SOIL AND LAND CLASSIFICATION IN SWAZILAND

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Abstract

The Swaziland soil classification, originally devised by Murdoch, has been revised to allow its use for the intensive soil surveys now required within the sugar industry. The original set groupings (which are themselves broad units of land potential) and most of the soil series have been retained, with the addition of new series where required. However, they are now defined using diagnostic horizons from the South African binomial system. In addition, the soils have been grouped into 9 "land classes", which are arranged in approximated best-to-worst order. These classes are designed for use in land planning and estate management, to allow maximisation of the potential of each soil type.

Introduction

Soil surveying in Swaziland was initiated in 1955 by G. Murdoch, who then worked for many years on the formulation and development of a national soil classification. The first important publication concerned a survey of the lower Usutu basin (Murdoch and Andriesse[10]), in which the foundations of the present system were laid down. This firstly involved the identification and description of a number of soil series as the basic mapping units.

The soil series was defined by Kellogg[3], but Murdoch[8] amended the wording to read:

"The soil series is a group of soils having soil horizons similar in differentiating characteristics and arrangement in the soil profile . . . and developed from a particular type of parent material. The soils within a series are essentially homogeneous in all soil profile characteristics . . . and such features as slope, stoniness, degree of erosion, topographic position and depth of bedrock".

The gaps shown in this definition were references to permissible variations in texture which have, since the time of preparation been acknowledged as being unsound or unnecessary.

The degree of precision used to define the range of variation permitted within a soil series is governed by the following 2 criteria;

(1) The units should be as precisely defined as possible to allow the surveyor to confidently distinguish between series in the field.

(2) The mapped units should be sufficiently large to be of practical value. Thus the definition should not be so narrow that areas of reasonable homogeneity are impossibly small to map, nor should it be so broad that the variation within the series definition covers soils of significantly different properties.

The Swaziland soil series are a compromise between these two somewhat contradictory statements, giving a balance between mappability and precision (Ballie[1]). The criteria used include the colour, texture, structure and depth of the various soil horizons, along with selected properties, such as the presence or absence of calcium carbonate. The criteria chosen to define the series may vary, those of most practical importance being selected in each case. For this reason the series occur on different levels of taxonomic similarity, that is the level of precision used in their definition is variable.

The soil series are then arranged into broader groupings called soil sets. The concept was adopted from the New Zealand Soil Bureau[11] who defined the set as a grouping of series with similar profile morphologies and similar land use potential and limitations. The series within the set may be genetically similar, but this is not necessarily so. The soil set was preferred as a higher grouping to the wholly genetic soil family or the catenary soil association because of its more direct application to land capability assessment (Ballie[1]). However, because slope position and soil properties are closely related, the soil sets do exhibit a certain amount of catenary character. In essence the soil set is the equivalent of the soil form, as used in the South African binomial system (MacVicar *et al*[5]), but has the advantage of being a unit of land potential as well as soil classification. This makes the set of considerable value in semi-detailed mapping and reconnaissance surveys.

There are 34 sets (containing 107 series), of which 24 occur in the sugar growing areas of the Lowveld. Each set is denoted by a letter, and in some cases also by the geographical region in which it occurs (Lowveld or Highveld). Each series has a name, the first letter of which corresponds to the soil set. The classification has been used successfully for numerous surveys, including a national coverage at 1 : 125,000 (Murdoch[9]).

The need for change

Although the classification is essentially well structured and of great practical value, there are a number of problems associated with its application to the small scale intensive surveys which are now required within the sugar industry. These may be summarised as follows:

- The classification was originally designed for national soil reconnaissance work, to identify areas of potentially fertile land. The sugar industry has surpassed that stage, and it has been found that the series definitions are insufficiently precise to produce detailed soil maps on a field by field basis.
- This lack of precision means that there are gaps, overlaps and "grey" areas in the classification, which make some soils very difficult or impossible to classify. Examples include the overlap between Z (Lowveld) and H sets, C (Lowveld) and K sets, R, L and W sets, as well as many others at the series level.
- New, distinct soil series have been discovered, and are of sufficient importance to warrant the creation of separate units to accommodate them.
- The classification in its present form, can be used successfully only by those having a sound knowledge of soil science, as well as a good deal of field experience.

Faced with the need for change, there were 2 options:

- To adopt a different, well established classification as a replacement. In particular, the South African binomial system[5] would have been suitable, but this approach was rejected because it would create considerable confusion, especially at the farm level. Also a great deal of previous and ongoing soils work has been based on the existing system, and so much of the available information would have become obsolete or difficult to use.

- To modify and improve the existing classification to suit current needs. This was a more sensible choice, as the present system is basically sound.

Revision of the classification

The main requirement is to provide more precise descriptions at the series level to allow easy identification in the field. This has been achieved by employing the diagnostic horizons from the South African binomial system (MacVicar *et al*[5]). Swaziland has similar climatic, geographical and geological conditions to the surrounding Republic, and as a result the soil types will also be very similar. With the sugar industry specifically in mind, the soil sets and series of the Lowveld have been redefined as described above. Also, in order that the sets might be altered as little as possible to retain their emphasis on land potential, further restrictions of soil colour, texture, depth and structure have been imposed on the groupings.

Table 1 gives details of how the various combinations of topsoil and subsoil horizons and their physical properties have been used to create a key for set identification. More detailed information concerning the properties of the soil profile is then used to identify the particular series within the set.

In most cases the topsoil/subsoil combinations correspond to South African forms. Topsoil classes have been added for undeveloped or degraded soils, and for depositional topsoils (humic and organic A horizons do not occur in the Swaziland Lowveld). In many cases however, the diagnostic subsoil horizon (and in some instances the topsoil horizon also) may vary within the same set and series. This is because the management - orientated set units cut across the more pedologically based soil forms.

Table 1

Key to the soil sets, using diagnostic horizons (topsoil and subsoil), colour, structure and texture (LS = loamy sand, SL = sandy loam, SCL = sandy clay loam, CL = clay loam, SC = sandy clay, C = clay).

Topsoil				Orthic			Melanic		Vertic			Alluvial or Colluvial (Orthic)	Undeveloped or degraded
Depth of whole soil (cm)				<35	>35		<35	>35	<35	>35			
Depth of topsoil (cm)					<60	>60				<90	>90	>15	
Subsoil		Colour	Modal Texture										
Hard rock	Topsoil →		LS-SL	O	P	J							
		Red	CL-C	S	R	R	S	C	S	K	V		U
		Brown		S	C	C							
Soft rock	Colours and →		LS-SL	O	P	J							
		Red	CL-C	S	R	R	S	C	S	K	V		U
		Brown		S	C	C							
Lithocutanic	→ Textures		LS-SL	O	P	J							
		Red	CL-C	S	R	R	S	C	S	K	V		U
		Brown		S	C	C							
Stratified alluvium					B	B						B	X
Neocutanic		Red	LS-SL		W	W						W	
			CL-C		R	R		R				N	
		Brown	LS-SL		B	B						B	
			CL-C		C	C		C				C	
Pedocutanic		Red	SCL		L	L						L	
			CL-C	S	R	R	S	R	S	K	V	N	
		Brown	SCL		P								
			CL-C	S	C	C	S	C	S	K	V	C	

Topsoil			Orthic			Melanic		Vertic			Alluvial or Colluvial (Orthic)	Undeveloped or degraded
Yellow brown apedal		SL		D	D						B	
		CL-C	S	C	C	S	C	S	K	V	C	
Red Apedal	Weakly Structured	SL		W	W						W	
		CL-C	S	R	R	S	R	S	K	V	N	
	Moderately to strongly struct.	SCL		L	L						L	
		CL-C	S	R	R	S	R	S	K	V	N	
Red apedal/soft plinthic		SL-SCL		F	F							
		CL-C	S	R	R							
Red structured		SCL		L	L						L	
		CL-C	S	R	R	S	R				N	
Red structured/soft plinthic			S	R	R							
Soft plinthic	With > 10% hard concretions	SC		H	E							
		CL-C	S	T	T	S	T					
	With < 10% hard concretions	SC		H	E							
		CL	S	D	D	S	D					
		C	S	T	T	S	T					
Firm gley		SC		H	E							I/Q
		CL	S	D	D	S	D	S	K	V		I/Y
		C	S	T	T	S	T	S	K	V		I/Y
E/gleycutanic				H	E							Q
Prismacutanic				H/Z	E							Q
Hard plinthic			G	G	E							

For example, W set consists of deep, red, light textured soils of alluvial origin, with an orthic A over a red apedal or red neocutanic B. The set therefore selects the series from both the Hutton and Oakleaf forms whose textures are sandy clay loam or lighter. Their structure will also be similar, and so from a management point of view they may be treated the same. This is in contrast to a grouping such as the Oakleaf form itself, which contains soils ranging in texture from sandy loam to clay, and in colour from dark brown to red. There are many other examples of groupings with such practical benefits in the new system. In some cases soils have been grouped together because they have one common managerial limitation. The series of S set, for example, are all shallow soils (less than 350 mm to weathering rock) with medium to heavy textures. Thus cane production will be influenced mainly by shallow rooting and reduced available moisture.

Areas of the classification which were previously vague or poorly defined have been clarified by the use of diagnostic horizons. For example, K set was previously described as a black or very dark grey cracking blocky clay, and C (Lowveld) set as a dark brown clay with strong blocky structure (Sutcliff[13]). C set occurs upslope from K set in a catenary sequence, being an intergrade between a brown calcareous soil and the vertic K set. In practice however, the differentiation of these 2 sets proved very difficult, as in some cases brown soils may show strongly vertic features, whilst in others black soils may show no vertic features at all (as with a melanic A). In order to make the division clear, all soils with a vertic A horizon now fall into K set (but may be S or V sets if very shallow or deep – see Table 1), whilst C (Lowveld) set contains soils with melanic or orthic topsoils only.

The importance of parent material and slope

The soils of the Swaziland sugar industry are derived from 3 distinct groups of geological strata. These are;

(1) Acid-intermediate rocks, mainly Ecca sandstones and shales, along with smaller areas of granite and rhyolite.

(2) Basic rocks, mainly Stormberg basalt and intrusive dolerite and gabbro (Karroo and later).

(3) Alluvial materials, occurring along present river courses, or as ancient deposits.

Soil parent material has long been recognised as an important factor in the classification of soils for the sugar industry. Beater[2] based his classification wholly on geological formations. More recently, the staff of the South African Sugar Association Experiment Station[12] have produced an integrated system for soil identification, which is based largely on soil forms, but introduces the factors of parent material and soil system (an association of soils that coincide with areas of similar climate, topography and age of the land surface, devised by MacVicar[4]). Therefore because any one parent material will always give rise to similar suites of soils, the members of a particular set will generally occur on only one of the 3 geological groupings described above. Also, because soil properties are strongly governed by slope position, each set will have a characteristic location in the landscape where it will normally be found. These environmental relationships are important and useful when identifying soils in the field (Meyer[6]).

Figure 1 illustrates the typical catenary sequences of soil sets which are likely to occur on the 3 main parent material groups. The effect of dolerite dykes, which are commonly found as instrusions into both sandstone and basalt is also shown. These will give rise to T set soils, with characteristic gravelly or concretionary subsoils, and also cause somewhat impeded drainage upslope, producing heavy textured or hydromorphic soils in a midslope position. In general, soil depth will increase downslope, whilst texture will become progressively heavier. This is of significance to the farmer, as the managerial properties will also change correspondingly down the slope. In the initial stages of farm planning, layouts can be arranged so that each field unit is made up of one soil type or a number of very similar soil types. In many cases this means that fields will run along the slope rather than from top to bottom, so avoiding a situation where soil (and rooting) depth and other soil properties vary greatly within the same field. The whole field can then be correctly managed as one unit.

Land Classification

The results of research and observation have shown that because of the different physical and chemical characteristics of the various soil types, the management practices carried out should differ substantially on each one (Moberly and

Table 2

Description of the land classes and their properties

Land Class	Sets/Series	Brief description	Main limitations and management requirements
I	R, N, L sets	Deep, red, well structured, medium to heavy textured, freely draining.	• Highly fertile and productive. • High N-mineralisation-use reduced rates of N. • N14 is the most suitable variety. • High TAM, good infiltration rates.
II	W, B, F sets, Daputi series	Deep, excessively draining, light textured, moderately to weakly structured, mainly of alluvial origin.	• High infiltration rate and moderate TAM. Overhead irrigation required. • Low CEC, high leaching rate - split fertilizer applications. • Parasitic nematodes may be a problem.
III	S set	Shallow, freely draining medium to heavy textured, well structured.	• Shallowness restricts rooting, TAM. • Use reduced rates of N. • Keep land levelling to a minimum-overhead irrigate if necessary.
IV	T set, D set (excluding Daputi series)	Imperfectly draining, moderately deep, medium to heavy textured, moderately structured.	• Require careful irrigation control. • Subsurface drainage will improve productivity. • Rooting restricted by gleyed or gravelly subsoil. • Deep T sets respond to 200 kg N/Ha.
V	K, C, V sets	Deep blocky or cracking clays with moderate to poor drainage.	• Difficult to manage under irrigation. • Infiltration rate declines rapidly on wetting. • Subsurface drainage often required - moling may be possible. • High CEC. Fix large amounts of K. • Very hard when dry, plastic when wet-cultivations must be timed.
VI	Z set, Homestead series.	Poorly draining, thin topsoil (often absent) changing to a coarsly structured subsoil with inherent salinity/sodicity problems.	• Restricted rooting, low TAM. • Good land levelling and irrigation management are essential. • Drainage/gypsum application required. • Poorly structured-degrades under irrigation. • Prone to compaction - winter harvest. • Highly erodable - use cover crop when fallow. • Harsh physical properties make stool eradication/cultivation very difficult.
VII	H set (except Homestead series) E, O, P, J, G, sets	Coarse sandy topsoil changing abruptly to a heavy textured and very poorly draining subsoil. High risk of salinity/sodicity build-up.	• Restricted rooting, very low TAM. • Excellent land levelling, irrigation control required for successful production. Perched water tables cause waterlogging of the topsoil. • Response to drainage and ameliorative measures is poor. • Harsh physical properties make stool eradication and cultivation extremely difficult. • Prone to compaction - winter harvest.
VIII	Q, Y, I sets	Highly degraded saline/alkaline clays with extreme waterlogging problems.	• High salinity/sodicity precludes cultivation. • Highly degraded condition makes reclamation nearly impossible.
IX	X, U sets	Shallow rocky areas and river sands (undeveloped soils).	• Lack of soil material or subjection to periodic flooding precludes cultivation.

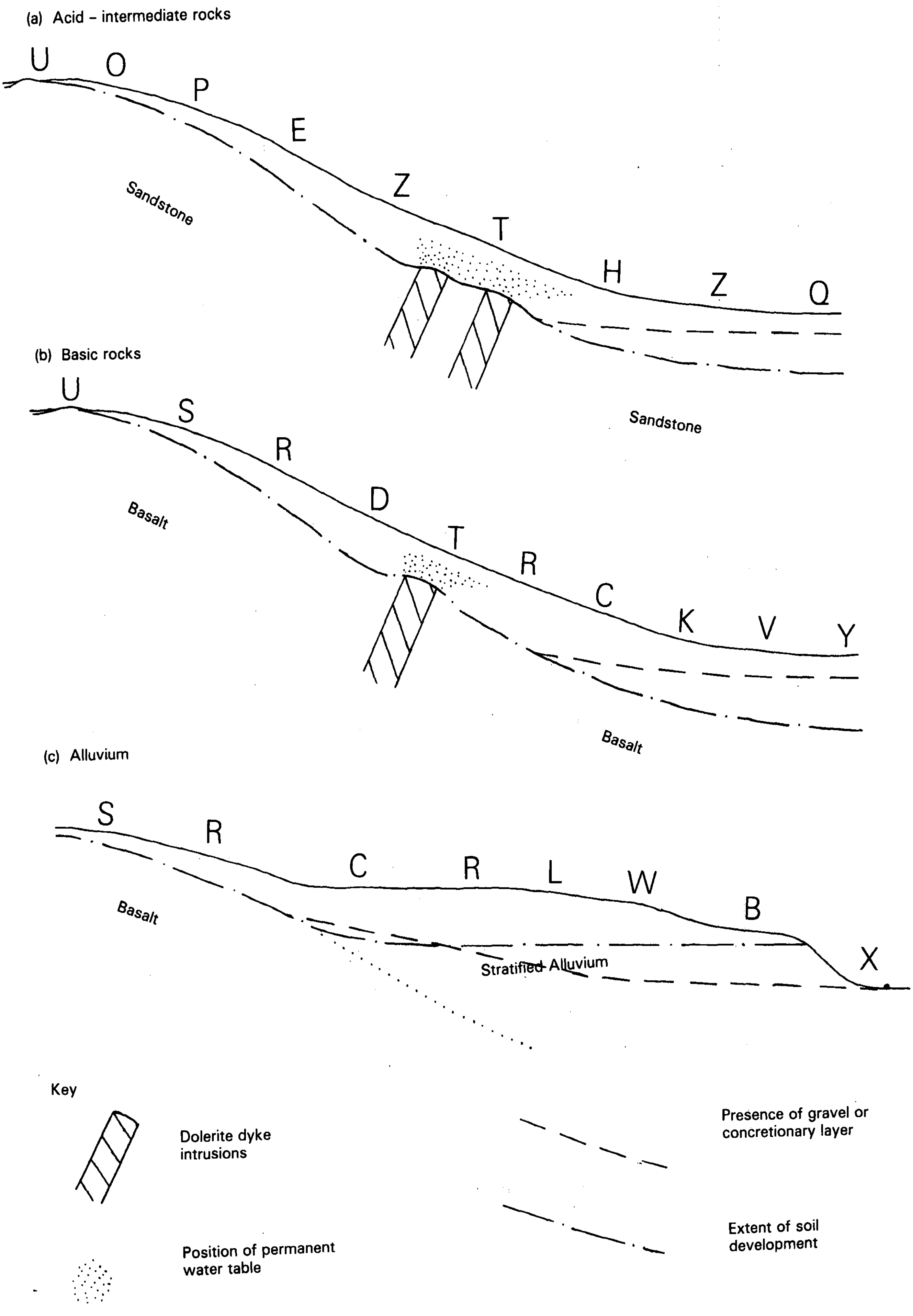

FIGURE 1 Idealised catenary sequence of soil sets

Meyer[7]). This includes irrigation regime, time of harvest and planting, fertilizer policy, ameliorative practices, cane variety and cultivation techniques. Farm layouts as described above will allow the correct management practices to be applied to each soil type on a field by field basis, and thus maximise production on each one. To assist in this approach, the Swaziland sets and series have been further grouped into 9 "land classes", containing soils of similar management requirements and potential.

The members of each class and their general agricultural properties are listed in Table 2.

The classes have been arranged in a best-to-worst order by employing a rating system of the relative merits and limitations of each one. Using the SA Sugar Association Experiment Station bulletin[12] as a guide, the most relevant properties were chosen for this purpose, and are listed in Table 3. Each land class was categorised with respect to each property simply as low, moderate or high in most cases, although the more important factors of drainage, total available moisture and rooting depth have been divided into 4 or 5 groups. Table 4 shows the rating of the limiting factors for each land class (classes VIII and IX have been omitted as they are uncultivable).

It can be seen from the totals colum that all the classes fall into a fairly clear order, except for III and IV. In this case drainage, as the most important soil factor (and one which is very expensive to rectify) has been used to place the freely draining S set (Class III) above the imperfectly draining T and D sets (Class IV).

Table 3

Rating of soil properties/limiting factors

Soil properties	Category	Rating
Cation exchange capacity (CEC) N mineralisation capacity K reserves Zn reserves Infiltration rate	Low Moderate High	3 2 1
P fixation Erosion hazard Tillage constraints Salinity/sodicity hazard	Low Moderate High	1 2 3
Rooting depth (cm) Total available moisture (TAM) (mm)	<40 40–60 60–80 >80	4 3 2 1
Drainage	Very good Good Moderate Poor Very poor	1 2 3 4 5

Using the land classes

In the initial stages of farm planning, the classes can be used to identify the most productive and problem free areas for development, and to assist in designing the most sensible field layouts for soil type and prevention of erosion.

Indications are given for the most suitable irrigation system, and whether a sub-surface drainage system is required. The agronomic properties guide the farmer on the importance of land levelling, whether ameliorants such as gypsum and filtercake will be beneficial, and what variety will be most suitable. In the growing crop irrigation scheduling, fertilizer policy, weed control methods and the use of agricultural chemicals can all be adapted to the needs of the particular soil type. The harvest schedule can be arranged so that fields which are susceptible to compaction are cut during the dry winter months. Prediction of management requirements using the land classes will improve productivity and profitability, as well as safeguarding against costly mistakes.

Conclusion

The revised soil classification is now simpler to use, and can be used by farmers and growers to identify their own soils. In addition, it is now strongly correlated with the binomial system, which will allow a much better exchange of information on soils between the sugar industries of the two countries in future. In its present form, the land class system is basis which can be built upon as our knowledge of the requirements of each soil type grows.

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Table 4

Rating of the limiting factors for each land class

	Chemical properties						Physical properties						
Land Class	CEC	N mineralisation capacity	P fixation	K reserves	Zn reserves	Salinity/ sodicity hazard	Drainage	Infiltration rate	Erosion hazard	Tillage constraints	Rooting depth	TAM	Total
I	1	1	2	2	1.5	1	2	1	1	1	1.5	1	16
II	3	3	1.5	2.5	2	1	1	1	2.5	1	1	1.5	21
III	1	2	2	2	2	1	2	2	1.5	1	3.5	3	23
IV	2	2	1	1.5	1.5	2	3.5	2	1.5	1.5	2.5	2	23
V	1	2	1.5	1.5	1.5	2.5	4	3	1	2.5	2.5	2.5	25.5
VI	2.5	3	1	2	3	3	5	3	3	3	3.5	3	35
VII	3	3	1	3	3	3	5	3	3	3	3.5	3.5	37

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