CONTROLLED INFIELD TRAFFIC

IN SUGARCANE PRODUCTION

A GUIDE TO SUGARCANE PRODUCTION SYSTEMS AIMED AT ELIMINATING STOOL DAMAGE

SASRI
SOUTH AFRICAN SUGARCANE
RESEARCH INSTITUTE

CONTROLLED INFIELD TRAFFIC IN SUGARCANE PRODUCTION

A guide to sugarcane production systems aimed at eliminating stool damage.

EDITOR

R van Antwerpen

CONTRIBUTING AUTHORS

R van Antwerpen, A Jumman, PB Tweddle, D Boote, N Miles, P Govender, LW Titshall
S Mhlaba, P Campbell, P Ramouthar, A Searle, D Wilkinson and G Lagerwall

ABOUT THIS MANUAL

*This document provides guidelines for sugarcane farmers wishing to implement a **controlled infield traffic system.** The term 'controlled traffic' refers to a system that does not allow the wheels of any infield vehicles or equipment to drive over the cane rows. The reason for this is simple: sugarcane stools suffer damage when driven over, resulting in significant yield losses.*

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South African Sugarcane Research Institute

170 Flanders Drive, Mount Edgecombe, 4300

Private Bag X02, Mount Edgecombe, 4300

Tel: (031) 508 7400 | Email: sasri@sugar.org.za

Website: www.sasri.org.za

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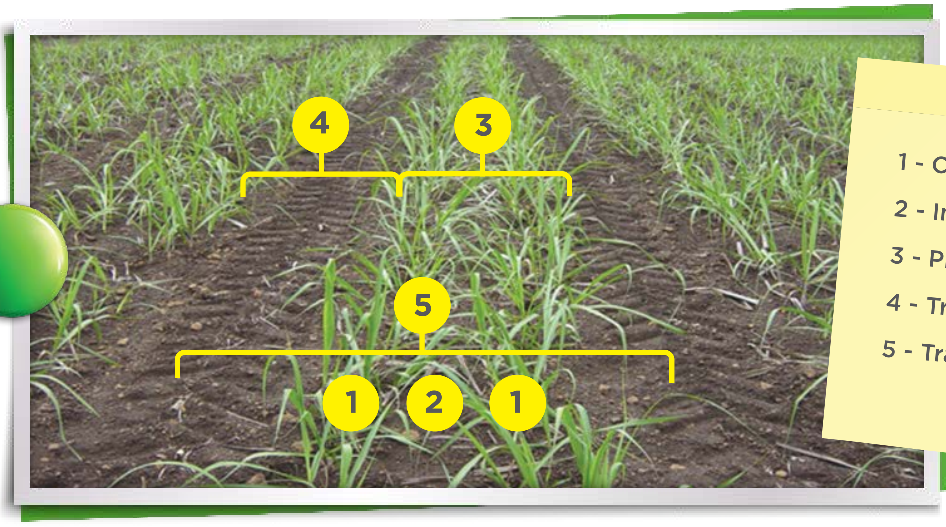
GLOSSARY

COMPACTION	The action of forcing together of soil particles, thereby reducing the space between particles and changing its physical properties. Such soils are referred to as being compacted. Specific soil property changes include reduced water infiltration rates, reduced ability to store water and restricted root development.
CONTROLLED TRAFFIC	Management of infield vehicle and equipment by dividing the field into separate zones for growing cane and for wheel traffic. The wheels of equipment are allowed only in the pre-planned traffic zones, year after year.
DUAL	Dual spacing or dual layout refers to a 'tramline' planting layout in a field. See definition of 'tramline' below.
GROWING AREA	Synonym for 'production bed' and 'production zone'. See definitions below.
INTERROW WIDTH	Synonym for 'interrow spacing', defined below.
INTERROW SPACING	Distance between cane rows in a production zone. Synonym for 'interrow width'.
MINIMUM TILLAGE	The least amount of soil disturbance required to plant and to maintain a cropping cycle.
PRECISION FARMING	Precise management of infield operations down to the level where nutrients are applied at different rates to different portions of fields, according to recommendations based on soil and plant analyses. GPS technology is normally used for precision wheel placement of fertiliser distribution.
PINEAPPLE PLANTING	Synonym for 'tramline' defined below.
PRODUCTION BED	Synonym for growing area and 'production zone'. See definition for 'production zone' below.
PRODUCTION ZONE	Space between wheel tracks (traffic zones) where sugarcane is grown. This space can consist of one or more cane rows and wheels are not allowed in this area. It can be flat (same height as the transport zone) or raised. Synonym for 'growing area' and 'production bed'.
REDUCED TILLAGE	Less intensive disturbance of the soil compared to conventional pre-planting and planting operations. This is not as restricted as minimum tillage.
TRAFFIC LANE	Synonym for 'traffic zone' and 'transport zone'. See definition of 'traffic zone' below.
TRAFFIC ZONE	Space between two production zones where wheel traffic is allowed and no cane is grown. Synonym for 'traffic lane' and 'transport zone'.
TRAFFIC ZONE SPACING	Distance from one traffic zone to the next, measured from the centre of the traffic zone to the centre of the next.
TRAMLINE	A field layout where two crop rows are planted closer to each other followed by a wider space (planned for wheel traffic). Fields planted in this pattern are referred to having a tramline layout. Synonym for 'pineapple planting'.
TRANSPORT ZONE	Synonym for 'traffic zone' and 'traffic lane'.
WHEEL TRACK SPACING	The spacing between the centre of wheel track to centre of next wheel track.



1 - Cane row
2 - Interrow
3 - Production zone
4 - Traffic zone
5 - Traffic zone spacing

1. INTRODUCTION

For a very long time, yield losses from stool damage were attributed to soil compaction. To fully appreciate the benefits of a controlled traffic system, stool damage and soil compaction have to be considered separately as causes of yield loss. While it is true that soil compaction will cause some reduction in yield, stool damage by infield vehicles is clearly the bigger culprit. In fact, under certain circumstances, soil compaction can be seen as beneficial, for example, it provides a firm surface for improved traction to infield vehicles. Stool damage, however, will never be regarded as beneficial under any circumstances and is responsible for severe reductions in yield.

A controlled traffic system keeps wheels away from the sugarcane stools and restricts them to the traffic zones where compaction is less harmful to the ratooning crop.

So where does one start with implementing a controlled traffic system? The answer to that question will depend on what your current practices are, and on how much you are prepared to change.

Some situations may simply require an adjustment of the wheel spacing of infield vehicles and equipment to match the traffic zone spacing. Other cases may require a change in farm and field layout so that traffic zone spacing matches equipment wheel spacing. Yet other scenarios may call for a combination of adjustments, i.e to both field layout and vehicle wheel spacing. The various permutations are discussed in detail in this document.

When making such a major change to the sugarcane production system, the farmer has to consider the implications of the change on various farm operations such as method of seedbed preparation, amount of seedcane per hectare, placement of fertilisers, where to sample for soil analyses, how to combat weeds, position of dripper tapes, and how to prepare the field for replanting. This document starts by dealing with the two major areas where fundamental changes have to be made when moving to a controlled traffic system, i.e. **FIELD LAYOUT** and **MECHANISATION.** Explanations of how other farming operations may have to be modified are provided under the sections **FERTILISATION and IRRIGATION.**

Information for this document comes from various sources: SASRI field trials, international literature, the experiences of the many sugarcane farmers in southern Africa who have already implemented controlled traffic systems and from tacit knowledge of SASRI researchers and extension staff.

Based on our knowledge regarding the costs of the various activities that make up a controlled traffic system, we are confident that farmers will benefit economically from such a system because of reduced stool damage, reduced weed control costs, increased number of ratoons and increased yields. International literature suggests that increase in yields alone could be up to 25%.

Growers considering the implementation of a controlled traffic system should, in the first instance, contact their SASRI Extension Specialist for advice and guidance.

2. FIELD LAYOUT

One of the fundamental issues that needs to be dealt with when choosing to implement a controlled traffic system is the farm and field layout. In planning the layout, you must consider all aspects of your farming operation. These include your daily rateable delivery (DRD), fertiliser and herbicide application methods, harvesting and loading operations, your irrigation system and surface water management (to prevent erosion). The accepted Land Use Planning (LUP) norms must also be adhered to when considering field layout which may require the updating of an existing land use plan or the drafting of a new LUP.

It is also important to keep potential future mechanisation plans in mind when changes are made to field layouts.

Terminology to be used in this document with regard to field zones and pertaining to controlled traffic are **traffic zone** and **production zone** (see Figure 1).

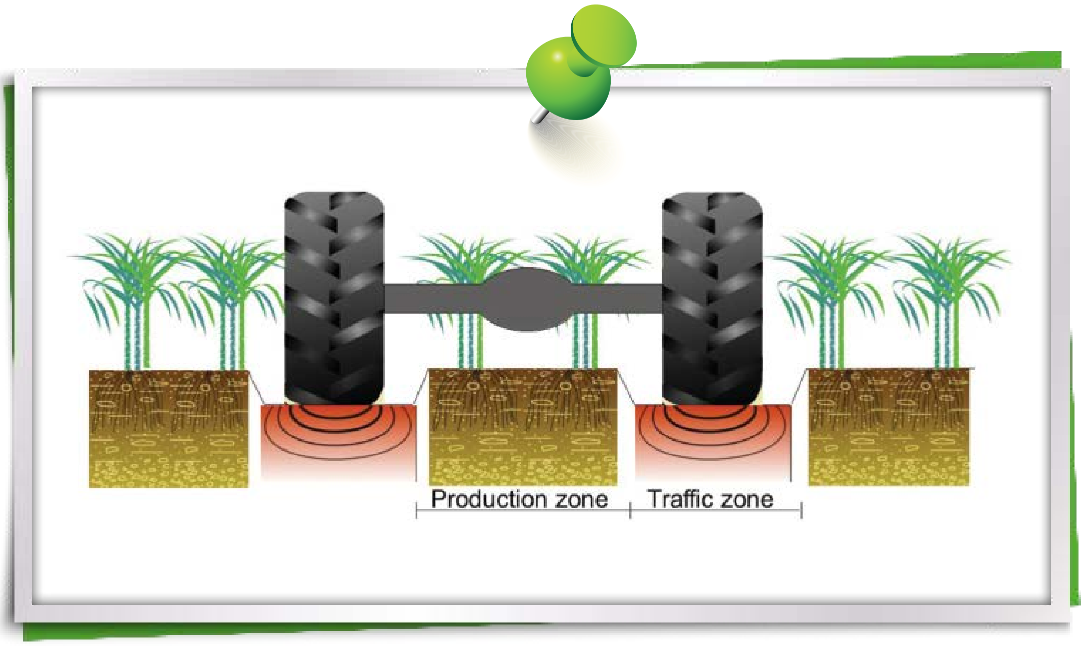


Figure 1: *Wheels of infield equipment should be kept in the traffic zone.*
The production zone can consist of more than one cane row if spacing permits.

2.1. Slope

What slopes are you working on? You should not be using infield traffic on slopes of 12% or greater. Rather consider implementing a minimum tillage system.

2.2. Row Spacing

An important consideration when switching to a controlled traffic system is row spacing. What is the wheel spacing of your current machinery? An important principle of controlled traffic is that all infield transport must be restricted to the traffic zone and should not be allowed to travel on the production zone. This means that the width of your traffic zone must be wide enough to accommodate the wheels of your equipment. In the South African sugar industry, a common spacing from the centre of one back wheel of a tractor to the centre of the next back wheel is 1.8 to 1.9 m and the common width of the tyres are about 0.5 m.

Thus, the distance from outside tyre wall to outside tyre wall is 2.3 to 2.4 m. Adding a small buffer distance of 0.15 m outside each tyre wall will require cane rows to be at least 2.7 m apart. The area between the tractor wheels (production zone) can be planted to sugarcane and to more than one row if the space allows (see Figure 1).

Many growers have found that they can maximise running meters of sugarcane per hectare by making use of dual cane rows also termed 'tramline' or 'pineapple' planting. Typical traffic zone spacing in the industry ranges from 1.8 m to 2.1 m (centre of traffic zone to centre of the next traffic zone) with dual cane rows planted between 0.4 m to 0.9 m apart in the production zone. This dual cane row spacing is usually influenced by the machinery used, management systems and individual preference.

For rainfed fields, the spacing between cane rows on the production zone should be as wide as possible, i.e. 0.7 to 0.9 m. This can also be adopted for irrigated fields but not fields irrigated with dripper systems. In the case of the latter, row spacing between dual rows on the production zone should be as close as possible. Practically this equates to a spacing of about 0.4 m.

2.3. Row length

Take your daily rateable delivery (DRD) into account and try to maximise row length to optimise infield mechanical operations for harvesters and cane haulage units. Look at joining shorter fields where possible to create longer runs. Infield transport should enter one end of the field and exit the other with a full load without any infield turning or crossing of lines. This is often more practical for fields in flat areas.

2.4. Raised production beds

The creation of a raised production bed (production zones) for controlled traffic may be advantageous for a number of reasons.

- The raised bed helps to control surface water flow, especially in hilly fields. To use this effectively, the slope of rows should have a fall of not more than 1:150 m. Each traffic zone becomes a small waterway eventually discharging its water into grassed waterways. To prevent uncontrolled water flow across rows, care should be taken not to allow water to form a dam in any part of the traffic zone along the contour.
- In fields with a high water table, raised beds helps to increase the distance between the stool and water table.
- Raised beds keep infield vehicles in traffic zones and prevents them from travelling across cane rows. The ground clearance of infield machinery needs to be considered when the production zone is raised.
- Raised beds create separate dedicated crop growing zones and traffic zones that can be easily seen after harvesting, during the loading operations.
- Base cutting during mechanical harvesting operations is improved with raised beds.
- Raised production beds may need annual building up and reshaping.

2.5. Irrigation & drainage

Many controlled traffic systems in the industry have come into being because of the damage caused by machinery to expensive irrigations systems. In addition, irrigation and drainage infrastructure tend to influence field layout, as well as the movement and operation of vehicles, tractors and implements. See irrigation section for details.

2.6. Harvesting

Many controlled traffic systems have been employed due to the weight and size of some infield equipment. Consider the harvesting methods you currently use and those you expect to use in future.

Your row width may be determined by the intake of a chopper harvester header. Headland space may be determined by the area required to turn harvesting equipment. Damage of fields at headlands is typically higher for larger infield extraction equipment. The total damaged area is nevertheless significantly reduced with the adoption of controlled traffic systems.

Figure 2: Infield traffic being constrained to dedicated cane extraction traffic lanes.

3. MECHANISATION

3.1. Making the switch

The mechanisation requirements for controlled traffic depend on the changes required to convert an existing system to a controlled traffic system. The changes are quick if the existing traffic zone spacing is suitable to allow for once-off adjustment of all equipment wheel spacings to match the traffic zone spacing.

A partially controlled traffic system could also be adopted where a particular component of the harvesting system does not allow for full adoption (e.g. land owners using non-slewing loaders). In such cases, infield extraction equipment could be made to follow the same traffic paths year after year, thus reducing the amount of uncontrolled traffic to areas affected by the cane loaders alone. The damage caused by non-slewing loading systems may range between 3% to 10% yield reduction per hectare.

A long-term vision of the desired objective in terms of harvesting system requirements will assist in deciding what efforts are required and how to manage the changes. The most urgent scenario would be where row spacings and wheel tracks do not match, resulting in continuous on-the-row stool damage. Stool damage caused by haulage vehicles can result in yield losses of anywhere between 10% and 50% each year. Understandably, a situation where row spacings have to be changed will require a longer-term transition period to convert the whole farm to a controlled traffic system. This, however, would be the most rewarding scenario as the mismatch of equipment and rows will cause the highest potential yield losses through stool damage and compaction.

There are many possible operational implications worth considering for those wanting to convert to a controlled traffic system. These are based on scenarios described and listed in Table 1. Growers also need to ensure that the wheel tracks (spacing) of contractors' equipment (CMS applicators, harvesters, haulage equipment, etc.) match that of the new field layout.

You should also consider mapping your transport lanes at planting by using GPS equipment. All subsequent infield vehicle activity can be auto-steered to follow the same route for the life of the crop or even the life of that field.

In the absence of GPS equipment, there are some low-tech solutions such as marking the transport lanes with painted stones or pavers to ensure that infield traffic operators are aware of the demarcated zones and by raising the production bed which will force traffic to stay in the traffic zone.

Table 1: A summary of three controlled traffic (CT) scenarios and their impact on infield operations when converting from conventional farming to controlled traffic.

	SCENARIO 1	SCENARIO 2	SCENARIO 3
Infield operations	Changing equipment to match row spacing: e.g. 1.2 m rows – change equipment to 2.4 m wheel spacing (immediate conversion)	Changing of row spacing to match equipment: e.g. 1.3 m to 1.8 m rows (long-term transition)	Changing row and equipment spacings: e.g. 1.3 m to 1.8 m duals & equipment to 1.8 m (long-term transition)
Crop eradication	No change	No change	No change
Land preparation	No change	No change	No change
Break crops	No change	No change	No change
Planting equipment	Adjust wheel tracks – add spacers or adjust wheel & rim settings.	Adjust furrow formers to new row spacing.	Adjust wheel tracks to 1.8 m; Adjust furrow formers to new row spacing.
Fertiliser application	No change	Adjust nozzle spacing* Recalibrate equipment.	Adjust nozzle spacing* Recalibrate equipment.
Weed control	No change	Check swaths match CT zone spacing.* Recalibrate equipment.	Check swaths to match CT zone spacing.* Recalibrate equipment.
Harvesting	No change	Adjust position of windrows.	Adjust position of windrows.
Loading	Align all traffic to the traffic zone.	Align all traffic to the traffic zone.	Align all traffic to the traffic zone.
Transport	Align all traffic to the traffic zone.	Align all traffic to the traffic zone.	Align all traffic to the traffic zone.

* *Note that two systems are used concurrently until full conversion has taken place.*

3.2. Additional equipment

If a raised bed (production zone) system is decided on, then you will need:

- bed forming equipment (Figure 3).
- narrow furrow formers (Figure 4). Often the wings of the ridgers are modified to form a suitable furrow shape and depth.

You may also consider a GPS tracking system for layout of individual rows, beds, irrigation systems, fertilisation, etc.

Figure 3a and 3b:
Production bed formers.

Figure 4: *Narrow furrow former.*

3.3. Break crops/fallowing/green manures

These operations should not change from the conventional system except that the traffic zone should not be disturbed and therefore no planting should take place there. Modified or specialised equipment will be required to till and plant in the production zone only. A minimum tillage seed drill set to plant in closely spaced rows in the production zone may be used.

3.4. Killing the old crop

This operation remains similar to that of the conventional system except that the compacted traffic zones must not be disturbed, unless absolutely essential. To achieve this, equipment might have to be altered to till only the production zone. Consult your SASRI Extension Specialist for further advice.

3.5. Planting

The amount of seedcane required will change proportionally to a change in the total row length per hectare.

Figure 5a and b: *Mechanical planters are available but may need to be modified for the desired traffic zone and cane row spacing configurations.*

Figure 6a and b: *Mechanical furrow closing devices are available and are often used in conjunction with a roller at the back to create a smooth bed (production zone) or field surface. This is an essential requirement for mechanical harvesting operations.*

3.6. Harvesting

Mechanical harvesting considerations:

- Chopper harvesting systems typically result in higher levels of infield traffic compared to other systems. The use of GPS auto-steering may be of great advantage particularly under green cane harvesting systems and immediately after harvest when cane rows are difficult to follow.
- Raised production zones may also help as a guide to keep equipment to traffic zones.
- When loaders are fitted with push-pilers, care must be taken to prevent unnecessary stool damage from the lifting tines.

- Reforming of the beds (production zones) may be required periodically. Use bed formers for fields newly converted to controlled traffic (see additional operations above). To reform beds between ratoons, use a disc (Figure 8).

Figure 7a and b: *Cane loader fitted with push-piler (left), and cane from several rows placed into one for loading (right).*

Figure 8: *A disc ridger being used to move soil from the traffic zone to the production zone. This operation can also be performed between ratoons.*

Manual harvesting considerations:

- the number of rows joined per windrow (depending on whether a change in row spacing is envisaged).
- the accurate placement of the windrow for effective loading and to avoid stool damage by the loader.
- the positioning of the windrow year-on-year to constrain traffic to the same traffic zones.

Cutter tasks and wages may need to be revised for different row spacing configurations. Some farmers double the cutter rate for first two harvest cycles only. This is typical of narrowly spaced dual row systems where the rows tend to merge together after a few harvest cycles. Changes in row spacing will have to be negotiated with labour.

3.7. Loading

Various degrees of controlled traffic may be employed depending on the system in use. Manual extraction of cane from fields will have the least damaging impact. This is sometimes practised on wet-prone fields or steep slopes. A cut-and-stack system with stacks constructed near the field edge would be considered a low impact system.

Some systems may require a dedicated extraction road (or strategically placed traffic zones) for infield haulage vehicles. One controlled traffic extraction route can be used to serve sixteen cane rows or one irrigation lateral. In such windrow systems, the placement of windrows is critical to ensure that the cane loader does not travel over the cane rows during the loading process. Field markers may be used to indicate the position of dedicated infield traffic lanes or position of windrows.

Figure 9: Fields laid out for haulage equipment to use exactly the same traffic zones every year. Note the cement block in the foreground marking the place where the truck is allowed to enter the field.

Non-slew loaders cannot be constrained to traffic zones only, however, they can be restricted to specific areas within fields by placing cane stalks from a few cane rows into one windrow for loading. Loader operators need to avoid excessive wheel slip that can aggravate infield soil compaction and stool damage. Infield gleaning of cane should be managed safely while also preventing unnecessary additional traffic infield.

Figure 10: *Dampers (shock absorbers) attached to the pedals of a three-wheel loader to reduce the incidence of wheel slip.*

Figure 11: *Although slew loaders are typically heavier than non-slew loaders, they are able to constrain infield travel to traffic zones.*

3.8. Transport

Damage of fields at headlands is typically higher for larger infield extraction equipment. The total damaged area is nevertheless significantly reduced with the adoption of a controlled traffic system. Various strategies can be employed to minimise field edge compaction and stool damage. Initiatives include:

- tractor/trailer shuttling to reduce infield payloads and improve field access.
- modified equipment drawbars and hitches such as ‘goosenecks’ for sharp turning at field edges.
- strategic ‘sacrifice’ of these field-ends during harvesting followed by care to ameliorate these areas.

__Figure 12a and b:__ Bin systems are used to minimise infield axle loads and facilitate rapid loading of road haulage vehicles at designated transfer stations. Alternative systems include hook lift systems, high-lift bins or forklift systems for field to road transloading operations.

__Figure 13a and b:__ High-lift systems are used to transfer cane between infield harvesters and road transport vehicles (typically used in mechanically harvested cane systems).

3.9. Traffic intensity calculations

A simple traffic intensity calculation can be used to compare the impact of different loading systems. The calculation is done as follows:

Traffic intensity (t.km/ha) = total weight of equipment (t) × row length (km/ha) × no of passes.

The traffic intensity values for a few different systems are presented in Table 2. Some basic assumptions have been made about distances to cane bundles, number of passes and additional infield travel distance of the equipment being used.

The table provides strategies for improvements within each loading system. It will also assist the farmer in decisions about changing systems by providing quick comparisons across loading systems.

Table 2: *Some examples of control traffic within different loading systems assuming a yield of 70t/ha and field dimensions of 35 m wide and 285 m long (1 ha field) with estimates of related traffic intensities.*

PROCESSES\SYSTEM:	CUT & STACK: 5-TON SELF-LOADING TRAILERS	CUT & WINDROW: 3 WHEEL LOADER + 12-TON BOX	CUT & WINDROW: SLEW LOADER + 12-TON BOX	CHOPPER HARVESTING: 14-TON CHOPPER + 12-TON TRAILERS
TRAFFIC INTENSITY: T.KM/HA = TOTAL WEIGHT OF EQUIPMENT (T) × ROW LENGTH (KM) × NUMBER OF PASSES	As little as **6 t.km/ha** if bundles are close to the field edge, going up to **44 t.km/ha**, if bundles are at various places in field requiring many more passes.	**38 t.km/ha**	**32 t.km/ha**	**340 t.km/ha**
STRATEGIES FOR BETTER POSITIONING OF CANE	Stacks at field edge or dedicated extraction lanes if stacks are created infield. Stacks should be aligned and orientated to avoid traffic of loaders on cane rows.	Increase number of cane rows per windrow; Windrow position; Dedicated extraction lanes; Constrain non-slew loader to “windrow loading zones”.	Increase number of rows per windrow; Windrow position; Restrict controlled traffic to dedicated extraction lanes.	High traffic levels - controlled traffic lanes are essential!
EXTRACTION LANE OPTIONS	Roadways at field edges or dedicated infield lanes.	Roadways, irrigation laterals, controlled traffic lanes infield.	Roadways, irrigation laterals, controlled traffic lanes infield.	Sticking to controlled traffic lanes is essential.

4. FERTILISATION

The vastly reduced stool damage and improved soil physical and biological conditions of the production zone under controlled traffic systems offer potential for significant increases in crop yields. However, for this to be realised, nutrients must be supplied timeously and in adequate amounts. Key considerations in this regard are the effective use of soil and leaf testing, together with appropriate nutrient application methods.

4.1. Soil sampling*

Topsoil (0-20 cm) sampling should be undertaken at least after every second ratoon crop. Samples should be collected immediately after harvest using a Beater auger. The sampling pattern is important due to the compaction effect that the controlled traffic system will have on the interrow zone; sampling should therefore be undertaken in the production zone only, and not in the traffic zone. One core sample should be taken on the cane row for every eight taken in the interrow, with a total of at least 27 cores being taken and combined to form one sample. Note that, in this system the 'interrow' refers to the spaces between the tramline cane rows in the production zone. Where single cane rows are used in the traffic control system, eight soil samples should be taken 25 to 30 cm on either side away from the cane row (avoid sampling close to the centre of the traffic zone) for every sample collected on the cane row.

When completing the FAS Soil Sample Submission Form, ensure that a realistic yield target is entered, as this strongly influences the nutrient recommendations.

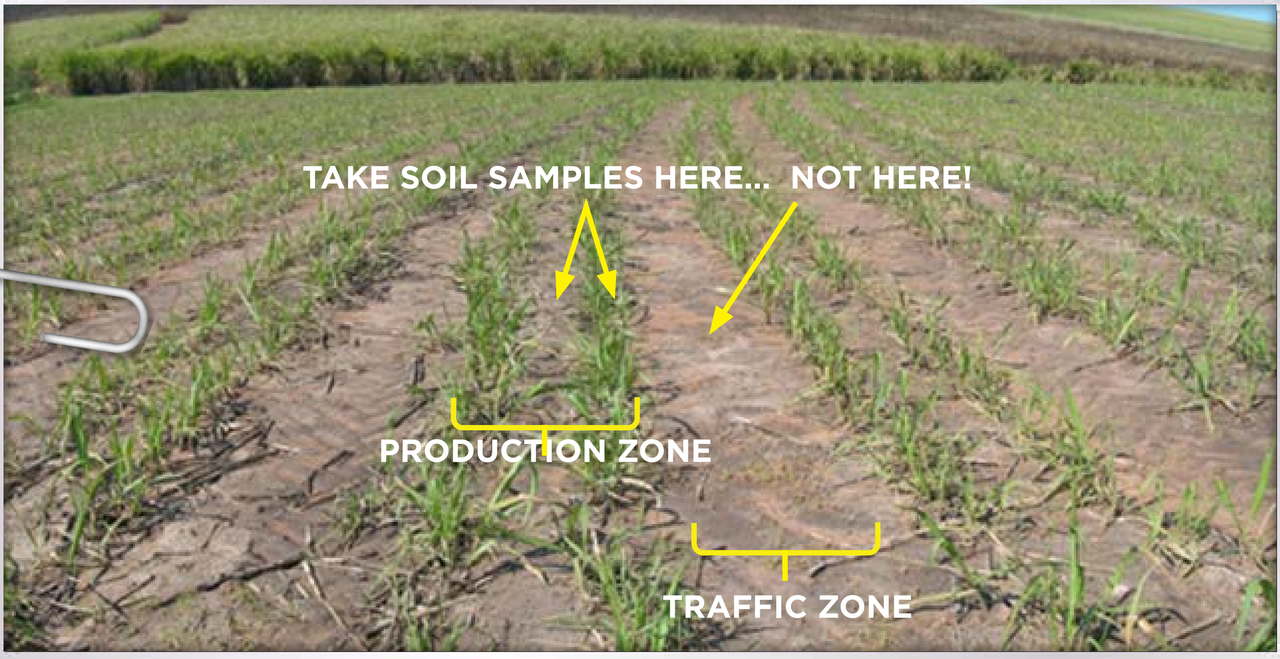


Figure 14: *Soil samples should be taken from the production zone, not from the traffic zone.*

*SASRI Information Sheet 7.16 provides detailed guidance on soil sampling.

4.2. Leaf sampling*

Leaf samples should ideally be collected from every ratoon crop, and at a suitably early stage of crop growth, to allow for possible nitrogen (N) deficiencies to be corrected by topdressing.

4.3. Application of fertilisers

When applying fertilisers in a controlled traffic cropping system, the application must be on the production zone and not on the traffic zone. Due to severe compaction in the traffic zone, there will be limited root growth in that area. Any fertiliser falling on the traffic zone will not move easily into the soil and will not be taken up effectively by the crop. The fertiliser will also be prone to erosion losses and denitrification losses where ponding occurs in the compacted zone. Therefore, to optimise returns from fertilisers, application methods and equipment will need to accommodate these considerations.

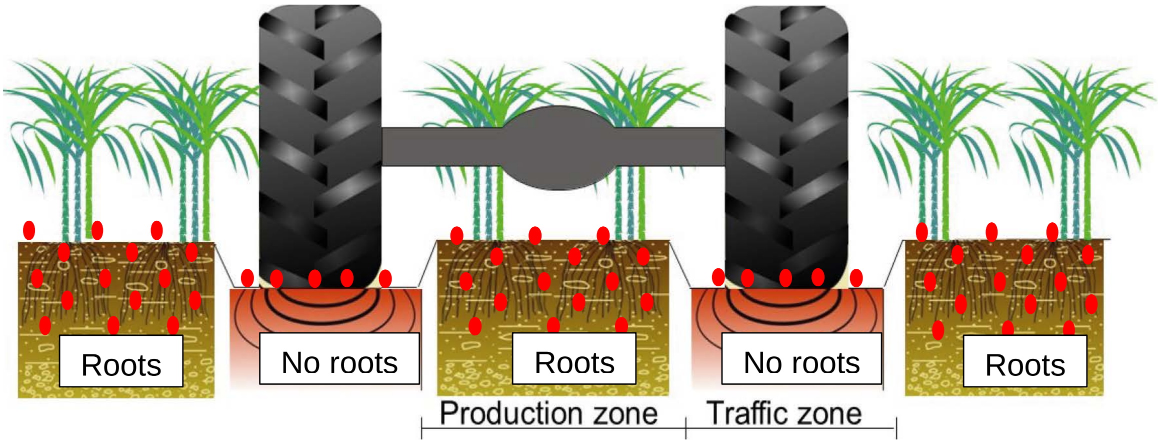


Figure 15: *Fertilisers should be applied on the production zone, not on the traffic zone.*

Each cane row in a controlled traffic system must be considered to determine the fertiliser to be applied. 'Mayfield' applicators or the 'tin and string' method are clearly ideal for applying nutrients only to the production zone of the controlled traffic operation. These may, however, need to be recalibrated to apply the correct amounts, and in some cases, it may be necessary to alter the application technique for a production zone carrying two or more cane rows. In this case, cane rows might have to be fertilised from two sides as walking on the production zone might be less comfortable than walking in the traffic lane.

*The method and timing of leaf sampling are outlined in SASRI's Information Sheet 7.15.

Figure 16a and b: *'Mayfield' applicators or the 'tin and string' method are ideal for applying nutrients only to the production zone of the controlled traffic operation.*

Tractor-mounted equipment will need to be adapted to concentrate the fertilisers on the production zone. In this respect, implements that broadcast fertilisers are not ideal.

If the fertiliser is band-applied, then the position of the fertiliser bands may need to be altered to that of the row spacing used in the controlled traffic system.

Figure 17: Tractor-mounted equipment will need to be adapted to concentrate the fertilisers on the production zone.

If fertiliser is incorporated, a dual cane row system may be able to share a common line in the centre between two closely spaced rows on the production bed. The wheel tracks of contractors' equipment (CMS, fertiliser, herbicide, etc.) should also match that of the crop row spacing and spacing of traffic zones.

For a change of row length per hectare, re-calibration of the amount of fertiliser to be applied is required for both manual and mechanical operations.

5. IRRIGATION

Control traffic systems can be implemented irrespective of the type of irrigation system used (flood, sprinkler, centre pivot or drip). Irrigation operation and maintenance do not radically change when converting to a control traffic system. Some irrigation systems, however, offer greater compatibility and alignment to controlled traffic systems. It may be opportune to modernise to a different irrigation system when converting to controlled traffic. In some instances, farmers adopt control traffic systems as a result of upgrading their irrigation system. See Table 3 for the impact of the different irrigation systems on various field operations.

5.1. Land Preparation

Irrigation systems do influence the shape and size of fields which will influence the travel paths of infield traffic. Flood and drip irrigation systems, for example, will typically comprise of long, narrow fields compared to the circular fields of centre pivots. Mechanical efficiencies (relating to length of run, number of turns, turning times, etc.) depend on the field/irrigation layout. These sensitivities must be considered when converting to a control traffic system. In flood irrigation, feeder open-canals are typically used to supply water to infield furrows. These open canals can inhibit the movement of vehicles, especially on entering or exiting a field.

In subsurface drip irrigation, GPS path guidance and mapping systems can be used for installation of the drip lines. Subsurface drip lines are usually installed before planting, or if mechanised, simultaneously with planting. By mapping the position of irrigation lines and the crop rows, subsequent vehicle activities (even in later ratoons) in the field are auto-steered to ensure that the sugarcane stools and irrigation equipment are not damaged. The auto-steering functionality is especially useful in mulched fields where the cane rows or irrigation lines are not visible. GPS path guidance systems are also useful during land preparation and allow for selective disturbance to the production zone and not to the traffic zones.

Where GPS path guidance and auto-steering systems are not used, it is often difficult to train tractor and vehicle drivers to stay off the sugarcane stools and drip lines. This is especially true when making use of independent harvesting contractors. In such cases, drip lines can be protected by using raised production beds, making it easier to distinguish between the traffic zone and the production zone.

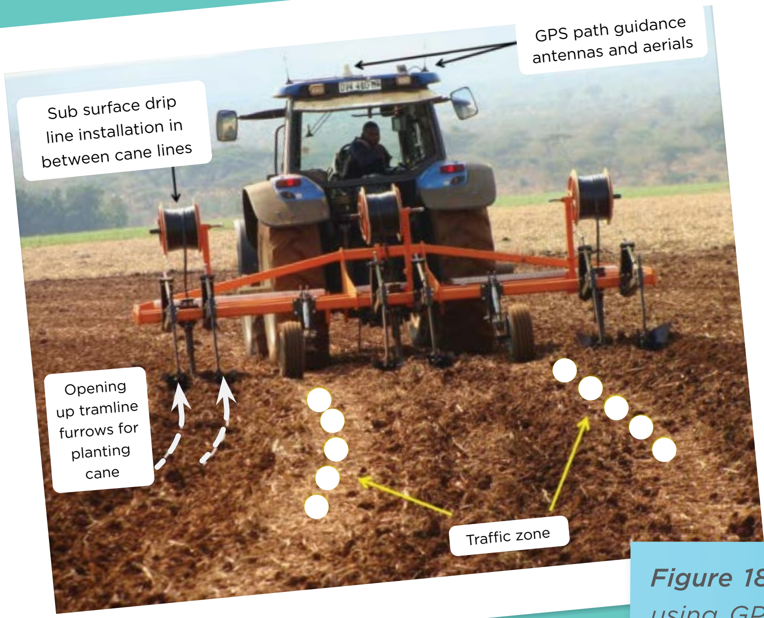


Figure 18: Subsurface drip installation using GPS path guidance in a control traffic system.

5.2. Break crops / Fallow crops / Green manure crops

Overhead irrigation systems, such as sprinklers and centre pivots, have no limitations for fallow or green manure crops. Drip irrigation, however, is limited to row crops. Hence, a drip system is well-suited to a sugarcane controlled traffic system but may not be appropriate for green manure crops which are not planted in rows. To combat the limitations with drip irrigation, some growers have timed the planting of green manures with seasonal rain to help the crop emerge, followed by using a pulsing regime of drip irrigation applications. Applying the water in pulses can allow for wider lateral distribution, depending on soil texture.

5.3. Planting

With overhead sprinkler systems (including centre pivots), growers can wet and soften the soil before preparing the soil for planting. This is not achievable with surface drip irrigation systems since dripper lines are usually placed during or immediately after planting. In the case of subsurface drip systems, labour must be careful not to damage the drip lines when cutting the cane stalks in the furrow during the planting operation. Care must also be taken to ensure that the dripper lines placed in interrows on the production bed can provide adequate water within reach of the germinating crop.

5.4. Fertigation

In modern systems such as drip and centre pivots where irrigation is uniform, fertilisers can be applied accurately through the irrigation systems. This functionality reduces the need for vehicle traffic in the field, also resulting in an economic benefit. In addition, fertiliser application can be split to better match crop demand (i.e. according to development stage and time of year) or variably applied at rates to irrigation blocks with different soils.

5.5. Field Maintenance

Controlled traffic systems offer the advantage of negating damage of drip lines or infield sprinkler hydrants since vehicles are limited to traffic lanes. However, surface drip lines are difficult to remove where the cane has lodged in fields with a tramline layout and will be damaged if the crop is burnt at harvest.

In fields with a tramline arrangement with a drip irrigation system only in the narrow interrow, weed pressure will be higher immediately after harvesting, and lower in the wider and drier traffic zone. However, weed pressure will be similar across the surface for overhead irrigation systems and following rain. The narrow interrow of a tramline layout will canopy quickly and shade out weeds reducing the necessity of a second herbicide application in this zone (an area represented by between 30 and 50% of the total surface area). Canopy development is slower in the wider traffic zone which will require follow-up weed control if wetted by overhead irrigation systems or rain.

5.6. Harvesting

Surface drip lines are typically removed before harvesting requiring more input from labour. If using subsurface drip, cutters must exercise care not to cut the buried dripper lines. In the case of mechanical harvesters, base cutting height must also be set such that subsurface drip lines and cane stools are not ripped out of the ground. The use of precision land levelling to ensure a smooth and constant slope can beneficially limit damage from mechanical harvesters, while simultaneously assisting with the management of excess surface water.

5.7. Loading & transport

The position of subsurface drip lines should be known, and infield traffic must be guided away from the irrigation equipment, especially when entering and exiting the field. Sprinkler irrigation hydrants should also be protected from vehicles. Some growers resort to widening the break line for irrigation laterals and place the lateral pipeline in the centre to accommodate heavy loading vehicles with wheels kept on either side of the irrigation hydrants, the widened irrigation lateral lines become dedicated tracks for heavy loading vehicles. Alternatively, others clearly mark sprinkler lateral lanes and keep heavy vehicles away altogether.

Table 3. *A summary of the impact of the different irrigation systems on various field operations.*

ITEM	FLOOD	SPRINKLER	CENTRE PIVOT	DRIP
LAND PREPARATION	Has implication for field layout and infield traffic. Dependent on rain to soften soil for land preparation before planting, including construction of furrows.	Protect sprinkler hydrants.	No limitations	Dependent on rain to soft-en soil for land preparation before planting. Install drip lines with GPS guided precise insertion, or use raised production beds to define cropped zone with drip lines. Use precision land levelling to minimise undulations that can cause mechanical harvesters to rip up drip lines and cane stools.
BREAK CROP	Limited to row crops.	No limitations	No limitations	Limited to row crops. Time planting to coincide with rainfall or use drip pulsing strategies to increase width of wetting onion.
PLANTING	No limitations	No limitations	No limitations	Care must be taken to ensure drip lines are not damaged when cutting cane stalks in the furrow during planting.
FERTILISER APPLICATION	No limitations	No limitations	Fertigation reduces the need for infield traffic. Also lends itself to precision application.	Fertigation reduces the need for infield traffic. Also lends itself to precision application.

Table 3. Continued: A summary of the impact of the different irrigation systems on various field operations.

ITEM	FLOOD	SPRINKLER	CENTRE PIVOT	DRIP
FIELD MAINTENANCE	No limitations	No limitations	No limitations	Both surface and subsurface drip on the tramline arrangement seem to result in slow canopy and therefore greater weed pressure on the traffic zone. Herbicide requires water to become active. Since drip wets small surface area, herbicide application is dependent more on rainfall. Some report lower weed pressure for drip because of less water in the traffic zone.
HARVESTING	No limitations	No limitations	No limitations	Labour cost and difficulty in removing surface drip line with tramline layout, especially in lodged cane. Danger of mechanical harvesters ripping out subsurface drip lines.
LOADING	Concrete feeder canals may inhibit the movement of vehicles.	Irrigation lateral lines (36 m apart) widened and marked for infield loading. Cane stacked away from laterals to protect the hydrants/hydromatic valves from traffic – hence by default it became a controlled traffic system.	No limitations	Heavy vehicles entering/exiting fields require enough headland space for turning to avoid damaging subsurface drip lines.

6. VARIETES, WEEDS AND PESTS

6.1. Varieties

All varieties are suitable for controlled traffic and will generally perform better under controlled traffic systems due to reduced stool damage. However, some varietal characteristics have management implications, e.g. some varieties are very upright. This means it will take longer to canopy in the wider traffic zone, and this gives weeds more time to establish.

6.2. Herbicide application

In fields with a tramline layout, the first herbicide application after harvest will be similar to fields with a conventional layout, but subsequent applications might require less herbicide because of possible quicker canopy in the close row spacing production zone. This equates to a potential saving of 30 to 50% on subsequent herbicide applications.

Adjustments to nozzle spacing may be required to overlap with the swath of the subsequent pass. Such adjustments require the equipment to be calibrated and checked for adherence to the nozzle manufacturer's recommendations for spacing, height and flow rate.

6.3. Nematicide application

No changes to nematicide application equipment are required. However, equipment must be recalibrated based on the new row spacing. As with fertilisers, application techniques for a production zone carrying two or more cane rows may have to be altered. Nematicides could be applied on both sides of the cane row, as it is easier to walk on the traffic zone than on the production zone. Make sure that the applicator is correctly calibrated for the new row spacing.

7. COSTS

Switching from a conventional field layout to a controlled traffic system will require an initial investment. It is not possible to include an estimated cost in a publication such as this due the number of variables involved and the volatility of costs. Additionally, the situation is different and unique to each farm and an estimate of costs might suit one farm but might be misleading to another. It is for these reasons that an economist should be approached for professional advice. Nevertheless, a list of variables and their possible impact on the cost is given in Table 4.

Table 4: *The expected economic impact of adopting the controlled traffic system compared to the conventional field layout system.*

ISSUES/PRACTICES/ EQUIPMENT	DIFFERENCE WHEN COMPARED TO THE CONVENTIONAL SYSTEM	ECONOMIC IMPACT OF THE CONTROLLED TRAFFIC SYSTEM
ROW LENGTH PER HECTARE	Depends on the row spacing of the current and new systems but row length is likely to be more.	Increased yields due to higher population for the first few ratoons.
SEEDCANE REQUIRED PER HECTARE	Depends on the row spacing of the current and new systems - likely to be more.	Increased planting costs – but will result in increased yields.
RATOONABILITY	Will be better compared to the conventional system due to reduced stool damage.	More ratoons per crop cycle.
FERTILISER PER HECTARE	No change as recommendations are based on a per hectare basis but application costs may be higher if the row length in the new system is greater.	Possibly higher application costs.

ISSUES/PRACTICES/ EQUIPMENT	DIFFERENCE WHEN COMPARED TO THE CONVENTIONAL SYSTEM	ECONOMIC IMPACT OF THE CONTROLLED TRAFFIC SYSTEM
HERBICIDES	Potential saving of up to a third of the area due to quicker canopy between the narrow-spaced rows of a tramline layout.	Reduced herbicide costs.
NEMATICIDES	Probably more if the total row length per hectare is longer than that of the conventional system.	Higher nematicide costs.
FUEL USE EFFICIENCY	Reduced wheel rolling resistance and driving over a firm surface will lead to better fuel use efficiencies.	Reduced fuel cost.
EQUIPMENT	All equipment currently used in a conventional system will suffice for a controlled traffic scenario. Small initial cost may be necessary to change wheel spacing. Important to ensure that wheel spacings are similar for all equipment.	Minimal once-off cost.
	In a mechanised system, small modifications may be needed e.g. for cane planters, fertiliser applicators, herbicide applicators.	Minimal once-off cost.
	In a mechanised system, new equipment may be needed such as bed formers and one should consider converting to slewing type loaders.	Cost could be substantial.
CROP YIELD	Will be higher due to reduced stool damage. Following planting, the early ratoons will yield even higher due to higher populations, but will eventually subside.	Increased yields.

SOUTH AFRICAN SUGAR ASSOCIATION

South African Sugarcane Research Institute

170 Flanders Drive, Mount Edgecombe, 4300

Private Bag X02, Mount Edgecombe, 4300

Tel: (031) 508 7400 **Email:** sasri@sugar.org.za

Website: www.sasri.org.za

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