CTF and PA Tools – the Perfect Match

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ABSTRACT

The paper briefly reviews the basics of CTF and the benefits for farming systems, and the available PA Tools and their value in CTF systems. The paper examines the platform created by CTF to improve the triple bottom line and the complementary use of PA Tools to provide the next steps for CTF. Highlights include understanding productivity drivers, causes of variability and management opportunities; automated record keeping and measure to manage; on-farm R&D for system improvement; and building partnerships for achieving goals.

THE BASICS OF CTF

CTF specifically recognises that cropping is mechanised, wheel compaction is good for wheeltracks but bad for crop growth, and wheeltracks are spatially distributed.

The Basics of the CTF system defined by our experience so far are:

1. Property management planning. The PMP is based on natural resource identification and suitability, goals and needs analysis, and infrastructure.
2. Designed paddock and farm layouts for water management and infrastructure. Paddock layouts consider surface water flow and drainage, waterlogging, soil types and properties, wind direction and erosion, access and efficient transport, and logistics.
3. Controlled traffic or permanent wheeltracks to manage compaction, increase infiltration, and provide access and timeliness, accuracy and efficiency. All tractor and harvester wheels are on defined wheel tracks. Wheel tracks are typically 3 m wide (to suit the harvester). Low cost machinery modifications are available.
4. Matching machinery and auto-steer = precision. Machinery should be reduced to planter, sprayer and harvester with chaser bin. 9, 11 and 12 m units are grain options. 2cm RTK GPS auto-steer is recommended, particularly for marking at planting.
5. High cover levels - zero tillage. Controlled traffic makes accurate, efficient, effective and flexible herbicide applications possible.
6. Farmer/adviser/supplier partnerships – a team approach. Each farmer/farm combination is unique. CTF systems are developed through partnerships between land managers and technical advisers.
7. Measure to manage for continuous improvement, record keeping, on-farm R&D and problem solving. Many new technologies are available, and they all work better with CTF.

The theme of this paper is **"everything works better with CTF."**

The farming system impacts from these few basics all seem to be positive.

1. Optimum resource allocation and use – natural and purchased
2. Natural resource quality, manage resource degradation (compaction, water and wind erosion, waterlogging, deep drainage and salinity)
3. Access, efficiency, effectiveness, flexibility and most of all timeliness
4. Precise row, inter-row, wheeltrack management
5. Higher water availability and crop water use, i.e. productivity
6. Opportunities for dynamic, innovative management and continuous improvement.

In summary, CTF is a comprehensive and strategic systems approach; it is aimed at sustainability; it is triple bottom line; and it provides the essential spatial framework for most new technologies. We have CTF solutions for grain, cotton and cane, horticulture is still a challenge. The challenges for CTF are to achieve maximum profitability (how to maximise our NRM and machinery) and maximum performance and personal benefits (automated record-keeping with appropriate processing, reporting and actions).

APPLYING THE BASICS

1. **Improved agronomy.** CTF improves the soil physical and chemical fertility and our agronomy must use this to produce higher yields and increased incomes. Soil water relations are optimised, the fundamental driver of dryland farming. Growers have stated their goal as "**PRODUCTIVITY IS LIMITED ONLY BY LACK OF WATER**". Much on-farm research is needed to determine how best to farm the non-degraded soils that CTF produces. Conventional research approaches (varieties, crops, herbicides, etc) must also use CTF as the base to produce relevant information. Machinery issues are critical and team approaches are needed to progress planters, sprayers and harvesters to optimise CTF systems. Growers have done on-farm R&D that can provide a base and direction for the future.
2. **Auto–steer, 2 cm GNSS.** Growers with auto-steer report that this was the best investment they ever made. With CORS networks and much reduced prices, RTK auto-steer is now a must, the first investment to make in CTF, for accuracy, reduced driver fatigue and all drivers perform equally well.
3. **On-farm R&D.** The controlled traffic system with yield mapping facilitates strip experiments. Grower managed trials within the farming system ensure that results are applicable and quickly adopted.
4. **GIS computer based farm record systems.** CTF systems support automatic recording of farm operations and measurements, and incorporation of all information into a GIS based system for all spatial data.
5. **Use remote sensing.** Remote sensing such as multi-spectral aerial or satellite imagery offers cost effective, high resolution data to measure farm performance and responses to treatments. It links with yield monitoring and the spatial accuracy of CTF and does not interfere with farm operations.
6. **Use efficiencies as performance indicators.** Efficiencies reduce the year to year and season to season variability. Measures such as water use efficiency, machinery efficiency, and financial efficiency are useful.

PRECISION AGRICULTURE TOOLS

PA tools are digital, spatial, temporal and measure something (collect data).

Digital means computer ready.

Spatial means accurately located in space (you know where you are), and in the computer we can overlay data. Space has 3 dimensions – x, y and z. Time is also recorded.

Sensors measure yield, spectra, radiation, electrical properties, etc. The most common spectral data are multi-spectral – colours, infrared, thermal, etc. and now hyper-spectral (256 or more bands) are available. Radiation (gamma, magnetics and radar) is widely used in geology. EM is an example of electrical properties. These PA sensors provide information about landscapes, soils and crops and their spatial distribution.

Other important measurements, e.g. soil sample analyses and soil water, salt and pH are not well suited to spatial collection.

PA Tools are used to define and manage variability in crop yield, maturity and quality. Management options depend on the scale of definition. We manage wheel tracks, inter-row and rows with high resolution data; and soil types and management zones with coarse resolution data. Management should be based on understanding causes.

We want to manage paddocks uniformly, particularly at harvest time. Reducing variability is important, e.g. from machinery or waterlogging. Creating variability is bad, e.g. with contour banks, land leveling, roads and fences, and variable fertiliser inputs.

Successful PA tools include:

1. **Imagery.** Imagery is the powerhouse of PA tools, it can provide digital, spatial, temporal data from a range of sensors very easily at a low cost. Imagery can be satellite, aerial or proximal (close to the target, e.g. hand held or on a machine) and each has a place depending largely on the area of interest. Each can deliver $1m^2$ pixels or less. Many sensors are available but these are in-direct measures of yield and biomass. So, we must evaluate the value of the data.
2. **Yield monitors.** The most basic measure of farm performance. Fundamentally the data quality depends on having a full comb all the time to ensure reliable and credible data. Yield maps should be "ground truthed" each season to remove known errors. Pixel size is about $400m^2$.
3. **Topography.** With RTK GNSS, topography to 5cm resolution can be easily collected at a reasonable price. Topography is essential data for farm layout design and particularly for waterlogging management. Topography is typically related to soil types and a useful indicator of soil distributions. Topography pixels are about $200m^2$. Growers with RTK GNSS can collect their own data.
4. **GNSS location.** The location log records where you are and where you have been when. These data are useful in GIS analyses to link an effect with prior actions.
5. **Soil properties.** These include EM (spatially measures electrical properties related to clay, water and salt content, pixel size about $200m^2$) and soil sampling for PAWC and nutrients. Soil samples do not provide spatial data, the pixel size could be $100,000m^2$.
6. **GIS Tools.** For data management and record keeping, for analyses and relationships among data layers, for identifying causes of variability, and for reporting as maps and graphs. These are

powerful tools but they depend on the quality of the data. If the data is variable, statistics can be used. This will hide the variability we want to understand and repair.

LINKING CTF AND PA TOOLS

CTF imposes a defined spatial distribution on all farm machinery activities, and defines variability by where it is and what caused it, e.g. wheel compaction. CTF ensures that one operation can be carried out in exact relation to past or future operations. CTF ensures quality data from yield monitors and the value of GIS analyses. When CTF is designed to reduce variability, particularly caused by waterlogging, erosion, compaction, fences and rocks, crops grow more uniformly and PA Tools work better. CTF supports collection of spatial, digital data in computer ready formats.

Imagery at small pixels is the key linkage with CTF because CTF aims to manage uniformly at about this scale, e.g. wheel track compaction, row and inter-row management. Therefore the variability created by random traffic is removed and other variability identified. The only value in high resolution imagery in non-CTF paddocks is to show why CTF is needed.

Imagery is also a proven agent of change. It shows what farmers know but in a way that can be understood and acted upon. Solutions become obvious. It is possible to drain low spots or move rock heaps, because then CTF will work much better. These in-efficiencies can be “managed” with random traffic.
Imagery is the tool but the driver of this change is the partnership between grower and adviser asking “what can we do with this information?” Many growers say “you have shown me what I already know”, but “If you know everything, it’s very hard to move forward”.

Yield monitors. CTF ensures a full comb all the time, and this allows automated analysis of yield data, only the headlands are “fuzzy”. The reliability and credibility of the data is assured and can be used with confidence. Yield maps no longer need to be stored for 5 years to find some consistency in the “fuzz”.

Topography data are crucial for CTF layouts and identify solutions to waterlogging and drainage issues. The links to landscape properties and soil types are useful.

Pixel size. Our previous work harvesting single rows of crop identified large variability across the planter and due to wheel tracks. This led us to imagery with pixel sizes of $1m^2$, which has further identified a wide range of variability associated with random traffic, poor machinery performance, paddock histories and layouts, erosion and waterlogging, and weeds, pests and diseases. The causes were identified from the spatial distribution of the variability combined with the knowledge of the grower. This variability is caused by grower management and our priority is to reduce and manage it. As Neale and Chapman (these proceedings) have shown, this approach has been successful but in the GRDC PA Initiative we were the only team (of 12) routinely using high resolution imagery.

The common PA approach is to define management zones based on coarse data sets – yield monitors, EMs and Landsat imagery. The pixel size is greater than $200m^2$ and at this scale the variability and causes described above are not obvious. Management zones are typically related to soil types and landscapes, and managed by variable rate inputs.

GIS. High quality data, as CTF can provide, maximises the value of GIS and the confidence in the outputs. This allows automated data processing, rapid reporting back to growers and in-depth analysis. Statistical methods to smooth the data are not needed. Undoubtedly, handling the increasing volumes of data and information (we call this Information Rich Agriculture) is difficult with deficiencies in both software and support services. More software options are coming available but our GRDC project highlighted major deficiencies in support services across all PA tools.

Site Specific Management. The accurate positioning of CTF and PA tools allow management at very specific locations. Examples include inter-row management for stubble handling, weed control, fertiliser application; row management for pest and disease control, and foliar sprays; and wheel track management for weeds and compaction. Precise management also applies to layouts for drainage and runoff control.

USING PA TOOLS TO MAXIMISE CTF

Our goals with CTF and PA Tools are to maximise the efficiencies and effectiveness of farming systems.

We plan to achieve these by:

1. Maximising resource quality and use, both natural and purchased resources. CTF creates the platform and PA Tools support operations. These answers are generally known, but there is an enormous job to achieve adoption across industries and to train and maintain support services.
2. Measure to manage and managing variability. CTF reduces variability and provides the system where PA Tools are effective. PA Tools provide the data, processing and presentation. The PA Tools/CTF combination is the basis of forensic agronomy – how we identify problems, causes and solutions (see below).
3. Measure to market in terms of impacts and products. CTF and PA Tools should be marketed as a sustainable, environmentally friendly farming system. We should produce current and new products of very high quality and market them with a competitive advantage.
4. Continuous improvement through new approaches to on-farm R&D (see below).
5. Cooperation with independence. ACTFA was, in part, established to support cooperation among CTF growers. We have started a contractor's register but there is much to do to support adoption, marketing and R&D needs. CTF/PA Tools is not "on the radar" and much lobbying is required across the board. Other issues like mobile phone and broadband internet are of concern to CTF growers.

Forensic agronomy is about finding the causes of problems in the farming system. As mentioned here and described by Neale and Chapman, PA Tools in a CTF system allow in-depth analysis of crop and soil responses that can frequently identify both the causes of variability and possible solutions.

At 1-4 m^2 pixel scales waterlogging and erosion can be clearly identified and options identified with topography data; machinery performance is also obvious (compaction, overlaps, misses, inefficiency, trees and rock heaps); insect and disease damage quantified; responses to inputs (lime, fertiliser, manures, etc.) quantified. This remote sensing provides a new dimension to crop management.

High resolution data also add value to coarse data layers such as yield monitoring and Landsat imagery. GIS skills are essential, analysis is slow and involves large amounts of information. Automated analysis will be possible in the future but problem expression in each paddock could be different. This is a new concept and we have little experience.

Farm/Farmer R&D. The CTF platform and the measurement capabilities of PA Tools offer a whole new way to do on-farm research. Using strip trials as the basic approach, farmer/adviser teams can design, implement, measure and interpret a wide range of experiments. The basic unit would be a planter or sprayer/spreader width, so treatments are realistically large and practically within the farming system.

With a GPS controller, the plan could be loaded in and operations would continue as usual. This automatically marks the plots. Treatments related to any input are possible but also new crops, rotations, etc. Rate trials would be standard.

Crop responses are measured spatially with imagery and yield monitors, at data intensities far greater than research plots, e.g. IKONOS satellite imagery at $1m^2$ pixels, or 10,000 values/hectare. Other sensors could measure temporal changes.

The opportunity exists to analyse the data as treatment means but more importantly as response curves related to the background paddock variability as measured in the control strips. In one experiment, the responses across the whole paddock conditions are measured. Options to improve poor areas are identified and the good areas show potential yields and realistic targets. The interruptions to normal farm operations are minimal, and the results are relevant and easily adopted.

This approach requires considerable development. The farmer /adviser team involves new skills and roles, planning needs are totally new, implementation should be straight-forward but new analysis and interpretation methods are needed. The adviser role requires new applications of the usual R&D skills and close partnerships with growers. Other technical support may be required to make sure the tools work.

But the potential outcomes are worth it.