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SOILS OF THE EASTERN TRANSVAAL SUGAR INDUSTRY AND SOME ASPECTS OF THEIR MANAGEMENT

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Abstract

The nature and distribution of soils in the Eastern Transvaal sugar industry are reviewed. Differences between the chemical and physical properties of the most important soil forms are considered, and their role with regard to various management practices such as land preparation, irrigation, drainage, time of harvest and use of fertilizers are discussed. Future requirements and research needs are also highlighted.

Introduction

Although the Eastern Transvaal sugar industry is located several hundred kilometres from the traditional cane belt in Natal, it forms an integral part of the economy of the South African sugar industry. In 1965, Maud and Von der Meden[11] identified the main soil series in the region as well as their moisture release characteristics. This was followed in 1969 by an intensive soil survey, in which the parent material on each farm was mapped (MacVicar and Perfect[9]). However, it is only recently that research results have shown that there is considerable merit in using the "soil form" based on the binomial system of classification (MacVicar and de Villiers[10]) to rationalise sugarcane management (Moberly and Meyer[15]). Increased interest in the binomial system of classification led to the revision in 1984 of the Experiment Station's bulletin on the identification of soils of the sugar industry (Anon[1]).

Location and climate

Most of the sugarcane is produced in the lower Crocodile valley. The area extends eastward as a long narrow belt from Kaapmuiden in the west, past Malelane and Hectorspruit to Komatipoort (Fig. 1). In the east, sugarcane is grown also in areas adjacent to the Komati and Lomati rivers. On the Lomati river the area of cultivation extends into a region of higher rainfall south of Malelane in the Kaalrug area. The region is one of hot summers and mild winters with a mean annual rainfall between 500 and 700 mm, while Class A pan evaporation varies from 1900 to 2100 mm.

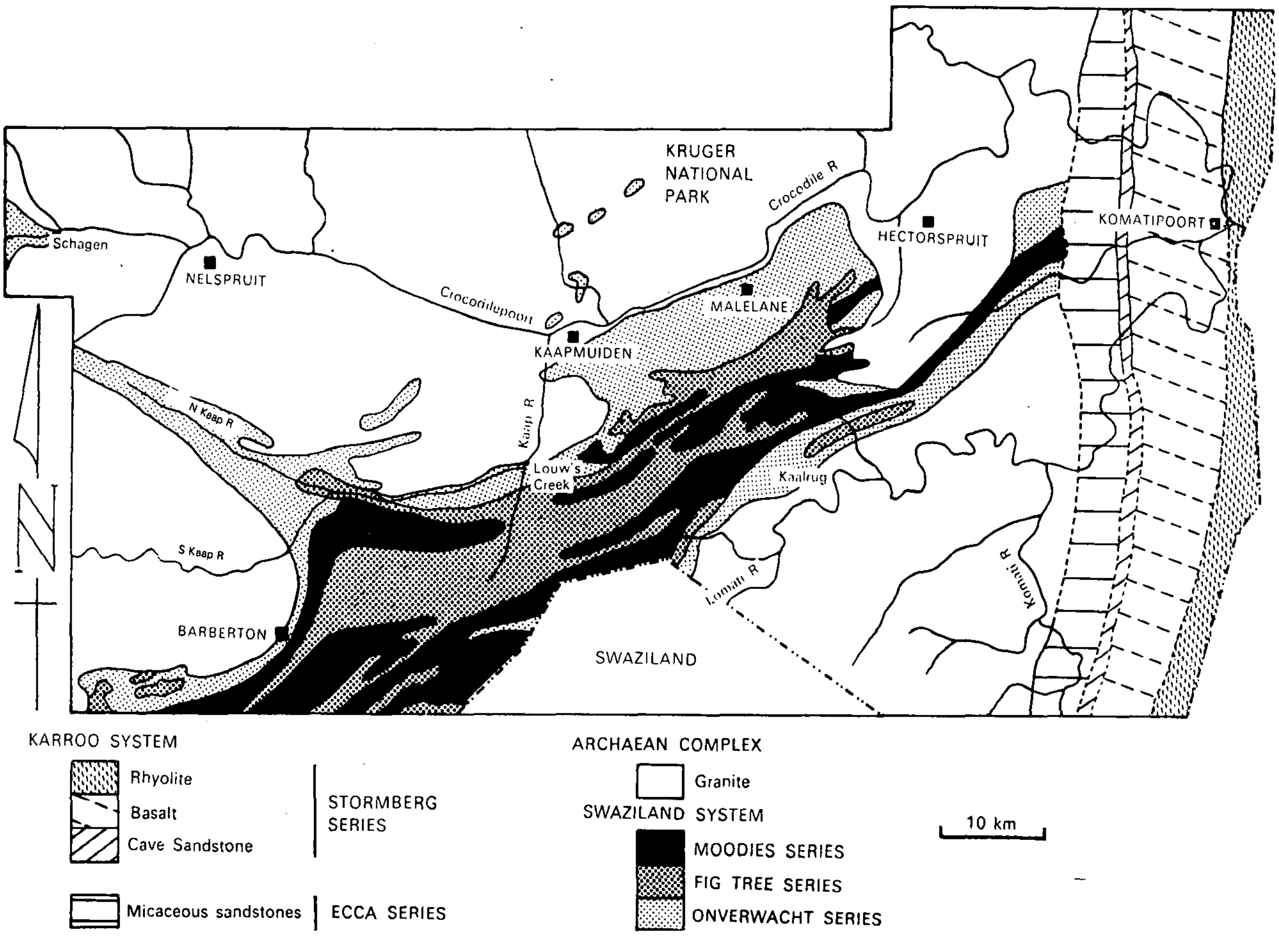

FIGURE 1 The geology of the Eastern Transvaal Sugar Industry (information taken from maps of the *Geological Survey*, Republic of South Africa

Nature and occurrence of soils

As with soils of the Natal sugar belt (Beater[5]) those in the Eastern Transvaal reflect very closely the geology of the area, which has been described in detail by MacVicar and Perfect[9] (see Fig. 1). It is evident from the descriptions of soil profiles made by Maud and von der Meden[11], and MacVicar and Perfect[9] that the soils may be roughly divided into three broad groups, based mainly on differences in colour and the nature of the parent material, as summarised in Table 1. These include:

- red-to-brown free-draining loams to clays of varying depth with stone inclusions derived mainly from Swaziland basic rocks, basalt and old alluvial terrace materials. This soil group comprises about 60% of the area under cane
- grey sands to sandy clay loams, some free-draining but many with restricted internal drainage, derived mainly from granite, recent alluvial deposits and Cave Sandstone. This is the second most extensive soil group occupying about 25% of the area
- black swelling clays, many with restricted drainage derived mainly from basalt and heavy alluvial deposits comprising about 15% of the area.

Representative soil forms and series from various locations, together with their selected physical and chemical properties, are given in Appendix I.

Red soils

Red clays: The majority of soils belong to the Glendale and Argent series within the Shortlands form. The Glendale series predominates in the drier parts of the region, particularly along the south bank of the Crocodile river from Kaapmuiden past Malelane, and extensively at Komatipoort, particularly on Tenbosch Estate. The Argent series is dominant in the elevated areas around Kaalrug. Depth to weathering rock varies from a few centimetres on stony ridges to about 1500 mm on undulating plains. These soils have good water intake rates (5 to 7 mm/h), are well-drained, and where they are deep and the volume of included stones is less than 20%, available moisture capacity ranges from 120 to 150 mm/m. They mineralise substantial amounts of nitrogen (N), are fairly well-supplied with calcium (Ca), magnesium (Mg) and potassium (K), and are subject to few leaching or denitrification problems. Salinity may develop with poor irrigation control and where the land surface is uneven.

Red loams: the dominant soil form is Hutton, though in the drier areas the soils are mainly of the Shorrocks series, gritty and usually less than 1200 mm deep. They are generally very porous. Available moisture capacity (AMC) is in the region of 150 to 170 mm/m. These soils have moderate reserves of Ca, Mg and K while the N mineralisation potential is well above average.

Grey soils

The granite-derived grey medium to coarse grained loamy sands to sandy loams occur extensively in the Crocodilepoort, Lomati plain and lower Kaap valley areas. Seven soil forms have been identified and these show a close relationship with position in the toposequence. The shallow Mispah and Glenrosa form soils occupy the crest position and in turn are replaced by the deep Cartref form soil in the midslope position. In lower slope to bottomland areas the soils become progressively more hydromorphic and forms such as the Kroonstad, Longlands, Estcourt and Katspruit predominate. These soil forms are characterised by severe physical and chemical limitations which include: low waterholding capacity (50 to 80 mm/m), high erodibility hazard, slow water intake rate and restricted internal drainage, poor aeration at depth, proneness to compaction especially when wet, low reserves of nutrients (especially N), high salinity/sodicity hazard, and a nematode hazard (where clay content is less than about 8%).

Black soils

The black blocky clays are uncommon and are found mainly in the Komatipoort area. The soils range from moderately shallow black cracking clays of the Arcadia form to wet sticky clays of the Rensburg form in bottomland areas. The black clays, if more than a metre deep, usually exhibit the

Table 1
Nature and distribution of soils in the Eastern Transvaal sugar industry

Main soil group	Extent (%)	Main soil forms	Main parent materials	Overall extent (%)	Approximate distribution (% parent material in each area)					
					Schagen to Nelspruit	Malelane	Hectorspruit	Komatipoort	Kaapmuiden to Louws Creek	Kaalrug
Red to brown sandy loams to blocky clays	62	Hutton	Swazi basic rock	39	20	60	28	3	50	44
		Shortlands	Basalt/diabase	18	-	10	12	55	6	1
		Hutton	Mixture of granite and Swazi basic rock	3	10	5	3	-	5	5
		Hutton/Oakleaf	Alluvium (old terraces)	4	10	5	7	10	3	6
Grey gritty loamy sands on rock to sandy loams on heavy clay	25	Mispah Glenrosa Cartref Longlands Kroonstad	Granite	18	45	15	40	10	20	7
		Estcourt	Middle Ecca and Cave	0,5	-	-	-	-	-	5
		Katspruit	Sandstone	0,5	-	-	-	-	-	5
		Fernwood Dundee	Alluvium (recent)	6	15	5	7	6	-	4
Black blocky clays on rock to clays on gley	13	Arcadia Milkwood	Diabase/basalt	9	-	-	3	10	10	16
		Bonheim Tambankulu	Swazi basic rock	2	-	-	-	1	1	1
		Willowbrook Rensburg	Alluvium	2	-	-	-	5	5	6

phenomenon of 'self-mulching', caused by swelling and shrinking of montmorillonite under conditions of varying moisture content. These soils are well supplied with Ca and Mg, have moderate reserves of P and K, and can mineralise substantial amounts of N.

The main limitations of these soils are: moderate water-holding capacity (130 to 150 mm/m), low capillary conductivity, high shrink/swell potential, plastic when wet, cloddy when dry, low water intake rate when wet, slow internal drainage, sensitive to sodium, and a moderate to high salinity hazard where drainage is poor (mainly Rensburg form).

Management of soils in the lowveld

A knowledge of soils can assist in improving cane management practices. The limitations of lowveld soils are summarised in Appendix II. Clearly the grey soil group has the most severe limitations, followed by the black (moderate) and red (slight) soil groups. The management practices on the grey group merit most attention.

Land preparation

When land is prepared for re-establishment of cane the two most important objectives are to ensure the destruction of the old cane stool and the timeous preparation of the seedbed for planting. A knowledge of soil type can help the grower to decide the best way to achieve these objectives.

- *Stool eradication:* This can be done by conventional ploughing or by minimum tillage. In the dry winter months the accepted method of killing the old cane stool on loams and clay soils is by using a mouldboard plough fitted with a depth control wheel to ensure a constant shallow plough depth of 75 to 100 mm (Shortlands, Hutton, Arcadia and Rensburg forms). On very sandy soils two shallow passes of a rotary hoe are more effective in destroying the old crop (Glenrosa, Cartref, Kroonstad, Longlands forms). Minimum tillage techniques (Moberly and Turner[16]) based on chemical eradication of the crop during the hot summer months can also be used. The technique is most effective in structureless, lighter textured soils. On deep heavy clays cane growth and weather conditions need to be ideal if chemicals are to kill the old stools effectively.
- *Tilth and timing of seedbed preparation:* Good tilth is difficult to achieve in black and red structured clays. These soils have a plastic consistency when wet and are hard and cloddy when dry. They can be satisfactorily worked only within a narrow moisture range. However, the red and grey light textured soils are not as sensitive to moisture change and can be worked at most times of the year (Moberly and Meyer[15]).

Fertilizer requirement

- *Nitrogen:* Soils of the lowveld vary considerably in the amount of N they can release to the cane crop by mineralisation of soil organic matter (Wood[19]). Results of numerous fertilizer trials have shown that the N requirement of cane can be reliably estimated from a knowledge of soil form and organic matter content. Lowveld soils have been classified into three categories (low, medium, and high) according to their potential to mineralise N from soil organic matter for crop use (Meyer *et al*[13]).

A knowledge of soils can also assist in deciding which N carrier to use. For example, anhydrous ammonia is not recommended where soil texture makes sealing the tine furrow difficult, as in the heavy black clays (Rensburg form) or shallow light coarse sandy grey soils with stone inclusions (e.g. Mispah form). Urea is recommended for all soils with pH values below 7,5 and ammonium sulphate in soils with pH values of 7,5 and above where volatilization losses are likely, while ammonium nitrate should be avoided on very sandy soils. Split applications of N fertilizer are recommended in poorly drained soils (Rensburg, Katspruit forms) in order to minimise N losses due to denitrification. Also in excessively drained grey sandy soils (Mispah, Cartref, Glenrosa forms) large N losses may occur from leaching.

- *Phosphorus:* The 1969 soil survey showed many of the Shortlands and Hutton form soils to be inherently low in available P, particularly where they occur in the wetter areas around Kaalrug. Some of the Arcadia form soils with free lime at depth, in the drier areas around Komatipoort, are also low in P and strongly P fixing. Meyer *et al*[14] showed that cane in the Eastern Transvaal was generally well supplied with P, with less than 15% of leaf samples being P deficient. Soils derived from Swazi basic rocks were most prone to P deficiency and often exhibited P fixation.
- *Potassium:* The grey sandy soils are generally low in K reserves and cane growing on these soils usually requires an application of K fertilizer to every crop. K reserves range from moderate to high in the red and black clays, but many of them contain 2:1 lattice clay minerals which are able to fix significant amounts of potassium (Wood and Meyer[20]). Recent results from N/K fertilizer trials in the Eastern Transvaal, Swaziland and Pongola confirmed that the existing 150 ppm soil K threshold value was too low for these heavy textured soils (Donaldson *et al.*[6]). Consequently the K threshold value for soils in the irrigated cane areas with more than 40% clay content and with melanic and heavy red orthic A horizons (Arcadia, Bonheim and Shortlands forms) was increased to 225 ppm (Anon[3]).
- *Sulphur:* Low sulphur (S) levels (less than 15 ppm) have been found on both red (Hutton) and grey granite-derived soils (Meyer[12]). A recent survey revealed that about 30% of both soil and leaf samples had marginal to deficient S contents (Meyer *et al.*[14]).
- *Minor elements:* Soil zinc reserves are from moderate to high in the red and black clays but generally low in the grey granite-derived sand. Iron chlorosis occurs in ratoon cane growing in the heavier soils of neutral to alkaline pH, and spraying with ferrous sulphate is necessary.

Irrigation

Soils should influence the choice of irrigation system, water application rates, frequency of irrigation cycles, suitability of water quality and cane drying off programmes. The cheaper furrow irrigation system is not efficient where soils have a low total available moisture (TAM) capacity (e.g. Estcourt, Longlands, Katspruit, Glenrosa forms) or a very high infiltration rate (Fernwood and some Dundee form soils). Overhead sprinkler irrigation can be used on most soils. Moberly and Meyer[15] indicated the range in AMC that can be expected on various soil forms. Before an irrigated cane crop is harvested it may be subjected to a period of drying-off (Thompson[18]) and a knowledge of soil form can assist in determining the length of the drying-off period where natural ripening is practised, e.g. a deep Hutton soil with a TAM of about 200 mm must be dried-off for eight to ten weeks in winter and four to five weeks in summer, whereas an Estcourt form soil with a TAM of about 50 mm needs only a quarter of this time.

Drainage and salinity

Irrigation control has been cited as one of the main practices requiring attention in the Eastern Transvaal (Anon[4]). Over-irrigation will lead to excessively wet conditions where drainage is inadequate, and eventually will result in salinisation. While drainage problems are unlikely on the red soils, the grey granite-derived soils of the Katspruit, Estcourt, Sterkspruit, Longlands and Kroonstad forms and black soils of the Bonheim and Rensburg forms are likely to require drainage. In 1971 the area affected by poor drainage was estimated to be 1325 ha or 14% of that under cane (Macvicar[8]). However, it is likely that the area is more extensive as apparently only soils derived from granite were considered. Factors such as low daily evaporation, due to reduced sunshine hours which occurred during the 1987/88 season, could exacerbate the wetness problem, as relatively few growers use an efficient irrigation control system.

Salinity/sodicity hazard is particularly high in the granite-derived soils as they are well supplied with feldspar minerals rich in sodium, and sodicity problems have been identified on granite soils in lower slope positions in the Louws Creek and Kaapmuiden areas.

Time of harvest

The harvesting season in the Eastern Transvaal is usually from April to December/January and includes some of the wet summer months which increases the danger of infield traffic causing soil compaction. The grey structureless Glenrosa, Longlands, Kroonstad and Westleigh form soils are particularly prone to compaction when wet and infield traffic causes smearing, capping and physical damage to cane stools (Swinford and Boevey[17]). Compaction and stool damage have also been observed on the free draining Hutton and Shortlands form soils (Anon[2]). On these deep irrigated red soils which have a high TAM, the drying off period prior to harvest could be extended to 8 or 10 weeks, or even longer in winter, rendering them less susceptible to compactive effects.

Future requirements

- To improve irrigation control in the Eastern Transvaal region wider use of the irrigation scheduling board described by George[7] should be considered. Improved yields and more efficient water use have resulted where this system has been implemented on farms at Pongola.
- Field boundaries should be rationalised in relation to soil form boundaries, in order to make TAM values more uniform. This would help minimise problems of over-irrigation and under-irrigation in the same field.
- Surface and subsurface drainage should be emphasised, particularly on the salinity prone granite soils in low lying areas.
- A survey is required to determine more accurately the extent of drainage and salinity/sodicity problems.
- Techniques such as vertical mulching and ridging to improve drainage in the grey soils need evaluating, while mole drainage should be practised in the bottomland black clays.
- There are indications that crop re-establishment is occurring more frequently on the grey soils which could be related to their physical degradation. Minimum tillage should be practised on these soils to help maintain structure and organic matter content.
- Consideration should be given to surveying Eastern Transvaal sugar industry soils using a system of mapping units based on the categories given in Appendix 2.

Conclusions

As the large variations in the chemical and physical properties of Eastern Transvaal soils are taken into account by growers, various management practices are likely to be more widely used. Other practices which are also affected by soil conditions include the choice of cane varieties, certain weed and pest control measures and the use of chemical ripeners (see Appendix 2). Growers should be encouraged to use a knowledge of soils, as with correct management practices there is no reason why soils with less favourable chemical and physical properties should not yield very good crops. By so doing a good balance can be achieved between the best possible soil treatment and maximum productivity.

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APPENDIX I

Physical and chemical composition of a range of soil profiles in the Eastern Transvaal sugar industry

Pro-file no	Locality	Parent material	Soil form	Soil series	Description	Diagnostic horizon	Depth (mm)	% particle size distribution					Exchangeable cations (me %)						
								Coarse sand	Medium to fine sand	Silt	Clay	Bulk density (g/ml)	pH (H_2O)	K	Na	Ca	Mg	CEC	Base satn (%)
1	Schagen to Alkmaar	Granite	Cartref	Grovedale	Grey sandy loam over a bleached sandy subsoil with clay tongues into granite	Orthic A E litho-cutanic B	0-200 200-500 500-600 600+	33 32 34 43	46 47 42 43	6 5 7 6	15 16 17 8	1.46 1.66 1,61 1,63	5,2 5,6 6.0 7,3	0.14 0,10 0,08 0,04	0,14 0,20 0,23 0,08	1.20 1.35 1,70 0,50	0.58 0.66 0,84 0,36	4.90 3.60 7.80 0.84	42 65 36 100+
2		Mixed granite/ Swazi basic rock	Hutton	Shorrocks	Red gritty sandy loam	Orthic A Red apedal B	0-150 150-450 450+	42 38 33	41 42 49	5 5 7	12 15 11	1,53 1,51 1,60	6,6 6,5 7,3	0,18 0,09 0,05	0,10 0,19 0,13	1,60 1,30 2,13	0,90 0,44 1,44	3,60 3,25 4,20	77 62 90
3	Nelspruit	Granite	Estcourt	Estcourt	Shallow grey sandy loam on heavy prismatic clay	Orthic A & E pris-cutanic B	0-150 150+	26 16	49 21	8 8	18 50	1,73 1,42	6,5 7,2	0,10 0,10	0,90 1,80	2,50 5,00	1,20 5,70	6,60 17,90	71 72
4	Malelane	Swazi basic rock	Shortlands	Glendale	Shallow red blocky clay with gravel inclusions	Orthic A Red struc-tured B	0-150 150-400	12 12	21 18	18 13	49 57	1,44 1,42	7,7 7,4	0,32 0,22	0,83 0,41	24,00 13.50	9,44 10,28	23,32 28,96	100 84
5					Deep red blocky clay with gravel inclusions		0-220 220-500 500-750+	6 4 4	23 15 10	7 9 10	61 72 76	1,31 1,26 1,24	6.3 7,3 7,9	0,78 0,26 0,25	0,78 1,26 1,35	10,50 9,50 22,50	6,78 10,28 14,44	25.96 23,29 22,00	90 95 91
6	Hectorspruit	Granite	Glenrosa	Glenrosa	Shallow grey gritty sandy clay loam	Orthic A litho-cutanic B	0-120 120-300 300-600+	35 38 30	34 33 19	7 7 8	24 22 43	1,77 1,79 1,61	5,9 6,1 5,7	0.45 0,36 0.18	0,23 0,35 0,42	5,50 10,25 6,00	2.89 2.71 4,65	11,07 10,86 14,32	82 100+ 79
7			Oakleaf	Allanridge	Deep brown fine sandy loam	Orthic A neocutanic B	0-230 230-750 750-1500+	17 18 16	63 65 63	6 10 9	14 8 12	1,45 1,49 1.51	7,9 8,0 8,5	0,54 0,27 0,13	0,21 0,36 0,30	10,00 17,50 16,02	1,66 1,56 1,20	7,68 5,79 7,29	100+ 100+ 100+
8	Tenbosch	Basalt	Shortlands	Shortlands	Shallow red blocky clay	Orthic A Red struc-tured B	0-250 250-560	4 4	18 18	20 13	58 65	1,14 1,16	7,0 7,5	0,84 0,49	0,41 1,00	16,50 13,00	4,11 5,16	23,57 27,46	93 72
9	Komatipoort	Basalt	Aracdia	Arcadia	Black blocky clay	Vertic A litho-cutanic B	0-350 350+	3 4	14 12	11 4	72 80	1,20 1,16	5,8 6,2	0,43 0,31	1,57 2,26	36,00 37,00	17,43 19,34	56.10 61,00	99 97
10	Kaalrug	Alluvium	Rensburg	Rensburg	Black blocky clay over sandy gley	Vertic A over gley	0-400 400+	4 8	19 52	17 6	55 28	1,31 1,56	7,9 8,4	0,20 0,10	0,30 0,20	16,90 4,60	28,70 9,80	45,40 12,30	100+ 100+
11	Louw's Creek	Alluvium	Hutton	Shigalo	Deep red structureless sandy clay	Orthic A A pedal B	0-200 200-750 750+	21 37 44	26 24 24	9 3 3	44 36 29	1,51 1,63 1,68	6,8 7,0 7,3	0,13 0,29 0,29	0,14 0,78 0,83	1,50 23,50 8,50	0,84 3,90 3,06	14,68 13,57 11,50	87 100+ 100+

APPENDIX II

Limitations and management requirements of various soil groups

Colour	Group	Texture	Soil forms	Limitations and management requirements	
Red	1	Sandy loams	Hutton Oakleaf	Minimal	° Very deep rooting ° The high TAM capacity of this soil group warrants planting with high yield potential cane varieties, eg N14 - Moderate to high N mineralisation
	2	Blocky clays	Shortlands	Slight	° Planting may be difficult - winter plough and spring plant ° High N mineralisation - use moderate levels of N - N14 most suitable variety - Suitable for long irrigation cycle - P inherently low
Black	3	Blocky mid-slope clays	Arcadia Milkwood Mayo	Moderate	° Variable intake rate. high wilting point - furrow irrigation preferable ° Planting tilth difficult - winter plough and spring plant ° Herbicide adsorption - High rates of surface applied herbicide necessary ° Moderate salinity/sodicity hazard - periodic soil monitoring necessary ° High CEC and strong K fixation
	4	Cracking clay over gley (bottomland)	Rensburg Willowbrook Bonheim	Moderate to poor	° Limitations as for Group 3, good irrigation control needed ° Poor drainage, salinity/sodicity: subsurface drains or cambered beds ° Cane extraction difficult - winter harvest ° High CEC and strong K fixation
Grey	5	Shallow loamy sands (upland)	Mispah Glenrosa Cartref	Poor	° Shallow rooting ° Low TAM - short irrigation cycles required - where water supply is limited trashing will be beneficial ° Low soil N and K status - relatively large amounts of N and K required - regular leaf sampling ° Low in organic matter will benefit from cover crop before replanting
	6	Shallow loams to blocky clays	Swartland Valsrivier	Poor to severe	° Severe moisture stress - frequent irrigation necessary ° Planting tilth difficult - winter plough, spring plant ° Salinity/sodicity hazard - good irrigation control - frequent soil monitoring for salinity/sodicity build-up ° Low in organic matter will benefit from cover crop before replanting
	7	Sandy loams on impervious subsoil	Longlands Westleigh Kroonstad Katspruit Estcourt	Severe	° Poorly drained - soil levelling and subsurface drains ° Low TAM and low intake rate - short cycles. strict irrigation control ° High salinity/sodicity hazard - regular soil monitoring and amelioration with gypsum may be necessary ° Very compactible - winter harvest ° Low N and K reserves - relatively high amounts of N and K needed- Split N application ° Poorly structured, degrades under irrigation - low in organic matter