Controlled Traffic for Broadacre Dryland Farming: Better than Sliced Bread

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Research and farmer innovations have established many components of improved farming systems for dryland agriculture on large area, grain belt farms. But relatively little progress has been made to increase productivity towards potential levels. In part, this is due to a development psychology - increase production by developing more country - but a major constraint has also been the lack of efficient and effective mechanisms to apply improved practices on farm. This Conference was planned in the belief that controlled traffic offered these mechanisms. I will argue in this paper that with controlled traffic, broadacre farming can be as technically advanced as irrigated agriculture, and that latest developments in soil, land and crop management can be applied. Also "it's time", as economic, environmental and social pressures threaten the survival of dryland agricultural industries.

I wish to acknowledge the contribution made to this paper by the large number of farmers, researchers, extension officers, consultants, machinery people, etc., who have interacted with me over the years. In many ways, our current controlled traffic program is the culmination of my career to date. I can claim very few of these ideas, perhaps my contribution has been to recognise the potential for controlled traffic to bring together an enormous range of developments and initiatives into an integrated, functional system. The aims of this paper are to present a travel documentary on how these concepts developed and to encourage further development by revisiting our information base and challenging our current management perceptions. The rigour of controlled traffic systems is proven when growers say "I don't understand why we farmed any other way". My basic contention is that controlled traffic simply makes good sense.

DRIVING FORCES: PROBLEMS AND NEEDS

Soil Compaction

Soil compaction, and more generally, soil structural degradation, are obvious problems. It is very easy to demonstrate that the vast majority of agricultural soils have structural degradation caused by the weight of tractors. We cannot avoid this but we can control it. The importance of this issue is that it highlights the need to consider soil management and to examine the health of the soil. And this is not difficult - a 30 cm deep pit is usually enough. But, it is essential that soil management becomes a basic component of the farming culture.

It is usually considered that compaction is worse in irrigated than dryland soils, but every dryland farm examined in Central Queensland has evidence of serious soil degradation. If we challenge this perception about dryland agriculture, the result is not surprising. Dryland cultivation and planting are typically done as soon as possible after rain (when the soil will provide traction), but the soil is too wet and weak to support the tractor weight. By comparison, irrigators have more management options.

Low Productivity

Current productivity (yields and $/ha returns) must be examined in relation to our environmental potential. A conservative goal for dryland farmers would be 10 kg cereals/ha/mm of stored water plus rainfall. We have to challenge our "good crop" standards and push towards optimum use of the resources that are free - rainfall and sunshine. We also need to consider higher value crops and how to increase the dollar returns.

Farm Efficiencies

This is the cost side of the cost/price squeeze that is strangling so much of agriculture. It is just too easy to find inefficiencies at levels of 10 or 20% in current farming practices: overlaps and misses, double operations and cutting out headlands and corners, wheel the soil and immediately dig it up again, farming within contour banks, etc. Many of these inefficiencies occur with each operation in the paddock, some are cumulative. In addition to waste, these practices **constrain** or **prevent** the adoption of improved, innovative practices such as residual herbicides, plant population management, directed spraying, etc. We must challenge the perception of efficiency.

Soil Erosion

Soil erosion is an irreversible loss of resources and must be a dominant threat to sustainability. This has always been recognised but how much progress have we made? In March 1994, a small flood in the Fitzroy River carried six million tonnes of suspended sediment out to sea. This was the first time we have attempted the measurements! The cost to producers is difficult to quantify, but who can deny the magnitude of the problem. Soon, environmental legislation may enforce a massive change in performance. We must challenge the perception of responsible farm management.

WHAT DO WE KNOW? *The light at the end of the tunnel*

Soil Compaction

Our program in Central Queensland started as a soil compaction and repair project. Demands by funding bodies and our own priorities, made us consider adoption strategies from the beginning. This inevitably drove us to the concepts of controlled traffic, permanent beds, zonal tillage, etc., and introduced a philosophy of soil management.

I was involved with the irrigated cotton industry as it evolved into a soil management philosophy over the last 15 years. It started with the "rip some and gypsum" approach - deep ripping, profile inversion (massive mould boards), etc. and has now developed to minimal tillage, permanent wheel tracks and controlled traffic. The "high energy input" solution was challenged and the final product is a minimal energy input approach. A basic principle is that we must select inherently good soils for our farming soils, and good soils only need minimal modification to be sustainably productive. A key element of the cotton soil management philosophy has been the SOILpak package.

The rapid adoption of controlled traffic in the irrigated cotton industry over only five years is great support for the attractiveness and feasibility of these concepts. Cotton growers now value their soil. This change to a soil management culture must now happen with dryland growers.

Low Productivity

A dominant issue is our expectations. Productivity means turning rainfall into yield. Droughts tend to create a focus on negativity but they should heighten our focus on efficient use of rainfall. The potential gains are enormous. Average cereal yields in Central Queensland are 1 - 2 t/ha from more than 600 mm annual rainfall. Efficient use of this rainfall would yield 6 t/ha. Soil water accumulation during fallows rarely exceeds 20% of rainfall received. Typically 70% of fallow rainfall is lost as soil evaporation. Our challenge is to convert much more of this rainfall into yield.

We know that surface management (stubble management and tillage) has little effect on soil evaporation, so we need to plant more often. We need to re-examine what a planting opportunity is. How much stored water is needed? What are the future implications of the "to plant" and "don't plant" options? We have measured fallows with over 300 mm rainfall that was all lost to soil evaporation. We did not recognise planting opportunities that could have produced 1 - 2 t/ha; and we lost the water anyway. In general, the shorter the fallow the more efficient it is.

In Central Queensland, most productivity is lost in good seasons. Average yields increase with seasonal rainfall, up to about the average rainfall value. More rain then does not seem to increase average yields. Wet seasons have many problems; too wet to plant, too many weeds, insufficient fertility, more disease, losses at harvest, etc. But the challenge is to do much better in these good seasons.

Drainage is also a loss mechanism for soil water, but the impact of controlled traffic is likely to be small. The maintenance of high cover levels and the improvement in soil structure may increase drainage during wet periods, but if cropping frequency increases, the impact on an annual basis should be small.

Rainfall after crop maturity or soon after harvest provides considerable opportunity. Zero tillage (direct drilling) technology is now available to control weeds and crop regrowth, and to plant into stubble. Soil fertility, particularly nitrogen availability, may then become limiting and the ability to sidedress fertiliser in a controlled traffic system offers the solution. This technology has not yet been developed, although there are plenty of ideas.

Farm Efficiencies

We have known for many years how senseless random traffic practices are: the enormous weight of tractors, the poor traction of cultivated soils, the cost of cultivating wheel tracks, the idea of planting in wheel tracks. The benefits of controlled traffic in direct cost reduction have been quantified (up to levels of 50%), and other potential benefits, such as use of a smaller tractor to do the same job and increased speed of some operations, have been demonstrated.

Row cropping approaches, made possible by controlled traffic, provide another quantum leap forward in farm efficiency. Basically, the opportunity is provided to do a perfect job in only one pass - no gaps, no overlaps. However, there are inefficiencies associated with headlands.

Dealing with contour banks is a difficult issue. Three fairly unpalatable options exist. One is to traffic over the banks - this will pull downs the banks, may increase cross-bank cracking and the bank channel is a wet spot. The second option is parallel contour banks which are difficult to design on uneven slopes and the third option is sacrifice areas within the contour bays where weeds etc can proliferate. We must challenge our design criteria.

Soil Erosion

We have an enormous information base on soil erosion and yet catastrophes still happen. Soil erosion has been our greatest challenge in the development of controlled traffic systems. I will try to establish some basic principles and examine how they can be applied.

The first principle seems to be that water runs down hill. Also, for rainfall runoff, the further it runs the larger the flow, the higher the energy and the greater the erosion. Contour banks reduce this length of run. But, the concept of contour cultivation tries to fight this principle and encourages flow across the slope. This will concentrate water into any low spots where downslope flow occurs, and the flow volume depends on the contributing area across the slope not on the distance between contour banks. When runoff occurs, the goal must be safe disposal. There is no doubt that many small downslope flows are much less erosive than large, concentrated flows.

The second principle is to optimise high infiltration conditions. Contour cultivation will increase infiltration by ponding water across the slope. This can reduce runoff when infiltration rates are high but our soils can have infiltration rates of 1 mm/hour or less when wet. Most of our soils are cracking clays and while in India, I saw a controlled traffic system called broad bed and furrow (BBF), that had changed the soil cracking pattern. Large cracks formed in the furrows. When runoff occurred, it collected in the furrows and was directed to these cracks. After 150 mm rain in a few storms, there was no runoff and the cracks were still open. This is the infiltration process that flood irrigators use, but we have not observed it in normal broadacre farms. Typically, cracks are closed at the surface by cultivation or by rain wetting the top 10 - 20 cm of soil.

The third principle is controlled traffic layouts will strongly influence water flow when runoff occurs. Water will flow along wheel tracks, crop rows, any cultivation furrows, etc. We have established two rules for our designs:

- The CT lines must drain to a safe disposal point - no reverse flows, no low spots. Disposal could be into a waterway or contour bank.

- All the runoff generated within each CT line must be retained in it - no cross flows.

These rules effectively maintain the runoff distributed across the landscape, just like the rainfall. The idea came from the Emerald Irrigation Area, where downslope hills and furrows have been used since inception of the scheme in 1974. When tested using the KINCON model, the potential was demonstrated but it is essential to prevent cross flows in the designed layout.

Stubble retention and reduced tillage have been universally shown to reduce soil erosion by a reduction in runoff, combined with a larger reduction in sediment concentration. High cover levels can only be maintained with the use of herbicides and there are additional benefits from attached stubble compared to slashed or plowed out stubble. The sophistication with herbicide application possible in controlled traffic systems ensures high performance while minimising the total herbicide input to reduce costs and environmental impact. Accurately marked wheel tracks provide opportunities to inter-row spray, spray at night, use residual herbicides, etc. And I think one of the most important things for farmers - the foam marker goes to the dump! The maintenance of high cover levels is particularly important at planting time, when runoff can be the difference between a fully wet seedbed and a layer of dry soil. One of the essential benefits of controlled traffic is the

ability to minimise tillage and this provides further insurance against erosion within the downslope configurations.

In summary, there are good reasons why soil erosion can be minimised in controlled traffic layouts, but we are researching these issues at Emerald, with a bed and furrow layout that is designed to ensure that our rules are kept. After two years, the results are very encouraging but it is fair to say that beds and furrows are not attractive to any of our broadacre collaborators. My current view is that a 3 m wide bed and furrow system is a good option in terms of erosion control, weed management, easily identified wheeltracks and compatibility between tractors and harvesters, but a 2 m wide system is better for some crops, for example, cotton.

ON-FARM EXPERIENCES

The adoption of these improved farming practices has been, at best, slow. An obvious constraint that little work has been done on effective ways to implement these technologies on-farm. And if each technology requires independent implementation, then the proposed system becomes too complex. The "better than sliced bread" part of controlled traffic is that it facilitates the implementation of all the technologies already discussed, and, we think, heaps more that have not yet been thought of. Controlled traffic is a unifying, encompassing farming system.

But is controlled traffic feasible and practical on broadacre farms? We established an R,D & E program on-farm to test this and to identify constraints to its use.

All expected benefits have already been demonstrated but it has not been easy. The major issue has been marking of the wheeltracks. Controlled traffic is a permanent set of parallel wheeltracks. They don't have to be straight, although I'm sure that helps, but they do have to be parallel with accurate guess rows. We think that the solution lies in automated tractor and implement guidance. The initial layout is crucial but wheeltrack identification has also been a problem, particularly in our self-mulching soils. Different planters and cultivators vary in their ability to fallow the tractor, hence the need for implement guidance and steering. Wheeltrack maintenance is also a problem. But our collaborators have all convinced themselves that this is their way of the future. As problems arise, they will be solved.

THE FUTURE

Controlled traffic looks like providing an integrated system that has a wide range of benefits with few, identified deficiencies. We think the most exciting thing however, is the opportunities for new inventions and innovative ideas. The ability to do the current operation in exact relation to previous operations is so powerful. Irrigators have demonstrated the benefits of interrow cultivation, directed spraying and precision harvesting. Dryland growers will benefit from these practices but we have already identified other opportunities such as furrow planting, planting between stubble rows and side dressed fertiliser. Some night time operations have advantages, such as herbicide efficacy. We should be able to design a tool to remove cotton and sorghum plants with minimum disturbance. Cotton and sorghum are very hard to kill after harvest, but with controlled traffic they could be ratooned and efficiently fertilised, sprayed, etc. Soil improvements between wheel tracks will take time to develop, but improved performance when moisture seeking and more even crop establishment have been reported.

This discussion has stressed the soil, land and crop management issues from a production viewpoint but the environmental benefits are consistent and complementary. Decreases in erosion, total

chemical application and soil degradation, and increased productivity are all environmentally friendly. Control traffic supports the concepts of responsible resource management.

While the interest in Australia is uniformly enthusiastic, there is no apparent enthusiasm in overseas countries. Considerable R&D was done in USA more than ten years ago, much of it similar to what we are doing now. The results were positive but interest and adoption by farmers has apparently been negligible. I do not know if they had an integrated approach to extension. The BBF concept has not been adopted in India despite considerable subsidies. I think they forgot to talk to the farmers. The technology has been described as "perfected yet rejected" - a sobering thought for researchers.

Controlled traffic gives us the opportunity to challenge all the agronomic rules of thumb and redevelop them for the 21st century. The future will see new equipment specifically designed for the improved soil condition and to do specific jobs. Tractors and headers will have the same wheel spacing and same tyre size. Our main challenge will be to achieve widespread adoption because change to minimum tillage and downslope layouts is antagonistic to a whole generation of developed perceptions. And there are risks because careless adoption of these practices could lead to increased erosion.

The development of these concepts have been strongly influenced by my experience in the irrigated cotton industry. For dryland farmers it is always worthwhile to look at what intensive agriculture is doing. Cottongrowers now prepare for next season as soon as possible after harvest. Dryland growers should be more urgent than irrigators with post harvest preparations because they do not know when the next planting opportunity will happen. In the future, post harvest management will become more urgent as the value of each planting opportunity is better appreciated, and the cost of missed opportunities recognised.

Like many before us, we were driven into controlled traffic to control soil compaction. But when the potential to control soil erosion was identified and we realised that many, possible management improvements were cumulative, we concluded:

Controlled traffic is better than sliced bread. It just makes good sense and the only surprise is that someone didn't think of it earlier.

Will there be a dryland broadacre revolution?