CONTROLLED TRAFFIC FARMING - THE FUTURE

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Controlled Traffic Farming (CTF) is a very recent concept, at the 1995 Conference we only referred to Controlled Traffic. That epitomises the rapidity of change that we have established. The change from CT to CTF is only one letter but the implications are enormous. CT means a farming practice for soil compaction management in isolation of other practices, CTF means a farming system that aims to include every aspect of farming as I will attempt to describe in this paper. At the 1995 Conference I attempted much the same, but it is interesting that our definition of "farming" has broadened considerably as we all strive harder for sustainability in terms of production, profitability, resource management, environment and our social structures. And our belief that these can be and must be achieved together has been reinforced by our experiences.

WHAT IS CONTROLLED TRAFFIC FARMING?

The essential elements are permanent wheel tracks (as few as possible), runoff controlling layouts, efficient use of inputs (seed, chemicals, energy, and rainfall), and the grower's FARMING SYSTEM.

- CTF is driven by RESOURCE MANAGEMENT ("great soils" - soil compaction, infiltration/runoff, erosion, drainage, root growth, zonal management);
- CTF supports BEST AGRONOMY/CROP MANAGEMENT ("great crops" - options, minimum tillage, timeliness, effective operations, efficiencies);
- CTF protects the ENVIRONMENT (clean runoff, balanced inputs);
- CTF is PROFITABLE (reduced costs, increased income);
- and CTF builds SOCIAL SYSTEMS (viable industries, responsible custodians, community and government support).

And we need performance indicators as goals and targets. Our Central Queensland performance indicators are high cover (more than 50%), low erosion (not visible), high farm water use efficiency (annual production/annual rainfall), high returns on investment (10%), and annual holidays for growers (four weeks).

OUR KNOWLEDGE IN 1995

I will briefly review our position in 1995. In 1995 I wrote that CT provided a delivery mechanism for improved practices; that CT could develop into an integrated, functional system; and that the issues were soil compaction, low productivity, farm efficiencies and soil erosion. We had established some basic rules:

- Soil compaction is predominantly caused by wheels and growers must change to a soil management culture. CT provided the opportunity for both physical change and attitudinal change.
- Productivity is based on perceptions of what yields a region can produce - again an attitudinal constraint. Efficiency indicators, such as water use efficiency, tractor efficiency, etc. provide useful criteria for performance assessment. Higher yields, more frequent planting and more flexibility in all operations were highlighted.

- CT means permanent wheel tracks and row cropping with major increases in efficiencies within the cropping system. This introduced the concept of zonal management - wheel tracks, crop rows and inter-rows and the ability to manage each zone separately. But how to achieve erosion control?
- Water flows downhill and concentrated flows increase erosion. CT lines will direct runoff and spread it across the landscape. Our CT designs provide in-paddock control of runoff to reduce flow concentration - a first. In addition, maximising infiltration by high cover, minimising compaction and accessing cracks with CT systems will reduce runoff and sediment concentration. CT can control erosion if layouts have no reverse flows, no cross flows and drain to safe disposal points, and if zero tillage and cropping systems maximise cover.
- CT was demonstrated as feasible and practical on a range of broadacre farms.
- In conclusion, CT is better than sliced bread, it makes good sense and the only surprise was that someone didn't think of it earlier.

The conclusions from the 1995 Conference were the birth of CTF as a sustainable farming system and the confidence to "Have a Go".

OUR KNOWLEDGE IN 1998

As discussed previously, we now understand that a sustainable farming system involves at least resource management, agronomy, environment, economics and social sub-systems. This "systems thinking" and our focus on farming systems not only provided a context to incorporate improved practices, it also gave us credibility with growers because they related to the system we were working on. We all owned the same system - CTF.

The Central Queensland adoption has continued to more than double each year and virtually every grower who has tried CTF is committed to full adoption across their cropping area. This fence to fence adoption is an amazing achievement for such a complex technology. The publicity following the 1995 Conference and presentations at Field Days and Workshops across the northern grainbelt have ensured that CTF is very widely known across the farming community in Australia. At many of these presentations growers were the primary speakers and their commitment, enthusiasm and passion have been the major influence in changing other grower's attitudes and providing them with the confidence to "Have a Go".

We have welcomed many visitors to Central Queensland and they have all contributed information and ideas. Massive areas of CTF in Northern NSW and southern Queensland are now indications of our impact. More importantly this wide adoption has had a tremendous synergistic effect on development of CTF. Every paddock is an experiment and CTF growers are great observers and willing to contribute to development. A major benefit has been a close relationship with growers and consultants in northern NSW. Their agronomy has been a revelation to us and stressed that higher yields will be more important than cost reductions in the economic performance of CTF. Recent economic analyses (with economist Fred Chudleigh of Emerald) indicates possible net returns of $300 per hectare and returns on capital invested of more than 10%. A reality check with four local growers supported these conclusions as being realistic. Achievement of high returns at Dalby, Moree and Gunnedah may be due to a more reliable climate but the average conditions in Central Queensland are very similar, we just have to learn how to manage the higher variability. Not an easy task but a rewarding area for future research. The exciting response is that research results from CQ will have wide application across the northern grain belt.

Bus tours have proved to be a very successful adoption vehicle, we estimate 80% of participants have gone home and adopted our message. A captive audience for 3 or 4 days is a wonderful

opportunity for discussion, clarification and reinforcement, and for planning the work program back home. We aim for many stimuli and for growers to talk to growers. I also believe a mix of enterprises is useful, particularly more intensive farms.

We now have a network across Australia, all contributing new ideas and experiences. Undoubtedly, Jamie Grant and Rob Taylor are the benchmarks for CTF and their contribution must be applauded by the industry. They challenge everything and know no barriers. Jamie's impact on our team has been pivotal as he started well before we did and is still well ahead. Jamie challenges us to look wider still and consider such diverse aspects as farm labour, legumes and floodplain management. Jamie has given us tremendous support and also introduced us to the importance of attitudinal change.

From Kingaroy, Richard Mason gave us his experience on higher slopes and red Kraznozems, and on dealing with a system and region in decline. The consultant groups of southern Queensland and northern New South Wales provided insights into crop production and efficiency, and now the Victorians and Western Australians are developing CTF for very different climates to ours. In preparing for this Conference I had several discussions with members of Southern Farming Systems in Victoria where adoption of CTF (raised beds and furrows) has increased from one ha to a few hundred hectares to 7000ha over three years. Similar to CTF in Queensland, components of their technology were tested fifteen years ago without adoption, why? Their program has many parallels to ours and the responses have almost been identical. I kept replying "we found that" and "our growers did that". This further reinforces that we are on a winner with CTF because in Victoria development is for drainage of wet soils during their wet winter.

Across the network the same principles seem to apply, the issues are similar, the solutions often similar, the technology is transferable, and the enthusiasm and optimism of the growers is just the same. The key points are systems thinking and attitudinal change. Surely this is a very powerful message - how can we harness it?

This success with adoption, with creating change, has made us analyse what we do. Why has CTF been so widely adopted, why are CTF growers so committed? We have concluded that it is the combination of a technology package with a people process. So it is a true partnership between the growers and the service providers. The strength of farming systems work is that the only place it can be done is on commercial farms, and the on-farm development program provides an effective action learning platform for all of us.

Our experience since 1995 has particularly emphasised the issue of grower attitudes. Introduction to CTF has been a great catalyst for attitudinal change - it throws away many perceptions that constrain our thinking and provides a clean slate. It is now clear that changes in grower attitudes are obvious performance indicators of our program. And those new attitudes will be the driving forces or the future.

Parallel changes in the attitudes of professional service providers are also required since we have similar entrenched beliefs that constrain both our ability to analyse problems and to find solutions. Undoubtedly the greatest challenge has been for soil conservationists who have achieved much over the last 30 or 40 years but still soil erosion is the major degradation issue across the northern grainbelt. Our approach has been to build on the sound theoretical base but to challenge the attitudes, practices and solutions that have developed. A solution developed in the 1960's demands re-examination in the massively changed farming environment of the 21st century.

Erosion is identified by growers as the main concern about our downslope layouts. However properly designed layouts on sloping lands have performed extremely well from Clermont to Gunnedah. After major storms in early 1997, we conducted aerial surveys of the erosion damage. This was a revelation to me and an experience that I would encourage everyone to share. Firstly it was very obvious that the major processes of erosion were rilling, broken contour banks, ineffective waterways and stripping of top soil in flooded areas. Due to the ease of aerial observations, these could and should be performance indicators for erosion control. To my knowledge no records of such performance have ever been taken. The damage was considerable. After some ground truthing, we estimated about 20 million tonnes of soil were moved - surely proof that new approaches to soil conservation are desperately needed The aerial inspection showed that rilling was independent of cover levels and was clearly a consequence of field operations around the contour, which concentrated runoff into rill lines. Unfortunately, rills in long term zero till paddocks were up to 0.5m deep and seriously restricted any following operations. Apparently this was due to no compacted layer in the soil profile. CTF paddocks performed extremely well. Even with low cover, erosion was small (less than 10t/ha), the contour channels were not silted and access was possible within 5 days. We concluded that downslope layouts designed to our rules would provide adequate in-paddock erosion control, and that contour banks and waterways must be better designed, constructed and maintained. Another interesting lesson has been that many growers fly over their properties and know the devastation caused by severe storms. They are extremely frustrated that all their efforts based on the best available advice have not been effective. Yet they have not demanded more research and better advice, and the service providers remain largely oblivious. Our future emphasis will be on whole farm design for runoff, erosion and traffic control.

THE FUTURE

Science

The application of a sound scientific base to develop CTF at the paddock scale is seen by many as lacking scientific rigor. Scaling-up creates challenges for science that have been highlighted by our success with adoption. Is our science ahead or behind?

On-farm research methodology: CTF can only be applied at a paddock scale using farm machinery - that clearly is the implication for any farming system research. How then can systems be compared? What is the value of replication if paddocks (plots) are hundreds of hectares in size? What measurements are useful at such scales? How can answers be achieved economically within a reasonable time frame? These questions are fundamental to farming systems research. Much current research studies cropping systems or soil management systems in isolation of the most basic component of modern agriculture - mechanisation. Our program suggests some positive directions for this scientific debate. The large scale implies considerable soil and landscape variation across sites and the multitude of inputs (weather, management) and decisions limit direct comparisons. For example, if comparing CTF and the conventional system, how are planting decisions made without bias? It is also necessary to have two sets of machinery! The most practical comparisons may be made, using appropriate indicators, between paddocks on different farms with the farmers optimising their own farming systems. But even the choice of indicators will be controversial.

And what do the growers want from science? Our experience suggests that their decisions will be based on observations of large areas, discussions with experienced and respected growers, and their own action learning. But science has a role to ensure that the science is sound and that the interpretations and extrapolations are reasonable. This implies that we have useful indicators of

production, economics, resource condition and off-site impacts. Yield monitoring will provide new insights (the highest yields in paddocks suggest crop water use efficiency higher than the physiological potential); water use efficiency is a key but we need methods that relate to annual rainfall not individual crops; aerial photographs after erosive events can quantify rilling, broken contour banks and waterway effectiveness; paddock records are essential; soil health may be measured by earthworm numbers, root growth or ease of digging; and techniques to measure suspended sediments which carry most environmental pollutants off farm will provide a useful data base.

Research issues: Specific issues for science include the long term effects of permanent wheeltracks; the agronomy of uncompacted soils (what are potential yields?) - yield increases must be achieved to fully benefit from CTF adoption (do we need new varieties, practices, etc.); the opportunities from accurate zonal management (potential innovations are boundless); automated guidance is an essential requirement (cost reduction for GPS and further development of video systems); and grain drying to allow early harvesting and preparation for the next crop.

Agronomic research that specifically uses the precision made possible with CTF is just beginning. Some manipulates the soil surface by moving stubble or creating furrows, and is looking at the value of side-dressed fertiliser - how late can it be applied? When is it useful? An interesting program is looking at manipulating crop phenology to better fit our variable and unreliable rainfall patterns. Essentially, this research aims to separate crop establishment from grain production. The basic concepts are: establishment needs little soil water, established plants and root systems can produce grain much quicker after rainfall than a sown crop, and rain is about four times more efficient in-crop than for fallow storage. Similar benefits may be achieved by ratooning.

The on-farm developments will identify many research needs and opportunities. Because problems are defined within the farming system, solutions will be directly applicable to that system - assured adoption. Will our scientists be able to research these problems and provide innovative solutions? It will certainly require attitudinal change.

CTF and floodplains. An essential future role for science is to identify and answer the new questions asked when CTF is applied to larger paddocks and across different situations. A burning issue is floodplains. It is surely reasonable to question current approaches to floodplain management that have been in place for nearly 50 years and have on occasions performed poorly. Also some of the principles have not been widely adopted (a result that threatens the whole floodplain), and farm efficiencies and high cover levels are not maintained in many strip cropping layouts. Some of the theory is debatable - is it desirable to encourage runoff from one strip to wet up an adjoining strip? Our approaches in terms of questioning current practices, involving growers and achieving adoption may have application.

Farms and Farmers

Best management practices (BMP): Development of BMP or environmental management systems (EMS) with linkages to environmental monitoring seems essential. Cotton's BMP program and the links to water quality at least for northern NSW streams is a positive direction. Research is needed to study the impact of on-farm improved management such as CTF on downstream water quality. This research should be industry funded.

Change in grower's attitudes will be the catalyst for a major effort on farmer driven BMP, EMS and Quality Assurance. Is there an opportunity to develop a CTF label as an indicator of sustainable production methods? Could this be accredited internationally? There is an industry

responsibility to farm efficiently and effectively with minimal environmental impact. I believe CTF is the sustainable future of broadacre cropping industries as permanent beds are for irrigated cotton, but major efforts are required to establish benchmarks and monitor performance, to increase community awareness and to gain community confidence. The cotton industry provides a template. These issues demand industry wide support. CTF growers must control their futures and provide the necessary leadership.

Whole farm layouts: CTF impacts on every activity on farm and whole farm planning is clearly needed to provide a robust, efficient and effective system. Whole farm layouts will incorporate runoff, erosion, drainage and traffic control (control the water, control the wheels). Control of run-on water and runoff disposal will be key elements. This is the next step but do we have the resources to cover the massive area of the Australian grainbelt? In many situations existing data can be used to develop layouts (as we now use contour bank layouts to design in-paddock CTF) but professional assessment will be essential as will be training of growers to assess and understand in-paddock impacts. Currently the necessary professional resources are not available and agencies have no policies to provide them. An industry priority should be to change those policies.

Machinery: The source of most of our opportunities and frustrations. But we have seen major changes with most tractor manufacturers now offering a 3m wheeltrack. If we can standardise on 3m for broadacre farming the benefits will be enormous. In fact if we don't standardise, the full potential of CTF will not be achieved. The biggest challenge could be to incorporate cotton into a 3m system. Would 3m cotton have some benefits? Growers will have to bite the bullet on sprayers. An economical, high clearance, fast tractor on 3m wheel spacings would offer more options. Surely this Conference could provide some clear directions for manufacturers.

Growers will reduce their machinery as cultivation becomes less used and lighter gear will suffice. But planting options will become even more important. Growers will have at least two planters - one for wet conditions, one for dry conditions. CTF will allow trafficability when the soil is still "too wet", and the opportunity to plant can not be lost. Are planters available to plant such soils? Soils will also be very soft and current depth control may not be successful as the raised bed farmers are finding. Can the wheel tracks provide depth control using radar systems? Stubble handling and inter-row fertilising are other essential components.

Guidance: The developments by the Mailler family are very exciting. They have developed a system for their own farm and then made it robust enough for commercial use. This pioneering development is the basis for real progress because they are testing the equipment at farm scale under field conditions - action learning. While this identifies problems it also assesses questions of quality - do we really need 2cm accuracy? Will it work over contour banks? How reliable is it?

A personal frustration of mine is that video guidance systems have not been developed for broadacre applications. I think that this technology has something to offer particularly in terms of high accuracy at a low price. If GPS can put us within 0.5m, could we then switch to video for the accurate in-field work? But there is a lot of development work needed to produce robust, reliable equipment suitable for broadacre use. As I understand, the technology is not the limitation.

National interaction: A national focal point and a national network are keys to sharing of information and rapid progress. The R,D&E program across Australia should be coordinated to reduce duplication and ensure vitality. Grower-scientist teams should be the building blocks. A communication program is essential - face to face, grower to grower works best and should be

encouraged, facilitated and supported by Governments and funding bodies. Other modern communication systems must be developed in parallel. I have also identified issues where industry wide and multi-Government approaches are needed. There are obvious deficiencies in current policies and practices. A National Network for Controlled Traffic Farming could initiate these changes. Australia is alone in the World with adoption of CTF, so there must be International opportunities. A National Network could facilitate this.

CONCLUSION

CTF is a whole systems approach to improved resource management. This has been rarely attempted before. The consequences have been higher productivity, lower costs, higher efficiencies, improved soil and land resources, and reduced off-farm environmental impact. These are quantum leaps forward for sustainability that can be achieved on most grain farms today.

CTF has also achieved unprecedented rates of adoption despite its complex and controversial components. CTF is now used successfully across more and more diverse environments. Australia leads the World. But is CTF accepted as the farming system of the 21st century by all agencies and funding bodies, and supported accordingly? No, and the most sceptical seem to be those closest to the developments. Peter Cornish has highlighted the poor performance of the northern grainbelt compared to the rest of Australia and I contend that the answer is a dominant focus on resource management issues. Are the breeding and agronomy programs conducted within improved resource management systems or in bare fallow, tilled systems? There is only a small input to study weeds, diseases and pests and the whole ecology of high stubble systems. Yet, these are our future. Is research ahead or behind?

Soil erosion must be the most significant resource management issue in the northern grain belt but it is not given the same priority that salinity and acidification receive in the South and West. Is it because the obvious effects of erosion are quickly removed as farmers plant and cultivate, but salinity and acidification cannot be so easily removed? The farm condition is the prime concern of growers who all want to pass it on better than when they started, yet the scientific community has let them down. Can we now rise to the challenge? Will we be able to fly over our farming areas after a heavy storm or a flood and be satisfied that erosion is under control?

I wish to acknowledge the thousands of inputs from a large number of people that have contributed to this paper. I particularly acknowledge the Central Queensland team - Stew Cannon and Wayne Chapman, the researchers led by Bruce Radford and Ken Rohde, and the initial six cooperators who took the first step - Rod Birch, Lyall Swaffer, Ian Buss, Murray Jones, Chas McDonald and Bob Mathieson.

Finally, I wish to dedicate this paper to the memory of Bob Mathieson, an inspiration to us all, a true pioneer, a tireless innovator, and a constructive and challenging critic - we miss you Bob.