

SOILS: A MANAGEMENT FACTOR IN SUGARCANE PRODUCTION IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Abstract

Results of research and observations over the years have shown that sugarcane management should differ substantially for the various soil forms with respect to practices such as land preparation, season of harvest, trash management, soil amendments, amounts of fertilizer, the use of agricultural chemicals, choice of cane variety and irrigation.

Introduction

There has been renewed interest in the classification of soils since the Department of Agriculture introduced the binomial system of soil classification for South Africa (MacVicar *et al*¹⁰) and with the SA Sugar Association Experiment Station's integrated system of soil classification which incorporates the original parent material system and the new binomial system (Meyer¹⁷).

The soils of the sugar industry differ substantially in their physical and chemical characteristics and one of the main reasons for developing a soil classification system is to enable farming areas to be mapped according to their land use capabilities so that appropriate agronomic practices can be followed.

Agronomic Practices

Land preparation and soil conservation

Cane fields are most vulnerable to soil erosion when they are ploughed and fallowed before replanting and before the plant crop has formed a complete leaf canopy. The highly erodible soils which are usually also very shallow are particularly vulnerable, but there are ways in which this potential hazard can be averted. It has been shown that deep tillage of soil when preparing land for planting is unnecessary in most soils of the Natal sugarcane belt (Moberly¹⁸). On highly erodible and poorly drained soils such as those of the Longlands form, the minimum tillage system, in which Roundup is used to kill the old crop, results in minimal soil erosion and improved cane yield when compared with the conventional system of preparing land (Moberly & Turner²⁰). In Mauritius, McIntyre *et al*¹² showed that cane yields increased where minimum tillage was practised in four trials on sloping land. Yield increases in subsequent ratoon crops have also been recorded in Natal and Mauritius. Soil which is lost through erosion cannot be replaced so every technique of preventing erosion should be employed. Minimum tillage is therefore recommended for erodible soils and sloping fields in the rainfed regions of the sugar industry. Soil form is undoubtedly the main factor determining the erodibility of soil, a characteristic which can be changed radically by mechanical operations. Arcadia or Swartland form soils for example, become as erodible as the weaker Cartref or Glenrosa forms when heavily worked. Erodibility ratings of some soil forms were reported by Platford²⁵ and are given in Table 1.

The minimum tillage system should be practised on the soils in Group 1 and preferably also those in Group 2, whereas on the Group 3 soils either system can be used. The recommended widths of the panels to be replanted are 35 m, 45 m and 55 m respectively for soil Groups 1, 2 and 3. In the highly erodible soils of Group 1, only a single panel on a hillside should be

TABLE 1
Erodibility ratings of some soils

Soil group	Soil depth	Soil form	Rating
1	Shallow	Mispah Longlands Westleigh Kroonstad Cartref	Very high to high
2	Moderate	Cartref Glenrosa Swartland Arcadia	Moderate
3	Deep	Fernwood Shortlands Hutton Inanda Griffin	Low

replanted at any one time but alternate panels may be replanted in soils of Groups 2 and 3.

Some soil forms are difficult to work when they are wet and those on which the minimum tillage system should be practised include Katspruit, Bonheim, Estcourt and Rensburg. The old crop is particularly difficult to eradicate mechanically in very sandy soils such as the Fernwood, Hutton (Clansthal) and Dundee forms and for this reason, chemical eradication and minimum tillage are again recommended.

Stool eradication

The importance of fields being free of volunteers at planting is well known but the methods of eradicating the old crop are not always effective and are affected by the type of soil. Eradicating the old crop with chemicals is effective only when treatment is applied to actively growing cane. Hence mechanical methods should be used during the dry winter months. In trials conducted by Dicks *et al*⁴ a shallow mouldboard ploughing followed by a discing or power harrowing was the most effective method of eradicating stools in a clay loam soil, and in a very sandy soil, a rotary hoe operating at a shallow depth was the most effective equipment.

Where chemical eradication of the old crop is considered to be too expensive and where labour is available, growers have resorted to hand hoeing or chipping which is very effective. Depending on the type of soil the operation requires between 30 and 50 labourers per hectare and as far as soil and water conservation is concerned this system is considerably superior to conventional ploughing but is not as effective as chemicals. The recommended methods of eradicating the crop from the various soil groups are given in Table 2.

Tilth and timing of seedbed preparation

With conventional land preparation the ease with which a good tilth may be obtained, and therefore the timing of the operation, is to a large extent dependent on soil type. For example good tilth is not easy to achieve in the black and red structured clays because they have a plastic consistency when wet and are hard and cloddy when dry. They can therefore only be satisfactorily worked over a narrow moisture range, usually

in spring under rainfed conditions. The consistency of the brown humic soils is not as sensitive to moisture change and these soils can be worked at almost any time of the year.

The final tilth preparation should be done only a day or two before planting. There is no need to prepare tilth deeper than 150 mm. In Table 3 the soil forms are grouped according to their consistency, the ease of obtaining a planting tilth and the recommended timing of the operation.

TABLE 2

Methods of eradicating the old crop for different soil forms

Soil group	Soil form	Comments
Grey (shallow)	Glenrosa Longlands Westleigh Kroonstad	Chemical spraying or hand chipping
Grey/Red (deep sands)	Fernwood Hutton (Clansthal) Cartref	Chemical spraying or hand chipping or rotary hoe (no rotary hoe on Cartref)
Grey/Black (bottomland)	Katspruit Bonheim Rensburg Willowbrook	Chemical spraying or shallow ploughing
All remaining non-erodible soils	Arcadia Shortlands Inanda, etc	Shallow plough or chemical spraying

TABLE 3

The timing and ease of soil tilth preparation for soil groups

Soil group	Soil description	Soil form	Consistency	Ability to obtain good tilth	Recommended time to prepare tilth
1	Grey sands Loamy sands	Fernwood Dundee Cartref	Soft when wet friable when dry	Easy	Any time
2	Brown humics	Inanda Kranskop Nomanci Magwa	Soft when wet friable when dry	Easy	Any time
3	Red loams	Hutton (Clansthal) (Shorrocks)	Soft when wet friable when dry	Easy	Any time
4	Grey sandy loams	Longlands Kroonstad Glenrosa Westleigh Estcourt	Soft to slightly plastic when wet, cemented when dry	Moderate	First spring rain
5	Red clay loams clays	Shortlands Hutton (Makatini)	Plastic when wet, cloddy when dry	Moderate	Spring
6	Black clays	Arcadia Bonheim Milkwood Rensburg	Very plastic and slippery when wet, hard and cloddy when dry	Difficult	Winter, early spring

Harvesting programme

The harvesting season usually extends from about April to January. If it lasts longer it includes some of the wet summer months when there is the danger of infield traffic causing soil compaction. Maud¹¹ showed that the tendency of most sugar-belt soils to become compacted is greatest when their moisture

content is near field capacity. At Pongola where a deep Makatini series soil of the Hutton form was severely compacted, bulk density increased and the macro pore space of the soil was reduced between 0 and 80 mm deep, but there was no adverse effect on the yield of ratoon cane (Johnston & Wood⁷). More recently, similar compaction treatments applied on soils of the Longlands, Westleigh and Katspruit forms caused severe yield reductions in ratoon cane (Swinford & Boevy²⁸).

When the grey, structureless, sandy loam soils (eg Longlands, Kroonstad, Westleigh and Glenrosa forms) are wet, infield traffic causes soil compaction, smearing, capping and physical damage to cane stools. Cane growing in these soils and in wet valley bottoms (eg Katspruit, Estcourt, Bonheim, Rensburg form soils), should also be harvested during the dry season. Soil compaction or damage to stools will be less severe on the free-draining, sandy or structured soils (eg Fernwood and Hutton forms), the brown humics (eg Inanda and Kranskop forms), and the red Hutton and Shortlands form soils. A suggested programme for harvesting according to soil group is given in Table 4.

TABLE 4

Suggested harvest programme based on soil groups

Soil group	Soil description	Soil form	Suggested harvest season
1	Valley bottom soils	Estcourt Katspruit Bonheim Rensburg	Winter
2	Grey sandy loams	Longlands Kroonstad Westleigh Glenrosa	Winter/spring
3	Clay and clay loams	Arcadia Tambankulu Milkwood Swartland Shortlands Hutton (Makatini)	Spring/summer
4	Brown humics	Inanda Kranskop Nomanci Magwa	Summer
5	Recent sands and alluvial soils	Fernwood Dundee Hutton (Clansthal)	Summer

Some fields with soils in Groups 3, 4 and 5 which are unlikely to compact severely should always be held in reserve for harvesting during wet periods.

Trash management

Soil type is one of many factors which influence the growth response of cane to a trash blanket. The soils which need the protection of a trash blanket most are the highly erodible, grey sandy loams on sloping ground. Experiments have shown that there is about a 6 ton yield response per hectare per annum to a trash blanket on these soils (Moberly & McIntyre²⁴) which is less than the average response of 9 tons per hectare per annum obtained from a cross-section of soils (Thompson²⁹). Where burning is inevitable, the recommendation is that the burnt tops be scattered as they provide a layer of mulch which protects the soil. In experiments conducted in the field, it was shown that scattering the tops was about 60% as effective as a full trash blanket in increasing cane yields (Moberly & McIntyre²⁴). The importance of a trash blanket or a thin mulch of scattered tops for each group of soils is shown in Table 5.

TABLE 5

Priority rating for a trash blanket or scattered tops for the soil groups

Soil group	Soil description	Soil forms	Rating	Comments
1	Grey sandy loams	Cartref Longlands Kroonstad Glenrosa Westleigh	High	Soils cap, become compacted, are highly erodible and have low intake rates; response to mulch is moderate
2	Red or dark-brown clay loams and clays	Shortlands Arcadia Milkwood Tambankulu Swartland Mayo Hutton	High	Response to mulch is greatest although soils are not highly erodible
3	Valley bottom soils	Katspruit Estcourt Bonheim Rensburg	Low	Soils are generally poorly drained and not likely to erode. Scattered tops will help prevent capping of Estcourt and Katspruit soils
4	Brown humic soils	Inanda Kranskop	Moderate	Not erodible, good intake rates, generally at higher altitudes with low winter temperatures so mulch is beneficial only in summer
5	Recent sands	Fernwood Hutton	Moderate	High intake rates, response to mulch is only moderate

TABLE 6

Recommendations for the use of filtercake at planting for the soil groups

Priority rating	Soil description	Soil form or area	Reasons
1	High P-fixing soils	Inanda Nomanci Magwa Kranskop Griffin Clovelly Hutton (Farningham)	The best responses including residual responses are obtained from the organic P in filtercake which is not readily fixed
2	Soils with a low P status	Midlands and virgin soils	The value of filtercake here is its high P content and it should be used at 30–40 t/ha applied in the furrow
3	All soils for winter and early spring planting		The high moisture content (about 70%) protects the seedcane from desiccation if planting rains are late
4	Heavy clay soils with coarse tith	Bonheim Rensburg Milkwood	Filtercake envelops the seed setts and reduces air pockets in a coarse seedbed
5	Recent sands	Fernwood Hutton (Clansthal)	The nematicide effect of filtercake is very shortlived

Soil Amendments and Nutrition

Soil analyses are essential for determining optimum nutrient requirements of the crop. A knowledge of the soil and soil system nevertheless allows some nutritional problems to be predicted.

Agricultural lime

Investigations by Reeve & Sumner,²⁶ Meyer,¹³ and Moberly and Meyer,¹⁹ showed that only the highly leached soils in the midlands (Hutton, Clovelly, Kranskop, Magwa, Nomanci and Griffin forms) are likely to require lime to neutralize the exchangeable aluminium which occurs at toxic levels. The soils

must be sampled well before replanting because if limestone is required, it must be mixed well into the soil to the depth to which it is ploughed before the cane is replanted.

Where the calcium and/or magnesium status of the soil is below the threshold level (common in Cartref, Fernwood, Hutton (Clansthal), Westleigh and the midlands soils listed above), dolomitic limestone may be applied to the surface of the soil and need not be incorporated.

Filtercake

Filtercake can result in worthwhile growth responses. Moberly & Meyer²¹ showed that where filtercake was applied in the planting furrow or broadcast prior to planting, substantial responses were obtained from cane grown in the midland soils which have an inherently low phosphorus status and where phosphorus fixation is commonly a problem (Meyer¹⁴). Where the phosphorus status of the soil is high, there is little to be gained from using filtercake unless it is used as a planting medium in winter or early spring or in clay soils where the planting tith is poor. Recommendations for the use of filtercake depending on soil forms, are given in Table 6.

Nitrogen

Laboratory studies (Wood^{31,32}) and field experiments (Leibbrandt,⁹ Meyer *et al.*,¹⁶ Moberly *et al.*²³) have shown that the amount of nitrogen available to the crop differs markedly between soils and is probably influenced by factors such as climate, aeration, moisture availability, organic matter and the depth of the soil. Differences in the response of ratoon cane grown in the Longlands, Mayo and Inanda form soils to nitrogen are shown in Figure 1.

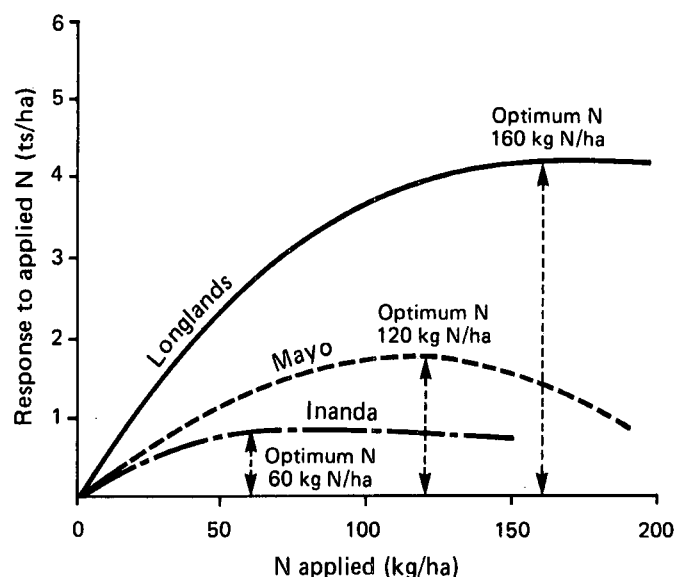


FIGURE 1 Ratoon cane responses to applied N in relation to soil form.

Available data suggested that the recommended amounts of nitrogen should be modified according to soil groups (Meyer *et al.*,¹⁶ Moberly²³). The ratio of nitrogen (kg) to be used per ton of cane expected in each of the soil forms is given in Table 7, but should be modified slightly according to factors such as soil depth and moisture availability.

Phosphorus

The midland soil forms (Inanda, Griffin, Magwa, Kranskop, Hutton and Clovelly) fix large amounts of phosphorus (Meyer¹⁴) so they should be thoroughly sampled prior to planting to determine their phosphorus fertilizer requirements. These were established during field trials conducted by Meyer & Dicks.¹⁵

TABLE 7
Nitrogen recommendations for cane based on soil form

Soil group	1	2	3	4
Soil form	Fernwood Cartref Longlands Westleigh Kroonstad Katspruit Glenrosa (light) Estcourt Sterkspruit Dundee	Glenrosa (heavy) Clovelly (light) Hutton (light) Oakleaf Swartland Bonheim Valsrivier Tambankulu Willowbrook Rensburg	Milkwood Mayo Inhoek Arcadia Hutton (moderate) Shortlands	Champagne Inanda Nomanci Kranskop Magwa Hutton (humic phase) Clovelly (humic phase) Griffin (humic phase)
Plant kg N ^{ha}	120	100	80	60
Ratoons kg N ^{ha}	1,6	1,3	1,0	0,8

Potassium

The optimum amount of potassium fertilizer which must be applied can only be determined by soil analysis. The amount of exchangeable potassium in clay loams and clay soils can be increased by the application of potassium fertilizer but only a small amount can be retained in sandy soils. The soil forms which are inherently low in exchangeable potassium, and in which there is little capacity for potassium to be held in the soil, are the Fernwood, Hutton (Clansthal series) and Cartref. Cane growing in these soils requires the highest amounts of potassium fertilizer (175 to 200 kg/ha). Other soil forms which are inherently low in exchangeable potassium, but in which the potassium reserve can be improved slightly over the years, are Longlands, Kroonstad, Westleigh, Katspruit, Glenrosa and Estcourt.

Leaf analysis

Leaf sampling should be concentrated on those crops growing in soils with inherent nutrient deficiencies; in soils which fix large amounts of phosphorus; or in soils that mineralise particularly large or small quantities of nitrogen. The third leaf nutrient status of cane growing in poorly drained soils or some of the humic soils (eg Inanda form), where zinc is likely to be deficient, should also be monitored regularly so that deficiencies or excessive levels can be recognised and corrected.

Agricultural Chemicals

Herbicides

A trash blanket or the use of herbicides is strongly recommended for controlling weeds on the highly erodible soil forms such as Cartref, Longlands, Kroonstad, Glenrosa, Westleigh and Katspruit, particularly on sloping land.

The amounts of herbicides to be used (particularly those which are applied to the soil for absorption by the germinating seed and the roots), vary according to soil type. Products such as Bimate, Velpar, Lasso, Dual, atrazine, Sutan Plus, Eptam Super and diuron should be used at high rates (Anon¹) on the brown humic soils of the midlands and the red and black clay loams and clays. The lowest rates should be used in the loamy sands and sandy loams. In the very weak sandy soils (clay < 5%) Donaldson and Turner⁶ showed that for plant cane, only the true pre-emergence herbicides should be used in conjunction with nematicides to avoid possible harmful interactions with the long term post-emergent herbicides.

Nematicides

Yield responses of cane to treatment with nematicides are worthwhile when they are applied to some weak sandy soils.

It is not always easy to establish which fields warrant treatment with these expensive chemicals, but responses to Temik are greater when applied to a Fernwood form soil than in a Clansthal series soil of the Hutton form (Moberly and Clowes²²). As a guide, any soil which contains less than about 8% clay may harbour parasitic nematodes which cause losses in cane yield. As the clay content declines from 8%, the probability of a response to treatment with nematicides increases. Yield responses to treatment with nematicides are likely to be obtained from cane growing in the soils shown in Table 8.

TABLE 8

Soils in which treatment with nematicides may be warranted

Priority rating	Clay %	Soil form
1	1-5	Fernwood Cartref Dundee
2	6-8	Clansthal Cartref Shepstone Longlands Kroonstad

Chemical ripeners

Ethrel and Polado are effective chemical ripeners of immature, actively growing cane. Ethrel should be used on cane which is harvested during the early part of the milling season and Polado on cane which is to be harvested early and late in the season (Rostron,²⁷ Clowes²). Polado should not be applied to cane which is stressed or which is likely to be stressed between the time of spraying and harvesting (Clowes & Inman-Bamber,³ Donaldson & Inman-Bamber⁵). In the rainfed areas of the sugar industry it is difficult to predict the probability of moisture stress occurring after the time of spraying, but a useful guide is the soil type and its estimated total available moisture (TAM). Soils with a low TAM on which the use of Polado could be hazardous, are shown in Table 9. The depth of the soil affects TAM. There are a few deep soils of the Longlands form with moderate amounts of available moisture and some shallow soils of the Shortlands form which make treatment with Polado hazardous.

TABLE 9

Soils on which cane in the rainfed areas should not be sprayed with Polado

Soil group	Soil form	Reasons for Recommendation
1	Fernwood Hutton (clay % < 8) Dundee (clay % < 8)	Stress due to nematodes
2	Cartref, Kroonstad, Longlands, Westleigh, Estcourt, Katspruit, Wasbank, Glenrosa, Swartland, Mispah, Milkwood	Low TAM

Varieties

Guidelines for the varieties suited to soil types in the rainfed areas of the cane belt are given in Table 10. In the northern semi-arid irrigated areas the incidence of smut disease is the overriding criterion for selecting varieties.

TABLE 10

Recommended varieties for the rainfed areas based on soil form

Soil group	Soil description	Soil form	Varieties
1	Very weak sands clay % 3	Fernwood	N8: more tolerant of nematode damage but susceptible to smut and rust
2	Weak sands clay % 3-5	Fernwood, Cartref, Dundee	N8, N13: both susceptible to smut and N8 to rust
3	Shallow soils and those with low TAM	Mispah, Swartland, Milkwood, Glenrosa, Longlands, Kroonstad, Westleigh, Wasbank, Cartref	N12 then N7 and N13: N12 is more drought tolerant than NCo 376; N7 and N13 slightly more tolerant
4	Deep loams, clay loams and clays with good TAM	Arcadia, Hutton, Mayo, Shortlands	NCo 376, N12, N14: high yield potential
5	Valley bottoms	Dundee, Inhoek, Bonheim, Rensburg	J59/3, N52/219 if smut is endemic and if eldana and drainage are not a problem. NCo 310 in smut-free areas
6	Brown humic to semi humic midland soils	Inanda, Kranskop, Nomanci, Magwa, Hutton, Griffin, Clovelly	N12 primarily with NCo 376 and NCo 293 where mosaic is not endemic

TABLE 11

Available moisture capacities of a range of soils

Soil group	Soil description	Soil form	Available moisture capacity (mm/metre)
1	Grey	Fernwood Estcourt	50- 80
		Katspruit Longlands	60- 90
		Kroonstad Dundee Glenrosa	70-110
		Swartland	80-100
2	Red	Hutton(Shorrocks)	100-150
		Shortlands	
3	Black	Arcadia	80-120
		Bonheim	
		Mayo	

Irrigation

Factors to be considered when deciding on an irrigation system include the terrain and soil type, the frequency of irrigation cycles, and precipitation rates. The cheaper furrow irrigation system is not efficient where soils have a low TAM (Estcourt, Longlands, Katspruit, Glenrosa, Wasbank, Kroonstad forms), or a very high infiltration rate (Fernwood and some Dundee soils). Furrow irrigation is most effective in soils with a deep profile, a moderate to high TAM, and with either a low or moderate intake rate (Shortlands, Hutton, Arcadia, Oakleaf, Milkwood, Rensburg, Bonheim forms).

Overhead sprinkler irrigation can be used successfully on the majority of soils but where the TAM is low and where a very

short cycle time is needed (three to five days in summer for the Fernwood or Estcourt soil forms), subsurface or drip irrigation may be contemplated. The range in available moisture capacities that can be expected for some soil forms is given in Table 11. These amounts are calculated from available moisture capacity in mm/m between 0,1 and 15 bars (Johnston⁸) and an estimate of the effective rooting depth for the given soil forms.

Drying off

Before an irrigated crop is harvested it may be subjected to a period of drying off (Thompson³⁰) but this should not be severe where Polado has been applied. The length of the drying off period depends on season and soil type; a deep Hutton soil with a TAM of about 200 mm must be dried-off for 8 to 10 weeks in winter and 4 to 5 weeks in summer, whereas an Estcourt soil form with a TAM of about 50 mm needs only a quarter of this time. The TAM of the soil in each field must be known and figures more precise than those given in Table 11 can be obtained from a soil physics laboratory and from observations of effective rooting depth.

Drainage Problems

The Bonheim, Rensburg, Estcourt and Katspruit soils are the most likely to require the installation of drains of some kind. These are followed by the Wasbank and Longlands soils followed by Westleigh, Kroonstad, Cartref and Tambankulu soils. The Bonheim and Estcourt soils are particularly prone to salinity/sodicity which invariably develops where drainage is not adequate.

Discussion and Conclusions

Agronomic practices are likely to become more varied as our knowledge of soils increases. If soils are adequately conserved and their management is appropriate to their characteristics then their productivity and hence the profitability of the farming operation must be substantially greater. Many decisions have to be made when a programme of operations is planned for a farm and they should, to a certain extent, be influenced by soil type. For example, to remove peak demands for tractors or labour, it may be necessary to change the timing of certain operations, which in turn, will be influenced by soil type. If the chipping technique is used to eradicate a crop on an erodible Cartref form soil in winter, this could make efficient use of labour at a time when the demand for manual workers is low. On the other hand, if Roundup is used on cane growing on a Fernwood soil in summer, instead of ploughing and harrowing the soil, a tractor could be released during a period of peak demand.

An attempt has been made to categorise soils according to such characteristics as their texture, limitations and management requirements (see Appendix I). To do this on the basis of individual soil forms would be complicated, and a concept of grouping soils by means of simple colour/texture criteria has been introduced. This omits much of the detailed information that is available concerning each soil form, but provided the most important management practices for each soil group are carried out, a useful start to the practice of management according to soils will have been made.

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APPENDIX I

Soil groups according to colour and texture as an aid to management

Group	Texture	Forms	Limitations and management requirements
Grey	Sandy loams on impervious subsoil	Longlands Westleigh Kroonstad Katspruit Estcourt	Low TAM : Good irrigation control, Polado hazardous in rainfed areas Poorly drained : Soil levelling and subsurface drains Low intake rate : Surface levelling, trash blanket or scattered tops Highly erodible : Minimum tillage, trash blanket or scattered tops Very compactible : Winter harvest Salinity/sodicity hazard : Install drains and soil sample down profile Low soil N & K reserves : Relatively high amounts of N and K, regular leaf sampling Low rainfall/irrigation efficiency : Variety N12
	Sand	Fernwood	Parasitic nematodes : Nematicides essential, variety N8 Sand drift and blasting of plant cane : Minimum tillage Low K reserves : Relatively large amounts of K Weed problems due to slow canopy : Close row spacing, use pre-emergent herbicides
	Loamy sands	Cartref Glenrosa Mispah	Parasitic nematodes : Nematicides where clay % < 8 Low TAM : Trash blanket or scattered tops, Polado hazardous Highly erodible : Minimum tillage, winter harvest Low rainfall/irrigation efficiency : Good irrigation control, variety N12 Low soil N & K status : Relatively large amounts of N & K, regular leaf sampling
	Loams on blocky clay	Swartland Valsrivier	Severe moisture stress : Trash blanket and irrigation (large responses) Planting tilth difficult : Winter plough, spring plant, use filtercake or water planting
Black	Blocky clay over gley	Willowbrook Bonheim Rensburg Tambankulu	Poor drainage, salinity/sodicity : Subsurface drains or cambered beds Moderate TAM : Good irrigation control, surface levelling Cane extraction difficult : Winter harvest Planting tilth difficult : Spring planting, use filtercake or water planting Herbicide adsorption : High rates of soil applied herbicides
	Blocky clay over weathering rock	Arcadia Milkwood Mayo	Severe moisture stress : Trash blanket and irrigation (large response) Planting tilth difficult : Winter plough, spring plant Herbicide adsorption : High rates of soil applied herbicides
Brown humic	Clay loams	Inanda Nomanci Kranskop Hutton (Farningham) Clovelly Griffin	Al toxicity, low Ca, Mg : Comprehensive soil sampling to determine lime requirements P low and fixation a problem : High levels of P commonly required Zn may be low : Soil and leaf sampling important High soil N : Use low rates of N
Red	Loamy sands to clays	Hutton (Clansthal) (Shorrocks) Shortlands	Parasitic nematodes in sandy soils : Nematicides where clay % < 8 Planting tilth difficult in heavy soils : Winter plough and spring plant in heavier soils Relatively high soil N : Use moderate levels of N