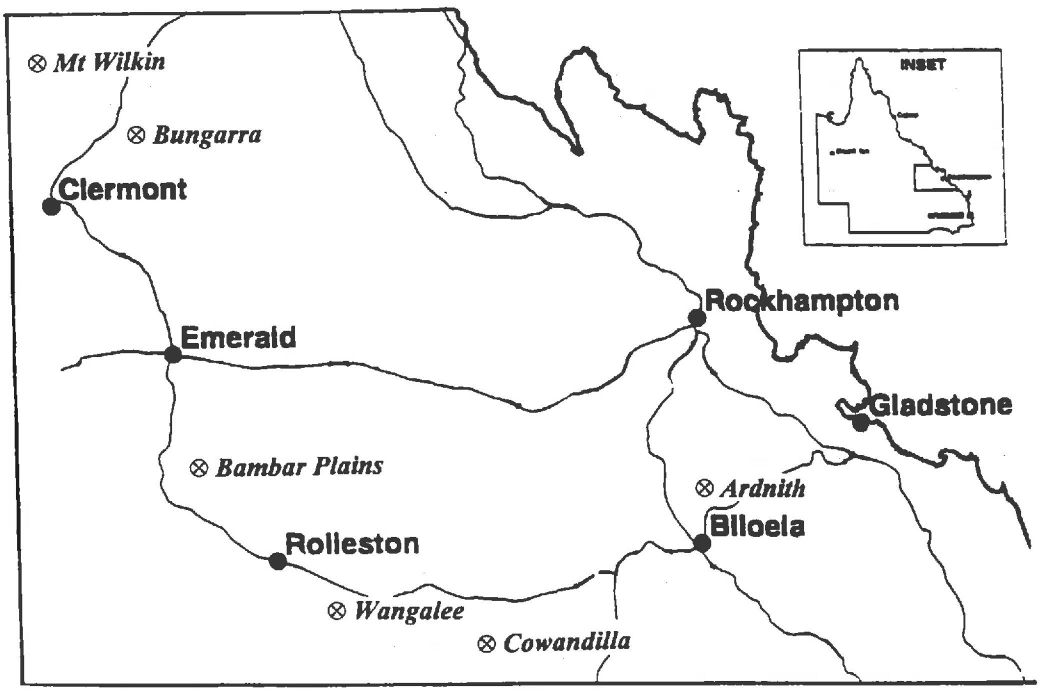
Throughout the Central Highlands, soil compaction is commonly observed in soil pits, and obvious crop effects include "right angle disease" and poor germination in tractor wheel tracks. One farmer has observed that "Tractor tracks from the last two workings are visible from the air, even months later." D. McGarry (pers. comm.) found that compaction was worse in dryland cultivation compared to irrigated land in the Emerald Irrigation Area.

DEVELOPMENT OF CONTROLLED TRAFFIC SYSTEMS ON-FARM

Our on-farm project recognised that to control soil compaction, the only available technique was controlled traffic (CT), and therefore we set out to study the development of CT layouts for broadacre farms. In early 1993, workshops and growers meetings were held and five farmer co-operators "volunteered" to experiment with our concepts. These were Rod Birch, "Mt Wilkin", Kilcummin; Lyall Swaffer, "Bungarra", Clermont; Ian Buss, "Bambar Plains", Orion; Murray Jones, "Wangalee", Rolleston; and Charles McDonald, "Cowandilla", Bauhinia (Figure 1). Our meetings also identified growers who had been developing their own CT approaches, in particular Bob Mathieson, "Ardnith", Biloela. These co-operators are distributed over a distance of over 500 km, from Kilcummin in the north, to Bauhinia Downs in the south, and east to Biloela. Their farming methods, soil types, land forms and machinery cover the spectrum of CQ farms. Our goals are to measure the benefits achieved on-farm (tractor and farm efficiencies, ease of operations, etc), to identify practical problems that would constrain adoption and to research new innovations made possible with CT. The controlled traffic project also aims to apply the findings of the soil compaction research discussed by Bruce Radford, Ken Rohde, Harry Harris and Jahangir Alam (these proceedings).

Our co-operators were attracted to CT for compaction control, ease of herbicide application (facilitating moves to zero till), and aiding dryland cotton production. Initially, grower's concerns included suitability and compatibility of tractors and implements, direction of permanent wheeltracks, and runoff and soil erosion. Direction of permanent wheeltracks has implications for visibility of operations due to sun glare, and impact of prevailing winds on spraying operations and harvesting of lodged crops. A soil erosion research program was established (Rohde and Yule, these proceedings). In practice, direction of layout has been determined more by runoff control considerations than by wind or sun direction. By September, 1995 CT has been established on 4 farms: Mt Wilkin (2 000 ha, rubber track tractor), Bungarra (100 ha, 4WD tractor), Wangalee (325 ha, steel track tractor) and Bob Mathieson's (170 ha, 2WD tractor). A planned layout on Cowandilla (both 4WD and steel track tractors) was unsuccessful due to tracking problems which saw the planter up to 2 m off line, and CT will be established on Bambar Plains (4WD tractor) as soon as a new planter is on site. The oldest sites are at Bob Mathieson's with 4 crops under CT and Lyall Swaffer established his block in 1992 as dryland cotton. Despite our extended drought since 1991, all co-operators have remained firmly committed to CT and have been encouraged by their experiences so far. With increased publicity associated with this Conference, many enquiries from growers have been received and all believe the system will enable greater accuracy when spraying and assist management of zero-tillage, reduce capital expenditure in the long run, confine soil compaction and improve soil structure.

Figure 1. Distribution of farms within the controlled traffic project



We have recommended farm layouts to minimise erosion risk by applying two basic rules:

- crop rows and permanent wheeltracks must drain to a safe disposal area (water way or contour bank) without reverse slopes or flat spots; and
- the furrows and ridges must contain all the runoff generated within the microcatchment. This distributes runoff across the area and prevents crossflows, which concentrate runoff and create rills and gullies with high erosion rates.

In the field these rules are hard to apply due to uneven slopes. However, Rod Birch has shown that it is possible to change the direction of layout in the second year with only limited problems of crop establishment in the previous wheeltracks. The co-operators use straight runs and plant over any contour banks. The exception is Bob Mathieson, who has developed a parallel contour bank system with narrow based contour banks and six passes of his implement between banks. However, Bob's layout also follows our runoff rules.

ON-FARM BENEFITS OF CONTROLLED TRAFFIC

All co-operators report benefits gained from the adoption of CT. These are described as follows:-

Accuracy of operation. The accuracy possible with CT impacts on all farming operations. Because of this, Rod Birch believes his CT farming system gives him more options. Last summer Rod demonstrated the potential of late fallow furrowing. This technique is useful where soil evaporation has dried the seedbed to 10 or 15 cm depth and the sub-soil is wet. Rewetting the seedbed requires 40-60 mm rain, so falls of 20-30 mm evaporate without providing a planting opportunity. A shallow furrow reduces the depth of dry soil to 5 cm or less, so that a 20 mm rainfall will link up with subsoil moisture in the furrow and any runoff is concentrated in the furrow. CT allows a planting opportunity by planting in the furrows.

Spraying. Bob Mathieson has found night spraying much easier, enabling spraying to be conducted in either more ideal or over a wider range of conditions. This can lead to improved efficacy on weeds in a crop or fallow spraying program, and on nocturnal insect pests.

Co-operators find spraying operations are easier and much less fatiguing without spray markers. Foam markers used in fallow spraying operations are often troublesome, and foam life is short in hot conditions. Foam markers have been rendered obsolete by CT. Overlaps are eliminated, which have substantially reduced spraying costs. For example, a 5% overlap when spraying 1L Roundup/ha costs approximately $500 over a 1000 hectare area, plus additional application costs. Spraying operations are conducted more easily and at higher speeds on more trafficable permanent wheeltracks, and they are trafficable sooner after rain than non-compacted soil. These benefits might enable reduced spraying charges to be negotiated with spraying contractors.

Efficient band spraying is possible with CT, due to the improved precision of machinery operations. Murray Jones, Rod Birch and Lyall Swaffer applied insecticides to young dryland cotton in a 30% band over the rows using ground rigs. The saving in chemicals greatly lowered costs. CT will also enable herbicides to be band-applied either over or between planted rows to reduce costs, and residual herbicides to be band-applied with subsequent planting of sensitive crops between the herbicide bands.

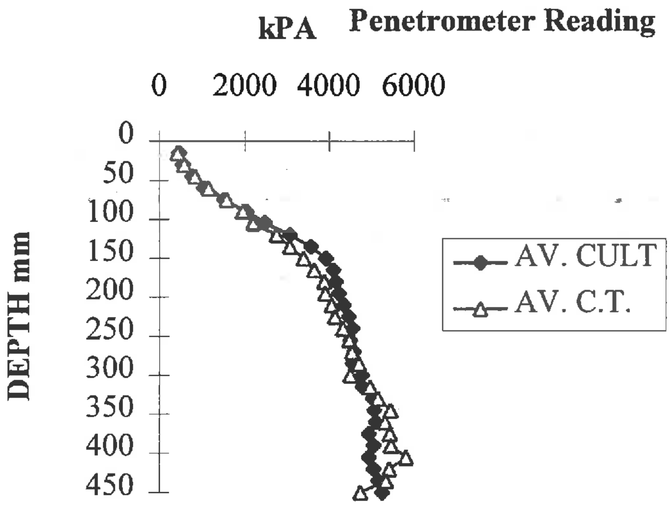
Environmental considerations will increasingly impact on agricultural practice. Limiting the amount of herbicide and insecticide used in dryland agriculture by targeting specific areas such as row spaces for weed control, or crop foliage for insect control, has environmental and sociological benefits in addition to agronomic and economic advantages.

Fertiliser application. Last season, nitrogen was side-dressed to sorghum when rain occurred after planting. Dry matter production, 125 days post planting, doubled for one site, however grain response at that time was not as pronounced. Yield increases between 10%-30% were recorded at harvest from the application of the equivalent of 20 units Nitrogen/ha at some reps. Although encouraging, variation across treatments and the limited nature of the trial indicate further work is needed. We expect side-dressing of crops with nitrogen will be beneficial when seasonal conditions improve during early crop growth, or following waterlogged conditions. Currently growers are unable to side-dress fertiliser due to lack of implements, inaccuracy of placement and interference from stubble. CT will also facilitate banded application of phosphorus and trace elements, such as zinc. CT will improve precision in fertiliser placement and timing of application, even in crops with comparatively narrow row spacings. The offset hitch Bob Mathieson developed allows him to side-dress fertiliser into 30 cm rows.

Tillage and planting. CT facilitates accurate tillage operations including selective tillage to help maintain stubble cover. Rod Birch considered sorghum stubble that was too stressed to consider spraying could be selectively cultivated without cultivating the inter-row areas. He will also interrow cultivate at times for weed control. Bob Mathieson has planted mung beans in rows that are offset to previous wheat rows, thereby improving establishment and stubble handling at planting. With 30 cm tyne spacings, the Gyral T226 can comfortably handle 3.6 t/ha wheat stubble and 1 t/ha mung bean stubble.

Soil compaction. Preliminary penetrometer results at Lyall Swaffer's (Figure 2) indicate decreased resistance to 30 cm in the crop zone. The higher readings for the CT area deeper in the profile probably reflect increased number of readings at depth for the CT paddock, as realistic results to 450 mm were difficult to record from the non-CT paddock. Growers expect the development of better structured soil in the crop zone to improve crop establishment, yield and uniformity. CT will also help to minimise harvest traffic effects on the paddock in wet harvest conditions, if trucks and chaser bins travel the compacted wheeltracks. We have not yet measured these responses.

Figure 2. Average penetrometer readings across two adjoining paddocks on "Bungarra", one with normal cultivation and one with controlled traffic.



Reduced costs. Fuel savings contribute directly to profit and Bob Mathieson has cut his fuel use at planting from 8 L/ha to 2.3 L/ha. Lyall Swaffer reported tillage operations were much easier to perform in his trial area than elsewhere on the farm. In future, fuel flow meters will allow us to quantify these benefits in the field. Farmers with wide machinery report that working within contour bays can reduce efficiency by as much as 20-30% due to overlaps in irregularly-shaped bays. Controlled traffic eliminates unnecessary overlap, either by farming within parallel banks as Bob Mathieson does, or by farming over banks. This avoids increased fuel, seed, chemical and fertiliser input costs, and maximises yields by avoiding double planting.

Improved cropping. Following this year's sorghum harvest, Brendon Swaffer felt that in the CT plot it took less time to fill the grain bin during harvest, indicating a probable higher yield. Most benefits will probably come from increased planting opportunities. Bob Mathieson believes it was the combination of zero-tillage and CT which allowed him to harvest a crop when most crops in his district failed. Even during the drought, Bob is preparing to harvest his sixth crop in three years. Ian Buss has said that "in his area, one spray can be the difference between getting a crop and not getting one."

ON-FARM PROBLEMS WITH CONTROLLED TRAFFIC

The on-farm testing program has highlighted several problems, both expected and unexpected.

Machinery Modifications. Some tillage equipment proved to be more adaptable than others. Lyall Swaffer's scariseeder with welded tyne mounts makes it difficult for him to manage both traditional and CT cultivation with the one machine. Consequently, the permanent pathways are cultivated at planting, although the bolt on tynes on his chisel plough are removed from behind the tractor wheels for primary workings. The matching of primary and secondary tillage equipment has not been a major impediment.

Harvester - Tractor Incompatibility. We have not included harvesting in our layout planning at this stage. Fortunately, wet harvests have not been a problem during the drought, and our co-operators have preferred to develop the CT system and react to any problems generated at harvest. The incompatible wheel spacings and differences in operating widths has been put in the "too hard basket" at this time. As grower's demands increase, we hope that machinery manufacturers will address this problem. Possibly this Conference will be the catalyst.

Installation Techniques and Marking. Row cropping marker arms have been successfully used to install permanent wheeltracks during planting operations by Bob and Rod, although they are looking forward to an easy to use and effective alternative. Lyall Swaffer tried installing pegs to guide for one run and then working visually from that run. This did not give accurate guess rows as tractor position was difficult to gauge in relation to the last pass. The resulting overlap or underlap reduced the fundamental advantage of CT. Guess row variation was minimised by Murray Jones who measured every track across a relatively flat 325 ha paddock. Each track was marked with a furrow and the tractor was driven directly over the furrow during the planting operation. This enabled dryland cotton to be inter-row cultivated over the past two seasons, with a 18.4m trailing cultivator. Drawbacks to the system are the length of time required to set up a paddock and, in common with marker arms, the high level of skill required to drive the tractor down a pre-defined mark. Straight driving is particularly difficult with articulated 4WD tractors.

In the short term, marker arms seem to be the best way to install the permanent wheeltracks. To date this has been done at planting, in anticipation of the tracks being defined by the lack of stubble in the wheeltracks in subsequent seasons. Bob Mathieson has found this a satisfactory solution, although the ability to see the position of the front wheel of his 2WD tractor relative to the wheeltrack, may be a contributing factor. Lyall Swaffer has increased the number of summer crop rows planted beneath the tractor compared to the rest of the planter. This has allowed easier identification of wheeltracks following harvest. Both Murray Jones and Rod Birch use a "gun sight" on the tractor to assist the driver to drive straight. We need a system to layout a paddock quickly and accurately, preferably vehicle-mounted and capable of covering at least 500 ha in a day.

Operator Skills. All co-operators have found it difficult to follow a marker furrow, and drive accurately on permanent wheeltracks while monitoring implement performance. This causes variable guess rows and subsequently inter-row cultivation is much more difficult. Weeds can grow unchecked in gaps. Accurate guess rows are essential in CT layouts to reduce overlap inefficiencies, and maximise opportunities. Although marker arms are working, they only provide a mark for the tractor operator to follow, they do not steer the tractor. Marker units suitable for large (18+m) equipment are heavy and require additional operator skills to operate. All co-operators agree the development of automated guidance systems are essential for effective operation of CT systems. We are collaborating with the University of Southern Queensland to develop systems for both tractor and implements.

Wheel Tracks. Finding the permanent wheeltracks following harvest has become an issue. Without matched harvester and tractor tracks, harvest operations leave extra wheel tracks in the field. This is compounded by the self mulching nature of many CQ soils which tends to remove surface distinctions during a growing season. Consequently, wheeltracks become blurred and header tracks cause confusion.

Herbicide effectiveness has been reduced on the wheeltracks probably due to dust interference and stressed weeds. Bob Mathieson has fitted extra nozzles over the wheel tracks to increase the chemical application rate, and increased his spray boom width to twice the implement width. Wheeltracks are trafficked alternately. It is unlikely this will be a viable solution on larger areas. Rod Birch is considering using high rates of residual herbicide on the wheeltrack area. Murray Jones has slashed the wheeltrack area which was not planted for dryland cotton. Mechanical control (scrapers, etc.) works well in experimental plots at Emerald and Gatton. Perennial woody weeds are already a problem for Bob Mathieson and he uses a blade plough when necessary.

CONCLUSION

On-farm development work is progressing well. Layout design and future recommendations are being tested commercially in a collaborative approach which links research and industry needs with extension and adoption. Preliminary feedback from growers is extremely encouraging. Controlled traffic appears to allow much easier adoption of existing research and extension objectives (maintenance of cover, etc.). As the project progresses, other effects are expected to emerge. Positive interactions with soil structure, soil water and soil fertility are expected. However, many of the benefits of CT described will only be achieved with a strong farmer commitment, and with achievement of the high level of precision in farming operations offered by the CT system. There are undoubtedly practical and technical issues yet to be resolved. While some farmers will be able to modify existing equipment to suit a CT system in the short term, there will be a need for additional capital investment on many farms to satisfactorily implement a CT system. For instance, many farmers will need to upgrade certain items of farm machinery by the fitting of marker arms, etc, with some farmers likely to opt for three-point linkage equipment in the long term. Much of the machinery in Central Queensland is reaching the end of its working life. This should aid the adoption of this technology as farmers will have an opportunity to replace existing plant with CT compatible equipment. Some farmers will need to re-shape contour banks to facilitate farming operations and traffic across them, and in some cases to alter soil conservation and fencing layouts for efficient farming operations and runoff control.

Many grain farmers integrate a livestock enterprise into their farming program. How this will affect management of a CT system is being assessed at Rod Birch's this season.

CT farming systems have many benefits to offer grain farmers. It is likely that CT systems will play a major role in improved soil water management and improved crop performance, by facilitating more convenient and efficient minimum tillage practices.

ACKNOWLEDGMENTS

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