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Soils of Hansen's block

Biloela Research Station extension

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CONTENTS

Page

List of figures

List of tables

List of photographs

List of maps

SUMMARY

The Hansen's block extension of the Biloela Research Station adjoins the western boundary of the research station, directly to the north of the Tognolini-Baldwin road. Hansen's block was purchased in January 1991and is situated on the Callide Valley alluvium. It is 40.3 ha in area and was bought to increase the area and underground irrigation water allocation for the research station.

A high intensity grid survey (1:5 000) was undertaken to identify and map the soils on the block. Three soil types, similar to those originally identified by the Biloela Research Station soil survey (Shields, 1989) were identified and described in detail. Tognolini is a fine self-mulching, black Vertosol, that occurs on the backplains, inter-levee flats and in a drainage depression that runs through the centre of the block. Woodall grades from a Vertosol or Dermosol with a dark brown surface and occurs on the relict levees in the southern part of the block. Callide, in comparison is a black Chromosol or Dermosol, that is found on the well developed levee situated on the northern part of Hansen's block. The two levee soils are usually underlain by buried sandy soil layers.

All three soils are strongly structured and well drained. They are low in total soluble salts and non-sodic in the upper subsoil, although Tognolini and Callide become slightly sodic in the lower subsoil. Levels of exchangeable cations are moderate to high and the cations are dominated by calcium, with calcium/magnesium (Ca/Mg) ratios usually >1. Soil fertility is high overall, with only total nitrogen (N) and organic carbon (C) levels less than optimal.

Particle size characteristics of the soils reflect soil formation and position in the landscape. The backplain soil is high in clay and silt, while the two levee soils are dominated by sand, and in particular fine sand.

Suitability of the soils for irrigated and rainfed crops grown in the area is also discussed.

1. INTRODUCTION

Hansen's block adjoins the south-western boundary of the Biloela Research Station on the northern side of the Tognolini-Baldwin road (Figure 1). It covers 40.3 ha and was purchased in January 1991 to increase the area of the research station and to provide extra water allocation from its licensed irrigation bore.

The soils of the Biloela Research Station were mapped and described in detail by Shields (1989). The same soil profile classes have been adopted for this survey. This report details only the properties of the soils of Hansen's block, though for convenience the soil boundaries and soil reference from the original research station soil survey of Shields (1989) are also shown on the soil map.

The objective of this survey was to describe and map the extent of the soils on Hansen's block and comment on their physical and chemical properties and suitability for irrigated and rainfed cropping. A detailed knowledge of the soils is also essential for undertaking agricultural experimental work and for management of the research station.

1.1 Climate (adapted from Shields 1989)

Rainfall is the major climatic element determining plant growth in central Queensland. Biloela Research Station has recorded a mean annual rainfall of 683 mm over a 72 year period from 1924 to 1996. Annual totals are highly variable, due to the convective origin of much of the rainfall and the sporadic incidence of rainfall depressions associated with tropical cyclones. Summer thunderstorms, which account for a high proportion of the summer rainfall, often produce high intensity rainfall that is highly erosive. The mean monthly pan evaporation exceeds rainfall in all months. Mean monthly and annual rainfall and evaporation values are presented in Table 1.

Table 1. Mean monthly rainfall, annual rainfall and pan evaporation for Biloela Research Station

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean rainfall (mm)	101	101	63	38	41	35	30	21	23	54	76	99	683
Mean pan evaporation (mm)	248	193	186	150	115	99	108	130	165	204	225	251	2074

Source: Bureau of Meteorology and Australian Rainman (Clewett *et al*., 1999)

Temperature data for Biloela Research Station is given in Table 2. Between October and March an average of 27 days experience maximum temperatures of at least 35^o C, but only a few days are likely to reach 38^o C. At least one heat wave, where temperatures exceed 37.8^o C over three consecutive days, occurs each summer. An average 19 days have minimum temperatures of less than 2^o C between May and September. At screen temperatures of 2^o C, light frosts can be expected. The eight days with minimum temperatures less than 0^o C represent the average number of heavy frosts that occur each year.

Table 2. Temperature data for Biloela Research Station

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Av max (°C)	33.2	32.2	31.2	28.9	25.4	22.2	21.9	23.9	29.8	31.7	31.5	32.9	28.3
Av min (°C)	19.8	19.5	17.7	13.7	10.1	6.5	5.2	5.6	8.6	13.2	16.4	18.4	12.9
Average days with -													
Max >35	8	5	2							1	4	7	27
Max >38	1	1									1	1	4
Min <2						5	9	5					19
Min <0						2	4	2					8

Source: Bureau of Meteorology

Further background information on the geology, landforms, vegetation and hydrology of the Callide Valley can be found in Shields (1989).

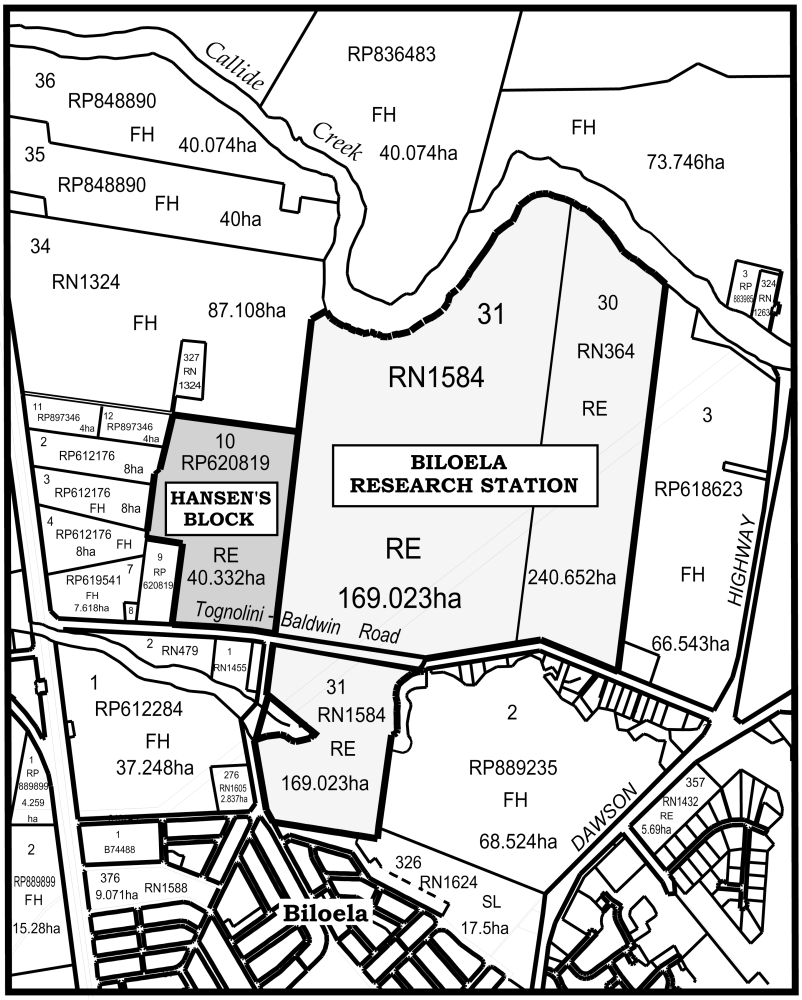


Figure 1. Location map, Biloela Research Station and Hansen's block

2. METHODS

Prior to the commencement of the survey, the soils of the Biloela Research Station were inspected in order to ensure accurate identification, and correlation of the soils on Hansen's block with those on the existing research station. As the research station is used for small plot size experiments, a detailed mapping scale of 1:5 000 was justified (Reid, 1988).

As with the Biloela Research Station soil survey, the soils on Hansen's block were described every 100 m along transects that were spaced 100 m apart. These transects were parallel with the north-south orientated eastern boundary of Hansen's block with the first transect starting 100 m west of the eastern boundary. Spacings along and between transects were measured with a 100 m tape. Extra soil observation sites were done on the relict levees and shallow drainage depression when these landforms were missed by the grid. A total of 53 sites were described in detail with the information recorded, in coded format, on the then Queensland Department of Primary Industries (QDPI) field sheets.

The soil profiles were examined, to a depth of 1.6 m, from an intact 50 mm diameter core, which was obtained by pushing a thin-walled steel tube with a cutting tip into the ground by a vehicle-mounted hydraulic rig. Soil properties were described in accordance with McDonald *et al.* (1990) and the soil profile was classified by the Northcote (1979) system, and later by the Australian Soil Classification (Isbell, 1996).

The location of each site was marked on a colour aerial photograph enlarged to an approximate scale of 1:5 000. Soil boundaries were drawn on this aerial photograph enlargement which was used also as the base map for the digital capture of the soil boundaries and site locations. The soil map of the Hansen's block has been added to the original research station soil map and is shown in a different colour.

Each of the soil types identified on Hansen's block was sampled at a representative location, with soil samples taken at 0.1 m intervals down the profile. A composite surface sample (0 to 0.1 m), made up of nine sub-samples, was also collected at each sampling site to characterise the soil fertility. Standard analyses (Baker and Eldershaw, 1993) were carried out on the soil samples at the Department of Natural Resources Analytical Centre laboratory at Indooroopilly, Brisbane. The particle size and water content at 15 bar pressure were input into the plant available water capacity (PAWC) model of Littleboy (1995), which calculates the soils' PAWC. Soil analytical data is presented on an oven dry basis (105^{o} C), unless otherwise stated (see Appendix II).

Soil and land data from each site were entered into a sequential ASCII file by a standard computer text editor program, and the worldwide applicable resource inventory system (WARIS) (Rosenthal *et al.*, 1986) set of programs were used to extract and analyse the data for each soil.

3. RESULTS

3.1 Soils

Three soils were identified, described and mapped on Hansen's block. These are the Callide, Woodall and Tognolini soils. Each of these soils occurs on a distinct landform. Callide is found on a well developed levee of a major drainage depression on the northern part of Hansen's block. Woodall appears to represent relict levees or levee remnants of a drainage depression that has migrated across the alluvial plain in a northerly direction. One such drainage depression currently crosses the middle of Hansen's block in an east-west direction. The migratory nature of these channels has left several relict levees stranded on the backplain on the southern part of the block. Tognolini occurs on the inter-levee flats, backplains and in the minor drainage depression, and is the most extensive soil on Hansen's block.

Although Hansen's block joins onto the western boundary of the Biloela Research Station, the soil boundaries south of the central drainage depression do not correspond with those of the research station, as this part of the research station was land planed in the 1980s, removing the relict levees. Shields (1989) considered the modified soil to be the non-cracking clay, Melton, whereas on Hansen's block the soil between the relict levees is the fine self-mulching, black cracking clay, Tognolini.

Appendix I shows the range of soil properties for each of the three soils, while Appendix II presents the profile morphology and analytical data for the sampled representative sites.

3.2 Soils of the very gently undulating levees

Callide

The Callide soil occurs on a well developed levee, of a major drainage depression, on the northern part of Hansen's block. This levee rises up one to two metres above the surrounding plain and has a slope of 1-2%. Callide is characterised by a high fine sand content in the topsoil and subsoil. Photograph 1 shows the levee on which Callide has formed, while Photograph 2 shows a profile of the Callide soil exposed in a backhoe pit.

Callide is a duplex to gradational soil (Chromosol to Dermosol) with a dark brown, silty loam to silty or fine sandy clay loam topsoil that is up to 0.3 m thick. The topsoil has a weak to moderate, subangular blocky structure when not cultivated, and a pH of 7.0-7.5. A dark grey, fine sandy light clay, transitional B1 horizon, that is only 0.15 m thick, is sometimes present. Otherwise where this does not occur, the topsoil directly overlies the clay subsoil.

The subsoil is a dark grey to dark brown, fine sandy light medium to medium clay with a strong, 5-10 mm, angular or subangular blocky structure, that often parts to a strong, 2-5 mm, blocky primary structure. Calcium carbonate segregations sometimes occur in the lower part of the subsoil, which has a pH range of 7.5-8.0.

In all but one profile examined, the subsoil was underlain by buried sandy layers below depths of 0.6-0.8 m. These layers are usually massive and range in texture from sand to sandy light clay. They are a lighter brown colour than the overlying subsoil and only very rarely do they have few to common, dark mottles or soft calcium carbonate segregations. The pH of these buried layers varies from 7.5 to 8.5.

Soil analytical data

Table 3 presents some typical chemical and physical analytical data, and chemical ratios for the Callide soil.

Table 3. Analytical data and chemical ratios for the Callide soil

Depth (m)	pH	EC dS/m	Cl^- %	CS	FS	S	C	CEC	Ca	Mg	Na	K	Ca/Mg ratio	ESP	R1 Disp ratio	CEC/Clay ratio
	1:5,soil:water			Particle Size %				Exchangeable Cations[1] cmol[+] kg^{-1}								
0.1	7.2	.07	.002	7	52	25	19	14	10	4.0	.23	1.2	2.5	2	.53	.7
0.3	7.7	.07	.005	3	52	22	25	14	10	4.2	.41	.58	2.4	3	.52	.6
0.4	8.0	.08	.002	3	43	18	37	27	16	6.3	1.0	.73	2.5	4	.55	.7
0.6	8.0	.11	.007	3	43	15	38	25	17	7.0	1.4	.63	2.4	6	.61	.7
0.9	7.9	.45	.060	2	42	22	37	27	16	7.1	1.8	.54	2.3	7	.68	.7
1.2	8.0	.76	.104	4	46	20	33	27	16	8.0	2.7	.53	2.0	10		.8
1.5	8.3	.70	.090													

[1] Cations extracted with alcoholic NH_4Cl at pH 8.5

These data indicate:

- A neutral surface pH (7.2), which becomes alkaline in the subsoil (8.0-8.3).
- Very low to low total soluble salt levels in the upper metre of the profile (0.07-0.45 dS/m). However, the salts increase to moderate levels below this (0.7-0.76 dS/m), which is most likely due to leakage from the irrigation bore only some 20 m to the north. These high salt levels in the lower subsoil are not typical for Callide, as the profile is normally freely draining and typically does not show this build up of salts (see Figure 2).
- A very high fine sand and silt content in the profile, particularly in the topsoil, which makes the topsoil, when cultivated, prone to crusting and hard setting upon drying after rainfall and irrigation.
- A moderate clay content increasing from 19-25% in the topsoil to 38-33% in the subsoil.
- The cation exchange capacity (CEC) is moderate to high (14-27 cmol[+] kg^{-1}) throughout the profile, and is dominated by calcium (10-17 cmol[+] kg^{-1}). As a result the calcium/magnesium (Ca/Mg) ratios are also high (2.0-2.5).
- The topsoil and upper subsoil are non-sodic with ESP's of 2-4, with the lower subsoil becoming sodic (ESP 6) from a depth of 0.6 m, and increasing to an ESP of 10 at 1.2 m
- The R1 dispersion ratios are only moderate throughout the profile (0.52-0.68), indicating that the subsoil is not dispersive. This is most likely due to the high calcium content. However the dispersion ratios do increase with increasing sodicity in the subsoil.
- The topsoil is prone to slaking under cultivation due to the high fine sand and silt content.
- Exchangeable potassium is high in the surface soil, but decreases to low levels in the subsoil (1.2-0.53 cmol[+] kg^{-1}).
- The clay activity ratio (CEC/clay) of 0.7-0.8 in the subsoil indicates a mixed illite-montmorillonite clay mineralogy.

Soil fertility

Table 4 presents the topsoil fertility data for the Callide soil.

Table 4. Callide topsoil (0-0.1 m) fertility data

Total N %	Bicarb. P mg/kg	Organic C %	Extr. K meq%	Zn mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg
0.11	86	1.4	1.0	1.1	2.0	17	36

These data show:

- Overall, Callide has a high fertility, with most nutrient levels being high.
- Total nitrogen and organic carbon are the only two nutrients at moderate levels. Organic carbon levels have decreased due to continuous cultivation over many years. The C/N ratio of 13 indicates the potential for mineralisation of organic nitrogen to an inorganic plant available form (Glendinning, 2000).
- Phosphorous and potassium levels are very high and high, respectively.
- Levels of all trace elements are adequate. However zinc deficiencies have been recorded for irrigated crops grown on Callide Valley alluvial soils.

Plant available water capacity

- Figure 2 shows the concentration of salts down the profile for the Callide soil (the data for this profile were taken from another representative Callide profile as the sampled profile on Hansen's block was affected by leakage from the nearby bore as mentioned previously). The graph shows a slight "salt bulge" at a depth of 1.2 m, which represents the long-term average depth of wetting in a dryland situation. These salt levels are not high enough to represent a restriction to rooting depth.
- Therefore Callide has a maximum rooting depth of 1.5 m (rooting depth varies from 1.0-1.5 m for crops grown in the Callide Valley).
- The PAWC of Callide varies from 105 to 115 mm, depending on the thickness and clay content of the buried soil layers.

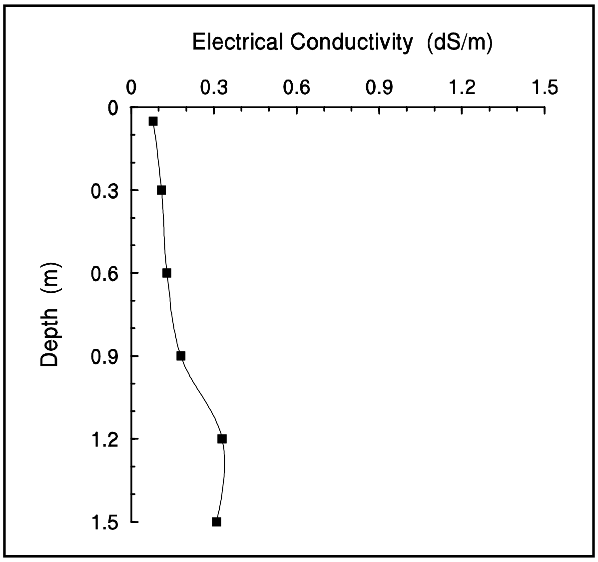


Figure 2. Total soluble salts profile for Callide

Woodall

Woodall occurs on the very low relict levees on the southern part of Hansen's block (Photograph 3). The main area of Woodall occurs as a continuous levee along the southern side of the shallow, central drainage depression. Three isolated areas of Woodall also occur further to the south and represent former levees left stranded by migration of the drainage depression. The levees have a very low relief, standing less than one metre above the surrounding plain.

The Woodall soil is a dark, non-cracking to weakly cracking clay soil (Dermosol to Vertosol) with a dark brown, fine sandy clay surface. It is often underlain by buried sandy soil layers below 0.5 m. The levees on which Woodall occurs, are characterised by a dark brown surface colour, (Photograph 3) and a higher sand content in the topsoil when compared to the surrounding Tognolini soil.

The topsoil, which is 0.1-0.15 m thick, is a dark brown, fine sandy light medium to medium clay with a strong, fine (<2 mm) subangular blocky to granular structure (when not cultivated) and a neutral pH. The topsoil overlies a black to dark grey, fine sandy light medium to medium clay subsoil, with either a strong lenticular or subangular blocky structure. Calcium carbonate nodules are sometimes present in the lower subsoil, below 0.9 m, and the pH varies from 8.0 to 8.5.

In half of the profiles described, the fine sandy clay subsoils overlie similar brown, buried soil layers to Callide, usually between depths of 0.5-1.0 m. These horizons consist of massive, dark brown sands, sandy clay loams and sandy clays. The sandy layers contain a greater proportion of coarse sand than the overlying soil. On two occasions this sandy material was underlain by a black, structured, medium clay which appears to represent a buried soil that was originally deposited in a backplain position. The buried sandy soil layers are non-calcareous with a pH of 8.0-8.5.

Soil analytical data

Table 5 presents some typical chemical and physical analytical data, and chemical ratios for the Woodall soil.

Table 5. Analytical data and chemical ratios for the Woodall soil

Depth (m)	pH	EC	Cl^-	Particle Size				Exchangeable Cations[1]					Ca/Mg ratio	ESP	R1 Disp ratio	CEC/Clay ratio
	1:5,soil:water	dS/m	%	CS	FS	S	C	CEC	Ca	Mg	Na	K				
				%				cmol[+] kg^{-1}								
0.1	7.0	.18	.005	19	22	29	33	23	14	7.1	.95	1.3	2.0	4	.64	.7
0.3	7.5	.16	.006	26	19	29	33	26	16	7.7	.67	.50	2.1	3	.61	.8
0.6	7.7	.17	.006	25	18	20	40	32	19	10	1.6	.46	1.9	5	.59	.8
0.9	8.2	.09	.004	48	23	7	23	18	11	5.8	1.2	.23	1.9	6	.63	n/a
1.2	8.4	.07	.003	56	27	4	11	14	8.4	4.4	.98	.17	1.9	7		n/a
1.5	8.4	.06	.005	53	27	4	15	17	8.9	7.2	1.5	.24	1.2	9		n/a

(1) Cations extracted with alcoholic NH_4Cl at pH 8.5

These data indicate:

- A neutral surface pH (7.0), with the subsoil gradually becoming alkaline (8.0-8.5).
- Total soluble salt levels are very low throughout the profile (< 0.2 dS/m), particularly in the buried soil layers below 0.6 m. This indicates that the soil profile is well drained.
- The clay content is only moderate (33-40%) in the topsoil and subsoil, but the silt content is high (20-29%). There are also significant quantities of sand (18-25% of coarse and fine sand) in the profile associated with its levee position.
- The buried soil layers below 0.6 m are dominated by coarse sand (48-56%) and fine sand (23-27%). Clay and silt contents are low indicating a discontinuity in the depositional environment between the two parts of this profile.
- The CEC is also only moderate (18-32 cmol[+] kg^{-1}) in the upper profile, and decreases to 14 cmol[+] kg^{-1} in the buried soil layer due its lower clay content. Calcium is the dominant cation and levels are moderate to high (8.4-19 cmol[+] kg^{-1}) throughout the profile, resulting in high Ca/Mg ratios of 1.9-2.1.
- The exchangeable sodium concentrations are low throughout, with ESP's between 3 to 7. Moderate R1 dispersion ratios of 0.59-0.63 indicate a non-dispersive soil, which is due to the high calcium and low sodium levels.
- Exchangeable potassium is high in the surface soil, but decreases to low levels in the subsoil (1.3-0.17 cmol[+] kg^{-1}).
- The clay activity ratios (0.7-0.75) indicate a mixed illite-montmorillonite clay mineralogy.

Soil fertility

Table 6 presents the topsoil fertility data for the Woodall soil.

Table 6. Woodall topsoil (0-0.1 m) fertility data

Total N %	Bicarb. P mg/kg	Organic C %	Extr. K meq%	Zn mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg
0.12	88	1.8	1.1	1.5	2.4	19	50

These data show:

- Overall, Woodall has high fertility, with levels similar to Callide.
- Total nitrogen and organic carbon are the only two nutrients at moderate levels. Organic carbon levels have decreased due to continuous cultivation over many years. The C/N ratio of 15 indicates the potential for mineralisation of organic nitrogen to an inorganic, plant available form (Glendinning, 2000).
- Phosphorous and potassium levels are very high and high, respectively.
- Levels of all trace elements are adequate. However zinc deficiencies have been recorded for irrigated crops grown on Callide Valley alluvial soils.

Plant available water capacity

- Figure 3 shows the levels of soluble salts down the Woodall profile. As mentioned earlier, these levels are low to very low, and do not represent a limitation to plant rooting depth.
- A rooting depth of 1.5 m has therefore been assumed.
- Woodall however has only a moderate PAWC of 115 mm, due to the moderate clay content in the upper profile, which then drops off rapidly in the buried, sandy soil layers below. For profiles where the buried soil layers are not present, the PAWC increases to 125 mm.

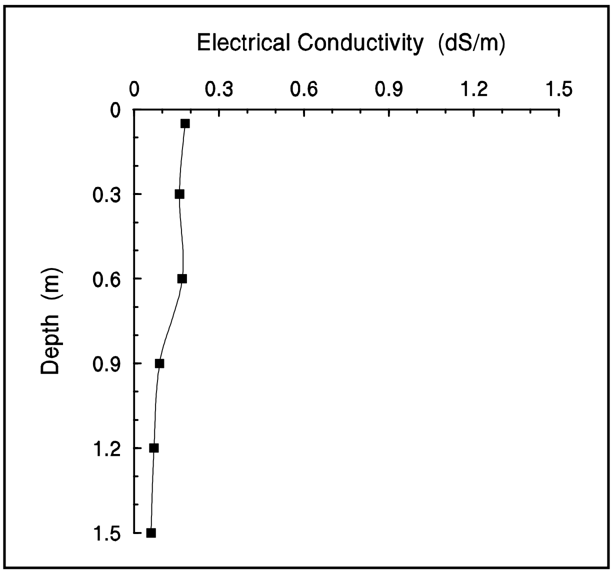


Figure 3. Total soluble salts profile for Woodall

3.3 Soils of the backplains, inter-levee flats and drainage depressions

Tognolini

Tognolini is best represented on the backplains on the south-western part of Hansen's block (Photograph 3). It also occurs on the flats between the levees and in the shallow drainage depression in the middle of the block (which is indicated by a dashed line on the soil map).

Tognolini is a fine self-mulching, black cracking clay (Vertosol). The topsoil is black with a silty light medium to medium clay texture and a very fine (<2 mm) granular structure. The topsoil overlies a black, silty medium to medium heavy clay subsoil that has a fine (2-5 mm) lenticular structure. Calcium carbonate nodules usually occur in the subsoil below 0.2 m and slickensides are often prominent in the lower subsoil. The topsoil has a neutral pH (7.5) which becomes alkaline in the subsoil (8.5).

The profile often remains black to very dark grey to a depth of 1.5 m, with a fine, lenticular structure and calcium carbonate nodules. Sometimes the lower subsoil becomes dark brown and can develop either a medium (5-20 mm) prismatic or blocky structure below depths of 0.6 m. In the vicinity of the Woodall or Callide soils, the subsoil maybe underlain by buried layers of dark brown to brown, massive sands, sandy clay loams and sandy clays. Photograph 4 shows a typical Tognolini profile with the black upper subsoil overlying the brown lower subsoil.

Soil analytical data

Table 7 presents some typical chemical and physical analytical data, and chemical ratios for the Tognolini soil.

Table 7. Analytical data and chemical ratios for the Tognolini soil

Depth (m)	pH 1:5,soil:water	EC dS/m 1:5,soil:water	Cl^- % 1:5,soil:water	Particle Size CS %	FS	S	C	Exchangeable Cations[1] CEC cmol[+] kg^{-1}	Ca	Mg	Na	K	Ca/Mg ratio	ESP	R1 Disp ratio	CEC/Clay ratio
0.1	7.4	.13	.004	2	21	31	51	51	27	16	1.3	1.0	1.7	2	.50	.9
0.3	8.0	.17	.012	1	14	29	57	52	28	21	1.9	.44	1.3	4	.50	.9
0.6	8.4	.25	.015	2	13	26	59	55	27	25	3.1	.38	1.1	6	.64	.9
0.9	8.6	.32	.020	2	17	28	58	47	20	24	4.7	.28	0.8	10	.72	.8
1.2	8.5	.39	.033	1	20	29	55	45	18	21	5.2	.26	0.9	12	-	.8
1.5	8.6	.34	.032	1	22	30	52	41	17	19	5.8	.21	0.9	14	.87	.8

[1] Cations extracted with alcoholic NH_4Cl at pH 8.5

These data indicate:

- A neutral surface pH (7.4), with an alkaline subsoil (8.0-8.5), indicating the presence of calcium carbonate segregations below 0.3 m.
- Levels of total soluble salts are low throughout the profile (< 0.4 dS/m). This indicates the profile is well drained. The peak salt content at 1.2 m indicates the long-term average depth of wetting under rainfed conditions (see Figure 4).

- There is very little variation in particle size down the profile. The high clay (51-59%) and silt (28-31%) contents, and very low coarse sand levels (1-2%) throughout the profile indicate a slow- moving depositional environment during soil formation (i.e. backplain areas).
- Tognolini has high cation exchange capacities of 41-55 cmol[+] kg^{-1} and high levels of calcium (17-28 cmol[+] kg^{-1}), which is the dominant cation in the upper 0.6 m of the profile. However, below this depth calcium decreases and magnesium becomes dominant. Therefore the Ca/Mg ratio decreases from 1.7 on the surface to 0.8-0.9 in the lower subsoil.
- Sodium concentrations also gradually build up down the profile. The lower subsoil from 0.6 m is sodic (ESP 6-14).
- The dispersion ratio increases down the profile as calcium levels decrease and magnesium and sodium levels increase. The dispersion ratios in the upper profile are only low to moderate (0.5-0.72), indicating this part of the upper profile is structurally stable, due to the high calcium levels and low sodicity. However, the high R_1 dispersion ratio at 1.5 m (0.87) indicates a potentially dispersive subsoil.
- Exchangeable potassium is high in the topsoil (1.0 cmol[+] kg^{-1}), but decreases to low levels in the subsoil.
- The clay activity ratios of 0.9-0.8 down the profile indicate a dominant montmorillonite clay mineralogy.

Soil fertility

Table 8 presents the topsoil fertility data for the Tognolini soil.

Table 8. Tognolini topsoil (0-0.1 m) fertility data

Total N %	Bicarb. P mg/kg	Organic C %	Extr. K meq%	Zn mg/kg	Cu mg/kg	Fe mg/kg	Mn mg/kg
0.12	107	1.8	1.2	1.7	2.9	26	25

These data show:

- Overall, Tognolini has high fertility. Most nutrients are slightly higher than for the other two soils.
- Total nitrogen and organic carbon are the only two nutrients at moderate levels. Organic carbon levels have decreased due to continuous cultivation over many years. The C/N ratio of 15 indicates the potential for mineralisation of organic nitrogen to an inorganic, plant available form (Glendinning, 2000).
- Phosphorous and potassium levels are very high and high, respectively.
- Levels of all trace elements are adequate. However zinc deficiencies have been recorded for irrigated crops grown on Callide Valley alluvial soils.

Plant available water capacity

- Figure 4 shows the salt content down the profile for Tognolini. This demonstrates a gradual increase in salts with depth. The total soluble salt levels are still in the low range however and do not represent a limitation to plant rooting depth.
- A rooting depth of 1.5 m has therefore been assumed.
- Tognolini has a high PAWC of 165 mm, which is the highest of the three soils on Hansen's block, and is due to its consistently high clay content throughout the profile.

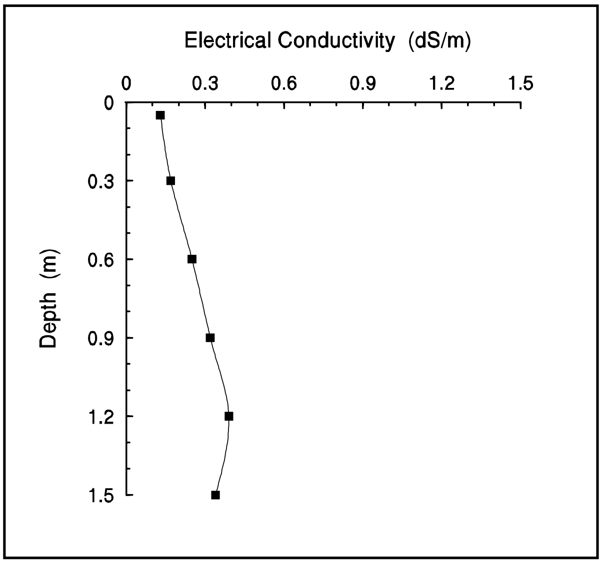
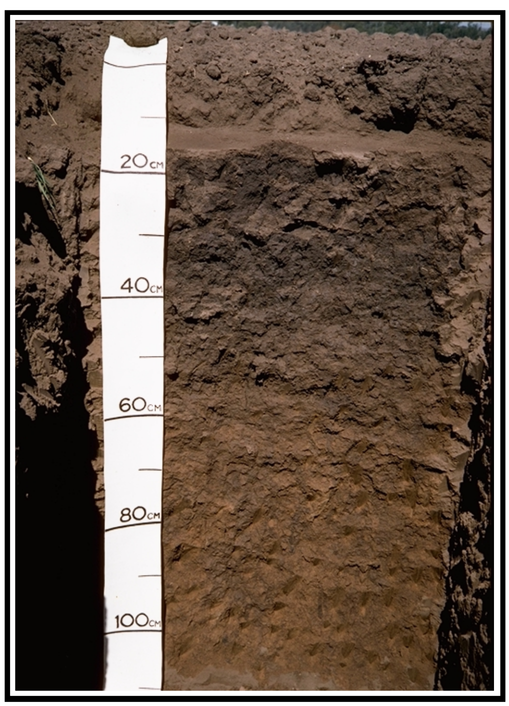


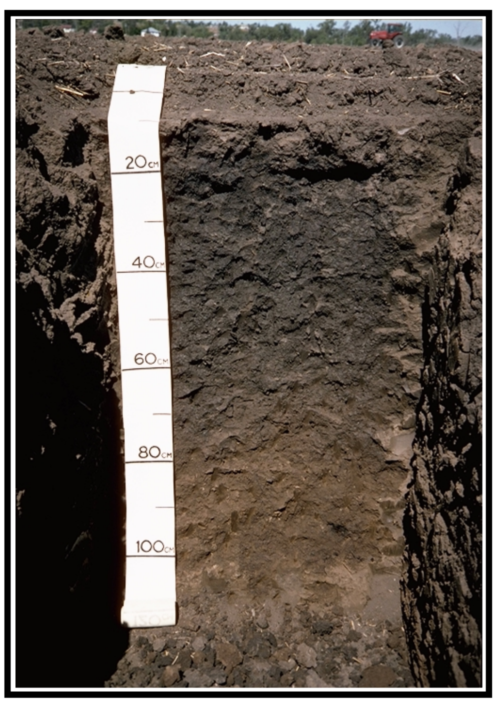
Figure 4. Total soluble salts profile for Tognolini

Photograph 1. Well developed levee, with the Callide soil, on the northern part of Hansen's block



Photograph 2. Callide soil profile showing the buried sandy soil layers below 0.6 m

Photograph 3. The backplains on the southern part of Hansen's block. Compare the Tognolini soil in the foreground, with the dark brown topsoil of the Woodall soil on the relict levee in the background.



Photograph 4. Tognolini soil profile

4. LAND USE

All three soils on Hansen's block are suitable for the main irrigated and rainfed crops grown in the Callide Valley (sorghum, cotton, lucerne, mungbeans, sunflowers, wheat, barley, oats and chickpeas). However the Callide soil is restricted to spray irrigation only, as it is too permeable for furrow irrigation. The levee landform it occurs on is unsuited to furrow irrigation as well. Callide is also prone to crusting after rainfall and irrigation due to the high fine sand and silt content in the topsoil. This can affect the emergence and thus establishment of those crops sensitive to crusting soils (eg navy beans and mungbeans). Furrow irrigation would also be limited in areas of Tognolini and Woodall due to the excessive permeability caused by the sand lenses in the lower part of the profile.

All soils are suitable for summer and winter rainfed crops as the soil water holding capacity, which is the main limitation to rainfed cropping in the district, is sufficient for reliable dryland cropping. However, Callide and Woodall soils may experience some variation in crop yields due to variation in the thickness and clay content of the underlying sand lenses, which reduce the water holding capacity. Crops will generally yield higher on the Tognolini soil due to its significantly higher plant available water capacity.

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- Ms Sue-Ellen Dear for entering the soil data into the WARIS file format.
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- Mr Neil Cliffe for providing updated climatic data from Australian Rainman and the Bureau of Meteorology
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APPENDIX 1

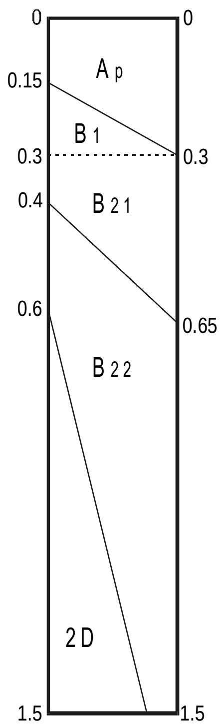
Soil profile diagrams and soil morphology descriptions

Soil: Callide

Landform: Levee

ASC: Haplic, Eutrophic/Hypocalcic, Black, Chromosol; Brown Dermosol

PPF's: Dd1.12, Gn3.22, Gn3.42



Ap: very dark brown or very dark grey brown (10YR 2/2, 3/2 m); silty loam, silty clay loam or clay loam, fine sandy; fragments (when cultivated) or weak to moderate, 2-10mm, subangular blocky; dry; moderately firm; pH 7.0-7.5; abrupt or gradual to –

B1: (when present) very dark grey brown (10YR 3/2 m); fine sandy clay loam to fine sandy light clay; massive (compacted) or moderate to strong, 2-20mm, subangular blocky; moderately moist; moderately firm; pH 7.5-8.0; clear or gradual to –

B21: very dark grey to dark brown (10YR 3/1, 3/2, 3/3 m); fine sandy light or fine sandy light medium clay; strong, 5-20mm, angular or subangular blocky structure usually parting to strong, 2-5mm, subangular blocky; moderately moist; moderately firm; pH 7.5-8.0; gradual to –

B22 (when present) very dark grey brown to dark brown (10YR 3/2, 3/3, 4/3 m); fine sandy light medium clay; strong, 10-20mm, prismatic structure parting to strong, 5-10mm, angular or subangular blocky; rarely <2%, soft or concretionary calcium carbonate segregations, < 2mm; usually non-calcareous; moist; moderately firm; pH 7.5-8.5; abrupt or clear to –

2D: (when present) dark brown to dark yellow brown (10YR 3/3, 4/3, 4/4 m); rarely, 2-20%, dark mottles; sand, sandy clay loam to sandy light clay; usually massive or moderate, 5-20mm, subangular blocky (for clay textures); loose to very firm; rarely 2-10%, soft calcium carbonate segregations, <2mm; usually non-calcareous; pH 7.5-8.5

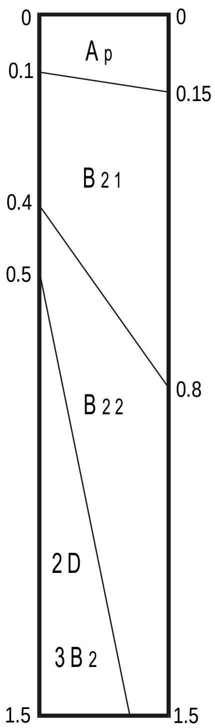
Appendix 1 Cont.

Soil: Woodall

Landform: Relict levees

ASC: Endocalcareous, Self-mulching, Black, Vertosol; or Black Dermosol

PPF's: Ug 5.1, Ug5.17, Uf6.32



Ap: very dark brown or very dark grey brown (10YR 2/2, 3/2 m); dark grey brown (10YR 4/2 d); fine sandy light medium clay or fine sandy medium clay; fragments (when cultivated) or strong, <2mm, subangular blocky or granular structure; dry; loose; pH 7.0-7.5; clear to –

B21: black to dark grey brown (10YR 2/1, 2/2, 3/1, 3/2 m); fine sandy light medium clay; strong, <2mm, lenticular or strong, 5-10mm, subangular blocky structure; moderately moist; moderately weak to firm; pH 8.0-8.5; gradual to –

B22: very dark brown to dark grey brown (10YR 2/2, 3/1, 3/2 m); occasionally, 2-20%, fine brown or red mottles; fine sandy light medium to medium clay; strong, 2-5mm, lenticular structure; moderately moist; moderately weak to firm; usually 2-10%, calcium carbonate, soft or nodules, <2-5mm; slightly calcareous; pH 8.5; abrupt or clear to –

2D1: (when present) dark brown (10YR 3/3, 4/3 m); occasionally 2-20%, dark or brown mottles, <5mm; sandy clay loam to sandy light clay; massive to moderate, 5-20 mm, subangular blocky; dry; moderately to very firm; non-calcareous; pH 8.0-8.5; abrupt to –

2D2: (when present) dark brown to brown (10YR 4/3, 4/4, 5/3 m); sand to coarse sand; massive to single grain; dry; loose to moderately weak; <2-10%, rounded gravels, 2-20mm; non-calcareous; pH 8.0-8.5

3B2: (when present) very dark grey (10YR 3/1 m); occasionally, 2-10%, brown mottles, 5-15mm; light medium to medium clay; strong, 2-5mm, lenticular structure; moderately moist; moderately to very firm; occasionally slightly calcareous; pH 8.0-8.5

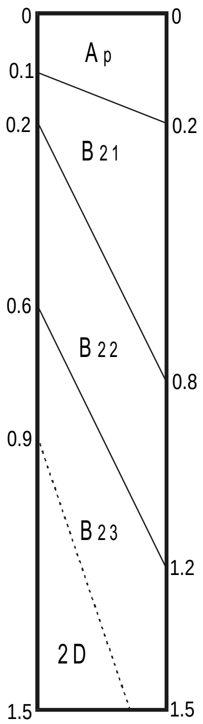
Appendix 1 Cont.

Soil: Tognolini

Landform: Backplains, inter-levee flats and drainage depression

ASC: Epi to Endocalcareous, Self-mulching, Black, Vertosol

PPF's: Ug5.1, Ug5.15, Ug5.17



Ap: black or very dark grey (10YR 2/1, 3/1 m); silty light medium to medium clay; fragments (when cultivated) to strong, <2mm, granular structure; dry; loose; pH 7.0-7.5; clear to –

B21: black to very dark grey brown (10YR 2/1, 3/1, 3/2 m); silty medium to medium heavy clay; strong, 2-5mm, lenticular parting to strong, <2mm, lenticular structure; moderately moist; moderately weak; pH 8.0-8.5; gradual to –

B22: black to very dark grey brown (10YR 2/1, 3/1, 3/2 m); silty medium to medium heavy clay; strong 5-10 mm lenticular parting to strong <2 mm lenticular structure; few slickensides; moderately moist; moderately weak; 2-10% calcium carbonate, soft or nodules, <2-5mm; slightly calcareous; pH 8.0-8.5; gradual to –

B23: very dark grey to dark brown (10YR 3/1, 3/2, 3/3 m); medium to medium heavy clay; strong, 2-10mm, lenticular or 5-20mm prismatic or blocky structure; few slickensides; moderately moist; moderately weak to firm; 2-10%, calcium carbonate, soft or nodules, 2-5mm; slightly calcareous; pH 8.0-8.5

2D: (when present) dark brown to brown (10YR 3/3, 3/4, 4/4 m); occasionally 2-20%, dark or brown mottles, <5-15mm; coarse sand to sandy clay loam and sandy medium clay; massive or single grain (for textures lighter than clay) otherwise moderate prismatic, 10-50mm; loose to very firm (depending on texture); occasionally, 2-20%, rounded gravels, 2-20mm; <2%, soft calcium carbonate segregations, <2mm; usually non-calcareous; pH 7.5-8.5

APPENDIX 2

Morphological and analytical data for sampled soil profiles

SOIL TYPE: Callide
SITE NO: S11
A.M.G. REFERENCE: 247,520 mE 7,301,920 mN ZONE 56

ASC: Sodic, Hypocalcic, Black, Chromosol
PRINCIPAL PROFILE FORM: Dd1.12

TYPE OF MICRORELIEF: zero or none
SURFACE COARSE FRAGMENTS: No coarse fragments

SUBSTRATE MATERIAL: Unconsolidated Quaternary alluvium
CONFIDENCE SUBSTRATE IS PARENT MATERIAL: Certain

SLOPE: 1 %
LANDFORM ELEMENT TYPE: Levee
LANDFORM PATTERN TYPE: Level plain <9m <1%

ANNUAL RAINFALL: 683 mm
CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

PROFILE MORPHOLOGY:

HORIZON	DEPTH	DESCRIPTION
A1	0 to .31 m	Very dark greyish brown (10YR3/2) moist; fine sandy clay loam; weak 2-5mm subangular blocky; dry; moderately firm; non-calcareous. sharp to-
B21	.31 to .48 m	Very dark brown (10YR2/2) moist; medium clay; strong 10-20mm angular blocky largest peds, parting to strong 5-10mm angular blocky next size peds; dry; very firm; non-calcareous. gradual to-
B22	.48 to 1.10 m	Dark brown (7.5YR3/2) moist; light medium clay; strong 10-20mm prismatic largest peds, parting to strong 5-10mm subangular blocky next size peds; dry; very firm; non-calcareous. diffuse to-
B23k	1.10 to 1.60 m	Dark brown (10YR3/3) moist; many 20-50% medium 5-15mm distinct brown mottles; medium clay; strong 10-20mm prismatic largest peds, parting to strong 5-10mm subangular blocky next size peds; moderately moist; moderately firm; very few <2% medium 2-6mm calcareous concretions, very few <2% fine <2mm calcareous soft segregations; slightly calcareous.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
B 0.10	7.3	.16	.002																					6.5
0.10	7.2	.07	.002	7	52	25	19	14	10	4.0	.23	1.2	.073	1.25	.029	1.7		9	.53					6.4
0.30	7.7	.07	.005	3	52	22	25	14	10	4.2	.41	.58	.062	1.27	.015	1.5		9	.52					6.8
0.40	8.0	.08	.002	3	43	18	37	27	16	6.3	1.0	.73	.080	1.33	.017	3.7		14	.55					6.9
0.60	8.0	.11	.007	3	43	15	38	25	17	7.0	1.4	.63	.098	1.34	.017	4.2		16	.61					7.0
0.90	7.9	.45	.060	2	42	22	37	27	16	7.1	1.8	.54	.083	1.34	.014	3.8		14	.68					7.3
1.20	8.0	.76	.104	4	46	20	33	20	16	8.0	2.7	.53	.065	1.33	.015	4.1								7.5
1.50	8.3	.70	.090																					7.6

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg			Cap	ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
B 0.10	1.4	.11	157	86	1			17	36	2	1.1		10									

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: 2.5:100,Soil:1M NH_4Cl @ pH 8.5 CEC methods: 2.5:100,Soil:1M NH_4Cl @ pH 8.5

Appendix 2 Cont.

SOIL TYPE: Woodall
SITE NO: S12
A.M.G. REFERENCE: 247,422 mE 7,301,280 mN ZONE 56

ASC: Melanic, Eutrophic, Black, Dermosol
PRINCIPAL PROFILE FORM: Uf6.32

TYPE OF MICRORELIEF: zero or none
SURFACE COARSE FRAGMENTS: No coarse fragments

SUBSTRATE MATERIAL: Unconsolidated Quaternary alluvium
CONFIDENCE SUBSTRATE IS PARENT MATERIAL: Certain

SLOPE: 0.5 %
LANDFORM ELEMENT TYPE: Relict levee
LANDFORM PATTERN TYPE: Level plain <9m <1%

ANNUAL RAINFALL: 683 mm
CONDITION OF SURFACE SOIL WHEN DRY: Recently cultivated

PROFILE MORPHOLOGY:

HORIZON	DEPTH	DESCRIPTION
AP	0 to .20 m	Black (10YR2/1) moist; fine sandy light medium clay; fragments; dry; non-calcareous. clear to-
B2	.20 to .70 m	Black (10YR2/1) moist; fine sandy medium clay; strong 10-20mm angular blocky parting to strong <2mm angular blocky; moderately moist; moderately firm; non-calcareous. gradual to-
B3	.70 to 1.00 m	Very dark greyish brown (10YR3/2) moist; common 10-20% medium 5-15mm distinct brown mottles; sandy light clay; very few <2% medium pebbles 6-20mm, rounded gravel, very few <2% small pebbles 2-6mm, rounded gravel; massive; moderately moist; moderately weak; non-calcareous. gradual to-
2D1	1.00 to 1.20 m	Brown (10YR4/3) moist; sandy clay loam; massive; moist; very weak; non-calcareous. abrupt to-
2D2	1.20 to 1.55 m	Brown (10YR4/3) moist; sand; few 2-10% medium pebbles 6-20mm, rounded gravel, very few <2% small pebbles 2-6mm, rounded gravel; massive; moist; very weak; non-calcareous.

Depth	1:5 Soil/Water			Particle Size				Exch. Cations					Total Elements			Moistures			Disp.Ratio		Exch	Exch	ECEC	pH
	pH	EC	Cl	CS	FS	S	C	CEC	Ca	Mg	Na	K	P	K	S	ADM	33*	1500*	R1	R2	Al	Acid		CaCl2
metres		dS/m	%	%				m.eq/100g					%			%					m.eq/100g			
	@ 40C		@105C	@ 105C				@ 105C					@ 80C			@ 105C			@ 40C		@ 105C			@ 40C
B 0.10	7.1	.14	.002																					6.7
0.10	7.0	.18	.005	19	22	29	33	23	14	7.1	.95	1.3	.750	1.20	.030	2.5		14	.74					6.6
0.30	7.5	.16	.006	26	19	29	33	26	16	7.7	.67	.50	.060	1.15	.019	3.8		13	.61					6.9
0.60	7.7	.17	.006	25	18	20	40	24	19	10	1.6	.46	.086	1.09	.020	4.1		15	.59					7.0
0.90	8.2	.09	.004	47	24	10	21	17	11	5.8	1.2	.23	.060	1.14	.012	2.0		8	.63					6.9
1.20	8.4	.07	.003	56	27	4	11	11	8.4	4.4	.98	.17	.048	1.16	.009	1.3		7						6.9
1.50	8.4	.06	.005	53	27	4	15	17	8.9	7.2	1.5	.24				2.2		7						6.9

Depth	Org.C	Tot.N	Extr. P		HCl	CaCl2 Extr		DTPA-extr.					Extractable			P		Alternative Cations				
	(W&B)		Acid	Bicarb.	K	K	P	Fe	Mn	Cu	Zn	B	SO4S	NO3N	NH4N	Buff	Equil	CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg		mg/kg					mg/kg			Cap	ug/L	m.eq/100g				
	@ 105C	@ 105C	@ 105C		@105C	@ 105C		@ 105C					@ 105C			@ 40C		@ 105C				
B 0.10	1.8	.12	220	88	1.1			19	50	2.4	1.5		9									

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: 2.5:100,Soil:1M NH_4Cl @ pH 8.5   CEC methods: 2.5:100,Soil:1M NH_4Cl @ pH 8.5

Appendix 2 Cont.

SOIL TYPE: Tognolini
SITE NO: S13
A.M.G. REFERENCE: 247,035 mE 7,301,335 mN ZONE 56

ASC: Endocalcareous, Self-mulching, Black, Vertosol
PRINCIPAL PROFILE FORM: Ug5.1

TYPE OF MICRORELIEF: zero or none
SURFACE COARSE FRAGMENTS: No coarse fragments

SUBSTRATE MATERIAL: Unconsolidated Quaternary alluvium
CONFIDENCE SUBSTRATE IS PARENT MATERIAL: Certain

SLOPE: 0 %
LANDFORM ELEMENT TYPE: Backplain
LANDFORM PATTERN TYPE: Level plain <9m <1%

ANNUAL RAINFALL: 683 mm
CONDITION OF SURFACE SOIL WHEN DRY: Periodic cracking, self-mulching

PROFILE MORPHOLOGY:

HORIZON	DEPTH	DESCRIPTION
AP	0 to .15 m	Very dark grey (10YR3/1) moist, dark grey (10YR4/1) dry; medium clay; fragments and moderate <2mm granular; dry; loose; non-calcareous. abrupt to-
B21	.15 to .50 m	Very dark grey (10YR3/1) moist; medium heavy clay; strong 2-5mm lenticular; moist; moderately weak. clear to-
B22	.50 to 1.15 m	Black (10YR2/1) moist; medium heavy clay; strong 2-5mm lenticular; moist; moderately weak; few 2-10% medium 2-6mm calcareous concretions, non-calcareous. diffuse to-
B23k	1.15 to 1.60 m	Very dark greyish brown (10YR3/2) moist; few 2-10% fine <5mm distinct brown mottles; light medium clay; strong 2-5mm lenticular; moderately moist; moderately weak; few 2-10% medium 2-6mm calcareous concretions, non-calcareous.

Depth	1:5 Soil/Water pH	EC	Cl	Particle Size CS	FS	S	C	Exch. Cations CEC	Ca	Mg	Na	K	Total Elements P	K	S	Moistures ADM	33*	1500*	Disp.Ratio R1	R2	Exch Al	Exch Acid	ECEC	pH CaCl2
metres		dS/m	%		%				m.eq/100g					%			%					m.eq/100g		
	@ 40C		@105C		@ 105C				@ 105C					@ 80C			@ 105C		@ 40C			@ 105C		@ 40C
B 0.10	7.2	.13	.003																					6.7
0.10	7.4	.13	.004	2	21	31	51	51	27	16	1.3	1.0	.088	1.00	.027	4.9		20	.50					6.7
0.30	8.0	.17	.012	1	14	29	57	52	28	21	1.9	.44	.059	.886	.019	4.9		24	.50					7.3
0.60	8.4	.25	.015	3	13	26	59	55	27	25	3.1	.38	.054	.854	.018	4.3		23	.64					7.5
0.90	8.6	.32	.020	2	17	28	58	47	20	24	4.7	.28	.043	.829	.017	5.1		24	.72					7.8
1.20	8.5	.39	.033	1	20	29	55	45	18	21	5.2	.26	.040	.915	.014	4.1								7.6
1.50	8.6	.34	.032	1	22	30	52	41	17	19	5.8	.21	.043	.938	.012	7.3		21	.87					7.9

Depth	Org.C (W&B)	Tot.N	Extr. P Acid	Bicarb.	HCl K	CaCl2 Extr K	P	DTPA-extr. Fe	Mn	Cu	Zn	B	Extractable SO4S	NO3N	NH4N	P Buff Cap	Equil	Alternative Cations CEC	Ca	Mg	Na	K
metres	%	%	mg/kg		meq%	mg/kg			mg/kg					mg/kg			ug/L			m.eq/100g		
	@ 105C	@ 105C	@ 105C		@105C	@ 105C			@ 105C					@ 105C			@ 40C			@ 105C		
B 0.10	1.8	.12	206	107	1.2			26	25	2.9	1.7		9									

* -33kPa (-0.33bar) and -1500kPa (-15 bar) using pressure plate apparatus.
Cation method: 2.5:100,Soil:1M NH_4Cl @ pH 8.5 CEC methods: 2.5:100,Soil:1M NH_4Cl @ pH 8.5