



Best Management Practices to Improve the Quality of Water Leaving Irrigated Sugarcane Farms: Guidelines for the Burdekin Region

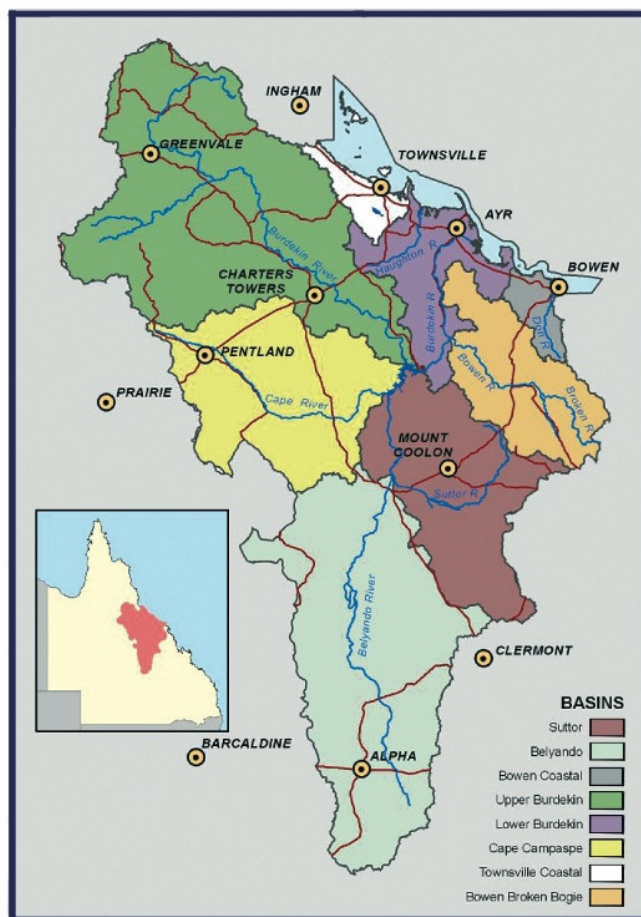
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Best management practices to improve the quality of water leaving irrigated sugarcane farms: Guidelines for the Burdekin region

2007

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Introduction

Recent research has raised concerns about the impact of land based pollutants on the Great Barrier Reef (Furnas 2003). This has led to the development of the Reef Water Quality Protection Plan (Anon 2003), which will require industries in catchments draining into the Great Barrier Reef (GBR) to meet water quality targets. As well as concerns over the GBR, there are other important environmental issues in these catchments, such as the quality of groundwater (Thorburn et al. 2002, Rasiah et al. 2003) or the ambient water quality conditions of freshwater ecosystems in coastal wetlands (Rayment 2003). Management practices to address GBR water quality concerns are likely to provide benefits for these other environmental issues, so a holistic approach should be taken to these problems.

Land use in catchments draining into the Great Barrier Reef (GBR) lagoon is dominated by agriculture; i.e. grazing, sugarcane and tropical horticulture. While grazing occupies the greatest area, sugarcane and tropical horticulture employ intensive production systems using large quantities of chemical inputs. Irrigation is also an important management practice in many areas within these industries. Thus it is important that management practices are developed and adopted to improve the quality of water leaving sugarcane and tropical horticulture farms in GBR catchments, despite their relatively small area. Of these two production systems, sugarcane occupies the largest area and is the focus of these guidelines. A key role for Regional NRM, peak industry and research bodies, and Queensland Department of Primary Industries is identified within Reef Plan to implement relevant strategies to reduce losses of contaminants from agricultural land uses.

The Burdekin region is Australia's largest sugar producing region with ~80,000 hectares under sugarcane producing approximately 30 % of Australia's sugar. It has some characteristics that differentiate it from the other main Australian sugarcane producing regions. Average yields are the higher than the other areas because of high rates of solar radiation. However, the region has relatively low rainfall (~ 1,000 mm/yr), so irrigation is an important aspect of sugarcane production. The relatively low rainfall and high production result in irrigation applications being greater than in the other main sugarcane producing regions. Unlike other irrigated sugarcane regions, the vast majority of irrigation is applied by furrow irrigation. These factors justify the Burdekin region being considered in isolation from other regions. However, many of the principles described in this report will be directly relevant to irrigated sugarcane production in other regions.

These guidelines describe management practices to improve the quality of water leaving irrigated sugarcane farms in the Burdekin region. They have been developed through the collaborative involvement of Burdekin Dry Tropics NRM, BSES, BBIFMAC, DPI&F, ACTFR, CSIRO and local canegrowers in support of Reef Plan and the Burdekin Dry Tropics Water Quality Improvement Plan.

The guidelines consider two main components: (1) a framework illustrating the links between specific water quality goals and on-farm management actions, and (2) a collation of detailed current management principles for sugarcane growing in the Burdekin region. Together these components provide the basis for assessing the potential water quality benefit of management practices and for developing specific on-farm management plans to improve water quality.

Water quality management principle framework

Need for a framework

Farm management practices are a complex mosaic of operations on various aspects of crop husbandry. Each of the numerous operations has an almost infinite variation in the way it can be practiced. These operations are conducted amongst a range of management objectives and practical constraints on a farm. For example, financial or lifestyle objectives need to be achieved within labour, equipment, financial and/or biophysical constraints. Thus, farmers operate within a management hierarchy of goals, strategies (to achieve the goal), tactics (to operationalise the strategy) and finally a specific set of actions (operations) on the farm. At each level in the hierarchy the farmer achieves what is possible subject to the constraints faced on the farm.

Changing operations to meet new objectives, such as environmental objectives, can be difficult because of the complex interaction between the operations and constraints. Imposition of new goals without consideration of the operational constraints can therefore hinder adoption of management practices to achieve these goals. This situation has seen a move away from “top down” imposition of goals (e.g. through regulation) to a “bottom up” approach, where each operation is viewed within the context of the new objective, as well as existing objectives and constraints. A “bottom up” approach will be most successful when the relationship between the specific operation and the objective are clearest, as meeting a new objective may require adoption of a different management strategy or tactic.

In agriculture, there is considerable uncertainty about the environmental outcome of a particular management practice. This occurs because multiple drivers (e.g. site and soil conditions at the time of the operation, weather conditions following the operation), often outside the influence of the farmer, will determine that outcome. This uncertainty is traditionally reduced through empirical experience accumulated from experiments and detailed data analysis (e.g. through simulation analyses). However, environmental objectives in Australian sugarcane production are relatively recent and so the empirical database linking environmental objectives with management outcomes is very sparse. Thus a bottom up approach to developing management practices to address environmental (e.g. water quality) objectives must be “connected” to the objective through sound biophysical principles.

This connection is facilitated by identifying relevant farm management goals, related management strategies that would address the goal, the tactics that would operationalise the strategies. The goals, strategies and tactics for improving the quality of water leaving irrigated sugarcane farms are described in the following section.

Description of the framework

Goals

For the Burdekin, four goals have been identified centring on the main water quality parameters of interest in sugarcane production (Davis 2006, Bainbridge et al. 2006), nitrogen and herbicide loads in water. The goals (TABLE 1) relate to:

- Water management: aiming to reduce the amount of water leaving farms through run off and deep drainage, both pathways that impact on off-site water quality.
- Nitrogen management: aiming to reducing the likely nitrogen concentrations in run off and deep drainage.
- Herbicide management: also aiming to reduce concentrations in run off and deep drainage, and

- Erosion management: aiming to reduce losses of sediment in run off as well as chemicals attached to these sediments.

While sediment loss from sugarcane farms is not currently regarded as an important issue in the Burdekin (Davis 2006, Bainbridge et al. 2006), it is included in the framework to make it more generally applicable.

Water and nitrogen are complex in a water quality context because both can “leave” farms through the crop, a pathway that has no direct local environmental impact. For water this loss is via evapotranspiration (ET), while for nitrogen it is the nitrogen contained in harvested cane and any burnt crop residue. Water received by the crop (i.e. irrigation plus rainfall) in excess of ET has the potential to increase run off and deep drainage. Similarly, nitrogen applied to the crop in excess of that lost through the crop has the potential to increase nitrogen concentrations in run off and deep drainage. Thus water quality goals for water and nitrogen are expressed as minimising the difference between water and nitrogen received by the crop and the losses through the crop. Framing the water and nitrogen goals in this way shows that there are two quite different strategies that can be employed to meet these goals, i.e.:

- Reduce applications of irrigation water or nitrogen fertiliser, and /or
- Increase ET or nitrogen in the crop.

This latter strategy can be achieved by increasing crop growth without increasing water or nitrogen inputs. Thus there can be a clear link between productivity and improved water quality.

The herbicide and sediment goals are treated in a simpler manner as there are no loss pathways that are mechanistically linked with crop production. Thus the goals focus on minimising losses of from farm fields.

Strategies, tactics and actions

For each goal there are a number strategies identified that will help achieve the goal (TABLE 1). With irrigation for example, the strategies are to decrease the amount of water applied and/or increase ET. The former can be achieved through the tactic of irrigation scheduling, i.e. better controlling the amount and timing irrigation applications. ET will be increased through better crop growth, resulting from overall improved variety selection and crop husbandry (weed control, etc). These are not mutually exclusive strategies and both could result in improved farm profitability.

There may be a number of tactics that can satisfy a strategy. Again, irrigation provides a good example: There are a number of irrigation scheduling techniques available that would be effective in ensuring that irrigation applications were matched to ET (TABLE 1). Different scheduling techniques may be suited to different farms – there is no need to be prescriptive about how this strategy (and many others) is operationalised.

There are interactions between the tactics employed to meet the different goals. For example, minimising nitrogen, herbicide and/or sediment losses from farms will generally be helped by minimising run off. On most irrigated farms, good irrigation management will be necessary to minimise run off. Thus, the nitrogen, herbicide and/or sediment management goals might not be met unless the water management goal is. This example highlights the holistic nature of the farming system. The different goals in TABLE 1 are colour coded to highlight these interactions. Some of these interactions are conflicting. For example, controlling weeds by cultivation will reduce the need for herbicide use, but will increase the chance of sediment loss. In this case the goals may need to be prioritised in the local context so that a choice of tactics can be made.

For each goal some example actions are listed in the framework to illustrate the on-ground implications of the goal. In reality however, a more complete list of management principles will be required to guide choice of actions. This list is the collation of detailed current management principles for sugarcane growing in the Burdekin region described below.

Infrastructure

Choice of strategies and tactics might be limited by factors beyond the immediate control of the farmer. Farm infrastructure, such as irrigation system or farm machinery, is a common external limitation. Conversely, overcoming these limitations may represent opportunities to meet goals. An example is the construction of recycling pits to catch and allow recycling of run off. Recycling pits could be an important in minimising run off, a tactic in all four goals. Other limitations/opportunities are smaller, for example the need for different farming implements to perform a particular tactic. While “small” (in financial terms), these limitations/opportunities may still be significant. Examples of these infrastructure limitations and opportunities are given in TABLE 1.

Monitoring

Ideally the quality of water leaving farms should be monitored to ensure water quality goals. However, direct monitoring is rarely feasible. The framework allows indirect monitoring opportunities to be identified (TABLE 1). Many of these are input oriented, e.g. evidence that a particular tactic was employed. For water and nitrogen, excesses or surpluses can be estimated from rules of thumb given in TABLE 1 providing a simple output-oriented monitoring metric.

Best management principles for sugarcane growth

To provide a “bottom up” approach to identifying farm management principles for improving water quality, the possible operations required for growing sugarcane in the Burdekin region were collated with a group for local farmers, as well as extension natural resource management staff (from BSES, DPI&F, BBIFMAC) and the support of BDTNRM and ACTFR. It was envisaged that a “bottom-up”, largely grower driven process would provide the best outcomes in terms of industry ownership and “best practice” guidelines with a basis grounded in reality.

A group of 10 local farmers from across the Burdekin region were approached and taken through a workshop process facilitated by a number of local industry extension and natural resource management staff. The farmers were selected with the intent of representing the range of different farming systems, scale of operations and varying farm management issues apparent across the region as a whole. The underlying aim of the workshop process was to document local growers’ perceptions of what constituted desirable or “best practice” farm management for their particular situations. Subsequently, the water quality management goals to which each of these practices would contribute was identified.

In order to promote meaningful discussion, the workshop process was carried out according to a set structure. A series of separate workshops were conducted dealing specifically with what were regarded as the three main local drivers of water quality namely; irrigation practices, nutrient and fertilizer management and finally pesticide management. Workshop discussion on each of these separate topics was then sequentially taken through every stage of a typical cane production cycle beginning at farm design and layout before progressing through fallow practices, land preparation, planting, crop husbandry, harvesting and crop eradication. While the primary emphasis of workshop discussion was focused upon practices relating directly to aspects of improved water quality management, other issues relating to productivity, crop husbandry and general farm management

were also highlighted in discussions, as these issues can also result in water quality benefits, as described above. Comments on issues and constraints relating to the uptake of particular practices were specifically encouraged. Upon completion of the final workshop, discussion outcomes were compiled, tabulated (Table 2) and sent back out to growers for review and comment. Local BSES staff were then also taken through a similar, although shorter workshop exercise based upon the document produced by the grower workshop process.

For the collation of management principles, the sugarcane production cycle was divided into 10 stages, viz:

1. Cane production system stage: farm design and layout (P, W, N)
2. Cane production system stage: fallow (P, W, N, H, S)
3. Cane production stage: land preparation (P, N, S)
4. Cane production stage: planting (P, S)
5. Crop husbandry: pest and weed control (P, H, S)
6. Crop husbandry: hilling-up (P, W)
7. Crop husbandry: irrigation (P, W, N)
8. Cane production stage: fertiliser application (P, N)
9. Cane production stage: harvest (P, W, N, H, S)
10. Cane production stage: crop eradication (P, H)

For each stage and phase, the water quality implications of the operation were identified. The following key is used to identify which goal the stage/phase or operation contributes to:

- Enhanced productivity: P
- Water management: W
- Nitrogen/fertiliser management: N
- Herbicide/Pesticide management: H
- Sediment management: S

In the above list, the goals contributed to in a particular stage/phase are indicated by the relevant colour coded letter. Each of the stages of the crop production cycle described in Table 2 is divided in three sections;

- A brief description of typical current practices employed by growers at each crop stage.
- Current 'best practice principles' from both environmental and productivity perspectives at each stage.
- An overview of local constraints and limitations (both internal and external) faced by growers in adopting many of the listed desired practices, as well as miscellaneous issues with a 'BMP' connotation.

Rather than a strongly prescriptive listing of specific 'best management practices' applicable to all growers, the intent of this process is to produce information with some level of inherent flexibility for example consistent with the management tactic level of the framework (Table 1) rather than specific actions. This will allow different components to integrate where appropriate with different hierarchical levels of the over-arching water quality framework described earlier. The diversity of farming systems, environmental and production issues and constraints facing various growers across the Burdekin district will require different combinations of actions, tactics and strategies when aiming to achieve the ultimate management goals outlined in Table 1.

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Table 1. A framework for management goals to improve the quality of water leaving irrigated sugarcane farms (Burdekin).

Management Level	Management objective			
Goals	Water management: <i>Minimise water excess [difference between water received (irrigation and rainfall) and lost through crop ET]</i>	Nitrogen management: <i>Minimise N surplus [difference between N applied and lost through harvested crop and burnt trash]</i>	Herbicides management: <i>Minimise herbicide losses</i>	Sediment management: <i>Minimise erosion</i>
Strategies	<ul style="list-style-type: none"> • Reduce the amount of irrigation applied through better control of timing irrigation and the amount of water applied at each irrigation • Increase ET through better crop growth 	<ul style="list-style-type: none"> • Fertilise to replace N or to realistic yields • Account for organic N and/or groundwater N • Increase N uptake through better crop growth 	<ul style="list-style-type: none"> • Minimise herbicide applications: • Maximise efficacy of product use 	<ul style="list-style-type: none"> • Avoid cultivations • Maintain surface cover

Tactics	<p><i>Timing:</i></p> <ul style="list-style-type: none"> • Schedule irrigations (eg, minipan WaterSense, soil sensors, etc.) 	<p><i>Amount:</i></p> <ul style="list-style-type: none"> • Aim to refill Soil Water Deficit 	<ul style="list-style-type: none"> • Identify N need from yield • Estimate and allow for other N inputs (legumes, mill mud, ground water) • Determine N rate • Minimise runoff and deep drainage • Minimise erosion • Specific crop husbandry management practices to improve growth 	<ul style="list-style-type: none"> • Apply correct chemical at lowest registered rate • Reduce need for herbicides by minimising weed population (trash blanketing, control seed banks) • Assess alternative control options (different chemicals, cultivation) • Move to <i>New Farming System</i> (to reduce need for Triazines) • Maximise product efficacy (timing and manner of application, post-application management) • Minimise runoff and deep drainage • Minimise erosion 	<ul style="list-style-type: none"> • Avoid bare fallow* • Minimum (or zero) tillage planting* • Avoid burning • Conserve trash • Reduce weeds • Minimise runoff • Move to <i>New Farming System</i>*
	<ul style="list-style-type: none"> • Specific crop husbandry management practices to improve growth 				
Example actions	<p><i>Timing:</i></p> <ul style="list-style-type: none"> • Irrigated on the specified date 	<p><i>Amount:</i></p> <ul style="list-style-type: none"> • Know SWD before irrigation event • System optimisation & performance (efficiency, uniformity, etc) to match application to SWD 	<ul style="list-style-type: none"> • Placement • Timing • Carrier • Application system performance • Specific actions to improve crop performance 	<ul style="list-style-type: none"> • Assess weed population (is spraying required?) • Assess alternate control options (different chemicals, cultivation) • Minimise off target application of chemicals • Minimise losses in run-off (delay irrig for “X” days after application, avoid times of forecast rain) • Application system set-up & 	<ul style="list-style-type: none"> • Maximise trash retention • Crop in fallow • Planting operations that minimise erosion • Herbicide weed control

	<ul style="list-style-type: none"> • Specific actions to improve crop performance 			
Infrastructure opportunities &/or limitations	<ul style="list-style-type: none"> • Irrigation system (furrow, overhead spray, trickle, etc) • Recycling pits • Irrigation water available when needed 	<ul style="list-style-type: none"> • Good quality fertiliser box • Recycling pits 	<ul style="list-style-type: none"> • Good quality spray rig (flow, pressure, output monitors on spray units) • Maximise trash retention • Recycling pits 	<ul style="list-style-type: none"> • Zero-till planter • Irrigation system for GCTB • Recycling pits
Direct monitoring	<ul style="list-style-type: none"> • Runoff and deep drainage 	<ul style="list-style-type: none"> • N in runoff and deep drainage 	<ul style="list-style-type: none"> • Herbicide losses 	<ul style="list-style-type: none"> • Sediment losses
Indirect monitoring	<ul style="list-style-type: none"> • Estimated excess: Irrigation and rainfall relative to ET [ET (mm) \approx TCH x 10] • Irrigation records (date and amount applied, soil water contents at irrigation, etc) 	<ul style="list-style-type: none"> • Estimated surplus: N applied relative to N removed [N removed \approx TCH x 1 (green) or 1.3 (burnt)] • Deployment of tactics to increase fertiliser use efficiency 	<ul style="list-style-type: none"> • Amount herbicide applied and products used • Method of application • Rain + irrig in “X” days after application 	<ul style="list-style-type: none"> • Cover • Number of cultivations

Table 2. Collation of stages and phases in sugarcane production in the Burdekin region linked to management goals for improved farm water quality.

Key (colour coded) to management goals:

Enhanced productivity: P

Water management: W

Nitrogen/fertiliser management: N

Herbicide/Pesticide management: H

Sediment management: S

Cane Production System Stage: Farm Design and Layout (P, W, N)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>Existing farms across the Burdekin district are designed to reflect local reliance on furrow irrigation. Delta farms tend to be smaller, and on-farm layouts may be constrained by infrastructure (roads, powerlines, channels and natural features such as undulating topography). Most effort is spent on optimizing current farm designs rather than drastic overhaul or restructuring of farm layouts. Farms in the BRIA area tend to be larger with longer row lengths reflecting flat topography and less permeable soils.</p> <p>Stripping and redistribution of topsoil and subsoil layers is sometimes undertaken by growers to manage soil infiltration and fertility changes</p>	<p><i>Crop nutrition/irrigation</i> – GPS soil, electro-magnetic and yield mapping of farm blocks to define variations in soil characteristics. This sets a template for a range of productivity and sustainability decisions such as salinity mapping, pinpointing ameliorant requirements and identifying appropriate nutrient management strategies.</p> <p><i>Irrigation/Crop Nutrition/Pest Control - Tailwater recycle pits offer a range of water use efficiency and environmental sustainability benefits for farm systems where irrigation run-off is an issue.</i></p> <p><i>Irrigation/crop nutrition:</i> ensure that integrity of the A horizon is maintained during leveling operations (i.e. avoid exposure of B horizon soils).</p> <p><i>Irrigation - on the basis of WUE/soil type data, row lengths greater than 600-700m on permeable soils tend to be</i></p>	<ul style="list-style-type: none"> - Current farm layout may also reflect location of irrigation outlets and other irrigation infrastructure. - Natural land contours in areas like the Delta and older BRIA areas can limit farm layout decisions regarding row length and slope and positioning of recycle pits. - <i>The possible future requirement of GCTB and irrigation efficiency issues may influence current decisions regarding row length in farm layout.</i> - Farm boundaries can pose problems in Delta areas in terms of grower capacity to significantly alter farm layout such as consideration of lengthening rows. - <i>Recycle pit installation can be limited by existing farm design and soil characteristics (i.e. sandy or ‘leakier’ sub-soils can be a big problem).</i> - Total costs can be a significant constraint to recycle pit installation (the costs of installing the pit itself can be cheap compared to often substantive associated infrastructure costs such as pipeline installation and power connection) - Land availability and loss of arable land can be a large factor in determining the viability of recycle pits, particularly on smaller sized farms typical of the Delta sub-district. - It is much easier for growers starting on the ‘blank sheet’ of a new block to optimize layout rather than to re-design existing layouts.

<p>associated with marked textural or structural variations in different soil horizons.</p>	<p>markedly inefficient (<50%) whereas row lengths greater than ca 1200m on low permeability soils tend to lead to decreased efficiencies.</p> <p><i>Further info/hints.</i></p> <p>-Order of materials being relaid after soil stripping is very important for subsequent paddock management (may need to seal off sandier subsoils in Delta area farms or manage sodicity at depth in BRIA farms)</p>	<p>-Topsoil stripping and redistribution is very expensive (ca. \$5000/ha)</p> <p>-Variable rate application of nutrients/fertilisers probably represents a future 'best practice' rather than a currently viable principle due to contemporary technological constraints.</p>
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Cane Production System Stage: Fallow (P, W, N, H, S)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>Two main strategies of breaking the sugar cane monoculture are employed by Burdekin growers; fallow crops (typically legume crops such as soybeans, mung beans, dolichos, lablab etc.) and the more common bare fallow approach. Weeds in bare fallows are typically controlled by cultivation (discings) or use of knockdown herbicides such as 2 -3 applications of chemicals such as glyphosate and 2 ,4-D.</p> <p>Some growers have weedy fallows but this is generally regarded as undesirable – although many use weeds to minimize erosion in flood prone areas.</p> <p>Fallow crops can confer numerous profitability and environmental benefits including improved soil organic matter and soil health, moisture retention and ground cover insurance against soil loss during wet season rain events in flood prone areas.</p> <p>Application of soil ameliorants (gypsum etc.) to improve water infiltration characteristics occurs at this stage.</p>	<p><i>Irrigation:</i> Laser leveling fallow plots where appropriate (both bare or cover cropped) improves subsequent irrigation efficiency throughout crop cycle.</p> <p><i>Pest Control:</i> Controlling weeds in the fallow should be the underlying aim for growers. Rather than a strictly defined ‘BMP’, a flexible case-by-case approach and vigilance is required. Timing of weed control is fundamental. If all weeds can be controlled in fallow with a cheap, ‘green’, effective herbicide (i.e glyphosate) it can significantly reduce future residual chemical requirements (‘prevention better than cure’). Frequency of application as well as chemical rates can be greatly reduced (within label recommendations) if weed problems are caught early.</p> <p><i>Further info and hints</i></p> <ul style="list-style-type: none"> - To derive maximum benefit from controlled traffic system, employ the permanent bed setup for fallow as well as crop, Setting up beds early in controlled traffic systems and utilizing same beds for fallow and subsequent crop can save water by creating a ‘moisture bank’ where it may be possible (climatic conditions permitting) to bring a plant crop up on existing moisture. - Effective weed control in a bare fallow also helps retain moisture in beds and can reduce water requirements in young plant cane - A well grown legume cover crop can greatly reduce nutrient and herbicide requirements in many situations and is particularly effective in the control of grassy weeds. - A well grown legume crop can also contribute substantial amounts of N, with an array of potential water quality benefits if accounted for appropriately in subsequent nutrient management strategy. - GPS bed forming a bare fallow paddock prior to wet season in preparation for planting can provide benefits in soil/furrow consolidation and sealing which can aid moisture retention and improve water application efficiency. 	<ul style="list-style-type: none"> - Insufficient water, lack of water allocation or infrastructure constraints can make an irrigated fallow crop unviable for some farmers. - Extra pumping and water costs associated with fallow management can be prohibitive. - Added workload in planting spraying and irrigating a fallow crop is often a lifestyle impediment (“you’re working 100% of farm rather than 80%”). - Control of vines in cover crops can be an issue, and often requires control with chemicals (the Soybean Growers Manual by FutureCane is a useful tool outlining control measures as well as general crop agronomy). - A late end to crush and harvest can limit feasibility of planting a fallow crop. - External pressures such as a late end to the crush can limit time and capacity for growers to laser-level between crops. - Bare Fallows are much less resource intensive for growers. - In some years (such as 2006) ameliorants such as gypsum are unavailable, or there is a long waiting period which can interfere with the planting of legume crops (particularly in BRIA farms and those with heavy and/or sodic soils) - Further research is required as to implications of laser leveling requirements in controlled traffic situation. - Current seed supply and quality can be issues for growers when considering a fallow crop. - Unseasonal climatic conditions can limit access to paddock to manage fallow. - Weed control by chemical rather than cultivation will reduce erosion potential, but may increase herbicide losses.

	<p>-Plant cover from a fallow crop can reduced erosion risks during rainfall events.</p>	
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Cane Production Stage: Land Preparation (P, N, S)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>A number of land preparation practices are currently employed across the Burdekin region ranging from conventional (traditional) land preparation to more recent management tactics such as minimum tillage and controlled traffic systems.</p> <p>Conventional Land Preparation: will depend on soil types, field conditions and farmer preference. Typically involves multiple ripping and discings, a laser brush over the blocks followed by marking out. Numbers of cultivations will vary from farm to farm.</p> <p>Minimum tillage: provides increased flexibility to farming operations (window of opportunity for planting is increased for example)</p> <p>Controlled-traffic – wide beds: crop row spacing is matched with equipment track width. Compaction and stool damage is minimized</p> <p>Fertilisers are sometimes applied during this stage (well prior to planting), predominantly phosphatic forms to minimize fertilizer management workload and have nutrients immediately available to crop.</p>	<p><i>Crop Husbandry:</i> Controlled traffic</p> <p><i>Crop Nutrition:</i> Soil testing should be carried out immediately after harvest</p> <p><i>Crop Nutrition:</i> Soil testing: provides valuable strategic info to farmers regarding future nutritional requirements, the requirement of any soil ameliorant application and matching of cane varieties to soil type characteristics.</p> <p><i>Further info and hints</i></p> <p>-Time cultivation or land leveling some time before likely wet season rain events to allow a period of soil consolidation.</p> <p>- this is the ideal time for EM mapping, but requires uniform soil moisture via rainfall or irrigation.</p>	<p>-Costs of conversion to GPS controlled traffic systems a constraint for many growers.</p> <p>-Availability of GPS contractors can be an issue.</p> <p>- Conversion to wide beds or minimum tillage often requires a partnership or agreement between several growers to proceed, as a range of equipment used across the group (i.e. planters and harvesters) needs modification which can be a considerable financial constraint.</p> <p>- External pressures from harvest and haul-out contractors regarding control traffic systems is a major impediment to adoption of newer farming systems.</p> <p>-While issues such as soil compaction are a recognized problem under conventional systems, data on the benefits and long-term sustainability of changing farming systems is still quite sparse and some growers are not prepared to take the risk of changing over their farming system and equipment to controlled traffic without more knowledge (particularly during or after periods of low income)</p> <p>- The focus on the benefits of conversion to new farming systems needs to shift to profitability rather than the traditional focus on productivity.</p> <p>- Growers can be open to new innovations but desire more information, particularly regarding failures of new farming systems where ‘news travels fast’ (accurate information needs to be presented, rather than hearsay).</p> <p>- Flooding on farms and associated run-off or deep leaching losses can pose limitations on applying fertilizer early.</p>

Cane Production Stage: Planting (P, S)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>2 main planting practices are utilised by Burdekin growers; planting into flat paddocks, planting into pre-formed beds with double disc opener planter (can be whole stick or billet, but billet planting is becoming the preferred method)</p> <p>Fertiliser tends to be applied at plant in a split approach with some applied at planting and the balance side dressed at a later date. Fertiliser may sometimes be applied underground pre-plant.</p> <p>The mercurial fungicide Shirtan is commonly used for pre-plant treatment of cane setts.</p> <p>A range of pesticide products such as chlorpyrifos, bifenthrin and fibrynol may be applied at planting for control of a range of pests such as canegrubs, crickets and wireworms.</p>	<p><i>Crop Husbandry:</i> Plant into preformed beds with a disc opener planter.</p> <p><i>Further Info and hints.</i></p> <ul style="list-style-type: none"> -Some cane varieties have different water requirements which may need to be addressed for particular blocks and may influence variety selection. -Avoid/delay a post-plant irrigation if a cold snap occurs -Plant into warm soil to improve strike (at least 19 degrees) - Zero till planting will minimize erosion risks. - Minimising the time over which seedbed preparation occurs will aid in reducing erosion risk, similarly appropriate timing (September to mid-November) should promote soil consolidation and reduce erosion risk. 	<ul style="list-style-type: none"> - Growers in some areas can be constrained by availability of new equipment such as double-disc open planters (DDOP) to trial on-farm, but this situation is changing rapidly as new equipment is adopted by greater numbers of growers. - Local information on benefits or failures of new innovations (planting systems) can be sparse. Much current information comes from trials conducted in other regions that are predominantly rain-fed rather than irrigated. - some anecdotal evidence suggests stool tipping associated with DDOP could be a problem in older rations of some varieties or on some soil types.

Crop Husbandry: Pest and Weed Control (P, H, S)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>Pests and weeds may require control measures at a number of stages during entire cane cycle:</p> <ul style="list-style-type: none"> - Weed control in fallows may involve 2-3 applications of knockdown herbicides. - As already mentioned pesticide products (insecticides) such as chlorpyrifos, imidacloprid, bifenthrin and fipronil are applied at planting. - Weed control in plant cane sees a variety of techniques used by growers. Some growers plant, irrigate and then apply pre-emergents, others plant, irrigate, wait until weeds come up and use a combination of knockdown and pre-emergent chemicals. Others just spray using knockdowns and use no pre-emergent herbicides. Otherwise weeds are controlled by cultivation. - Ratoon crops are usually irrigated and weeds controlled with 2-3 applications of knockdown herbicide mixes (gramoxone, 2-4 D, atrazine) . - Last ratoon crops can be sprayed out with roundup on existing beds. Fusilade is sometimes used to completely kill out stubborn crops. 	<ul style="list-style-type: none"> - As already mentioned effective weed control during fallow periods can greatly alleviate needs for intensive weed control at later crop stages. - In older ratoons do not use residual products that may affect future alternative rotational crops (eg: Velpar or atrazine prior to soybeans). - In areas where herbicide losses are a potentially serious problem for water quality, consider mechanical weed control. - Consider retaining trash to reduce weed numbers and erosion. <p><i>Further info and hints.</i></p> <ul style="list-style-type: none"> - Effective weed control also has irrigation benefits due to lack of weeds physically impeding water flow down furrows as well as extracting moisture that can otherwise be used by the cane crop. 	<ul style="list-style-type: none"> - Farmers commonly rely on agribusiness agents and chemical representatives for recommendations regarding rates and specific products. The BMP concept therefore needs to be extended beyond growers to agronomists, chemical re-sellers and agri-business in general. - Provision to growers of better local information regarding off-site movement of chemicals may be beneficial to sustainability initiatives. - There are not many viable industry alternatives or strategies regarding some pesticide products currently at risk of de-registration (i.e. atrazine and diuron). - Some uncertainty exists regarding chemical usage in alternative crops (growers and agri-business need to be educated in chemical usage in alternative crops) - is continual use of 'knockdown' herbicides a viable industry alternative if some of the more prevalently used residuals are deregistered? - Weather, particularly rainfall and its effect on weed vigour can have significant influence on weed spraying requirements. - SusCon Maxi is only currently registered for use at hill-up stages and not at planting use. - Diuron is often used as a knockdown spike (at lower rates), usually in a mix with gramoxone or 2-4, D rather than sole use as a residual. Is there any future potential for atrazine use to be modified in a similar way? - In the event of a late harvest pre-emergent residual herbicides are more likely to be used in order to avoid issues with paddock access during wet season. - The environmental impact of Moddus ripener is currently unknown. - Metarhizium may last longer under new farming system (needs further research).

Crop Husbandry: Hilling-Up (P, W)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>Final application of supplemental nutrients occurs at this stage.</p> <p>Some knockdown and/or residual herbicides (pendamethalin, gramoxone and 2-4 D) are applied after hill-up on heavier clay soils. Pesticides such as chlorpyrifos and imidacloprid are commonly applied at hill-up stage, primarily in cane grub affected regions the Delta region.</p>	<p><i>Crop Husbandry</i>- Ensure hill and row profile are suitable to irrigation and harvester.</p> <p><i>Irrigation- Controlled compaction (compaction of the interspace rather than the hill) after hill-up can allow water to ‘get through’ more effectively and minimize deep drainage losses on some soil types.</i></p> <ul style="list-style-type: none"> - Altering furrow shape along the drill can benefit irrigation efficiency. <p><i>Further info and hints</i></p> <ul style="list-style-type: none"> - Spring tynes along edges of furrows an alternative technique that may benefit some situations in ratoon crops to improve water penetrations particularly after wet weather harvesting. 	<ul style="list-style-type: none"> - v-shaped furrow or traffic in moist soils may assist in controlled compaction. - u- shaped furrows may assist in soils with poor water penetration.

Crop Husbandry: Irrigation (P, W, N)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>A broad range of approaches are used by growers to match irrigation to crop water demand including experience and guesswork, minipan scheduling, growth measurements, tensiometers and enviroscans.</p>	<p><i>Irrigation</i> - Match applied water to crop requirements while minimizing losses</p> <p><i>Nutrition</i> - irrigate prior to fertilizer application in a burnt cane system.</p> <p><i>Nutrition</i> - groundwater should be tested regularly for nutrients and conductivity (professional advice may be required for any mixing recommendations).</p> <p><i>Irrigation</i> - growers should be aware of groundwater trends in local area</p> <p><i>Further info and hints</i></p> <ul style="list-style-type: none"> - Watering at night may improve irrigation efficiencies (reduces evaporation). - changing application rate to reflect soil condition (cultivated or consolidated) and soil type can reduce losses. - Selective/controlled compaction may be necessary to ensure water can ‘get through’ on more permeable soils. - It may pay to wait longer before irrigation after side-dressed fertilizer application rather than stool split (may reduce nutrient losses). - Quantitative scheduling instruments (minipans, tensiometers and enviroscans) are particularly useful tools. 	<ul style="list-style-type: none"> - Infrastructure limitations (pumping costs or access to channel water) forces some growers to rely solely on low quality groundwater. Costs of a pipeline for example to enable utilization of surface-water can be substantial. - Moisture in blocks at harvesting is a determinant for irrigation scheduling (if a block is dry the crop will be irrigated before fertilizer application) - Water availability can be a problem in BRIA, particularly when all growers need water at much the same time after rainfall and the delivery capacity of the system is limited. - There is currently minimal commercial scale data on efficacy of potentially more efficient watering alternatives such as overhead or trickle irrigation in local situations. - A range of small and large scale trials of trickle irrigation have highlighted issues such as rat damage to trickle tape, emitter efficiency, maintenance costs and underlying economics as significant issues that have discouraged more widespread adoption. - unrecognized costs associated with access to groundwater in Delta may not encourage efficiency. - Electricity costs may be cheaper at night and/or weekend (Tariff 65) - Current water pricing policy for the BRIA area (where growers pay for set amounts of water allocation regardless of use) does not encourage irrigation efficiency. - End-banking of furrows can be used to minimize run-off losses in some Delta area farms with high infiltration soils. - Over-irrigation of young cane (both in plant and ratoon) is a common problem.

Cane Production Stage: Fertiliser Application (P, N)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>Nutrient management involves an array of crop type, soil type and associated management issues. Sub-soil application of granular fertiliser products (urea etc.) is the standard approach for the majority of local growers. Early season harvesting sees fertilizer applied after first irrigation. Many growers stool split straight after harvest (mainly September onwards), but won't water for some time after nutrient application. If split fertilizer occurs, most growers will wait until crop is ca. 50cm in height before applying second application. Dunder (usually as liquid 1-shot) is typically applied to top of stool straight after harvester, before waiting as long as possible before irrigation. There tends to be little variation in rates as growers move through the ratoon cycle, although some growers will scale back rates of some nutrients in older ratoons.</p> <p>Leaf testing is only occasionally used as a trouble-shooting or 'double-checking' diagnostic tool.</p>	<p>Nutrient budgeting/replacement should be the main driver underlying nutrient application and management.</p> <p><i>Crop Nutrition: Regular soil testing to tailor nutrient management strategy.</i></p> <p><i>Crop Nutrition - the '6 easy steps' BSES fertilizer course should be followed to determine fertilizer rates.</i></p> <p><i>Crop Nutrition: Subsoil application of granular products.</i></p> <p><i>Crop Nutrition: Base supplemental fertilizer application on all nutrient sources available to crop (ie. nutrient contribution from groundwater, mill by-products or breakdown of fallow crops)</i></p> <p><i>Crop Nutrition- Do not apply N to plant crops following a fallow legume.</i></p> <p><i>Crop Nutrition - Regularly monitor amount of N available in irrigation water (N concentration and irrigation volumes) and reduce fertilizer input accordingly</i></p> <p><i>Crop Nutrition: Hill profile and fertilizer depth needs to be matched in some areas (BRIA)</i></p> <p><i>Irrigation: delay irrigation after application for at least two days to allow granular products to bind with soil before wetting.</i></p> <p><i>Irrigation: delay irrigation after dunder application for as long as possible (2 weeks or longer).</i></p> <p><i>Irrigation - Extra effort</i></p>	<ul style="list-style-type: none"> - There is a current lack of confidence that nitrogen produced by fallow crops will actually be available for uptake by subsequent cane crops. (BSES does provide a Nitrogen testing service that may engender more confidence for growers). - A well grown and uniform legume fallow crop is necessary to realistically consider scaling back subsequent nutrient application. - Granular products will not bind adequately if soil is too dry. - Delaying fertilizer application after harvest can create problems if soils harden, making subsequent fertilizer application less efficient. - Variability in mill production data (bin weight) can be a constraint to farmers trialing different approaches (i.e. BSES guidelines) and adhering to them. - There may be a lack of confidence in BSES recommendations amongst some growers. - A range of perception issues come into play with nutrient management strategies. Traditional mindsets such as visual aspects of crop size, crop tonnage, productivity report ranking and competitive environment can all influence growers nutrient management decisions. - 'Benchmarking', with all figures on the table amongst a grower group may be a good way to get a more detailed understanding of actual efficiency and the 'real cost of production' for different farmers. - Confidence in the linkage between management and CCS, specifically being able to grow the same amount of sugar for less cost is a big constraint. - Costs of leaf testing an impediment, as well as practical information on what results mean. - A growers approach to nutrient management may be determined by both their short and long term goals for soil health and fertilizer management. - Detailed record keeping by growers is not a common practice for a variety of reasons (i.e. long-term nature of crop cycle, capacity for easy data retrieval). - The majority of growers are currently constrained by a lack of available technology to adequately mesh together all of the aspects of precision agriculture such as EM, yield and soil mapping and precision fertilizer application.

	<p>(quantitative scheduling, appropriate irrigation cut-off) should be taken to minimize losses for first three irrigations after fertilizer application.</p> <p><i>Crop Nutrition-</i> In burnt cane systems fertilizer should be placed into moist soil.</p> <p><i>Further Info and Hints.</i> In a trash blanket system fertilizer should be applied before irrigation</p>	
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Cane Production Stage: Harvest (P, W, N, H, S)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>Two main harvesting approaches are used by Burdekin growers; conventional burnt cane systems where the crop is burnt just prior to harvest and Green Cane Trash Blanket (GCTB) approaches.</p> <p>Benefits of GCTB systems can include improved soil health and reduction in reliance on herbicidal weed control and improved moisture retention in young cane</p>	<ul style="list-style-type: none"> - Optimize harvester efficiency (blade sharpness, travel at correct speed, feed train optimisation etc.)??? <i>Irrigation</i>- efforts should be made to retain run-off water on farm after harvest <i>Irrigation</i>- irrigation scheduling has to be adjusted (reduced irrigations) to suit GCTB systems in early crop stages prior to full canopy cover. <i>Further Info and hints</i> - GCTB systems can be beneficial on some soils by creating better moisture retention characteristics and improved hill soakage compared with conventional burnt systems. - GCTB can reduce weed populations and the need for chemical or cultivation control. - Under GCTB systems N applications should be reduced in fallow plant crops. 	<ul style="list-style-type: none"> - The size of the Burdekin crop is the primary impediment to more widespread adoption of GCTB. Crop size poses harvesting challenges as well as creating subsequent irrigation problems related to trash in furrows causing problems with regard to ‘getting water through drills’. - Some cane varieties drop a lot of trash before harvesting which makes GCTB more viable. - The benefits conferred by GCTB systems in soil type management and associated irrigation efficacy do tend to be block specific (related to length, slope, soil type and row profile) rather than applicable to all soil types. - GCTB can reduce grass weed infestations, but broad leaf weeds, vines and nut grass in particular still pose some problems. - Waterlogging can be a significant problem for GCTB systems on flatter paddocks of the BRIA. -Harvesting contractors can be very reluctant to cut green due to significantly increased harvesting times. Resultant raised harvesting prices when a contractor will cut green can make the decision to cut green economically unviable for growers. -A notable information gap is the lack of knowledge regarding relationships between water quality effects and post-harvest irrigation - Water quality issues associated with GCTB systems have not yet been fully investigated. -‘v-ing’ out furrows in GCTB systems (parting trash and compacting furrow) to improve irrigation efficiency can cause subsequent harvesting problems by affecting harvester stability.

Cane Production Stage: Crop Eradication (P, H)

Existing Practices	Current Best Practice Principles	Issues & Constraints for farmer uptake
<p>Growers on conventional beds tend to disc, rip or hoe out crop. Some growers on conventional and pre-formed beds simply spray-out crop with glyphosate after an irrigation. Use of additional herbicide products such as fluazifop – P may be necessary to completely kill out crop in some situations.</p>	<p>- Spray-out rather than cultivation on permanent beds is preferred as this practice retains bed integrity.</p> <p><i>Further Info and hints</i></p> <p>- last ratoon crops, particularly on permanent beds may require irrigation to promote enough growth to ensure efficient kill with herbicides ('too dry a crop won't get a good kill').</p>	<p>- The availability of water can be a constraint for crop eradication</p>



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