SmartCane Harvesting and Ratoon Management
SmartCane Harvesting and Ratoon Management

by

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The SmartCane booklets will serve as a reference for growers and their advisors. They will also be used to demonstrate the commitment of the industry to profitable, yet sustainable sugarcane production.

2. GLOSSARY OF TECHNICAL TERMS

It is inevitable that specialist and technical words have to be used in this publication. To assist those not familiar with some of the words used, a list of technical terms has been included. This can be used as a reference source while reading the booklet.

**Adjuvant**: A substance that enhances the action of a pesticide when added to a spray solution.

**Basecutter**: The rotary blades that sever the cane stalk at ground level and feed it butt first into the roller feedtrain of the harvester.

**Best Management Practice (BMP)**: Methods that have been determined to be the most effective, practical means of managing an activity to ensure environmental harm is minimised using cost-effective measures that make the most profitable use of inputs.

**Billet**: Short piece of sugarcane usually containing two or more nodes.

**Choppers**: The mechanism on a harvester that cuts the cane into billets and propels the cane/trash bundles into the primary extractor.

**Cleaning chamber**: The chamber that houses the primary extractor fan that separates the trash from the billets on the harvester.

**Controlled-release insecticide**: Insecticide formulated so the active ingredient is released at a controlled rate, prolonging efficacy.

**Coulter**: A sharp, flat, vertical steel disc that cuts into soil or cane trash.

**Denitrification**: One of the main ways nitrogen in fertiliser is lost. The process involves conversion of the nitrogen fertiliser to nitrous oxide and nitrogen gas which is lost to the atmosphere. It occurs in anaerobic, waterlogged conditions and is caused by certain bacteria in the soil.

**Dunder**: A by-product of ethanol production and a rich source of potassium. Used as a fertiliser on cane farms in several districts of Queensland.

**Effective rainfall**: The quantity of rainfall retained in the soil profile after taking account of runoff and deep drainage losses.

**Extractor fans**: See “primary extractor fan” and “secondary extractor fan”.

**Extraneous Matter (EM)**: Comprises of material other than cane stalks that passes through the harvester. It includes trash, tops, suckers, cane stools and soil.
**Feedtrain:** The series of rollers that feed the cane butt first to the choppers in the harvester.

**Global Positioning System (GPS):** A combination of hardware and software components designed to accurately determine locations using signals from selected satellites.

**Green cane trash blanket (GCTB):** The layer of sugarcane residues covering the ground after harvest of a crop which had not previously been burnt.

**Harvester front:** Also referred to as “crop dividers”. They separate lodged cane and direct the cane to the basecutters and into the harvester.

**Improved cropping system:** A sugarcane cropping system based on the concepts of reduced tillage, controlled traffic and legume break crops. It is often referred to as the “new farming system”.

**Integrated weed management:** A range of practices that should be used in combination to manage weeds within the sugarcane production system.

**Legume:** Plants such as cowpeas, soybeans and peanuts which can supply nitrogen to the soil by the process called nitrogen fixation.

**Legume break cropping:** The growing of a legume crop between crop cycles of sugarcane to break the sugarcane monoculture.

**Metarhizium:** A naturally occurring fungus which infects canegrubs.

**Mineralisation:** The process whereby nutrients bound in organic forms are converted to forms available for uptake by plants.

**Minimum tillage:** The minimum amount of cultivation or soil disturbance necessary for crop production. Related terms are conservation tillage and reduced tillage.

**Monoculture:** Practice of growing the same type of agricultural crop continuously without breaking the cycle using alternative crops or fallow periods.

**Near infrared reflectance (NIR):** A rapid non-destructive analytical technique used for simultaneous prediction of multiple chemical elements and other constituents in agricultural products.

**Organic matter:** Consists of plant residues, soil organisms and animal remains. It contains many of the essential plant nutrients which are slowly available for plant growth. It acts as a reservoir of plant nutrients, helps conserve moisture, improves the physical structure of the soil and provides a favourable environment for soil micro-organisms. Organic matter (%) may be estimated as 1.7 x organic carbon (%).

**Pachymetra:** A soil fungus associated with root rot of sugarcane.

**Pheromone:** Chemicals produced by insects to influence the behaviour of other members of the species, eg. sex pheromone to attract mates.

**Ploughout - replant:** Also called replant. The plant crop which is established very soon after the harvest of the previous crop without the benefit of an extended fallow period or legume break crop.

**Primary extractor fan:** The fan in the cleaning chamber of a harvester that causes a strong upward air stream that separates the trash from the billets.

**Productivity:** The amount of sugar produced per hectare.

**Raster:** Regular pattern of hairs on the rear end of canegrubs, in front of the anus.

**Replant:** See “Ploughout – replant”.

**Secondary extractor fan:** The fan at the top end of the elevator on the harvester that causes an additional strong air current that separates the trash from the cane.

**Sugarcane crop cycle:** Successive crops of sugarcane that includes a plant crop and a number of ratoon crops (usually three to four). After the final ratoon, the regrowth will be destroyed by either chemical or physical means.

**Supplementary irrigation:** Irrigation water applied to the crop to ‘top-up’ water requirements not met by rainfall.

**Sustainable sugarcane production:** Profitable cane production achieved in combination with the maintenance of soil, water and biodiversity resources on-farm and with minimal off-site impacts.

**Volatilisation:** The loss of nitrogen to the atmosphere when urea is converted to ammonia gas.
The Australian sugar industry is committed to producing sugarcane in a sustainable manner. This means that sugarcane production is aimed at both profitability and environmental sustainability and achieved by using best management practices.

The booklet entitled SmartCane Plant Cane Establishment and Management covered the full range of activities relating to plant crop management. It dealt with planning, land preparation, choice of variety, planting operations, and weed and pest management. In line with the usual sequence of sugarcane cropping, harvesting of the plant crop is the next operation. This booklet therefore covers harvesting and subsequent management of the ratoon crops.

All cane supplied to Australian sugar mills is mechanically harvested. This is done by contractors or growers who own harvesters. They are responsible for the harvest of growers’ cane and delivery to a railway siding or loading pad ready for transport to a mill. The first section of this booklet encourages the adoption of best practice within these operations.

Management of the ratoon cane is important because the bulk of cane supply in any one year is from ratoon crops. This represents about 75% to 80% of cane supplied to Queensland mills. The length of the ratoon cycle varies, but a plant crop and three ratoon crops are typical for the Queensland industry. A range of ratoon best management practices will be discussed in this booklet. These cover managing the crop at harvest, nutrient management, irrigation, and weed and pest management.

Sustainable sugarcane production can only be achieved by using best management practices on-farm.

4. PHILOSOPHY OF BEST MANAGEMENT PRACTICE

Sustainable sugarcane production can only be achieved by using best management practices on-farm. As indicated in the other SmartCane booklets, best management practice means having the best chance of success in minimising the risk of loss in productivity (loss of yield), loss in profitability (loss of income), loss of applied inputs (leaching, run-off and/or gaseous losses of nutrients, herbicides, pesticides, etc) and loss of soil resources (erosion and fertility losses).

Fundamental to this philosophy are:

- The elements of sustainable sugarcane production (profitable cane production in combination with environmental responsibility)
- The basic components of the ‘improved farming system’ as developed by the Sugar Yield Decline Joint Venture include breaking of the monoculture through fallow cropping, controlled in-field trafficking and the adoption of minimum tillage principles

Best management practice should therefore be considered across the entire farming system, with the basic principles established and used:

- Prior to the fallow period, by ensuring that a appropriate land rectification occurs
- During the fallow period
- At planting
- During the plant crop
- At harvest
- During the ratoon crops

The basic philosophy is that there are no set recipes, but rather the recognition of on-farm management styles that allow for progress towards the adoption of an improved farming system that is based on best practice principles. Different regions, soil types and climates may require slightly different management techniques to achieve best practice.

It recognises that green cane trash blanketing should be practised when and wherever appropriate and the need to burn cane should continue to be reassessed.
Knowledge of soils should be used as the basis for making many management decisions on-farm. These include: appropriate land preparation; amelioration of problem areas and planting practices; balanced and sustainable nutrient management; effective yet sustainable weed control; efficient water management through appropriate irrigation and drainage practices; and best practice harvest scheduling. Best management practice also incorporates sustainable pest and disease management strategies and the need to adopt harvesting best practice.

Importantly, the concept of best management practice recognises that the sugarcane production system is evolving. It also recognises that the adoption of best management practice on-farm should be underpinned by appropriate farm management planning that incorporates economic assessments, good budgeting, effective record keeping and the need for workplace health and safety (WH&S).

The focus of this booklet is the use of best management practice principles during harvesting and the growing of the ratoon crops.

5. CURRENT SUGARCANE CROPPING SYSTEM

The current farming system has developed with time. It is a product of past practices that have been used for many years, together with some newer innovations. Modifications have occurred as the system (or components thereof) has been used and further developed.

Research, development and extension programs have contributed to this development by initiating new (or alternative) techniques or philosophies, and facilitating the incorporation of these into the evolving system. The diversity of the industry has resulted in slightly different systems being in place according to local needs and experiences.

The continuum of on-farm operations and management styles may result in some ‘accepted’ practices being more compatible with agreed best practice options than others.

**Fundamental aspects of the recommended sugarcane production system**

The current recommended sugarcane production system has certain characteristics that are fundamental to the concept of best management practice. These include:

- Row-spacing configurations that match the wheel-spacings of harvesters and other farm machinery or vehicles
- Planting of fallow break crops
- Minimum cultivation necessary to suit soil types or conditions and available planters
- Nutrient application rates within current guidelines
- Use of mill by-products and other ameliorants as soil conditioners with account taken of nutrient inputs
- Subsurface applied fertiliser to plant and ratoon cane
- Appropriate targeted pest, disease and weed control
- Land grading to facilitate drainage and irrigation
- Irrigation (when appropriate) that enables the cane plant to receive the right amount of water in the right place at the right time
- Well-presented crops for harvesting to ensure quality cane delivered to the mill
- Maintenance of trash after harvesting where appropriate with the aim of not burning cane or trash in the long term
These practices have been adopted, either fully or partially, on many sugarcane farms. However, there are still situations on some farms where best practice options need to be considered as alternatives to current practices.

### Occurrences where best practice alternatives need to be considered

Where growers use the following practices, they are encouraged to consider best practice alternatives:

- Replanting without using a break crop at the end of a sugarcane crop cycle
- Limited falls that may or may not contain volunteer cane
- Trash not retained, particularly after harvesting the last ratoon in a crop cycle prior to fallowing, although it may be removed to prepare for laser levelling
- Excessive cultivation aimed at ‘full’ land preparation
- Ineffective weed control
- Row spacings that are incompatible with the width of current harvesters, machinery and vehicles
- Uneven land surface profile causing periodic localised waterlogging
- A routine of insecticide application (eg. ‘always’, ‘never’) without regard to current risk levels
- Fertiliser applications that are not linked to the concept of sustainable sugarcane production

6. **IMPROVED SUGARCANE CROPPING SYSTEM**

As indicated previously, the basic principles of sustainable sugarcane production and improved farming system are the basis for the overall improved sugarcane cropping system. Importantly, these principles need to be established prior to the planned fallow period at the end of the previous crop cycle. Once this is done, these principles need to be continued into the plant and subsequent ratoon crops and with each harvest operation during the crop cycle.

The success of a ratoon crop is dependent on the condition of the cane stool after harvest, the health of the soil and the growth of the ratooning plant. Many factors can influence ratoon growth. These include the effect of the preceding harvest operation, soil moisture, variety being grown, nutrient availability, weed competition, pests and diseases.

Soil health issues have been covered in the *SmartCane Fallow and Land Management* and *SmartCane Plant Cane Establishment and Management* booklets.

The following are important components of harvesting and ratoon management:

- Farm layout to optimise harvesting efficiency
- Use of GPS guidance to keep the harvester and haul-outs over the row
- A correct row profile to prevent harvest losses, stool shattering and splitting
- Harvesting plans to maximise cane maturity
- Harvester maintenance, optimisation and settings to improve efficiency and reduce losses during harvesting
- Green cane trash blanketing where appropriate to ensure agronomic, economic, environmental and social benefits
- Nutrient management according to the SIX EASY STEPS program to ensure profitable cane production is achieved with minimal on and off-site effects
- Placement of fertilisers (preferably below the soil surface) to ensure minimal gaseous or run-off losses
- Efficient irrigation practices
- Early control of weeds to prevent competition with cane and the follow-up use of post-emergent herbicides
- Risk assessment before applying insecticide
The options presented here reinforce the basic principle that there are no set ‘recipes’, but rather a set of guidelines that allow for progress towards the adoption of various best management practices within sets of specific circumstances. Slightly different systems may be in place in different areas according to local needs and experiences. The improved cropping system will continue to evolve.

Since the introduction of mechanised harvesting, the Australian sugar industry has sought to constantly improve the efficiency of harvester operations to increase productivity and minimise sugar losses whilst maintaining cane quality. The practice of green cane harvesting, rather than burning, brought the advantages of weed control without constant cultivation and improved moisture retention. However, it also created challenges in terms of striking a balance between effective cane cleaning to minimise extraneous matter in the cane supply without excessive cane loss. With the ever rising costs of fuel, wages and consumables, harvesting businesses have focussed on improving harvester productivity by increasing pour rates and improving field efficiency. The following outlines some of the key issues to consider when trying to adopt a best practice approach to harvesting.

Harvesting best practice encompasses several interconnected aspects that include:

- Farm layout (Figure 1)
- Row length and profile
- Presentation of cane for efficient harvesting
- Harvest planning
- Harvester setup and operation
- Appropriate harvester groundspeeds to ensure efficient and optimum basecutter operations
- Harvester hygiene and sterilising of harvester components when moving from one farm to another
- Consideration of weather conditions
- Well-presented headlands that allow efficient turning of harvesters and haulouts
- Efficient supply of bins and a reliable sugar milling system

These aspects are important for harvesting efficiency, but also result in environmental benefits. The importance of these will vary from district to district. The choice of practices will depend on physical and climatic constraints for a particular farm. This reinforces the use of principles rather than a set recipe for harvesting best practice.

Figure 1: Farm layout - one of the factors that contributes to harvesting best practice.
Farm layout and presentation for efficient harvesting

In order to contain harvesting costs in the midst of rising costs, improving farm layout is critical to increasing the efficiency of the harvest operations. The aim of any changes to block layout, headlands or farming practices is to increase the amount of actual cutting time. This is achieved by reducing in-field non-harvesting time (e.g. turning or waiting for haulouts) and by improving crop presentation to the harvester. Optimising row length, maintaining haul roads and wide smooth headlands are important to efficiency and safety. Combining smaller blocks or adjusting harvest routine to cut several blocks at once by crossing adjacent headlands can significantly improve harvester efficiency.

Another important factor in ensuring efficient harvesting operation is the continuity of bin supply. This will help to minimise time lost during harvesting operations.

Consistent and appropriate row spacing that matches infield machinery ensures a distinct traffic zone in the interspace. The use of GPS guidance will keep the harvester and haulouts over the cane row. This will contribute to improved ratooning of the cane by minimising soil compaction and physical damage to the stools. Use of GPS guidance on the harvester allows for accurate basecutter adjustments to suit the row profile. Research investigating the impact of basecutter damage on ratooning cane has indicated that a consistent row profile which matches the basecutter setup can significantly reduce stool damage at harvest.

The importance of a correct row profile for specific situations becomes apparent at harvest. A poor row profile can result in increased losses at harvest as well as stool shattering and splitting that hinder subsequent ratooning. This damage can cause infection of the damaged stubble stalks by fungal rots, which may contribute to poor ratoons. The correct row profile needs to be established early and be appropriate for soil type and irrigation application method. Basecutter height adjustments at harvest can be made to improve the cutting and gathering of cane in some circumstances, but cannot compensate for a poor match between row profile and machine setup.

Harvesting plan and varieties

Growers and operators can work together to develop a more efficient farm layout and a harvest strategy to maximise cane maturity at harvest. Where adjoining blocks can be harvested together, ensure the varieties selected match soil types and mature at the same time (early, mid, late). This will enable the operator to simply cross the headland and continue harvesting. However, it is not always possible to have the same blocks harvested together each year. It is important to plan the order in which blocks of cane will be harvested according to crop maturity, farm layout, the predicted peak in CCS and seasonal weather conditions.

Apart from maturity, other varietal characteristics such as growth habit and presentation for harvesting are important when choosing varieties. Obviously, these decisions are made prior to planting, but these varietal characteristics become important during harvesting. BSES’s web-based resource QCaneSelect™ allows selection of the most appropriate variety for each paddock.
Harvester setup and operation

Machine maintenance, and in particular the condition of basecutter and chopper blades, has a significant impact on the degree of harvester damage and sugar losses. Checking and adjusting basecutter blades to ensure they are long and square will reduce stool damage and avoid cutting too deep, thus reducing soil intake to the harvester. Maintaining sharp, correctly timed chopper knives is critical. Research has shown sugar loss in the chopping process can triple with blunt/damaged knives.

Feedtrain optimisation, where feed roller speeds are synchronised and matched to the chopper rotational speed, reduces juice loss when the cane is cut into billets. This also improves the harvester’s feeding ability and produces a more even flow of material through the choppers and into the cleaning chamber. Consequently, losses of both juice and billet pieces are reduced in both the choppers and primary extractor increasing efficiency and reducing potential environmental effects.

Modified harvester fronts are another option to improve the gathering and feeding characteristics of harvesters. These fronts, which are commercially available as retrofits, provide less aggressive separation of tangled crops, improved flotation and better operator visibility.

Discussions between growers and their harvesting contractors are recommended to identify harvest options for wet periods. In such cases, it may be best to cut ploughed-out blocks in preference to damaging plant, first or possibly second ratoon crops. This strategy will enable growers to protect future ratoons from unnecessary damage from harvesting in wet conditions.

Harvester trials conducted to develop Harvesting Best Practice (HBP) guidelines have indicated that extractor fanspeeds should be reduced as much as possible to minimise cane losses through the primary extractor. Higher fanspeeds increase losses. Figure 2 demonstrates the rapid increase in cane loss as fan speed increases. For newer extractor systems such as the 1500 mm diameter Cameco and anti-vortex systems, the same principle applies, but even lower fan speeds are necessary to minimise losses due to their increased air flow.

For the best results it is important for the crop to be erect, have a reasonable yield and be well presented for the harvester. Harvester cleaning systems have limited capacity to separate cane and extraneous matter (EM) with the high pour rates possible with current machines. Moderate pour rates enable effective cleaning which reduces the EM content in the cane supply. Improved farm layout and crop presentation for efficient harvesting are the most appropriate options for improving pour rate. This is especially the case with increasing operating costs.

In order to minimise the risk of spreading sugarcane diseases, especially Ratoon Stunting Disease (RSD), it is important to be mindful of harvester hygiene. Ideally the whole harvester should be sterilised when it moves between blocks. Special attention needs to be given to the crop dividers, base cutters and choppers. As a minimum, this cleaning and sterilising procedure should occur as the harvester moves from one farm to another.

For a more in-depth explanation of sustainable and efficient harvesting practices, growers are referred to the Harvesting Best Practice Manual for Chopper Extractor Harvesters (Sandell and Agnew, 2002) and Harvesting Best Practice: The Money Issues.
8. MANAGING THE CROP AT HARVEST

This section deals with the management of the cane at harvest. Green cane harvesting, (where cane is not burnt prior to harvest), should be practised whenever possible. Wide adoption of this practice has occurred across the Queensland sugar industry (Table 1). Data from most mill areas indicate in excess of 85% of the crop is harvested green. The most apparent exception is the Burdekin region where it may not always be possible, although the longer-term objective is to harvest green.

Factors influencing the lack of adoption of green cane harvesting in some circumstances relate to soil, block and harvesting conditions, certain irrigation systems and the amount of extraneous matter following harvesting. These will be explained more fully in the section below. Whole crop harvesting (including trash) is an option being investigated for use in some areas.

Table 1: Percentage of mill area crops harvested green over the period 1990 to 2007.

<table>
<thead>
<tr>
<th>Region</th>
<th>Mill area</th>
<th>Percentage of crop harvested green</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>Mossman</td>
<td>78.5</td>
</tr>
<tr>
<td></td>
<td>Tableland</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mulgrave</td>
<td>80.4</td>
</tr>
<tr>
<td></td>
<td>Babinda</td>
<td>80.2</td>
</tr>
<tr>
<td></td>
<td>South Johnstone</td>
<td>44.3</td>
</tr>
<tr>
<td></td>
<td>Tully</td>
<td>38.1</td>
</tr>
<tr>
<td></td>
<td>Victoria</td>
<td>96.8</td>
</tr>
<tr>
<td></td>
<td>Macknade</td>
<td>95.5</td>
</tr>
<tr>
<td>Burdekin</td>
<td>Invicta</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>Pioneer</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>Kalamia</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Inkerman</td>
<td>0.8</td>
</tr>
<tr>
<td>Central</td>
<td>Proserpine</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>Marian</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>Pleystowe</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td>Racecourse</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td>Farleigh</td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td>Plane Creek</td>
<td>23.8</td>
</tr>
<tr>
<td>Southern</td>
<td>Bingera</td>
<td>29.9</td>
</tr>
<tr>
<td></td>
<td>Millaquin</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>Isis</td>
<td>37.1</td>
</tr>
<tr>
<td></td>
<td>Maryborough</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>Rocky Point</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>Queensland</td>
<td>33.6</td>
</tr>
</tbody>
</table>
Apart from harvesting green, the practice of green cane trash blanketing (GCTB) is recommended where appropriate. With this system, the sugarcane residue (leaves, tops and some stalk material) that covers the ground after green harvesting is retained as mulch. This is often referred to as a trash blanket.

A typical trash blanket consists of 8 – 15 tonnes/ha of organic material. The return of this material to the soil surface has important agronomic, environmental, financial and social benefits (Table 2), especially when compared to the traditional burnt cane system (cane burnt prior to harvest).

Although certain agronomic challenges exist with the implementation of GCTB (Table 3), many of these have now been eliminated. However, several of these are still unresolved in some areas. This is particularly the case in the Burdekin district. It is hoped that future technologies may help overcome some of these limitations.

The practice of burning a trash blanket is discouraged, even though it is used in some districts to enable the replant of sugarcane shortly after harvest of the last ratoon of the previous crop cycle. The use of fallows or break crops (as suggested in the SmartCane Fallow and Land Management booklet) should result in this practice being eliminated from the sugarcane cropping system. The practice of burning a trash blanket negates the benefits of GCTB used within the crop cycle.

### Table 2: Benefits of GCTB.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Benefit</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agronomic</td>
<td>Increased resources</td>
<td>Improved soil moisture content</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improved nutrient availability</td>
</tr>
<tr>
<td></td>
<td>Improved conditions</td>
<td>Improved soil structure, Better water infiltration</td>
</tr>
<tr>
<td></td>
<td>Reduced losses</td>
<td>Less soil erosion</td>
</tr>
<tr>
<td>Economic</td>
<td>Cost savings</td>
<td>Less chemicals, Less machinery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less labour, Increased water use efficiency</td>
</tr>
<tr>
<td>Environmental</td>
<td>Improved conditions</td>
<td>Reduced smoke, Reduced ash fallout</td>
</tr>
<tr>
<td>Social</td>
<td>Improved conditions</td>
<td>Improved WH&amp;S, Decreased workload, Improved lifestyle</td>
</tr>
</tbody>
</table>

### Table 3: Factors affecting implementation of GCTB in some areas.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large amounts of trash, especially with some varieties</td>
<td>High levels of extraneous matter supplied to the mill</td>
<td>Amount of material passing through the mill</td>
</tr>
<tr>
<td></td>
<td>High levels of trash in cane paddocks especially with long rows</td>
<td>Reducing milling efficiency</td>
</tr>
<tr>
<td>Soil types</td>
<td>Increased moisture in low-lying areas and in soils susceptible to waterlogging</td>
<td>Difficulty with furrow irrigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Risk of accidental trash fires</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yield loss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poor regrowth*</td>
</tr>
</tbody>
</table>

*Can be related to low soil temperature under the trash blanket in some areas.*
9. NUTRIENT MANAGEMENT

The SIX EASY STEPS nutrient management program forms the basis of current best nutrient management practice for sugarcane production. This approach is aimed at sustainable nutrient management that promotes profitable sugarcane production in combination with environmental responsibility. This means the maintenance of fertility on-farm is as important as strategies that minimise off-site effects.

Risk management of applied nutrients

In line with the Australian fertiliser industry’s FERTCARE® program it is recognised that nutrient losses that pose a risk to productivity, profitability and the environment can be divided into a number of categories (as defined in Table 4). Losses of nutrients from the farm are therefore not only of environmental concern, but they also represent losses in efficiency that ultimately affect farm profitability. It is therefore in the interest of everyone to minimise these losses.

Table 4: Explanation of loss pathways for nutrients.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leach</td>
<td>Nutrients that move below the rooting depth of crops as a result of water draining through the soil profile. This affects the quality of the groundwater.</td>
</tr>
<tr>
<td>Run</td>
<td>Nutrients that move away from the point of application due to surface water movement. This can be soluble form or attached to sediments.</td>
</tr>
<tr>
<td>Load</td>
<td>Nutrients or heavy metals that accumulate due to the application of fertiliser or other products, often due to high application rates.</td>
</tr>
<tr>
<td>Blow</td>
<td>Nutrients are lost by erosion or gaseous loses into the atmosphere.</td>
</tr>
<tr>
<td>Mine</td>
<td>Decline of soil fertility to excessive cropping without replenishing the nutrients removed. Unwanted species (weeds) also contribute to mining of nutrients.</td>
</tr>
</tbody>
</table>

Soil-specific nutrient management

As indicated in the SmartCane Plant Cane Establishment and Management booklet, sustainable nutrient management is inextricably linked to the management of soils. This requires recognition that soils differ markedly from one another (both within and across farms and districts) and that each soil and the nutrients applied are managed according to:

- The specific properties of the soil (chemical, physical, and in-field properties such as colour, depth, sequence of soil layers and position in the landscape)
- The chemical and physical makeup of fertilisers
- The chemical processes that occur within the soil
- The interaction of the applied nutrients with the soil

Balanced nutrition

Linked to the concept of soil-specific nutrient management is the need for balanced nutrition. Balanced nutrition implies that all essential plant nutrients need to be present at appropriate concentrations in the soil to enable optimum crop growth and yields. This concept is well demonstrated using the ‘staves of a barrel’ analogy (Figure 3) where each stave represents an individual nutrient. With ‘balanced’ nutrition, the ‘barrel’ has the ability to be filled to capacity (achieving optimum yield). This is illustrated by barrel (a). If one or more of the nutrients are below appropriate concentrations, then yield will be negatively affected. This is illustrated by barrel (b) with the capacity limited by the shortest stave. Barrel (c) (with one stave longer than the others) illustrates that over-application of one nutrient (at the possible expense of others) will not improve yields.
Basic principles for sustainable nutrient management

Four basic principles need to be followed when nutrient inputs are determined. These are summarised in Table 5 and they apply to both plant and ratoon cane.

A combination of soil testing and leaf analysis is the most appropriate way of determining what nutrients need to be applied to maintain soil fertility, achieve balanced nutrition, prevent the build-up of luxury amounts of particular nutrients and produce profitable crops.

Soil testing is best done at the end of the previous sugarcane crop cycle and prior to re-establishment. This will enable development of a nutrient management plan covering the plant crop and a number of ratoons. Guidelines for soil sampling are provided as an Appendix in the *SmartCane Plant Cane Establishment and Management* booklet. Analysis of leaf samples collected during the ratoon crops of a crop cycle (Figure 4) enables the adequacy of nutrient inputs to be determined. Leaf sampling guidelines are provided as Appendix 1 in this booklet.

Nutrient management guidelines for ratoon cane

The SIX EASY STEPS program includes nutrient management guidelines for the full range of essential nutrients: (nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg) silicon (Si), zinc (Zn) and copper (Cu). It also provides guidelines for ameliorating acid and sodic soils.

Table 5: Some basic principles when considering nutrient inputs.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Apply nutrients when they are needed.</td>
</tr>
<tr>
<td>2.</td>
<td>Do not apply nutrients when they are already present in sufficient quantities in the soil.</td>
</tr>
<tr>
<td>3.</td>
<td>Do not apply one nutrient at the expense of another (or others).</td>
</tr>
<tr>
<td>4.</td>
<td>Do not be tempted by systems or ‘gimmicks’ that promise unrealistic benefits. If it sounds too good to be true, it probably is!</td>
</tr>
</tbody>
</table>

The program is delivered to industry by means of short courses that are supported by a series of district-specific workbooks that are regularly updated to ensure information is current and relevant. A series of soil-specific nutrient management booklets are also being progressively developed for the various districts of the industry.

The N recommendations for plant cane are included in the *SmartCane Plant Cane Establishment and Management* booklet. Table 6 provides information on the N requirement for ratoon cane. As with plant cane, these guidelines are based on a combination of district yield potential and soil organic C (an indicator of the soil’s N mineralisation potential).

![Figure 3: Staves of a barrel analogy indicating the need for balanced nutrition.](image1)

![Figure 4: Leaf sampling.](image2)
Table 6: SIX EASY STEPS guidelines for N applications for ratoon cane based on soil organic C.

<table>
<thead>
<tr>
<th>District</th>
<th>District yield potential (t cane/ha)</th>
<th>Soil organic C (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 0.4</td>
<td>0.4 - 0.8</td>
</tr>
<tr>
<td>Wet tropics</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>Herbert</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>Burdekin (lower yield potential) / Tablelands</td>
<td>150</td>
<td>190</td>
</tr>
<tr>
<td>Burdekin (higher yield potential)</td>
<td>180</td>
<td>220</td>
</tr>
<tr>
<td>Proserpine</td>
<td>130</td>
<td>170</td>
</tr>
<tr>
<td>Mackay</td>
<td>130</td>
<td>170</td>
</tr>
<tr>
<td>Plane Creek</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>Bundaberg</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>Isis</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>Maryborough</td>
<td>120</td>
<td>160</td>
</tr>
</tbody>
</table>

The SIX EASY STEPS program also recognises the carry-over of nitrogen into the ratoons following legume fallow crops grown prior to sugarcane. The amount of N available to the ratoon crops following legume fallows will be dependent on the type of legume, how well it was grown and whether the grain was harvested. Data from the Sugar Yield Decline Joint Venture and BSES trials suggest that N applied to the first ratoon sugarcane crop after a good legume fallow can be reduced. The reduction in N applied will depend on several factors such as legume residue management, soil type, climate and tillage practices.

Guidelines for the other nutrients (P, K, S, Ca, Mg, Zn and Cu) in ratoon crops are available within the SIX EASY STEPS program.

Substantial amounts of nutrients are added to a block of cane through the application of mill by-products. However, the amount of nutrients added is affected by:

- The particular mill by-product applied (eg. both mill mud and mud/ash mixtures contain N, mill ash contains little available N)
- Variability of the nutrient content of the mill by-products (because the cane supply source is variable and because soil types differ between and within districts). We suggest that you consult with your local extension staff
- Application rate of the by-products used. Typical application rates vary from district to district but usually range from 100 to 250 wet tonnes per hectare (contract spreaders can indicate what application rates they are able to apply on your farm)
- Ratio of the components of the mud/ash mixtures (although this can differ from load to load, average nutrient contents are used for convenience)

Not all the nutrients in applied mill by-products are available for uptake in the plant crop, as they are in organic forms. Some of the total amounts of nutrients applied become available with time and the benefit is carried over several ratoon crops (Table 7). The composting of mill mud/ash is being investigated in several areas. The lower moisture content of the composted material will allow the product to be transported more economically and therefore enable greater distribution across mill districts.
Table 7: Estimate of available nutrients to successive crops after the application of a mill by-product.

### Nutrient contribution from mill mud applied at 150 wet t/ha

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Plant crop (kg/ha)</th>
<th>First ratoon crop (kg/ha)</th>
<th>Second ratoon crop (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>80</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td></td>
<td>Sufficient P for 2 crop cycles</td>
<td></td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>40</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td></td>
<td>Sufficient Mg for 1 crop cycle</td>
<td></td>
</tr>
<tr>
<td>Lime*</td>
<td>2 t/ha</td>
<td></td>
<td>Also effective into ratoon crops</td>
</tr>
</tbody>
</table>

### Nutrient contribution from mill mud/ash mixture applied at 150 wet t/ha

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Plant crop (kg/ha)</th>
<th>First ratoon crop (kg/ha)</th>
<th>Second ratoon crop (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>50</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td></td>
<td>Sufficient P for 2 crop cycles</td>
<td></td>
</tr>
<tr>
<td>Potassium (K)</td>
<td></td>
<td>Sufficient K for 1 crop</td>
<td>0</td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>10</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td></td>
<td>Sufficient Mg for 1 crop cycle</td>
<td></td>
</tr>
<tr>
<td>Lime*</td>
<td>2 t/ha</td>
<td></td>
<td>Also effective into ratoon crops</td>
</tr>
</tbody>
</table>

*Lime application can adjust soil pH and supply Ca.*

The SIX EASY STEPS program recognises the nutrient contribution from other sources. These include residual fertiliser from horticultural crop production grown between crop cycles of sugarcane, N and K in irrigation water and the substantial amounts of K in dunder (by-product of ethanol production). The program also includes allowance for blocks that will produce lower yields than normally expected (older ratoons, drought affected cane, etc). In such cases a lower yield potential should be used to determine N inputs.

### Factors that may influence ratoon crop potentials

Several factors influence the growth/production of ratoon crops, and nutrient inputs should reflect the management strategy that the grower uses to grow the best possible crop during adverse conditions. These conditions include:

- **Adverse weather:**
  - Floods and subsequent waterlogged soils
  - Reduced rainfall (including reduced irrigation water availability)

- **Periods of low sugar prices and high costs of production**
- **Predominance of older ratoon crops**

### Nutrient applications

Fertilisers come in different forms (granular, liquid, mill by-product and organic), each with different nutrients and varying amounts of each nutrient. It is important that growers select the most appropriate fertiliser types for each situation, while maintaining balanced nutrition and managing the associated risks.

Most inorganic fertilisers are purchased as a mixture. Ratoon cane mixtures are usually applied as “one shot blends”. These include fertilisers based on urea or calcium ammonium nitrate (CAN). Urea-based blends should not be applied to the surface of a trash blanket, but should be applied into the soil below the trash to prevent volatilisation. If applied to the surface of a trash blanket, sufficient rainfall or irrigation is required to wash the fertiliser into the soil. CAN blends are more suitable for surface application. Fertiliser blends for ratoon cane usually contain potassium (as muriate of potash), possibly phosphorus (DAP) and sulphur (ammonium sulphate).
Liquid fertilisers include both commercially available nutrient solutions and products based on dunder. The dunder-based fertilisers are naturally high in potassium and are usually fortified with other nutrients, including nitrogen, phosphorus and sulphur. As with granular mixtures, dunder-based products that contain urea should be applied subsurface or washed into the soil with rainfall or irrigation, to prevent volatilisation losses.

Mill by-products (mentioned earlier) and organic fertilisers are usually applied prior to planting. Use of these products in ratoon cane is limited. However, if they are applied they should be worked into the soil to minimise the risk of nutrient losses off-site.

Subsurface application of fertilisers (granular or liquid) is best achieved through coulters or coulter/tine combinations, either by stool splitting with a single coulter delivering the fertiliser in the cane row, or by dual coulters beside the cane row.

Appropriate timing of fertiliser application is also an important tool in reducing the risk of fertiliser losses due to leaching, run-off and/or denitrification. The best period for fertiliser applications is when the ratoon crop is well established and is actively growing. This allows the crop to take up nutrients efficiently and act as a nutrient store. The risk of nutrient losses increases if the fertiliser is applied too early (before the onset of rain or irrigation) or too late (when heavy late spring or summer rains have commenced).

Nutrient monitoring tools that allow growers to check on the adequacy of their nutrient management strategies include leaf analysis and possible cane analysis by near infrared reflectance (NIR) at some mills. Together with soil analysis, these tools can assist in identifying nutrient trends in particular blocks and enable growers to adjust their nutrient program with confidence. Records of crop sequences and fertiliser/amendment applications will allow growers to track all nutrient sources.

By utilising the strategies above, growers are maximising profitability, caring for the wider environment and maintaining their on-farm resources.
10. IRRIGATION

In several cane growing regions in Australia, insufficient or unreliable rainfall means that irrigation is necessary to ensure productivity is maintained at economically sustainable levels. The degree of irrigation required depends on environmental factors including the amount of effective rainfall received, temperature, solar radiation, wind and evaporation. All of these have a direct effect on crop growth and water use.

Irrigation requirement varies from region to region and area to area. Table 8 illustrates the annual crop water use in cane growing regions compared with effective rainfall levels. The resultant crop water deficits show the wide variation in irrigation requirement which ranges from minor, through supplementary, to full irrigation.

The availability of water to meet irrigation demand has a direct bearing on irrigation practice. Where water supplies are plentiful eg. Burdekin, full on-demand irrigation is possible. Restricted supplies (eg. Bundaberg and Mackay) limit irrigation applied and require particular strategies to make irrigation more effective and economical.

Irrigation also needs to be integrated with other farm practices such as fertilising practices, ratooning operations, cultivation practice and harvesting. It will also be influenced by infrastructure including natural attributes of soil type, water access and delivery, farm design, block size and dimensions, irrigation systems, pumping capacity and availability of water.

Sustainable irrigation is dependent upon crop response and returns from sugar or other related enterprises. Usually, response of sugarcane is strongest at the lower levels of applied water, provided irrigation is scheduled effectively and strategically. However, profits are optimised after the break-even point of total production costs is reached (Figure 5). At relatively high levels of irrigation, however, returns quickly become marginal and the resource is wasted.

<table>
<thead>
<tr>
<th>District</th>
<th>Annual crop water use (mm)</th>
<th>Effective rainfall (mm)</th>
<th>Irrigation requirement (mm)</th>
<th>Level of irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cairns/Mossman</td>
<td>1630</td>
<td>1360</td>
<td>270</td>
<td>LS</td>
</tr>
<tr>
<td>Mareeba/Dimbulah</td>
<td>1550</td>
<td>405</td>
<td>1145</td>
<td>F</td>
</tr>
<tr>
<td>Atherton</td>
<td>1170</td>
<td>760</td>
<td>410</td>
<td>MS</td>
</tr>
<tr>
<td>Tully/Babinda</td>
<td>1310</td>
<td>1500</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Herbert</td>
<td>1350</td>
<td>1100</td>
<td>250</td>
<td>LS-MS</td>
</tr>
<tr>
<td>Burdekin</td>
<td>1520</td>
<td>450</td>
<td>1070</td>
<td>F</td>
</tr>
<tr>
<td>Proserpine/Mackay/Sarina</td>
<td>1490</td>
<td>630</td>
<td>860</td>
<td>MS-ES</td>
</tr>
<tr>
<td>Bundaberg/Isis/Maryborough</td>
<td>1360</td>
<td>580</td>
<td>780</td>
<td>ES</td>
</tr>
<tr>
<td>Rocky Point</td>
<td>1150</td>
<td>990</td>
<td>160</td>
<td>LS</td>
</tr>
<tr>
<td>Northern NSW</td>
<td>1200</td>
<td>1000</td>
<td>200</td>
<td>LS</td>
</tr>
</tbody>
</table>

Nil: No irrigation, LS: Limited supplementary, MS: Moderate supplementary irrigation, ES: Extensive supplementary irrigation, F: Full irrigation
Principles of effective irrigation:

To achieve optimal results from irrigation, three principles need to be met:

- Applying the right amount of water
- At the right time
- Irrigating efficiently and economically

Irrigation systems:

The most common irrigation systems used in sugarcane include:

- Furrow irrigation (flood, surface)
- High pressure overhead systems (hard and soft hose travelling guns)
- Low pressure overhead systems (centre pivot, lateral move, boom irrigators)
- Drip irrigation (trickle)

Other systems, such as sprinklers, are still used to a minor extent for special purposes eg. germinating plant cane, seed plots, etc.

Selection of irrigation type is dependent on such factors as soil type, availability and cost of water, block size and farm layout, slope and landform, infrastructure and equipment, and pumping costs. In some areas, one type predominates (eg. furrow in the Burdekin), while in others a mixture of several systems are used both at a district and farm level.

Fine-tuning irrigation practices on-farm by adopting appropriate strategies for individual farms not only contributes to productivity and profitability, but also ensures that the water resource is well managed.

Soil, water and crop

Different soils have different abilities to store water. The total water available to a crop is called Plant Available Water Capacity (PAWC) and, of this, the amount that is easily extractable by plants is called readily available water (RAW). As a crop grows, the root system becomes more extensive and therefore has the potential to access more of the stored water. For efficiency, the amount of irrigation applied should aim to supply sufficient water to wet the soil to the extent of the root zone (or a little further to invite roots deeper) but not in excess of the soil’s water holding capacity.
Once the soil profile has been filled after irrigation or rainfall, subsequent irrigation should be applied in accordance with crop needs. Allowance should be made for progressive growth and the resultant heavier use of soil water. Application rates should not exceed the soil’s water holding capacity. If that is likely, shortening the irrigation interval (days) would be necessary to maintain an adequate moisture supply for the crop.

Meeting this requirement helps satisfy the first principle of irrigation – applying the right amount of water for both crop needs and soil capacity.

Crop water use varies according to growth patterns which are influenced by crop factors such as age of cane, variety, prevailing weather and stored soil moisture. If not replenished by rain, soil moisture diminishes steadily until growth is slowed. If the soil water content is allowed to run down substantially, growth will take time to recover when moisture is replenished. Irrigation schedules are usually designed to ensure growth does not fall below 50% of normal expected growth rates. This usually aligns with the soil’s readily available water.

Monitoring soil moisture with aids such as WaterSense, capacitance meters (EnviroSCAN, Diviner, etc), evaporation mini-pan and tensiometers, will provide continuous evaluation of soil moisture levels and greatly assists in maintaining effective schedules.

By adjusting the amount of irrigation to both the soil’s capacity and crop water use at the time, the second principle of irrigation – applying irrigation at the right time - is achieved.

Application efficiency relates to getting the desired amount of water onto the crop as evenly as possible and with minimum wastage. The ability to do this differs between irrigation systems: in general, furrow irrigation is the least efficient, with high pressure water cannon marginally better, low pressure overhead systems better still, and drip irrigation the most efficient of all. However, all systems will perform efficiently provided they are suitable for the situation and are set up and operated correctly.

For example, some studies have shown that furrow irrigation with tail-water return can be the most efficient system and least costly overall.

To evaluate application efficiency, it is important to measure inputs such as application rates and duration. To gain a more accurate picture of application, evaluation programs such as SIRMOD and IPARM for furrow systems, TRAVGUN for high pressure travelling guns, WetUp for drip systems and OVERsched for pivot and other low-pressure systems are very useful. These are usually available through local water officers and extension officers and are particularly helpful in identifying application problems such as uneven wetting and deep drainage. Additionally, moisture monitoring aids such as tensiometers or capacitance meters set up in different sites in a field will help assess application efficiency.

Where irrigation is adequate, efficient application ensures optimal results for the irrigated area while keeping wastage to a bare minimum and achieving the most economical outcomes – the third principle of efficient irrigation.
**Water quality**

Irrigation water sources are mainly surface supplies from large public dams and delivered to irrigation areas and farms either by open channels or pipes. In most areas, groundwater is also an important component of supplies and on-farm water storages play a minor, yet significant role in some districts. Surface water supplies from public storages are generally of satisfactory quality. However, when storage levels are lowered severely, water quality can deteriorate due to increased salinity, turbidity and low oxygen levels. Groundwaters are more likely to suffer quality problems which can include the major components of water quality viz. salinity, sodicity hazard (sodium adsorption ratio and residual alkali), toxic ions and presence of corrosive materials, eg. iron compounds. Regular use of waters with these characteristics may detrimentally affect plants, crops, soils and equipment. Remedial treatments will probably be necessary in these cases.

Salinity is a measure of the total quantity of dissolved salts and is best estimated by measurement of the electrical conductivity (EC) of water. The standard EC unit is decisiemens per metre (dS/m), although conductivity meters often read in millisiemens per centimetre (mS/cm) or microsiemens per centimetre (µS/cm); mS/cm are equivalent to dS/m and µS/cm are one-thousandth of that measure.

The sodium absorption ratio (SAR) is a prediction of how water will affect soil sodicity. Sodic soils disperse easily, have poor infiltration and drainage characteristics and are difficult to cultivate and irrigate. Soil dispersion is likely to be greater with low salinity water. The risks associated with different SAR values are shown in Table 9.

Relatively high levels of chlorine, sodium, boron, lithium and other ions are toxic to some crops but rarely to sugarcane. More unusual water sources such as sewage effluent, should be monitored to avoid problems with long-term use. These could include corrosive materials such as iron compounds, colloidal clay and sand. Waters with low pH or high chlorine content are generally corrosive. Those with high chlorine content are particularly corrosive in turbine pumps.

Where water penetration is a problem, especially with low salinity water, the addition of gypsum as a soil amendment or dissolved in the irrigation water may be necessary.

Information relating to water quality types and corrective measures for water of poor water quality is obtainable from extension officers.

---

**Table 9: Soil dispersion risk categories.**

<table>
<thead>
<tr>
<th>SAR</th>
<th>EC (dS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 - 0.3</td>
</tr>
<tr>
<td>1 - 10</td>
<td>high</td>
</tr>
<tr>
<td>10 - 18</td>
<td>high</td>
</tr>
<tr>
<td>18 - 26</td>
<td>high</td>
</tr>
<tr>
<td>Over 26</td>
<td>high</td>
</tr>
</tbody>
</table>
11. WEED MANAGEMENT

Yield loss from weed competition combined with the cost of weed control is estimated to exceed $70 million annually. Weeds compete with sugarcane for light, nutrients and moisture significantly reducing yields (Figure 6) in a relatively short period of time. Implementing a timely, cost-effective weed management strategy is vital to maximise yields.

Controlling weeds in areas adjacent to canelands is one of the most important strategy to minimise the impact of weeds on the farm. The most cost–effective and easiest method in controlling weeds is by reducing the weed seedbank. By preventing weed seed entering the paddock (slashing headlands, spraying around fence lines, hydrants, pumps, water channels, sheds, machinery, etc), the weed pressure in blocks of cane is greatly reduced.

Widespread use of green cane trash blanketing has reduced the amount of weeds germinating because of the barrier that the trash blanket provides. Adoption of minimum tillage practices has reduced soil disturbance and subsequent germination of weed seed. However, these changed practices have resulted in wider use and greater reliance on herbicides to control weeds in ratoon cane. As indicated in the SmartCane Plant Cane Establishment and Management booklet, the inappropriate use of herbicides can be the cause of significant environmental risks. These risks can be minimised by using appropriate on-farm management strategies. These include timing of application, using recommended rates, product choice and possible use of band spraying. Choosing the right strategy will increase grower returns and minimise off-farm impacts.

Best Practice Weed Management incorporates a grower’s knowledge of the physical attributes of their farm, associated weed species and the products and equipment that are available for use. Integrating this knowledge will enable growers to make informed decisions about weed management strategies most appropriate for their farms. Understanding soil types, weed species and product efficacy are the keys to successful weed management.

Figure 6: Weed competition affecting cane growth.

A range of publications, pamphlets, workshop materials and advice relating to weed management issues are available from extension officer and agribusiness representatives. Additional information on related topics (eg. soil properties, weather forecasts and technical information) are available from various sources including internet sites. The overall principle is to apply the right herbicide correctly and at the right time. An incorrectly used herbicide is an expensive waste of time and money. Read the label to ensure correct usage of the product.

Figure 7: Effect of four weeks of weed competition on the left.
Integrated Weed Management (IWM)

IWM allows a range of cost-effective weed management options to be used for effective weed control in an environmentally responsible manner. These include:

- **Reducing the weed seedbank**
  This is critical to minimising the weed pressure on-farm.

- **Practising good hygiene procedures**
  Cleaning down machinery (e.g., slashers) will minimise the introduction of weed seed to your farm.

- **Using appropriate cultural practices**
  Trash blanketing where possible will suppress weeds, especially grasses.

- **Applying suitable herbicides**
  Where weed pressure is expected to be high, certain residual herbicides may be applied to the trash blanket as soon as possible after harvest. These herbicides should ideally be applied as a band application over the row. This greatly reduces the amount of applied herbicide thus reducing potential for off-site impacts. Care needs to be taken with this strategy and growers are encouraged to seek advice on appropriate products, timing of application and rates.
  Alternative post emergent products can also be used after weed emergence which may be delayed by the trash layer.

- **Utilising mechanical control**
  Mechanical control is most appropriate in non-trash blanket systems (operations such as side dressing and filling-in also reduces weed population).

Correct timing of herbicide application is critical for successful weed control. An effective integrated weed management program should include reducing the weed seedbank and controlling weeds early. Small weeds (i.e., 2-3 leaf stage) are much easier and cheaper to kill than large ones (Figure 8). Paraquat will be effective at lower rates on the small grass. Large “woody” or flowered weeds are often too difficult to effectively control with herbicides, especially at lower rates.

It is also important to apply herbicides to weeds using the correct volume of water. A general guide is “small weeds = lower water volume”. Please consult specific product labels for more information.

![Figure 8: Smaller weeds are much easier to control than larger ones.](image)

![Figure 9: A high clearance tractor being used for applying herbicide.](image)

Herbicide application equipment usually consists of a tank, pump, boom, delivery hoses and spray nozzles. These may consist of spray rigs attached to a tractor by three point linkage or purpose built self propelled units that are suited to spraying large areas. A high clearance tractor can be useful when applying herbicides to crops past the out-of-hand stage (Figure 9).

Equipment must be maintained on a regular basis. Changing nozzles and calibrating regularly are essential. Nozzle replacement can be costly, but this cost is insignificant compared to the potential cost of ineffective weed control. The selection of appropriate nozzles is most important in delivering chemical to the target weed (Figure 10). Inappropriate application rates and nozzle types can lead to excess product application and/or spray drift, leading to the target weed receiving excess or insufficient quantities of herbicide, respectively. Ineffective use of herbicides can be expensive and may also result in unwanted environmental impacts.
Nozzles are designed to create the correct sized droplets for specific purposes with a range of spread patterns. In relation to ‘phenoxy-based’ or ‘Group 1” products such as 2,4-D, Starane® and MPCA formulations, there is now a label requirement that nozzles MUST create coarse to very coarse droplets to minimise spray drift (Figure 11). Air-inducted nozzle types are designed for this purpose. Please consult an extension officer or your supplier for further information regarding nozzle selection.

Correct application timing relative to monsoonal (heavy rain) events is also important to minimise off-site movement.

The correct “adjuvant” is as important as product choice and nozzle selection in delivering a lethal dose to the target weed and keeping it there. Adjuvants (surfactants, oils, acidifiers) have a variety of functions such as spreading, wetting, penetrating and modifying droplet formation and behaviour, and can also be effective for drift management.

As mentioned above, it is now a label requirement that when applying phenoxy based herbicides such as 2,4-D or Starane®, applicators must use nozzles which create a coarse to very coarse droplet, in order to minimise drift onto susceptible plants. Wind speeds must also be between 3 and 15 km/hr.

Using good quality water is very important, especially when applying glyphosate. Hard water (water that doesn’t easily lather) is high in calcium and magnesium ions. This water will ‘tie-up’ glyphosate and reduce the efficacy of the product. If water quality is in doubt, it is recommended that a water sample be sent for analysis. There are a number of commercially available products that can remedy water quality problems.

Keeping good records of product rates, spray pressure, nozzles, water application volumes, weather conditions and weed types is an excellent way of building a clear picture of weed types and weed management on-farm. Record keeping of herbicide applications is a legal requirement. Growers are strongly advised to complete or update their ChemCert training. ChemCert delivers essential farm safety information which includes product handling, disposal and personal protection equipment (PPE).

Important information about solubility and mobility of herbicides and the persistence after application and risk periods can be found in the SmartCane Plant Cane Establishment and Management booklet. Summary guidelines for safe usage and chemical use recording are also included. One important principle worth highlighting is the need to read product labels for important information on usage and safety requirements.

A planned weed control program is essential for successful weed management. ‘If you fail to plan, you plan to fail.’ Timely preparations on product choice, application methods, nozzles and equipment maintenance will facilitate good weed management.

**Products**

A program consisting of both pre-emergent residual and post-emergent control is most valuable in controlling weeds over a period of time. Information about herbicides that are registered for this purpose are included in the BSES Herbicide Manual. More detailed information can be obtained from the appropriate product labels. Care must be taken to match the product to the soil type and weed species.
12. PEST MANAGEMENT

A range of invertebrate and vertebrate pests may attack sugarcane ratoons. Their effect on crop productivity will depend on the pests involved and could include:

- Reduction in yield or quality of the crop at the next harvest
- Reduction in yield or quality in the longer term, stools damaged by canegrubs may be lost at harvest, reducing productivity for the remainder of the crop cycle
- High risk of infestation in the next crop cycle, if the infested ratoon is due for ploughout and suitable management strategies are not put in place before, during or after planting
- Reduced suitability of crops as plant sources

Pest monitoring is fundamental to best practice pest management in all agricultural systems, including sugarcane. The occurrence of pests in ratoons is usually sporadic. Control measures will be worthwhile in some years, but their routine application would be wasteful and uneconomic. The only way to ensure that controls are applied when needed, and not wasted when not needed, is to have some form of monitoring system in place. This could be direct monitoring of the pest and/or indirect monitoring of its damage at one or more levels (individual fields, farms and locality or district). Possible monitoring systems are discussed later for individual pests.

Monitoring will allow an estimate of the risk of pest damage to a field and so the possible need for some form of control action such as application of pesticide. However, even where a particular pest is present and is likely to cause crop damage, control measures may not be justified if the cost of control is likely to exceed any loss of productivity due to pest damage.

Where pests are a constraint on productivity, losses should be minimised by adopting an integrated pest management (IPM) strategy. IPM combines a variety of suitable management techniques rather than relying on a single control option such as a pesticide. Principles of IPM are discussed in the previous booklet, SmartCane Plant Cane Establishment and Management.

Aspects of pest management for particular pests are discussed below.

**Canegrubs**

Nineteen species of canegrubs can be found in sugarcane fields in Australia. Canegrubs have 1-year or 2-year life cycles; typically, those with 1-year cycles damage cane in late summer and autumn while those with 2-year cycles damage cane in late spring-summer. For effective canegrub management, it is important that canegrubs be confirmed as the cause of any crop damage, and that the species of grub be identified; some white grubs found in cane are not canegrubs and are harmless. Canegrubs can be identified by their raster pattern (Figure 12) and Identification guides to the species in each region are available from BSES.

**Figure 12:** Canegrub identification by raster pattern.

For canegrubs with 1-year cycles, such as greyback canegrub and southern 1-year canegrub, either the grubs or their damage can be monitored in February-May, depending on the district. If damage is likely to be severe, then some change in harvest sequence might be needed, eg. early harvest before quality declines too greatly. It will be too late to apply control measures in infested fields, because they will be inaccessible to machinery, but control action may be needed after harvest to prevent damage in the next crop or the next crop cycle. Nearby fields may also be at risk and require management steps to be put in place.
Monitoring systems, decision-making and management options (eg. insecticides, trap-cropping) for greyback cane grub in ratoons are outlined in the *GrubPlan* booklet published by BSES.

For cane grubs with 2-year cycles, such as *French’s, negatoria* and *Childers cane grubs*, grubs that are present in spring can be controlled directly by ‘knockdown’ insecticides applied soon after harvest, to prevent damage that would otherwise occur in late spring and summer. A simple cost-benefit analysis using data from previous insecticide trials suggests that, for Childers cane grub, a threshold grub density of 4-5/stool would be sufficient to justify treatment based solely on improved productivity at the next harvest (Figure 13). Longer-term benefits of treatment (improved ratooning and delayed ploughout) have not been allowed for in this analysis, and the threshold would be lower if these were taken into account.

The sooner knockdown treatments are applied against 2-year grubs in spring, the greater the crop response and the return on investment. Damage is sometimes not noticed until well after harvest, eg. December-January, when crops fail to respond to fertiliser and irrigation. Most of the grub damage has been done by then and crop response to treatment is often poor. For best results, crops should be monitored in early spring or, even better, in the preceding autumn. Two-year grubs that will damage crops in summer were already present as smaller larvae in the preceding autumn, and their early detection will allow management plans to be put in place well in advance, eg. harvest schedules can be re-arranged to allow timely treatment.

The break-even point (where the response lines cross the red line) has been calculated as the grub density at which the value of the extra cane at the next harvest due to treatment equals the cost of insecticide plus application costs (assumed to be $200/ha). The threshold number of grubs at the break-even point did not change much with sugar price – the threshold was about 4 grubs/stool at $450/t and 5/stool at $250/t. Above the threshold, it was still worthwhile using insecticide even with a low sugar price. Additional benefits of treatment, such as better ratooning after harvest and delay in need for replanting, have not been factored into this analysis, but must also be considered when making decisions about grub control.

**Figure 13:** The extra gross margin from use of insecticide against different densities of Childers grubs in ratoons, calculated from yields at the next harvest in nine trials, at three different sugar prices.
If plant crops were treated with controlled-release products such as suSCon® Blue and suSCon® Maxi, then monitoring of ratoons in those fields may not be needed for the first 2 or 3 years after planting. However, one valid management strategy, particularly in low-risk areas or low-risk years, is to not treat plant crops with insecticide or use a 1-year treatment such as Confidor® Guard, and monitor ratoons across the farm for grubs or early signs of damage. Treatments can then be applied if needed or withheld if there are no signs of infestations.

Insecticides that can currently be used against canegrubs in ratoons are liquid products containing imidacloprid (e.g. Confidor® Guard, Senator®) and Rugby® granules containing cadusafos. These are not registered for all canegrub species, so label directions should be checked before use. An implement with one or two coulters per row will be needed to apply these products to ratoons (eg. Figure 14).

**Figure 14:** Side view of possible configuration of coulter and tine implement for application of imidaclorpid liquid in ratoons (diagram supplied by Bayer CropScience).

**Soldier flies**

Larvae of soldier flies suck sap from the roots of sugarcane plants and are a serious problem in some districts. They are usually in low numbers in the plant crop but increase in ratoons. Their presence is indicated by slow ratooning and gappy ratoons, with edge rows and end stools often unaffected. Their presence should be confirmed by checking for larvae under stools from September onwards. Currently, there is no way to control soldier fly numbers in infested ratoons, although their effect can be minimised by harvesting infested blocks when ratooning conditions are good. However, the presence of soldier fly in ratoons indicates that management steps should be taken to minimise the carry-over of larvae into the next crop cycle. These steps include having a long break from cane by harvesting the final ratoon crop early and planting the next crop late, and having a break that is free of grassy weeds and volunteers, eg. by growing a good crop of soybeans.

**Weevil borers**

Adult weevil borers lay their eggs in sugarcane stalks and their larvae burrow inside the stalk, reducing stalk weight and encouraging rot that leads to reduced sugar content and quality. The presence of weevil borers in fields can be checked by slicing open a sample of stalks and checking for the distinctive legless larvae and characteristic sawdust-like frass and fibrous cocoons. The adult population on a farm can also be monitored using split-billet or pheromone traps.

Best management practice for weevil borer control includes good farm hygiene and best-practice harvesting (cut cane close to the ground, minimise extractor losses and billet spillage, etc). Any pest damage (eg. rat damage) or farm practice that causes a break or crack in the rind allows fermentation to occur, which attracts egg-laying weevils. Billets or whole stalks left in fields after harvest allow borers to breed and re-infest young cane.

One insecticide, Regent® (fipronil), is currently registered for control of weevil borers. It can profitably be used (according to label directions) in years when borer numbers are high or in varieties that are particularly susceptible. Application of Regent® should especially be considered to protect plant sources that might otherwise be ruined by borer damage.
**Armyworms**

The larvae or caterpillars of several species of armyworms may strip the leaves of sugarcane plants. Most damage is caused by night-feeding armyworms, which are much more abundant in ratoons than in plant crops because the adult moths are attracted to fields by the decomposition odour produced by trash blankets after harvest. Armyworm infestations may be controlled by sprays of several registered insecticides but the benefits of treatment have been difficult to demonstrate, as crops can tolerate some leaf damage and, in practice, much of the damage has often been done before infestations are noticed and treatment applied.

Armyworms are attacked by a variety of parasites and diseases that will eventually bring populations under control and the breeding of these natural enemies will be interrupted by insecticide sprays. Insecticide treatment is rarely worthwhile in northern regions. Spraying may sometimes be beneficial in southern regions where crop growth is slower after harvest, but a sample of larvae should first be examined to ensure that they have not already finished most of their feeding.

**Rats**

Ground rats and climbing rats bite holes in cane stalks, reducing yield and introducing rot organisms that lower CCS. Rat-bitten stalks are also prone to attack by cane weevil borers. Rats cause large cane losses in some years, and are among the most serious of the pests infesting cane in Australia. Rats have a high reproductive potential when their preferred food is abundant, so best practice weed control in paddocks and headlands is essential for effective rat management in cane. Rats shelter in non-crop harbourage areas such as poorly maintained drains and poorly vegetated creeks, river banks and steep slopes when crops are harvested. They then re-invade ratoons from these harbourages. Harbourages should be managed by slashing, spraying, fencing and grazing, or revegetating with tree species to reduce their suitability for rats. Strategic baiting with registered rodenticides, Racumin® or RATOFF®, may be needed when indicated by a monitoring program at a regional or a farm level. Timing is critical for baiting, and rodenticides are most effective if deployed before populations explode.

**Nematodes**

Several species of plant-pathogenic nematodes, particularly root-knot and root-lesion nematode, attack cane roots and can reach large numbers in ratoon crops. Apparent nematode damage can be confirmed by sending a sample of soil or roots to an appropriate laboratory to allow numbers to be counted. Nematicides can be applied to reduce nematode damage, although they are less effective in plant crops than in ratoons and nematode numbers bounce back quickly. Monitoring of the final ratoon crop for nematodes, before ploughout, can be a useful guide to fallowing strategies and suitability of different break and cash crops that may be grown in rotation with cane.

**Other pests**

Many other pests can affect sugarcane, as noted in the booklet *SmartCane Plant Cane Establishment and Management*. Information on detecting and managing these pests can be found in the book *Australian Sugarcane Pests* available from BSES.
13. **CONCLUSIONS**

This booklet covers best management practice relating to harvesting and ratoon management. It builds on the concepts of:

- Sustainable sugarcane production (profitable cane production in combination with care for the environment)
- The improved farming system that incorporates the concepts of break cropping (especially with a legume), controlled traffic and minimum or zonal tillage

Topics included in the booklet include current best practice options relating to harvesting and ratoon crop management. The latter covers managing the crop at harvest, nutrient management, irrigation, and weed and pest management. These form the backbone of aspects identified as being important to consider during harvesting and the ratoon management periods within the sugarcane production system (Figure 15).

Topics presented in this booklet should be considered in conjunction with information included in the other booklets in the **SmartCane** series. Topics covered in one booklet often complement or build on information covered in the others.

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**Figure 15**: Aspects of sugarcane management that need consideration during harvesting and ratoon crop management.
Farm management differs from person to person and from farm to farm. A single ‘recipe’ for all situations is not possible. However, some growers are possibly closer to best management than others. This self-evaluation (Table 10) is aimed at identifying each grower’s perception of best management practice and if and where improvements can be made in adopting best management principles and strategies.

In undertaking this self-assessment, it is important to distinguish between your attitude to a particular principle or strategy and the actual adoption on farm. For example, you may fully support the idea of best management practice and give it a rating of 1 (strongly agree), but you may only give it a rating of 3 in terms of compliance or adoption on your farm.

Table 10: Self evaluation for identifying best management practice.

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<thead>
<tr>
<th>Statements</th>
<th>Attitude</th>
<th>Adoption</th>
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<tr>
<td>Best management practice is based on the principles of sustainable sugarcane production and the improved farming system.</td>
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<tr>
<td>Best management practice recognised that farm practices are continually improving. This applies to both plant and ratoon cane.</td>
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<td>Optimising harvester settings, cane row profile and field layout will ensure improved harvesting efficiency and reduced cane losses.</td>
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<td>Optimal results from irrigation will be achieved by applying the right amount of water, at the right time and by irrigating efficiently and economically.</td>
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<tr>
<td>Harvesting to a plan that takes into account varietal maturity levels and crop age maximises returns from yield and CCS.</td>
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<tr>
<td>Timing is of the essence in managing weeds. Chemical controls should be appropriate and environmentally acceptable.</td>
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<tr>
<td>Reduction of the weed seedbank is a critical component of an integrated weed management strategy.</td>
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<tr>
<td>Nutrient inputs for ratoon cane can be determined by using the SIX EASY STEPS guidelines.</td>
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<tr>
<td>Ongoing pest and disease monitoring is important to ensure yield losses do not occur unnecessarily.</td>
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<tr>
<td>Ongoing pest and disease monitoring is important to ensure that pesticides are not applied unnecessarily.</td>
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15. FURTHER READING

The material covered in this booklet includes information drawn from various sources. This expertise and knowledge is gratefully acknowledged, particularly in relation to the following publications and/or reports. The list also provides details of some further reading options.


APPENDIX 1: LEAF SAMPLING

Leaf sampling allows you to:
- Check on the adequacy of fertiliser recommendations and the nutrients you have applied to your cane
- Adjust fertiliser rates if necessary next season (or in the current crop if the cane was young enough at the time of sampling)
- Identify possible nutrient problems associated with ‘poor cane’
- Monitor nutrient trends at the block, farm and regional levels

It is important that leaves are sampled correctly and that all the details requested on the BSES leaf Analysis Service labels be supplied as accurately as possible. This will enable meaningful interpretation of the analysis results. Leaf sample labels and brown paper packets are available from BSES Experiment Stations and Extension Offices.

If you would like to make use of this facility or get more information regarding leaf analysis, please contact your local extension officer.

Dried samples should be submitted to your local BSES office. Alternatively you can post or dispatch them by courier to:

BSES Limited Leaf Analysis Service
Ashfield Road
Bundaberg Qld 4670

Three easy steps to successful leaf sampling

Step 1
- Select leaves from stalks of average height
- Sample the third leaf from the top of the stalk
- Counting from the top of the plant, the first leaf is the one that is more than half-unrolled. The third leaf usually corresponds to the top visible dewlap
- Collect 30-40 leaves at random from across the entire block of cane being sampled

Step 2
- Fold the leaves in half (top to base) and cut a 100-200 mm length from these folded leaves (giving a total 200-300 mm section of each leaf). Retain these middle 200-300 mm sections of the leaf blades and discard the remaining top and bottom sections
- Strip out and discard the midrib from each 200-300 mm section

Step 3
- Bundle the leaf strips together and attach a completed BSES Leaf Analysis label
- Place the sample in a cool environment (polystyrene cooler) until it can be dried in an oven (about 60° C) or a well ventilated area
- Once the sample is dry, place it in a clean paper bag or envelope and send it to BSES

NB: To ensure meaningful interpretation of the analysis results, make sure that the following guidelines are adhered to:
- Cane is sampled during the prescribed leaf-sampling season (January to April)
- Cane is the correct age (3-7 months) at the time of sampling
- Cane has been growing vigorously during the month prior to sampling
- Cane is not affected by moisture stress at the time of sampling
- Cane is also unaffected by any other factors, such as disease, insect damage, etc
- At least six weeks has passed since fertiliser applications
- Hands, equipment and working surfaces are clean and uncontaminated