



SmartCane Plant Cane Establishment and Management

SmartCane Best Management Practice Booklet





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CONTENTS

1. ACKNOWLEDGEMENTS	1
2. GLOSSARY OF TECHNICAL TERMS	2
3. INTRODUCTION	5
4. PHILOSOPHY OF BEST MANAGEMENT PRACTICE	6
5. CURRENT SUGARCANE CROPPING SYSTEMS	7
6. THE IMPROVED FARMING SYSTEM	8
7. SOIL ANALYSIS	10
8. LAND PREPARATION	12
9. PLANTING	15
10. PEST CONTROL	23
11. WEED CONTROL	25
12. CULTIVATION OF PLANT CANE	29
13. CONCLUSIONS	30
14. SELF EVALUATION	31
15. FURTHER READING	32
APPENDIX 1: SOIL SAMPLING GUIDELINES	33



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2. GLOSSARY OF TECHNICAL TERMS

Acid soil: Soil with a pH below 7. Sugarcane is very tolerant of acid soils. See "pH".

Adelina: A beneficial soil-dwelling protozoan which parasitises canegrubs.

Approved seed: Disease-free planting material of varieties that are true-to-type.

Ameliorant: An improver such as lime, gypsum, organic matter and mill by-products. A soil ameliorant improves the structure, biota and nutritional level of the soil.

Ammonium (NH_4^+): One of the two forms of nitrogen which plants can use for growth, the other being nitrate (NO_3^-).

Anaerobic: The absence of oxygen in soil or water that limits most forms of plant and animal life. Denitrification by certain soil organisms occurs under waterlogged, anaerobic conditions.

Ash: (a) The inorganic matter in sugar. High levels cause sugar manufacturing difficulties.

Increased ash can result from excessive potash use, growing sugarcane on saline soil, or using saline irrigation water.

(b) A sugar mill by-product from the burning of bagasse. Mill ash can be used as source of potassium and silicon, and for ameliorating sodic soils.

Autumn plant: Is a crop planted between the beginning of the calendar year and the onset of cooler conditions.

Bare fallow: Where there is no crop grown between sugarcane crop cycles.

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.

Biota: All of the organisms, including animals, plants, fungi and microorganisms, found in a particular location at a particular time.

Billet: Also called sett. Short piece of sugarcane usually containing two or more nodes that is used as planting material.

Cation: Positively charged ion, including calcium, magnesium, potassium, sodium, hydrogen, aluminium and ammonium.

See "IONS" and "EXCHANGEABLE CATIONS".

Cation exchange capacity (CEC): An indication of the soil's nutrient holding ability (soil fertility). Measure of the soil's capacity to hold and exchange cations which determines uptake by plants. The higher the clay content of the soil, the higher the CEC and the lower the leaching susceptibility of the soil.

Clean seed plot: A managed block of disease-free seed of varieties that are true-to-type.

Compaction: A reduction in pore space in soil (meaning less air space and poorer infiltration rates) caused by machinery traffic and inappropriate tillage.

Controlled traffic: Practice of permanently separating crop growth zones from traffic zones and matching row-spacing with machinery wheel spacing.

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 are lost to the atmosphere. Occurs in anaerobic, waterlogged conditions and is caused by certain bacteria in the soil.

Dissipation rate: The rate at which a substance breaks down and becomes ineffective.

Double disc opener planting: A technique that enables no tillage or minimum tillage planting to be undertaken. The planter contains two coulter discs that meet at a point to slice through stubble and part the soil to allow the cane billet to be placed in a position that will allow good soil-to-billet contact.

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



Billet: Also called sett. Short piece of sugarcane usually containing two or more nodes that is used as planting material.



Exchangeable cations: Positively charged ions, including calcium, magnesium, potassium, sodium and aluminium which are available for plant uptake.

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

Hooded sprayer: A herbicide applicator with shrouded application nozzles that allow inter-row spraying therefore limiting herbicide spray drift potential.

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

Integrated Pest Management (IPM): The use of different techniques in combination to control pests with an emphasis on methods that are least injurious to the environment and most specific to the particular pest.

Leaching: Rainwater or irrigation water washing soluble nutrients downwards through the soil profile into the water table which might discharge into local waterways.

Legume: Plants such as cowpeas and beans 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: An endemic Australian fungal genus which parasitises the greyback canegrub.

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.

Nitrate (NO_3^-): One of the two forms of nitrogen which plants can use for growth, the other being ammonium (NH_4^+).

Nitrogen (N): One of 16 nutrients essential for growth of plants. Present in organic matter and as nitrogen gas (N), nitrite (NO_2^-), nitrous oxide (N_2O), nitric oxide (NO), ammonia (NH_3), ammonium (NH_4^+) and nitrate (NO_3^-). Only the ammonium and nitrate forms can be used by plants from the soil.

Nitrogen fixation: The process whereby atmospheric nitrogen is converted to amino nitrogen. This process must occur before the atmospheric nitrogen can be used by plants. The most widely known example is the association between *Rhizobium* bacteria and legume roots.

Organic carbon: A measure of the organic matter content of the soil. The carbon content of organic matter is relatively constant. Soils have low organic carbon if below 1%, soils greater than 4% are peaty and may indicate terrain that is difficult to drain and where decomposition of the organic matter is slow.

Organic matter: Consists of plant residues, soil organisms and animal remains. Contains many of the essential plant nutrients which are slowly available for plant growth. 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 $1.72 \times$ organic carbon (%).

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

pH: A measure of acidity or alkalinity (of the soil, water, etc) on a scale of 0 (extreme acidity) to 14 (extreme alkalinity). Pure water has a pH of 7. The scale is logarithmic: a change of one unit on the scale represents a 10-fold change in acidity. Sugarcane is tolerant of soils that would be too acidic for other crops. The normal pH range for canegrowing is 5.2 to 6.0, apart from the Burdekin Delta region where pH levels are commonly around neutral (7.0).



IPM: *The use of different techniques in combination to control pests with an emphasis on methods that are least injurious to the environment and most specific to the particular pest.*



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.

Potash: The general term used for muriate of potash or potassium chloride. Contains 50% potassium and is manufactured by refining natural potash salts.

Potash burn: Damage to young roots and eyes of germinating cane setts as a result of placing potassium fertiliser on, or very close to, the cane setts. Caused by the high solubility and salt effect of muriate of potash.

Productivity: The amount of sugar produced per hectare.

Replant: See "Ploughout – Replant".

Sett: See "Billet".

Soil compaction: See "Compaction".

Spring plant: Is a crop planted when temperatures rise in late winter to the end of October.

Strategic tillage: Tillage that minimises the area of land that is cultivated and the number of cultivations. Usually the zone of cultivation is restricted to the row area. Also referred to as zonal tillage.

Subsurface-applied fertiliser: Fertiliser buried below the soil surface. With suitable equipment, fertiliser can be subsurface-applied through a green trash blanket.

Surface-applied fertiliser: Fertiliser applied in bands or as a broadcast application either on top of the green or burnt trash blanket or on the soil surface.

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 either by chemical or physical means.

Sustainable sugarcane production: Profitable cane production achieved in combination with the maintenance of the soil, water and biodiversity resources onfarm and with minimal offsite effects.

Trash blanket: See "Green cane trash blanket".

Volatilisation: The loss of nitrogen to the atmosphere when urea is converted to ammonia gas.

Yield decline: The loss of productive capacity of sugarcane growing soils caused by a combination of the long-term monoculture and farming techniques that adversely affect soil structure and biota.

Zero tillage: The practice where cane is planted directly into untilled land.

Zonal tillage: See "Strategic tillage".

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***Yield decline:** The loss of productive capacity of sugarcane growing soils caused by a combination of the long-term monoculture and farming techniques that adversely affect soil structure and biota.*

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3. INTRODUCTION

The Australian sugarcane industry has made strong gains in environmentally sound practices. The industry works with scientific and community organisations and continues to adapt farming practices and implement research findings that address issues related to the environment.

This booklet provides a guide to the production of a profitable plant crop while utilising industry practices that minimise adverse environmental impacts without compromising production. Best management practice is continually evolving. A single set of precise practices cannot be recommended for all situations. In other words, there is no recipe for best management practice.

The establishment of the plant cane crop is the most expensive and most critical activity to the foundation of a profitable crop cycle.

Forward planning is essential for the success of the plant crop. The following series of steps need to be well executed to achieve a successful plant crop. This will enable a profitable crop cycle over the following four to six years or more:

- Soil analysis
- Dealing with the previous legume crop or other previous use of the land
- Land preparation
- Planting: variety selection and planting operations
- Row spacing, controlled traffic and minimum tillage
- Pest and disease control
- Weed control
- Cultivation

At the end of the crop cycle, a well managed legume break crop is recommended before planting the new crop.

A soil test will reveal the nutrient status of the soil. Any soil deficiencies or irregularities can be rectified before planting. Land levelling for drainage should be completed preferably before the wet season prior to planting or prior to forming beds into which legumes are planted.

The selection of the most appropriate variety for the soil type and time of harvest is extremely important in achieving maximum potential profitability. The changing of varieties at each crop cycle will minimise the build-up of soil pathogens over successive crop cycles. Planting material should be sourced from a clean seed plot to minimise the risk of pest and disease impacts.

In the past, growers have adopted a range of row-spacings onfarm. However, spacing cane rows at approximately 1.8 metres will accommodate the width of most machinery used in the field and greatly reduce the impact of soil compaction. A controlled traffic and minimum tillage system of growing cane on wider row spacings is a cheaper and more sustainable system of cane growing than conventional cultivation based on traditional 1.5 metre-wide spaced rows. Continuing research will identify which varieties are suited to wide rows. Conversion from the traditional 1.5 metre-wide spaced row and fully-cultivated system to the 1.8 metre controlled traffic or minimum tillage system is recommended. However, it is recognised the timeframe to do so will be influenced by the financial constraints of individual growers and the need to clarify certain aspects of the 'new' system for particular circumstances.

At planting, adequate soil moisture, close soil-sett contact, fungicide application to the setts, correct fertiliser selection and placement, and adequate soil cover over the sett will influence the success of the plant crop. Weed and pest control in the plant crop is also vital to the establishment of a profitable crop cycle.

Products that claim to produce great benefits without having the research results to support the claims should be avoided. Such products may sometimes perform as claimed by the manufacturers or resellers. Often, however, the products represent a poor investment by the cane grower as the claims cannot be substantiated.

If in doubt about a product, growers should contact an independent source of advice such as their local BSES extension officer or agronomist.

4. PHILOSOPHY OF BEST MANAGEMENT PRACTICE

Management of inputs and operations in sugarcane production should be aimed at sustainability. This means that profitable cane production needs to be achieved in combination with the maintenance of resources onfarm and with minimal offsite effects. In simple terms, this means that we should continue to consider our 'back pockets' when planning the application of inputs and execution of operations onfarm. However, we should also be maintaining our farm resources for future generations, and be mindful of caring for the wider environment by neither applying excessive amounts of nutrients or ameliorants nor conducting operations that may cause onsite degradation or offsite effects.

Best management practice means having the best chance of success in minimising the risk of losses in productivity (loss of yield), profitability (loss of income), applied inputs (leaching, runoff and/or gaseous losses of nutrients, pesticides, etc) and soil resources (erosion and fertility losses).

Best management practice should therefore be considered across the entire farming system and cover the following key considerations:

- Soil management
- Crop and harvest management
- Water management
- Pests, disease and weed management
- Workplace health, safety and skills management
- Landscape and biodiversity management
- Business management

The basic philosophy is that there are no set recipes, but rather the recognition of onfarm 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. Fundamental to this philosophy are the basic components of the 'new farming system' as defined by the Sugar Yield Decline Joint Venture. They include breaking of the monoculture through fallow cropping, controlled infield trafficking and

the adoption of minimum tillage principles. It also recognises that green cane trash blanketing should be practised when and wherever appropriate and the need to burn cane and trash blankets should continue to be reassessed.

Knowledge of soils should be used as the basis for making many management decisions onfarm. 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
- 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 onfarm 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).

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Importantly, the concept of best management practice recognises that the sugarcane production system is evolving.

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5. CURRENT SUGARCANE CROPPING SYSTEMS

The current farming system has developed with time. It is a product of past practices that have been used for many years, together with newer innovations. This system (or components thereof) has undergone modification with time.

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 onfarm operations and management styles may result in some 'accepted' practices being more compatible with agreed best-practice options than others.

The guidelines presented within this booklet aim to detail the most appropriate options available. However, it should be recognised that components of the overall best-practice 'system' may be more suited to some circumstances than others. This reinforces the basic principle that there are no set 'recipes', but rather a set of guidelines that will allow for progress towards the adoption of various best management practices within a set of specific circumstances.

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:

- The use of harvesting and other farm machinery and vehicles that match row-spacing configurations
- Planting of fallow break crops
- Minimum cultivation necessary to suit available planters
- Nutrient application rates within current guidelines
- Use of mill by-products as soil conditioners with account taken of nutrient inputs
- Subsurface applied fertiliser to plant and ratoon cane

- Appropriate targeted pest, disease and weed control
- 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:

- Row spacings that are incompatible with the width of current harvesters, machinery and vehicles
- Replanting without using fallow break crops
- Limited fallows that may or may not contain volunteer cane
- The burning of trash blankets after harvesting the last ratoon in a crop cycle prior to fallowing or replanting
- Burning of cane prior to harvest. Harvesting crops without burning has positive benefits such as recycling nutrients and organic carbon, suppressing weeds, and conserving soil moisture; so the need to burn cane should continue to be reassessed. Harvesting green may not be practical for some farms due to factors including soil types, amount of trash from some cane varieties, row lengths, and flood irrigation. New technologies in the future may overcome some of these limitations
- Excessive cultivation aimed at full land preparation
- Fertiliser rates in excess of the current guidelines
- Use of mill by-products without taking account of nutrient inputs
- Sub-standard pest, disease and weed control

6. THE IMPROVED FARMING SYSTEM

An investigation by the Sugar Yield Decline Joint Venture commenced in 1993 to tackle the issue of yield decline – the loss of productive capacity of sugarcane growing soils under long term monoculture – in the Australian sugar industry. This 14-year research program has led to the development of realistic, achievable guidelines for implementing a sustainable sugarcane farming system.

The three pillars underpinning the Improved Farming System are:

- The inclusion of a well managed legume crop in the break year at the end of each cropping cycle
- Wider row spacing allowing for controlled trafficking of machinery
- Tillage reduced to the minimum required to produce sound, healthy crops

The improved farming system has the potential to significantly reduce farming costs, improve soil health and arrest sugarcane yield decline. The benefits are medium to long term and result from gradually improving soil health and enhanced sustainability. The implementation of the improved farming system is not achieved by recipe farming. Each grower will experiment with the various aspects of the system and develop strategies that best suit their farm situation.

Legumes

Legumes provide an improved balance in soil biology, fewer root pathogens, improved soil structure, biologically fixed nitrogen and better cane growth and yield. The implementation of a legume break crop goes a long way to improving soil health.

Issues relating to the management of legumes are covered in the *SmartCane Fallow and Land Management* booklet.

Controlled traffic

Traditionally, the distance between rows has been about 1.52 metres. While that spacing was acceptable many years ago when farm machinery was relatively light and narrow and cane was cut by hand, today most harvesting and haulout machinery has a track width of about 1.83 metres. At a row spacing of 1.52 metres, 90% of the total area can be compacted by the machinery. Controlled traffic within the cane block will minimise the adverse effects of soil compaction. The key to controlled traffic is a row spacing that provides compatibility between machinery and cane row spacing. Currently the appropriate row spacing needed to achieve this is 1.83 metres.

The uncultivated interspace provides a traffic zone leaving the uncompacted drills in good condition for cane growth and optimum productivity over the crop cycle. Conventional row spacing is about 1.52 metres. Of the three foundations of the improved farming system, moving to wider row spacing has proved to be the most challenging change for growers.

Reduced or zonal tillage

Tillage of the stool area only with the inter-row maintained as a controlled traffic zone will significantly reduce tillage costs, save time and preserve soil moisture. Cane and sugar yields under the reduced tillage system are comparable to conventional tillage farming while overall costs are very significantly reduced.

Other advantages of reduced tillage include the build-up of beneficial soil organisms such as *Metarhizium*, *Adelina* and earthworms, improved timeliness of operations, enhanced soil moisture retention, improved soil structure, less damage to soil structure and lower organic matter losses. Because fewer passes are required, the grower can better select the most appropriate time to till. After rain, the hard wheel tracks of the interspace become trafficable sooner.

Example of an improved farming system

There is no single way to implement the improved farming system. Each grower will need to experiment and adapt the system to suit their particular situation. Below is a guide to the steps involved in one example of a successful improved cropping system:

- The previous cane stool is destroyed in the block to be fallowed or planted with a legume break crop
- Blades of a rotary hoe are removed and multiple rows of cane are destroyed at the one time
- In the untouched interspace, the remaining green trash provides nutrients, erosion protection and weed suppression
- From this point, the interspace becomes a controlled traffic zone
- Rows of soybeans are planted into the old stool area
- Initial spraying of pre-emergent herbicide
- Any volunteer cane in the soybeans controlled by a grass selective herbicide (eg. Fusilade®)
- Grass and vines controlled in the inter-row when they are small with low rates of paraquat (can use hooded sprayer)
- Once the soybeans have matured, everything (including any weeds) is sprayed with a knockdown weedicide (such as Roundup® or Reglone®)
- Strategic cultivation of old stool area commences
- Prepare planting zone with two passes of implement consisting of a coulter with two small discs on either side that cut away the dead rows of soybean stubble
- Behind the discs are three ripper legs in triangular formation for deep cultivation of the old stool area
- On the back of the implement are two gangs of ratooning discs which throw soil back into the centre of the row
- An adjustable roller follows, which presses the cultivated strip. It also acts as a ground wheel to adjust the depth of cultivation. This produces a slight mound to plant into

- A tyne is mounted either side of the roller which leaves a mark in the interspace to guide the driver for planting
- On light soils, one or two passes are sufficient. On heavier clay soils, an extra cultivation or two is sometimes required

There is no single way to implement the improved farming system. Each grower will need to experiment and adapt the system to suit their particular situation.

7. SOIL ANALYSIS

The basis of profitable fertiliser programs is the soil test. Soil nutrient analysis provides useful information about the chemical and nutrient properties of a particular soil and it will assist in determining fertiliser type and rate and identify any nutrient imbalances or deficiencies. A soil test should be viewed as a sound investment or an insurance policy: investment in the future crop cycle and insurance against unseen nutritional problems and, consequently, reduced income. A soil test should not be regarded as a cost.



Figure 1: Soil sampling for nutrient analysis.



Figure 2: Zinc deficient leaves.



Figure 3: Calcium and magnesium deficient plant cane.



Figure 4: Applying agricultural lime to calcium deficient soil.

Table 1. Important steps in soil testing.

Step	Activity	Description
1	Sample collection	Collect soil samples according to a grid or zig-zag pattern. It is extremely important that a soil sample is representative of the block (volume of soil) from which it is collected.
2	Sample analysis	Submit samples to a reputable laboratory for analysis. Make sure that the laboratory conducts assays (tests) that are compatible with the SIX EASY STEPS guidelines.
3	Interpretation of results and calculation of nutrient inputs	Ensure sound interpretation of the results and appropriate fertiliser recommendations by having an understanding of the basic process of determining nutrient requirements, and obtain advice from capable advisers or extension officers.
4	Fertiliser application	Apply fertilisers at the appropriate rates and keep records of the nutrient inputs.

There are four important steps involved in the soil testing process (Table 1). Each of these steps needs to be carried out with care to ensure meaningful results.

Soil assays done in the laboratory are carried out on 10 g samples that are weighed from about 500 g of soil submitted to the laboratory (Figure 5). Usually, this 500 g sample is a sub-sample of the 10 kg of soil sampled collected from the block of cane (an average 2 hectare area) which contains about 6000 tonnes of soil in the plough layer.

It is important that the small amount of soil analysed in the laboratory reflects the chemical, physical and nutrient status of the soil in the particular block of cane so that appropriate requirements can be determined.

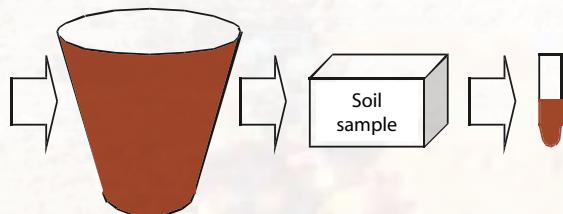
In view of this, it is extremely important that a soil sample is representative of the volume of soil from which it is collected. This is achieved by collecting the sample from the block using a grid or zig-zag pattern. Guidelines for soil sampling are provided in Appendix 1.



Each of these steps needs to be carried out with care to ensure meaningful results.



Soil: 6 000 tonnes



5-10 kg

500 g

10 g

Figure 5: Soil (10 g) analysed in the laboratory is a sub-sample of the soil sample collected in the field.

8. LAND PREPARATION

Land preparation is a vital, but sometimes unnecessarily costly management practice which has a major impact on the productivity of the following crop cycle.

Two approaches to land preparation can usually be taken: conventional (full) cultivation or zonal (minimum) tillage.

CONVENTIONAL TILLAGE: Only under certain circumstances does best management practice favour conventional (full) tillage. These circumstances include changing row direction, mixing the soil and changing row location to dilute levels of the soil fungus *Pachymetra*, land levelling to improve drainage, realigning a block, or widening row spacing to implement controlled traffic farming. The conventional system of full tillage utilises cultivation to break up row compaction accumulated over the previous crop cycle.

ZONAL TILLAGE: In most instances, best management practice involves zonal tillage of only the row area in preparation for planting. The inter-row remains undisturbed to be used as a traffic zone through which farmers gain a number of immediate and long term benefits.

ZERO TILLAGE: Zero tillage prior to planting is a rare practice which is applicable and recommended in very limited circumstances because research is still in progress. It may be suitable on some lighter textured soils to preserve soil biota and soil moisture, and keep weed seeds in the soil profile undisturbed with a reduced germination rate.



Figure 6: Zero till planting directly into legume stubble.

Conventional cultivation

Conventional cultivation involves several passes with various implements to break up the soil to a depth of 25-30 cm to provide an adequate seed bed in which to plant the new crop. Several issues arise in relation to conventional cultivation.

Excessive tillage can cause damage to the soil structure without improving the chance of a sound germination of the plant cane. Besides resulting in long term, even permanent, damage to the soil, costs to the grower are unnecessarily increased. A fine, powdery soil tilth is unnecessary for the establishment of a sugarcane crop. The number of operations necessary to bring the soil to an adequate seed bed is dependent on soil type and conditions. Pulverising the soil is detrimental to sustainable farming and is financially inept. Research by the **Sugar Yield Decline Joint Venture** has supported the recommendation that aggressive tillage to produce fine soil for planting is uneconomic, unnecessary and unsustainable. Furthermore the creation of a flat surface using a heavy roller causes the fine soil particles to seal and prevents the entry of air and water.

Commencing land preparation too early when the soil is too wet will cause the production of large clods or slabs of dirt that do not provide adequate soil-sett contact for sound germination. Soils with significant clay content will be smeared resulting in poor seed bed structure. While it is not always possible to cultivate at the most appropriate time, particularly in north Queensland when conditions may remain wet, growers should resist cultivating too early. The advantages of getting the crop into the ground early will be more than offset by the poor soil preparation which will have adverse impacts over the whole crop cycle.

In wet areas, the formation of raised beds prior to planting may overcome serious germination and productivity issues associated with waterlogging.

In summary, full cultivation should involve just enough mechanical operations with tyned and disced implements to achieve an adequate seed bed. The soil should never be pulverised with a rotary hoe to a fine, powdery tilth.



Figure 7: Zonal tillage involving only two passes with a ripper/disc/roller implement before planting cane.

At the conventional row spacing of 1.52 m, machinery may compact 90% of the total area. Just one pass of a tractor could cause 75% of the total compaction. Further passes will pack the soil even harder and deeper. Very few cane roots penetrate the inter-row in the conventional system because of compaction.

Zonal or minimum tillage

Zonal tillage is the practice of cultivating only the row area (approximately 30 cm deep and 75 cm wide) in which to plant the next cane crop. The inter-row area remains undisturbed. When rows are

planted approximately 1.83 m apart, the undisturbed inter-row area is utilised as a controlled traffic zone keeping wheels off the row and not compacting the main cane growing zone.

Zonal tillage provides farmers with a number of benefits. The most immediate and obvious benefit is a marked reduction in farm input costs and time. Importantly, soil moisture is better preserved and erosion is reduced.

Many beneficial soil organisms are adversely affected by tillage. Organisms such as *Metarhizium* and *Adelina* which have a role in the natural control of canegrubs will die out under cultivation.



Figure 8: One rotary pass is often adequate for seed bed preparation after ripping.

Zonal tillage assists in retaining soil organic matter. Organic matter has an important role in soil structure, water and nutrient retention and soil biological activity. Cultivation is a major destroyer of the organic component of the soil.

Timeliness of operations is enhanced under zonal tillage.

Cane yields produced under zonal tillage and conventional tillage are comparable.

In far north Queensland, a zonal tillage implement consisting of rippers, discs and a roller has been used very successfully on farms to prepare blocks for planting on a range of soil types. Generally, just two to three passes with the implement through the sprayed-out legume crop are necessary. The number of passes required will depend on the soil type, moisture content and degree of compaction. Judicious use of a rotary hoe (one pass) usually after a single pass with a ripper can also produce an adequate seed bed.

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Zonal tillage assists in retaining soil organic matter. Organic matter has an important role in soil structure, water and nutrient retention and soil biological activity.

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Figure 9: Rotary hoe modified for zonal tillage in the last ratoon crop.



Zero tillage

True zero tillage describes the practice of direct drilling seed cane into undisturbed soil in a sprayed-out cane block or legume crop with no prior cultivation. The advantages of zero tillage include cost savings, moisture retention, preservation of beneficial soil biota and leaving buried weed seeds undisturbed which are less likely to germinate. Zero tillage is a relatively uncommon practice in sugarcane as some cultivation to reshape the drill prior to planting or to prepare an adequate seed bed is usually required. Zero tillage is still being assessed and evaluated.

The zero tilled block could contain just sprayed-out cane or sprayed-out cane plus a direct-drilled legume crop planted after the cane had been sprayed out.

Figure 10: Planting cane directly into soybean stubble with no prior cultivation. Undisturbed stubble on right.



9. PLANTING

Planting is one of the most expensive and important farm management activities as it largely determines farm profitability for the next four or more years.

Selection of planting material

Growers should have a mother plot of well managed and maintained planting material on their farm or have access to an approved seed plot.

Selection of planting material should take into account the following factors to achieve the best results:

- Pest and disease status
- Erectness
- Internode length and number
- Sett and bud quality
- Nutrition and vigour
- Variety suitability for soil type and time of harvest

PESTS AND DISEASES: The most common pest and disease problems affecting planting material are sugarcane weevil borer damage, ratoon stunting disease and chlorotic streak disease. Planting material should have no obvious pest and disease problems and should always have been inspected by staff from the local productivity service. Hot water treatment of planting material at 50°C for three hours will eliminate diseases that might be in the cane. Maintaining a high standard of farm hygiene will prevent reinfection. Harvesters and other machinery used to cut planting material should be regularly sterilised to prevent disease transmission.

ERECTNESS: Erect cane is more likely to be of higher quality than lodged cane which is difficult to cut for whole stick planters. While lodged cane can be easily handled by harvesters for billet planters, it can be of poor quality and suffer eye and billet damage during cutting. Erect plant cane or first ratoon crops yielding 75 to 100 t/ha are excellent sources of planting material.

INTERNODE LENGTH AND NUMBER: Setts should have two or three nodes. As nodes are barriers to the movement of diseases such as pineapple disease through the sett, single node setts should be avoided. Internode length should be sufficiently short to achieve two or three nodes.

BILLET AND BUD QUALITY: Sound eyes or buds are crucial to the production of a successful plant crop. Particular attention must be paid to cane used in billet planters as eyes are very susceptible to damage during mechanical harvesting. To minimise eye and sett damage, the harvester used to cut plants may require modifications. Rubber coated or well worn feed rollers will reduce rind and bud damage. Reducing pressure from feed rollers will prevent cracking and splitting of billets. Sharp basecutter and chopper knives will produce cleanly cut ends. Piped cane where the billet centre is longitudinally hollow should be avoided if possible as fungal diseases can more easily infect the planted billet. The natural barrier afforded by the growth ring between the nodes is missing in piped cane. Piped cane is a particular problem if cold or wet conditions occur after planting as germination is slowed causing greater opportunity for fungal diseases to infect the sett.

NUTRITION AND VIGOUR: Because the shoot germinates before roots have formed, nutrition is initially obtained from the planted sett. If the sett has a nutritional deficiency, the vigour of the young plant cane will be reduced. Well nourished plant sources provide setts that germinate faster and usually produce better crops than poorly grown, nutritionally deficient cane. An application of approximately 25 kg/ha of nitrogen to the plant source four to six weeks before cutting plants can increase the early vigour of plant cane. This extra nitrogen application is particularly useful if the plant source experienced wet conditions during the growing period. If conditions are dry before cutting the cane for plants, irrigation will assist in restoring vigour to the planting material.

Do not use cane from a plant source that is over-mature or has been sprayed recently with a herbicide such as 2,4-D.

VARIETY SUITABILITY: Choose the appropriate variety for the soil type and for the proposed time of harvest. BSES Limited regularly produces variety guides which list the known characteristics of approved varieties. Information on early, mid and late season maturing varieties and the most suitable soil types are provided in the guides. An important factor to consider is ensuring the farm has a mix of varieties that reach their maximum CCS throughout the harvesting season.



Figure 11: Whole stick planting.

Another factor to consider is tolerance to diseases particularly sugarcane smut and the root rot disease *Pachymetra*. Varieties should be changed each time a block is planted. Rotation of varieties will assist in preventing the build-up of soil disease levels that will reduce cane yields and profitability.

Planters

Two methods of planting may be used. Whole stalk planters cut full sticks of cane into approximately 300 mm billets or setts and plant them. The increasingly popular billet planting uses billets that have already been cut by a harvester and loaded into the planter.

WHOLE STICK PLANTERS: Whole stick planters have generally produced superior germination to billet planters and generally use less cane. However, whole stick planting is more labour intensive. For this reason, billet planting is now the preferred method.

DOUBLE DISC PLANTERS: Double disc opener planters enable direct drill planting in minimum tillage and zero tillage situations. These planters rely on two angled coulters meeting at a point. The coulters cut through remaining stubble, part the soil and allow the cane setts to be planted. Ensure the correct amount of soil covers the setts as early experience with double disc openers highlighted the shallow depth of planting (leading to a higher risk of stool tipping) and inadequate depth of soil cover as potential problems.



Figure 12: Billet planting.

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The increasingly popular billet planting uses billets that have already been cut by a harvester and loaded into the planter.

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Figure 13: Double disc opener planter.

BILLET PLANTERS: With billet planters, it is particularly important to ensure billets are not damaged by the harvester. To achieve good quality billets with no damage to the eyes, it might be necessary to fit rubber-coated feed rollers to the harvester. Splitting of billets can be avoided by maintaining sharp chopper knives and basecutter blades.



Figure14: Rubber coated harvester feed rollers improve the quality of billets for planting.

Planting time

Planting time is influenced by the weather and the germinating speed of different varieties.

WEATHER: Rainfall and temperature are the climatic factors which have most influence on the time of planting. In north Queensland (Mossman to Ingham), planting occurs first on the relatively dry Atherton Tableland in March. In the rest of the north, planting usually commences in late April-early May and continues until September with a break only during very cold winter periods. Planting can commence as early as March in the drier Burdekin district and may continue through winter providing temperatures are not excessively cold. In south Queensland (from Bundaberg-Childers south), two distinct planting times occur. Autumn planting (March-April) takes place if blocks are dry enough following the annual wet season. Spring planting then occurs following a break during the coldest of the winter period. In all areas, planting should be completed by October at the latest.

For successful germination, the soil temperature must be greater than 17°C. However between 17 and 22°C germination is greatly reduced compared to the optimal soil temperature of 28-32°C. As a general rule, the higher the temperature, the faster the germination.

VARIETY: The speed with which a variety germinates may determine when it is planted. Slow germinating varieties are often unsuitable for planting just before winter or very late in the year close to the wet season. The depth of soil cover on the slower germinating varieties should be kept to a minimum while drill shape after planting should allow as much sun and warmth into the bottom of the furrow as possible.

Row spacing

Unless direct drill planting into pre-existing rows takes place, the block to be planted should be marked out to allow the planter to plant straight, evenly spaced rows. An alternative is to use GPS guidance for this purpose.

At a row spacing of 1.52 metres, 90% of the total area may be compacted by the machinery. If the row spacing is less than 1.50 metres, serious damage will be caused to the cane stool by the wheels in addition to the compaction over practically the entire block. Under moist conditions, these problems will be exacerbated.

WIDE ROWS: Rows spaced at 1.83 metres (Figure 15) will cater for the machinery used on cane farms today, confining compaction to the interspace and eliminating stool damage. In the medium term, soil health will be improved and a more sustainable farming system will ensue. However, trials using single 1.83-metre rows have initially produced lower yields than the conventional 1.52-metre rows. On the other hand, dual rows 0.5 metres apart on a 1.83-metre row spacing have generally produced yields comparable to conventionally planted cane. This system is gaining popularity throughout the industry.

VARIETIES FOR WIDE ROWS: Contemporary sugarcane varieties have been selected in trials conducted on the conventional row spacing of approximately 1.52 metres. Current research is trialling promising new varieties on 1.83-metre rows with some early encouraging results for both dual and single rows. Continuing research will identify varieties that are suited to wide row planting.



Figure 15: Dual row planting on 1.8 m spacing.

Planting depth and drill shape

Conventionally, sugarcane is planted in a furrow formed by the planter (Figure 16). Billets (or setts) should be placed end to end in the furrow and covered with soil to ensure good contact with the sett to promote sound germination. Rolling the drill with a press wheel may be necessary to provide adequate soil-sett contact, particularly if the soil is lumpy and cloddy. The furrow is 120 mm to 200 mm below the soil surface with up to 100 mm of soil then covering the sett. More soil is required in dry conditions; less in cold, wet situations.

As the plant cane grows, soil is pulled into the furrow (a process called filling-in) on two or three occasions until the raised drill or row is higher than the interspaces on each side. This raised drill shape provides a suitable profile for the cane harvester to operate efficiently throughout the life of the entire crop cycle.

As a counter to wet soil conditions, growers in high rainfall areas sometimes plant into pre-formed raised drills or beds (Figure 16). The sett is planted above the surrounding soil level thus keeping the sett out of saturated soil. This practice is called ridge or mound planting or bed planting.



Billets (or setts) should be placed end to end in the furrow and covered with soil to ensure good contact with the sett to promote sound germination.



Conventional

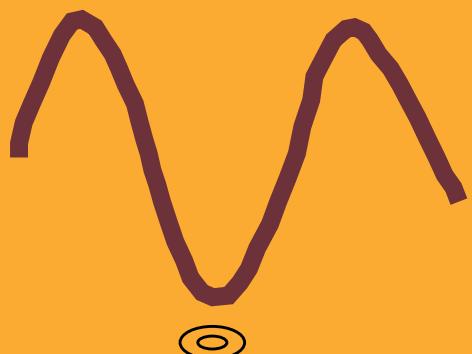


Figure 16: Profiles for conventional (above) and mound (below) planting.

Mound



Fertiliser application

The SIX EASY STEPS approach is the delivery mechanism for promoting sustainable sugarcane production through the adoption of soil-specific nutrient management guidelines. These guidelines have been developed by refining the generalised guidelines (that were traditionally used across regions and soils) by combining past information with more recent research and development outcomes.

The SIX EASY STEPS program is based on the premise that sustainable nutrient management aims for profitable cane production in combination with environmental responsibility. It therefore has dual objectives where each should not be viewed in isolation to the other.

In terms of the environment, it considers both the onfarm (maintenance of soil fertility for future generations) and offsite effects (nutrient losses through various mechanisms and channels). The process therefore starts in the planning stage when decisions are made about onfarm inputs and operations. Fundamental to this is the principle that soils should be managed according to their basic properties, the processes that occur within soils, and the interaction of applied nutrients with soils.

The other important principle is that soils differ markedly from one another, both within and across regions. Recognising these differences (in terms of colour, texture, structure, depth and position in the landscape) and using this knowledge in combination with soil chemical and physical properties to guide nutrient inputs, will ensure that both the on- and off-farm environments are

considered. This is because the risk of losses will be minimised in terms of profitability, productivity, nutrients, onfarm fertility, etc.

The SIX EASY STEPS program provides sets of district-specific guidelines for nutrient inputs to plant and replant cane.

Because excess nitrogen may generate higher than normal plant growth in waterways, wetlands and marine environments, applications and placement of fertiliser should adhere to industry recommendations.

Nitrogen management guidelines within the SIX EASY STEPS program are based on a combination of district yield potential and soil N mineralisation index. The district yield potential is used to establish the base N application rate (according to an estimate previously developed by CSIRO scientists that 1.4 kg N per tonne of cane is required up to a cane yield of 100 tonnes/ha and 1 kg N per tonne/ha thereafter). Inputs are then adjusted according to the N mineralisation index, which is based on soil organic carbon (%).

Where the district yield potential is set at 120 tonnes cane/hectare (Wet Tropics, Herbert, Plane Creek, Bundaberg, Isis, and Maryborough), the baseline N application rate is 160 kg N/ha. Information for districts with higher yield potentials is also available. Adjustment to take account of the contribution of N from the soil organic matter (according to the N mineralisation index) results in a set of guidelines for N fertiliser inputs as shown in Table 2.

Table 2: N mineralisation index and nitrogen rates for areas where the district yield potential is set at 120 tonnes cane/ha (eg. Wet Tropics, Herbert, Plane Creek, Bundaberg, Isis and Maryborough).

N mineralisation index	Organic Carbon %	Recommended N application rates (kg/ha)
Very Low	<0.4	160
Low	0.41-0.8	150
Medium Low	0.81-1.2	140
Medium	1.21-1.6	130
Medium High	1.61-2.0	120
High	2.01-2.4	110
Very High	>2.4	100

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Often, the plant crop's entire phosphorus and potassium requirements and part of its nitrogen needs are applied at planting.

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Phosphorus requirement is based on the available soil P test value determined in the laboratory by a dilute sulphuric acid extraction which is usually shown as “BSES P” in soil assay reports. This is then modified by the soil's ability to fix added P (P sorption) which determines how much of the fertiliser P will be available to the crop. The P sorption class of each soil is based on the Phosphorus Buffer Index (PBI) which is measured in the laboratory.

Nutrient management guidelines for nitrogen, phosphorus, potassium, sulphur, calcium, magnesium, silicon, zinc and copper, and ameliorant inputs for remediation of soil pH and sodicity, are provided for plant (and ratoon) cane in booklets and nutrient management short courses that are being progressively developed for each of the districts of the Australian sugar industry.

A well-managed and productive crop is the best way of utilising nutrients and reducing the risk of nutrient runoff. Several processes can cause nutrients or their by-products to move offsite from the point of placement and, therefore, may cause environmental harm and economic losses to the grower:

- Volatilisation results in urea forming ammonia gas that is lost to the atmosphere. The risk of volatilisation is very high when surface-applied urea-based fertilisers are subject to moisture from dew or light rain that is insufficient to wash the fertiliser into the soil.
- Denitrification involves conversion of the nitrogen fertiliser to nitrous oxides and nitrogen gas which are lost to the atmosphere. Denitrification occurs in anaerobic, waterlogged conditions and is caused by certain bacteria in the soil.

- Runoff and associated erosion causes nutrients to move offsite either dissolved in water or attached to sediment.
- Leaching of nutrients in solution down the soil profile into water tables can result in pollution of aquifers, wetlands and waterways.

As a general rule, fertiliser should be subsurface applied to reduce the risk of runoff from the farm into waterways and to reduce the volatilisation of nitrogen into the atmosphere. Following the application of soil ameliorants or the production of a legume break crop, nutrient applications must be reduced to account for the inputs from the ameliorant or legume.

To ensure the correct fertiliser rate is being applied, the fertiliser box should be calibrated regularly including at the commencement of each season and with each batch of fertiliser or with each change of fertiliser product.

AT PLANTING: Fertiliser is usually applied concurrently with planting. Nitrogen and phosphorus alone or with the addition of potassium are applied in bands on each side of, and away from, the sett. Often the plant crop's entire phosphorus and potassium requirements and part of its nitrogen needs are applied at planting. Direct contact with the sett will result in fertiliser burn to the eyes of the sett, particularly if the planting mixture contains muriate of potash. Sandy soils are especially prone to fertiliser burn when clear separation of sett and fertiliser does not occur.



Table 3: Calculation of N contribution from a fallow legume (as supplied by the Sugar Yield Decline Joint Venture). * Mike Bell, 2007.

Legume crop	Fallow crop dry mass (t/ha)	N (%)	Total N contribution (kg N/ha)	N contribution if grain harvested (kg/ha)
Soybean	8	3.5	360	120
	6		270	90
	4		180	60
	2		90	30
Peanut*	8	3	N/A	125
	6			100
	4			65
	2			25
Cowpea	8	2.8	290	100
	6		220	75
	4		145	50
	2		70	25
Lablab	8	2.3	240	80
	6		180	60
	4		120	40
	2		60	20

The N contribution from fallow legume crops can be substantial (as indicated in Table 3). This source of N should be used to adjust the amount of nitrogen fertiliser required for soils with different N mineralisation index values (Table 4). Following a

well-grown legume break crop, nitrogen at planting can be eliminated providing the legume crop has been maintained until close to the time of planting of the cane crop.

Table 4: Nitrogen requirement for plant cane (Schroeder, *et al.*, 2005.)

Crop	N mineralisation index						
	Very Low	Low	Medium Low	Medium	Medium High	High	Very High
Replant cane	160	150	140	130	120	110	100
Plant cane after a grass/bare fallow	140	130	120	110	100	90	80
Plant cane after a poor legume crop (eg. 2 t/ha cowpea green manure: N rate minus 70 kg N/ha)	90	80	70	60	50	40	30
Plant cane after a good legume crop (eg. 6 t/ha soybean: N rate minus 270 kg N/ha)	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Plant cane after a good legume crop harvested for grain (eg. 6 t/ha soybean: N rate minus 90 kg N/ha)	70	60	50	40	30	20	10

The SIX EASY STEPS program recommends that all other sources of nutrients be taken into account when nutrient inputs are planned. These could be from the use of mill by-products (mill mud, mill ash, dunder etc), residual nutrient from other crops, and nutrients in irrigation water.

Following the application of filter mud, filter mud-mill ash mixture or dunder, it may be possible to markedly reduce fertiliser nitrogen, phosphorus and potassium inputs to the plant cane. Table 5 lists the approximate nutrient content in various mill by-products. Some of these nutrients are not immediately available for plant uptake because they are present in organic form.

However, when large amounts of mill by-products are used, it is important to prevent these from reaching waterways to prevent the possibility of de-oxygenation and possible fish kills.

TOP DRESSING: Any remaining nitrogen fertiliser requirement is applied following germination of the plant cane at a stage called top dressing. It often takes place at the first fill-in stage when soil is pulled into the furrow.

In some instances, nitrogen should be reduced or eliminated at the top dressing stage. Following a well grown legume break crop, additional nitrogen may be unnecessary. After an application of mill mud or mill mud-mill ash mixture, nitrogen inputs can be reduced.

Apart from the SIX EASY STEPS program (and its supporting publications) important information about nutrient management can be found in the BSES publication *Manual of Cane Growing* (2000).

Fungicide application

Fungicide is applied at planting to control the soil-borne fungus *Ceratocystis paradoxa* which is responsible for pineapple disease. Infection occurs through the cut ends of setts and through damage to the stalk rind including growth cracks. Piped cane is prone to rapid invasion of fungal spores even if the ends of the setts have been covered in fungicide spray. Well grown and carefully cut plant cane sources are important in the prevention of fungal diseases.

For the fungicide to be effective, the cut ends of the setts must be covered with the fungicide spray in whole stick planters. The spray system should be operated at a pressure of 200 to 250 kPa. Sett coverage should be assessed by including a dye in the fungicide solution. Defective or misdirected nozzles can then be rectified and recalibrated.

The dip system used in billet planters normally provides very effective coverage. However, the fungicide solution must be regularly replaced (at least twice each day) as accumulated soil and trash will quickly reduce the efficacy of the fungicide.

Table 5: Nutrients applied by typical applications of mill by-products (kg/ha).

Plant nutrient	Filter mud (150** t/ha)	Filter mud-ash (150** t/ha)	Ash (150** t/ha)	Liquid dunder after re-boiling (5 cubic metres/ha)	Biostil dunder (3 cubic metres/ha)
Nitrogen	465*	360*	60*	16*	24*
Phosphorus	360*	300	120	1*	2*
Potassium	120	195	390	112	90
Calcium	645	600	435	17	24
Magnesium	135	165	225	9	18
Sulfur	80	50	N/A	13	9*

* Additional fertiliser may be required as nutrients are in organic forms and are not immediately available for plant uptake.

** Application rate varies substantially across regions, as does nutrient content.

10. PEST CONTROL

Effective pest management depends on the integration of available tools including monitoring of pest numbers, cultural and chemical controls to minimise pest numbers and reduce input costs and good record keeping.

IPM: Integrated pest management (IPM) of canegrubs has evolved in recent years. IPM is the practice of utilising a variety of techniques and methods to minimise damage to crops caused by pests such as canegrubs while minimising production costs and preserving the environment as much as possible. IPM cannot be implemented using a set recipe. The use of IPM is governed by each particular situation. Monitoring of the pest situation allows an IPM plan to be devised using a range of the elements comprising the IPM tool box. IPM avoids pesticide application over the whole farm for complete grub eradication. IPM must have a local basis for effective outcomes. The efforts of an individual grower will be negated if neighbouring farms are havens for canegrubs.



Figure 17: Lodged sorghum trap crop infested with canegrubs.

Canegrub IPM involves the use of all or some of the following techniques: pesticide application, biological control, time of harvest, trap cropping, fallowing or planting a non-susceptible rotation crop, green cane trash blanket, minimum tillage, and less susceptible sugarcane varieties. A key ingredient of IPM is monitoring of the pest to determine crop damage and the canegrub population status – whether grub numbers are increasing, the current grub density, and where grubs are located on the farm and neighbouring region.

Pesticides are effective at killing canegrubs but are very expensive and may be hazardous to the environment. Naturally occurring parasites of canegrubs including the fungus *Metarhizium anisopliae* and the protozoan *Adelina* are destroyed by pesticides.

Biological control of canegrubs involves the preservation of natural predators such as *Metarhizium* and *Adelina*. Minimum tillage and the preservation of a green cane trash blanket enhances the conditions under which these beneficial predators can live.

Harvesting sequence can have an impact on canegrubs. Harvesting valuable and vulnerable blocks late will reduce the risk of canegrub infestation the following year. Trap cropping might also be a useful technique. Early cut cane can be used as a greyback beetle lure. This crop can be treated with the insecticide imidacloprid or other product to kill the grubs in the lure crop. Alternatively, early cut cane can be used as a



Figure 18: Canegrub – the sugar industry's worst pest.

sacrifice crop and ploughed out to destroy grubs. Strips of sorghum are proven trap crops. Once infested with canegrubs, the sorghum strip is ploughed out to destroy the pests.

While all sugarcane varieties are prone to attack by canegrubs, some varieties are not as adversely affected as others.

Further information on IPM can be found in the *Manual of Cane Growing* (2000).

CANEGRUBS: Canegrubs, the larvae of various species of endemic beetle, eat sugarcane roots. Yields of grub-damaged cane are severely affected. Under high canegrub populations, cane stools can die. Stools are prone to tipping out of the ground and being pulled out during harvesting. Losses will be experienced in both the current crop and subsequent ratoon crops unless the expensive option of ploughing out and replanting the current grub-affected crop occurs.

Canegrub species have one- or two-year life cycles. Differences in pesticide treatment apply to each situation. Insecticides based on the active ingredients imidacloprid (Confidor® Guard, Confidor® CR, suSCon® maxi) or chlorpyrifos (suSCon® Blue) are registered for canegrub control as are several other chemicals. The biological insecticide BioCane™ has as its active ingredient a naturally occurring fungus, *Metarhizium anisopliae*, which controls the greyback canegrub, the most damaging of Australian canegrubs.

WIREWORMS: The sugarcane wireworm is the larva of the click beetle. Wireworms bore into the eyes of germinating setts and into new shoots resulting in poor germination. Chlorpyrifos (eg. Lorsban®) is registered to control wireworms. The pesticide is sprayed over the setts at planting.



Figure 19: Wireworm (A) and click beetle (B).

SYMPHYLANS: Belonging to the species *Hanseniella* and resembling very small, white centipedes, symphylans eat actively growing sett and shoot roots of young cane leaving small pits. Chlorpyrifos (eg. Lorsban®) sprayed over the setts at planting is registered to control symphylans.



Figure 20: Symphylan.

OTHER PESTS: Many other pests affect sugarcane and are controlled, if warranted and if a method is available, after planting. Pests include cane rats, soldier flies, funnel ants, armyworms, sugarcane weevil borers, field crickets, mole crickets, locusts, bud moths, moth borers, ratoon shoot borers, rhyparida, aphids, termites, mealybugs, linear bugs, scale, froghoppers, black beetles, ground pearls, cicadas, pigs, wallabies, coots and cockatoos. Apart from the major pests, and the sporadically important sugarcane weevil borer, most of the other pests have a minor impact over the whole industry although individual farms can be heavily impacted (eg. by pigs).

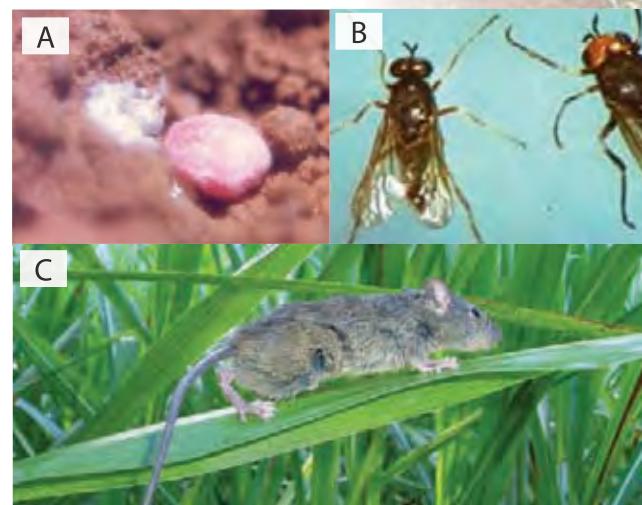


Figure 21: Pink ground pearl (A), soldier flies (B), and climbing rat (*Melomys burtoni*) (C).

11. WEED CONTROL

Weeds are the most important pest of sugarcane. Mechanical cultivation of plant cane (see "Cultivation of Plant Cane" page 29) and herbicides are widely used for grass, broadleaf weed, sedge and vine control. The inappropriate use of herbicides carries significant environmental risks which must be addressed to ensure that detrimental off-farm impacts do not occur. For the Australian sugar industry, which occupies coastal areas adjacent to the Great Barrier Reef World Heritage zone and rapidly expanding urban and tourist regions, the risks are particularly pronounced.

Monetary losses from weeds

Research by BSES Limited has highlighted the huge monetary losses that will occur if weed control of plant cane is delayed or omitted. Figure 22 summarises the results of trials conducted in south, central and north Queensland where weed control in plant cane was delayed by four, eight and twelve weeks and where no weed control was conducted at all. Losses due to weed competition are significant in all areas of the Australian sugar industry.

Weed control by mechanical cultivation, herbicide application or a combination of both in the early stages of sugarcane growth in the plant crop is critical.

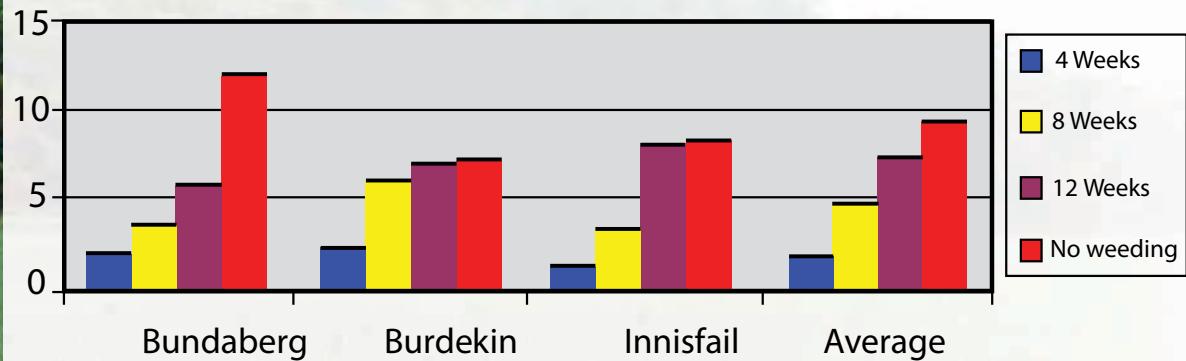
Herbicide properties

Herbicides must be selected and used in such a way that they do not adversely impact on the environment.

SOLUBILITY AND MOBILITY: Herbicides are manufactured in a wide range of formulations such as emulsifiable concentrates, wettable powders and water dispersible granules. The degree of solubility of a herbicide in water does not necessarily indicate the herbicide's risk of moving offsite in water. For example, glyphosate and paraquat are both highly water soluble but are extremely tightly bound to the soil particles. Hence, any offsite movement of these herbicides is limited to sediment movement.

On the other hand, atrazine is only moderately soluble in water but is much less tightly bound to soil particles than glyphosate and paraquat. Therefore, atrazine has the potential to leach into groundwater and to enter waterways either in runoff water or groundwater. Figure 23 shows that predicting herbicide mobility based on its water solubility alone can be misleading.

Yield loss (tonnes sugar/ hectare) from weed competition



Source: BSES-SRDC weed competition trials 1997-98

Figure 22: Effect of weed competition in plant cane.

HERBICIDE BEHAVIOUR ON SOILS

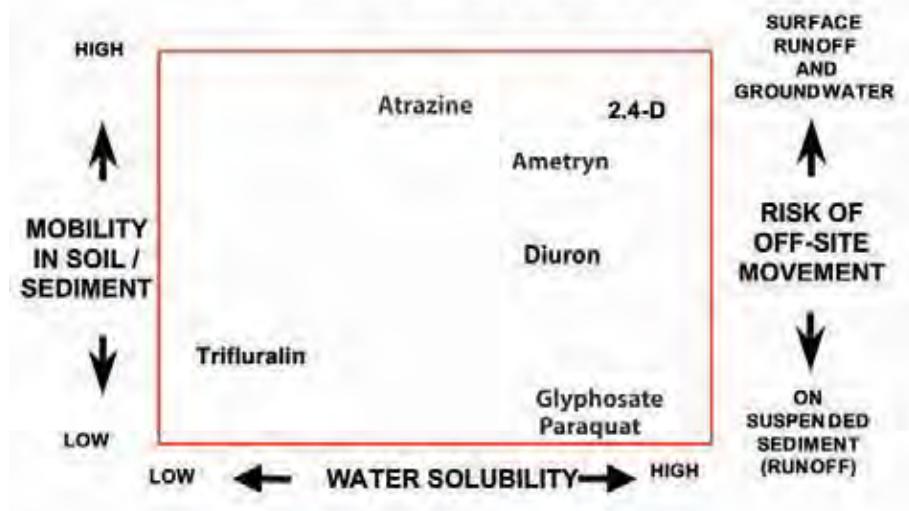


Figure 23: Variation in mobility and solubility of some commonly used sugarcane herbicides (after Simpson, *et al.* 2001).

Trifluralin, glyphosate and paraquat are tightly bound to the soil and will, generally, only move offsite with sediment loss. Atrazine, ametryn and 2,4-D do not adhere strongly to soil particles and are prone to offsite movement in water runoff or leaching.

PERSISTENCE AFTER APPLICATION AND RISK PERIODS:

When herbicides are applied, natural processes immediately begin to break them down. Those processes include photodegradation, volatility, oxidation, chemical hydrolysis, and biological and microbiological breakdown. These combined processes determine the persistence and fate of the product and ensure registered herbicides have a limited life cycle in the field.

The highest risk period occurs in the few weeks after application. Differences in the pesticide type, soil type and weather conditions during the herbicide dissipation period govern how long the peak risk period lasts.

Table 6 shows the differences in the breakdown of several herbicides on a range of soil types in a south Queensland trial. The time taken for the herbicide to break down to half the initial concentration is called the dissipation rate (DT_{50}).

As a general rule, herbicides break down rapidly. The highest risk period is the few days immediately after application. However, instances may occur where a herbicide will persist for a very long time. Diuron applied to a red ferrosol illustrates this point (Table 6).

Table 6: Field dissipation rates (DT_{50}) for pesticides in Bundaberg soils (0-2.5 cm). Source: Simpson, *et al.* (2001)

Soil	pH	Organic carbon (%)	Clay content (%)	DT ₅₀ (days)			
				Atrazine	Ametryn	Diuron	2,4-D
Grey kandosol	7.2	0.80	3	3 – 13	3.5	13	–
Redoxic hydrosol	7.1	0.72	8	2.5 – 27.5	2	15.5	1.8
Red ferrosol	6.0	1.23	63	1 – 7	14.5	>250	12
Yellow chromosol	5.1	0.95	6	2.5	4	–	–

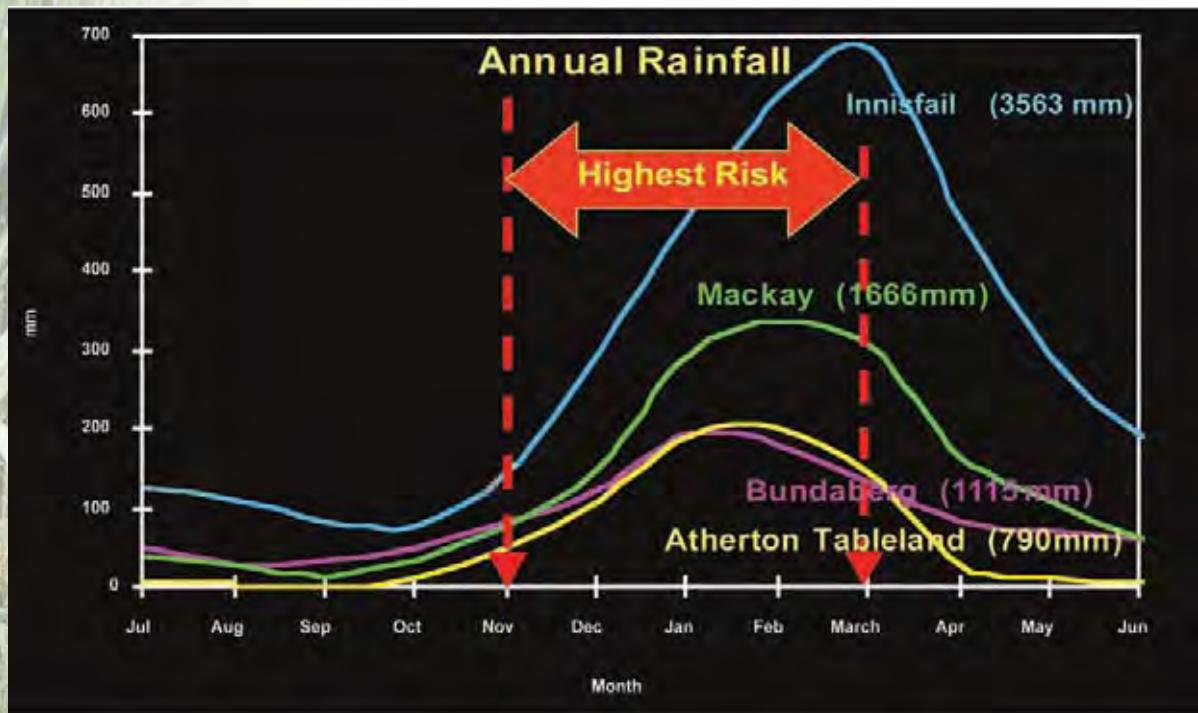


Figure 24: Major risk period for the offsite movement of herbicides . Source: Simpson, *et al.* (2001)

Where possible, herbicides should not be applied during periods when the risk of offsite losses is high. The period when the threat of offsite movement of herbicides is highest is when heavy rainfall or irrigation occurs soon after herbicide application. In general, the highest risk period aligns with the “wet season” between November and March as shown in Figure 24. In particular, herbicides containing soluble, mobile chemicals such as diuron and atrazine should be applied very cautiously in the high risk period.

Weed growth is at its most prolific during these hot, wet months. The risk of herbicides leaving the paddock can be reduced by applying a residual pre-emergent herbicide when the chances of heavy rainfall are low.

SafeGauge for Pesticides is a software application that assesses the risk of chemicals entering a water body. The program integrates soil hydrology, site characteristics and climatic records with pesticide

properties and farm management practices. It then assesses potential risk for pesticide contamination of surface and subsurface water as a result of pesticide use and farm management practices. *SafeGauge for Pesticides* enables the user to be aware of the effects of changing farm management practices at the farm block level, especially the timing of pesticide applications, on the potential risk to water bodies from pesticide losses.

Safe usage and chemical use recording

Weed control can be achieved by mechanical cultivation, herbicide application or a combination of both. Herbicides must be selected and used in such a way that they do not adversely impact on the environment. Herbicide usage must be carefully managed in terms of timing of application and herbicide selection. Areas close to waterways are particularly environmentally sensitive.

Everyone applying herbicides should be trained in their correct usage. Training courses such as *ChemCert* will provide accreditation for herbicide application. Read labels carefully and follow recommended application rates which should never be exceeded. Apply herbicides only when weather conditions are suitable to reduce the risk of offsite movement of the herbicides.

High risk periods should be avoided as much as possible.

Pre-emergent herbicides, cultivation and post-emergent contact sprays should be considered as options to manage weeds in the young plant cane crop. A pre-emergent herbicide application just prior to the out-of-hand stage provides protection against germinating weeds until the crop canopy fills in sufficiently to provide natural protection. Be aware of the high risk period between November and March.

In summary, use the following strategies if possible:

- Apply herbicides to the soil early during crop growth as necessary
- Use pre-emergent herbicides at the out-of-hand stage
- Avoid applying herbicides in the high risk “wet season” or use contact herbicides if unavoidable, a safer option than residuals
- In-crop application with hooded sprayers of the environmentally safe herbicide glyphosate can replace the use of higher risk mobile herbicides
- A change to a less mobile product or even the ‘no chemical’ option may be needed if the environmental risk is seen as too high to be acceptable
- Use the *SafeGauge for Pesticides* software to assist in decision making with a herbicide program

“

Apply herbicides only when weather conditions are suitable to reduce the risk of offsite movement of the herbicides.

”



“

Cutting away with discs or mouldboards reshapes the drill to remove steep walls that may collapse into the furrow. Small weeds are removed during the process.

”

12. CULTIVATION OF PLANT CANE

Cultivation of cane after planting fills in the furrow to eventually form a raised or mounded row suitable for mechanical harvesting. Cultivation is one of the strategies employed to control weeds.

The furrow should be kept open with minimum soil cover to promote tillering. This would not apply when double-disc opener planters are used.

The first mechanical operation after planting is usually a step called cutting away. Cutting away with discs or mouldboards reshapes the drill to remove steep walls that may collapse into the furrow. Small weeds are removed during the process. Larger weeds that are not eliminated with cutting away could be removed with spinners or smothered with soil during filling-in. Pre-emergence or carefully placed post-emergent herbicides may have a role in weed control if cultivation does not provide satisfactory results.

Once tillering has reached a satisfactory stage ie. when three or four tillers develop from each primary shoot, filling in of the drill should commence. After two or three passes, the final mound should be 100-150 mm above a flat interspace. If furrow irrigation is practised, the mound should be a minimum of 100 mm high.

A well-defined row profile is extremely important to provide optimum harvesting conditions.

The timing of the final working or cultivation is dictated by the height of the plant cane. At this point, a pre-emergent herbicide applied to the soil surface will provide broadleaf weed and grass control for up to several months by which time the cane canopy has filled in. A healthy, full canopy will prevent further broadleaf weeds and grasses from germinating.

13. CONCLUSIONS

This booklet covers best management practice relating to plant cane establishment and plant cane management. It covers information on the improved farming system that is based on a combination of legume break crop, controlled traffic and minimum or zonal tillage. It also provides best management practice guidelines for other aspects of sugarcane management that

need consideration at planting and during the plant crop (Figure 25). Some of the aspects that have not been dealt with specifically here (eg. irrigation and water use efficiency) will be dealt with in the booklet entitled *SmartCane Harvesting and Ratoon Management*.

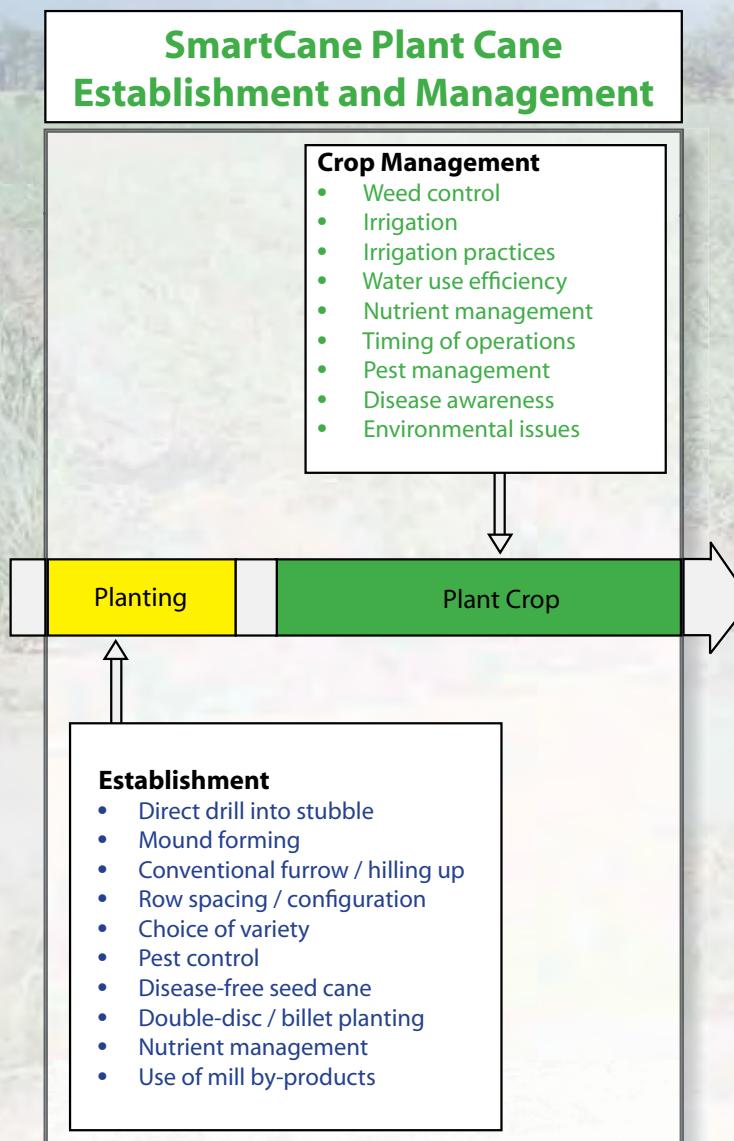


Figure 25: Aspects of sugarcane management that need consideration at planting and during the plant crop.

14. SELF EVALUATION

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 closer to best management than others. This self evaluation is aimed at identifying an individual's perception of best management practice and if and where improvements can be made for 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 onfarm. For example, you may fully support the idea of best management practice and give it a rating of 1 (strongly agree), but may only give it a rating of 3 in terms of compliance / adoption on your farm.

Table 7: Self evaluation for identifying best management practice.

Rate each of these statements according to the scale of 1 to 5 in relation to attitude and onfarm adoption		1	2	3	4	5
• The concept of best management practice recognises that farm practices are continually improving	Attitude					
	Adoption					
• Soil analysis is the basis of sustainable fertiliser use on my farm	Attitude					
	Adoption					
• Zonal tillage provides a number of benefits – reduction in farm costs and time, improved soil moisture status and reduced risk of erosion	Attitude					
	Adoption					
• Best management practice requires all aspects of farm management to be assessed to identify where improvements can be made	Attitude					
	Adoption					
• Selection of planting material should be based on the evaluation of a number of factors* to achieve the best results	Attitude					
	Adoption					
• Planting time is influenced by the weather and the germinating speed of varieties	Attitude					
	Adoption					
• Cane rows spaced at 1.83 m will cater for current machinery, confining compaction to the inter-space and eliminating stool damage	Attitude					
	Adoption					
• Nutrient inputs are determined by using the SIX EASY STEPS guidelines that are aimed at sustainable sugarcane production	Attitude					
	Adoption					
• Effective pest management depends on the integration of available tools including monitoring and cultural and chemical controls	Attitude					
	Adoption					
• Weeds need to be controlled effectively to prevent monetary losses Control measures should be environmentally responsible	Attitude					
	Adoption					

* Pest and disease status, erectness, internode length and number, sett and bud quality, nutrition and vigour, and variety suitability for soil type and time of harvest.

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.

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Schroeder, B.L., Wood, A.W., Moody, P.W., Stewart, R.L., Panitz, J.H. and Benn, J. (2007). **Soil-Specific Nutrient Management Guidelines for Sugarcane Production in the Johnstone Catchment.** Technical Publication TE07001, BSES Limited, Indooroopilly, 60 pp.

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APPENDIX 1: SOIL SAMPLING GUIDELINES

A number of important steps should be followed when soil sampling a block of land that is used for sugarcane production:

- **Determine** the area that is to be sampled.
- **Ensure** that the area being sampled does not exceed 2 or 3 hectares and that it is relatively uniform.
- **If** a block consists of more than one distinct soil type, sample them separately.
- **Avoid** areas that differ in crop growth, or where large amounts of mill mud or other amendments have been dumped (sample such areas separately if necessary).
- **Sampling** is best done with an auger (either a turning auger (Figure 1) or a soil tube).
- **At** least 10 or 12 'augerings' of soil should be collected from the area to a depth of about 20 – 25 cm using a zig-zag or grid pattern as shown in Figure 2.
- **The** basic principle is that more 'augerings' are better than less.
- **All** the 'augerings' should be collected in a good-quality plastic bag or a clean plastic bucket to form a single composite sample.
- **Care** should be taken not to use a bucket with a galvanised handle as this source of zinc could contaminate the soil sample.
- **After** collection, all the 'augerings' should be mixed thoroughly to ensure a uniform sample.
- **Preferably** dispatch the complete sample to a reputable laboratory for analysis.
- **If** the complete sample is too cumbersome, a portion (500 g – 1 kg) should be sub-sampled for dispatch to the laboratory.
- **Ideally** this sub-sampling should occur after air-drying and initial sieving, but facilities to do so may not always be available. Assistance may possibly be obtained from your extension officer or adviser.
- **Supply** as many details as possible on a label and on the sample bag to ensure that the sample can be easily identified, and that meaningful interpretation of the results is possible.
- **It** is important that soil assays conducted by the laboratory corresponds to those calibrated for sugarcane production.



Figure 1: Soil sampling using a turning auger.

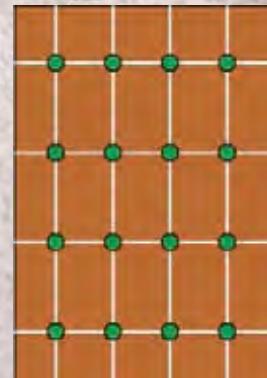
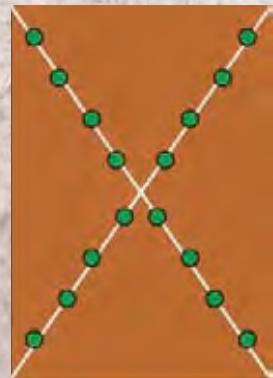


Figure 2: Some suggested sampling patterns within blocks of cane.



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