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SOILS OF THE DELTA HORTICULTURAL RESEARCH STATION, BOWEN, NORTH QUEENSLAND

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SOILS OF THE DELTA HORTICULTURAL RESEARCH STATION, BOWEN, NORTH QUEENSLAND

by

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CONTENTS

1. INTRODUCTION

1.1 Background

The horticultural industry in the Bowen area is based on the Don River delta and levees and small areas of local creek alluvial deposits. Principal crops are mangoes, tomatoes and capsicums with a variety of cucurbit and other small crops associated. All crops are irrigated, mainly from underground sources.

A detailed summary of climatic parameters for Bowen is given by Commonwealth Bureau of Meteorology (1970) while the geology of the area is covered by Paine (1972). The most detailed information available on soil distribution in the area is the 1:1 000 000 study by Isbell and Murtha (1970).

The detailed distribution of soils in the developed area and adjacent lands that might be considered for development is not known. Continuing Departmental research and extension activities and the expansion of the area developed for horticulture require that detailed soils information be obtained.

1.2 Purpose and Extent of Survey

The Delta Horticultural Research Station (DHRS) (see attached map) serves as a research and extension base for Departmental activities in the Bowen horticultural area.

The objectives of this survey were to obtain data on the soils of the Research Station in a manner that would assist the planning, implementation and extrapolation of the research program.

2. METHODS

Soil descriptions were made at 108 sites in the 10.2 ha of the Station on traverses located in such a way that all farm blocks presently developed for trials had two sites described on a diagonal while all other blocks had one site. Profiles were hand augered or exposed with 5 cm diameter thin walled soil sampling tubes to 150 cm. A 0 - 10 cm surface sample was also collected for a laboratory pH determination at each site.

Site and soil morphological descriptions were coded onto Soil Survey Data Preparation Forms and the data retrieved and sorted by computer. Final hand sorting was then used to allocate sites to soil profile classes (Beckett and Webster 1971) which are groupings of soils

such that the variation in distinguishing characteristics among soil profile classes is greater than the variation within soil profile classes.

The morphological characteristics used in grouping site descriptions into soil profile classes were:

(a) Principal Profile Form (Northcote 1971).

(b) Soil reaction trend (Northcote 1971).

(c) Profile field textures, with emphasis on depth to, and thickness and degree of horizon development of, a given field texture horizon.

The texture classification used was that of Northcote (1971) while the horizon nomenclature was as defined by McDonald (1977).

The scale for the survey was 1:2 500 and the enclosed map was produced. The map was compiled by examining the distribution of soil profile classes at 108 described sites with some interlining, mainly examining surface field texture.

3. SOIL MORPHOLOGY, CLASSIFICATION AND DISTRIBUTION

3.1 Soil Profile Classes

Seven soil profile classes have been described. Brief descriptions are:-

Don : Alkaline dark and brown duplex soils with 30 cm of fine sandy clay loam to clay loam Ap horizon.

Station : Alkaline dark and brown gradational soils with 30 cm of clay loam to fine sandy clay loam Ap horizon.

Horto : Alkaline dark and brown light and light medium non-cracking clays.

Colet : Alkaline dark and brown light and medium non-cracking and very weakly cracking clays.

Lamber : Neutral to alkaline dark non-cracking clays overlying variable sandy and clayey D horizons below 35 cm.

Delta : Neutral to alkaline dark medium textured alluvial soils.

Rio : Neutral to alkaline dark medium textured alluvial soils overlying clayey D horizons below 100 cm.

Full descriptions of soil profile classes follow and descriptions and analytical data for profiles selected as representative of soil profile classes are given in Appendix 1.

3.2 Soil Distribution and Variability

The enclosed map gives the distribution of mapping units while their soil profile class composition is estimated in Table 1.

TABLE 1: Mapping unit composition

Code	Map unit	Dominant soil profile class (>70%)	Minor soil profile class (>30%)
Do	Don	Don	Station
St	Station	Station	Don
Ho	Horto	Horto	Colet Lamber, Don
Co	Colet	Colet	Lamber, Horto Don
La	Lamber	Lamber	Colet Horto, Don, Delta, Rio
De	Delta	Delta	Rio
Ri	Rio	Rio	Delta

The soil profile classes represent the most homogeneous grouping of the described profiles it was possible to produce. At 1:2 500 scale of mapping, soil profile classes have been mapped as simple mapping units. Variability within the Lamber, Delta and Rio soil profile classes is exceedingly high due to the presence of layered D horizons with variable lateral extent. Where the D horizons are absent as in Don, Station, Horto and Colet, neither the layering nor the extreme variability are evident.

It would have proved impossible to separate the seven soil profile classes if the defined scale of survey had been 1:25 000, the accepted scale for farm design purposes. At the lower density of ground observations used in 1:25 000 surveys, relatively few profiles in the Lamber and Rio soil profile classes would have been encountered. Those encountered would probably have been treated as variants of other soil profile classes.

Conventions used in the description of soil profile classes are given in Appendix 2.

3.3 The Origins of Soil Variability

The origins of the intense soil variability encountered on the Station may be explained by examining the horizons present in the soil profile classes. Horizonation has been determined by:

(a) A range of depositional regimes over time that have given the marked layering sequences with different particle size distributions present in Delta, Rio and Lamber soil profile classes.

(b) Pedological processes as evidenced by the relatively well developed profiles of Colet, Horto, Station and Don.

Three types of material with varying particle size distributions and degrees of pedological development can be identified in the described profiles:

. Fine and medium textured materials with strong pedological development. This occurs in the A and B horizons of Don, Station, Colet and Horto and some D horizons of Rio.

. Coarse textured materials with minimal pedological development. This occurs in some D horizons of Delta, Rio and Lamber. In some profiles, two such coarse layers occur, one older and occurring below and separate from the other.

. Medium textured materials with minimal pedological development. This occurs in the A and some D horizons of Delta and Rio and occasionally in some D horizons of Lamber. Up to three medium textured D horizons are found in Delta and Rio.

3.4 Plant Responses to Soil Variability

The usually coarse textured D horizons under Lamber and Rio soil profile classes will probably give soil water relations such that tree crop and small crop performance on them will differ from that on the other soil profile classes.

While relatively uniform plant responses may be expected on the more homogeneous soil profile classes, plant response on Lamber and Rio is likely to vary with the wide range in depth to, thickness of and texture of the D horizons.

4. SOIL CHEMICAL AND PHYSICAL CHARACTERISTICS

4.1 General

The important chemical and physical characteristics of soil profile classes as shown by the sampled profiles are discussed below. Methods of analysis and general interpretations described by Bruce and Rayment (1982) were used. Data of interest for 0 - 10 cm bulk samples of each soil profile class are given in Table 2.

4.2 Nutrient Status

pH

Though soil profile classes with developed profiles (Don, Station, Colet, and Horto) consistently have alkaline soil reaction trends, all soil profile classes are neutral at the surface. The average 1:5 soil:water pH for all 108 sites was 6.8 while averages for individual soil profile classes ranged from 6.6 for Horto to 6.9 for Delta and Don. There is no significant variation between soil profile classes and the ranges within them are similar.

Surface pH of all soil profile classes falls within the range 6.5 to 7.5 where there is little likelihood of pH induced deficiencies or toxicities.

Phosphorus

Table 2 shows that all sampled soils are very high in acid extractable phosphorus and medium to high in bicarbonate extractable phosphorus. These levels suggest that the use of phosphate fertilizers could be reduced or discontinued.

Horto, Colet and Lamber have only a limited history of phosphate fertilization suggesting that these soils may be naturally high in phosphorus.

Potassium, calcium and magnesium

Potassium levels are medium to very high in all soil profile classes while calcium and magnesium levels appear adequate. A reduction in potassium fertilizer use could be considered on most soils.

Sulphur

All sampled sites had more than 0.01% total sulphur, the level above which response does not usually occur.

Carbon and nitrogen

As organic carbon and total nitrogen levels are low to medium, nitrogen availability is likely to be generally low.

Manganese

Extractable manganese levels are medium to high but are well below the level of 500 ppm above which toxicities can occur.

Zinc and copper

Zinc and copper levels are medium and toxicities are unlikely at the levels recorded.

4.3 Salinity

Table 2 shows that the Horto, Colet, Lamber, Delta and Rio sampled sites have very low salinity (E.C.) at the surface while Station is low and Don medium. Appendix 1 shows that, while there is slight increase in salinity in the D horizon of Lamber and Rio, levels throughout Horto, Colet, Lamber, Delta and Rio are low throughout the sampled profiles.

4.4 Particle Size Distribution

Coarse sand and clay contents of sampled profiles are shown in Table 3. While clay contents are lower than would be expected from field textures, particle size distributions generally reflect the principal profile forms (Northcote 1971) for sites where the profile is developed to 150 cm. Low coarse sand contents of Don at 30 - 60 cm and Colet at 90 cm, low clay in Horto at 60 cm and high clay in Station at 150 cm all suggest layered alluvial parent materials. Where D horizons were identified (Appendix 1) particle size analyses confirm the obvious layering.

4.5 Cation Exchange Capacity

Cation exchange capacity (CEC) is a function of clay content, clay activity and organic matter content. High CEC favours greater nutrient retention and is commonly associated with a high water holding capacity.

The CEC in sampled profiles is shown in Table 4. It is generally moderate but where clay content is below 10 per cent, CEC is low. It may be related linearly to clay content (R^2 = 0.58) and clay plus silt content (R^2 = 0.76). As the inclusion of silt in the relationship accounts for a further 18 per cent of the variability in CEC, it appears that either the silt fraction has considerable cation exchange capacity or that clay dispersion was not complete.

4.6 Exchangeable Sodium

Table 4 shows that the Station, Horto and Colet profiles are non sodic throughout. While Delta is sodic at 110 - 120 cm, its low clay content and CEC at this depth will minimize any effect.

Rio and Lamber profiles are strongly sodic at 140 - 150 cm and at 80 - 150 cm respectively. The depths of this sodicity are such that there should be little direct effect on plant growth but it may cause temporary perched water tables to develop in sandy D horizons above.

TABLE 2: Selected analytical data for 0 - 10 cm bulk samples

	Soil profile class						
	Don	Station	Horto	Colet	Lamber	Delta	Rio
pH	6.7	6.0	6.9	7.0	7.1	6.8	6.4
E.C. mS cm^{-1}	0.53	0.41	0.06	0.08	0.09	0.06	0.05
Acid extr. P ppm	530	690	480	320	420	290	480
Bicarb. extr. P ppm	110+	100+	103	99	65	36	56
Repl. K m. equiv. 100 g^{-1}	0.77	0.73	1.2	0.56	0.75	0.33	0.58
Exch. Ca m. equiv. 100 g^{-1}	11	6.6	15	18	13	4.5	4.1
Exch. Mg m. equiv. 100 g^{-1}	7.3	3.1	8.9	12	8.3	1.8	1.8
Total S %	0.028	0.037	0.028	0.020	0.040	0.015	0.013
Organic C %	1.4	1.1	2.4	1.7	2.5	1.1	0.61
Total N %	0.10	0.19	0.16	0.10	0.19	0.05	0.05
Extr. Fe ppm	40	104	170	94	114	48	90
Extr. Mn ppm	67	74	44	54	40	28	30
Extr. Cu ppm	2.7	1.8	4.6	3.8	5.5	0.9	2.1
Extr. Zn ppm	9.6	4.9	2.5	2.4	4.7	2.9	3.4
Coarse sand %	6	23	3	3	20	82	48
Fine sand %	54	52	37	38	38	13	39
Silt %	21	14	34	32	24	5	9
Clay %	18	8	28	29	16	3	4

TABLE 3: Coarse sand and clay contents of soil profile classes (SPC)

Depth (cm)	% Coarse sand							% Clay						
	Do*	St	Ho	Co	La	De	Ri	Do	St	Ho	Co	La	De	Ri
0-10	11	23	2	2	25	78	49	21	11	28	32	15	1	4
20-30	4	12	2	5	8	81	53	22	19	26	28	26	1	3
50-60	7	6	15	13	53	67	34	39	22	16	21	3	1	2
80-90	17	4	28	9	10	57	81	30	16	20	40	16	2	1
110-120	15	4	26	15	15	84	17	29	15	28	27	32	1	12
140-150	15	5	27	19	20	27	3	21	29	31	22	24	8	30

* See Table 1 for SPC codes

TABLE 4: CEC, exchangeable sodium percentages (ESP) and available water for soil profile classes

Depth (cm)	CEC meq. 100 g^{-1}							ESP							Available water**						
	Do*	St	Ho	Co	La	De	Ri	Do	St	Ho	Co	La	De	Ri	Do	St	Ho	Co	La	De	Ri
0-10	19	14	30	31	21	10	7	4.3	1.4	0.70	1.6	1.0	0.10	1.4	14	10	17	15	14	5	6
20-30	22	18	30	27	25	4	8	9.5	1.7	1.0	1.1	1.7	0.25	1.3	15	13	16	16	16	2	6
50-60	26	25	26	18	5	8	5	33	2.1	1.2	1.2	8.0	0.01	2.0	25	15	18	13	2	4	2
80-90	17	18	18	19	16	10	3	47	1.7	2.3	0.05	31	0.02	3.3	17	12	16	12	17	12	0
110-120	12	17	18	14	23	2	4	59	1.2	3.4	0.07	43	10	5.0			13				
140-150	13	25		12	20	14	16	64	1.5			47	0.71	28							

* See Table 1 for SPC codes

** Available water = ($-^1/_3$ bar) - (-15 bar)

The Don profile is sodic at 20 - 30 cm and strongly sodic below this. Such sodicity is likely to reduce plant available water by slowing water accession and, at 80 - 90 cm and below, it may prevent root penetration.

Appendix 1 shows that exchangeable magnesium is high in some sodic horizons so the effects of sodicity may be accentuated.

4.7 Available Water

Table 4 shows that available water throughout Station, Horto, Colet and Lamber profiles is generally high. Don profile also has high available water throughout but high sodicity may reduce the ability of plants to exploit this.

Available water for Lamber is relatively high. The strong layering effect evident in clay content (Table 3) suggests that water will perch above the clay in the 50 - 60 cm layer. This will tend to increase available water. However, with over irrigation, water logging may also occur.

Available water throughout the Delta and Rio profiles is low. They will therefore require more frequent irrigation than the other soils.

5. LAND USE

5.1 Specific Soil Considerations

Don and Station

Though seedbed characteristics in these soils are presently reasonable, the high fine sand and silt contents in the surface predispose them to hard setting if overworked. The continuous use of rotary hoes on these soils may destroy surface structure and also cause the development of a cultivation pan.

These soils have good surface drainage and fair to high available water ranges but low permeability, particularly in Don, may cause damage to crops sensitive to waterlogging.

Horto, Colet and Lamber

These are the most difficult soils to manage on the Research Station. Their management difficulties appear to be associated with the proportions of fine sand, silt and clay in surface soils. Fine sand, silt and clay are in approximately equal proportions and this may be responsible for the difficulty in preparing satisfactory seedbeds.

The surface soils contain sufficient clay to produce a coarse seedbed on cultivation but the aggregates do not readily swell and shrink on wetting and drying. Aggregates will therefore tend to slake to form a surface crust rather than self mulch. The high clay content at the surface will also give a narrow moisture range within which these soils can be successfully cultivated.

Waterlogging will be a problem because these soils occur on low slopes in low landscape positions. Levelling to obtain slopes sufficient to prevent water ponding in furrows may be necessary for crops sensitive to waterlogging and the establishment of permanent tail drains is recommended.

Although the soils have a high available water range, infiltration rate may be low as they do not crack. Irrigation increment may be reduced by slow water entry.

Two alternatives are available for management:

(i) Establishing adequate furrow slopes and tail drains and growing large seeded crops tolerant to waterlogging.

(ii) Use of soil amendments in conjunction with adequate furrow slopes and tail drains to grow a range of horticultural crops.

Soil amendments used in the Bowen area include, in order of decreasing cost, river sand, lime, gypsum and organic matter.

Delta and Rio

These are generally freely draining soils with good surface drainage, desirable seedbed characteristics but low available water. They will therefore require more frequent irrigation than the other soils of the Research Station. Trickle or spray irrigation would be most efficient, as high through drainage losses may be expected with furrow irrigation.

From a research point of view, the intense short range variability in depth to, and texture of, D horizons may affect results from deep rooting crops.

5.2 Crop Suitability

Station, Don, Delta and Rio are suited to a wide range of horticultural crops. Delta and Rio are best suited to tree crops because of their better internal drainage, the unsuitability of furrow irrigation and their distribution on the station.

Horto, Colet and Lamber are poorly suited to a range of horticultural crops unless major soil improvement programs are undertaken (see 5.1).

5.3 Irrigation Water Quality

Salinity levels

Irrigation water is drawn from underground sources. The quality of underground water in deltaic deposits can vary greatly over short distances and with time. Between 1966 and 1977, water conductivity in bore 25575 ranged from low salinity hazard (0.61 mS cm^{-1}) to levels where crop damage may be expected under certain conditions (1.70 mS cm^{-1}). The mean of 12 samples taken over this period was 0.84 mS cm^{-1} with a standard deviation of 0.29.

Sodium hazard

The water sampled on 4.4.77 had a medium sodium hazard (residual sodium bicarbonate of 2.3 meq. L^{-1} and sodium absorption ratio of 6.75). Continued long term use of this water would result in:

- Raising exchangeable sodium percentage (ESP) of the soil, particularly of surface soil where evaporative accumulation of salts will occur.
- Increasing pH of surface soils.
- Structural deterioration of soils as they become more dispersive with increasing ESP. This deterioration will be more marked on soils with significant clay contents at the surface (Horto, Colet and Lamber) than on soils with low clay contents (Delta and Rio).

The use of gypsum to reduce S.A.R. and residual sodium bicarbonate level of water whenever necessary is recommended.

6. ACKNOWLEDGEMENTS

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APPENDIX 1

Morphological and Analytical Data for Representative Soil Profiles

Notes:

DHRS	Delta Horticultural Research Station.
AMG	Australian Map Grid Reference.
Colours	Those of Oyama and Takehara (1967). All colours are moist colours.
Structure	As defined in Soil Survey Manual (Soil Survey Staff 1951).
Horizon Nomenclature	As defined by McDonald (1977).

Field texture - particle size correlations

Over 600 field textures were taken on this survey area by the three authors. Only two of these field textures were silty in nature and coded as such.

All soils except Delta and Rio have appreciable amounts of silt from their particle size analysis. This, however, was not evident in field texturing.

Estimates of clay percent from field textures in seven sampled profiles, correlated poorly with clay percent from particle size analysis but well with clay + silt percent. This result suggests that the authors have consistently textured clay + silt as clay and in Rio and Delta fine sand + clay as clay.

The reasons for this are unknown as two of the authors have extensive field experience with soils high in fine sand. It is significant, however, that field textures are often better assessments of field behaviour than particle size analysis (Thomas, personal communication 1976).

Laboratory Methods	Are those used by Agricultural Chemistry Branch (Bruce and Rayment 1982). Particle size, CEC, exchangeable cations, total element percentages and organic carbon results are reported on an oven dry basis while other results are on an air dry basis.
Soil Taxonomy	Classifications to subgroup category of Soil Taxonomy (Soil Survey Staff 1975) are given. These classifications are based on limited data and are approximations based on data available.

Soil Profile Class: DON
Great Soil Group: No suitable group
Parent Material: Don River alluvia
Topography: Deltaic plain

Map Unit:
Soil Taxonomy: Udic Haplustalf
A.M.G. Ref:
Air Photo Ref:
Location: Delta Horticultural Research Station, Bowen

Site No: C4
P.P.F.: Dd 1.13

Vegetation: Fallow cultivation

Profile Morphology: Surface - Hard setting.

Ap	0 - 20 cm	Black (10YR 2/1); fine sandy clay loam; moderate medium subangular blocky. Clear to -
B_{21}	20 - 60 cm	Brownish black (10YR 2/2); light medium clay to medium clay; strong coarse subangular blocky; smooth ped; dry hard. Clear to -
B_{22}	60 - 90 cm	Dark brown (10YR 3/3); medium clay; strong coarse subangular blocky; dry hard; trace amounts of manganiferous and carbonate concretions. Clear to -
B_{23}	90 - 150 cm	Brown (10YR 4/6); light medium clay to medium clay; strong coarse subangular blocky; dry hard; trace amounts of manganiferous and carbonate concretions.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) mScm^{-1}	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Moisture % 1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.			A.D.	
Ø9428	0-10	6.7	0.63	0.054		11	50	22	21	19	10	6.8	0.72	0.82	0.113	1.48	0.03	2.6	24	10
Ø9430	20-30	7.2	0.11	0.010		4	53	23	22	22	11	16	0.21	2.1				2.8	27	12
Ø9433	50-60	8.4	0.30	0.020		0.7	40	16	39	26	7.0	13	0.15	8.5	0.036	1.07	0.022	3.3	44	19
Ø9436	80-90	9.6	0.54	0.027		17	42	10	30	17	4.1	7.7	0.15	8.0	0.084	1.19	0.014	2.1	32	15
Ø9439	110-120	9.7	0.37	0.011		15	50	9	29	12	0.8	4.4	0.13	7.0	0.068	1.51	0.008	1.8		
Ø9442	140-150	9.9	0.44	0.006		15	52	8	21	13	1.0	4.1	0.18	8.3	0.063	1.39	0.009	2.5		

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100g	Fe D.T.P.A.	Mn D.T.P.A.	Cu Extr. ppm	Zn Extr. ppm	B ppm
Ø9428	0-10	1.5	0.10	564	100+	0.62	80	76	2.7	9.0	
Ø9429	10-20	1.2	0.09	490	100+	0.45	97	24	2.6	5.4	

Soil Profile Class: STATION
Great Soil Group: No suitable group
Parent Material: Don River alluvia
Topography: Deltaic plain - low lying areas

Map Unit:
Soil Taxonomy: Pachic Haplustoll
A.M.G. Ref:
Air Photo Ref:
Location: Delta Horticultural Research Station, Bowen

Site No: C11
P.P.F.: Gn 3.43

Vegetation: Fallow cultivation

Profile Morphology: Surface - Hard setting.

Ap	0 - 30 cm	Brownish black (10YR 2/2); clay loam sandy; moderate medium subangular blocky; firm. Clear to -
A_3	30 - 40 cm	Brownish black (10YR 2/3); sandy clay; moderate medium subangular blocky; firm. Clear to -
B_{21}	40 - 100 cm	Brownish black (10YR 2/2); light clay; moderate medium subangular blocky; smooth ped; slightly hard. Clear to -
B_{22}	100 - 120 cm	Brownish black (10YR 2/3), weak yellow mottle; sandy clay; moderate medium subangular blocky; smooth ped; slightly hard; trace amounts of manganiferous concretions and soft patches. Clear to -
B_{23}	120 - 150 cm	Dark brown (10YR 3/3), weak yellow mottle; light medium clay; moderate medium subangular blocky; smooth ped; trace amounts of manganiferous concretions and soft patches.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) mScm^{-1}	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	P	K	S	Moisture % 1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.			A.D.	
Ø9380	0-10	5.9	0.46	0.017		23	49	16	11	14	6.6	3.3	0.59	0.20	0.111	1.85	0.020	2.2	17	7
Ø9382	20-30	6.7	0.10	0.006		12	51	19	19	18	12	5.0	0.29	0.31	0.098	1.74	0.014	4.8	23	10
Ø9385	50-60	7.1	0.08	0.004		6	47	27	22	25	17	9.9	0.09	0.54	0.075	1.38	0.015	7.5	28	13
Ø9388	80-90	7.0	0.11	0.007		4	60	20	16	18	12	7.5	0.08	0.31	0.066	1.32	0.013	3.1	21	9
Ø9391	110-120	6.9	0.22	0.016		4	65	14	15	17	9.9	9.5	0.05	0.21	0.052	1.18	0.018	3.3		
Ø9394	140-150	7.5	0.21	0.015		5	48	19	29	25	13	12	0.17	0.37	0.034	1.15	0.016	5.6		

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100g	Fe D.T.P.A.	Mn D.T.P.A.	Cu Extr. ppm	Zn Extr. ppm	B ppm
Ø9380	0-10	0.85	0.07	705	100+	0.76	102	63	1.7	5.4	
Ø9381	10-20	0.79	0.08	690	100+	0.65	94	40	1.8	4.6	

Soil Profile Class: HORTO
Great Soil Group: No suitable group
Parent Material: Don River alluvia
Topography: Deltaic plain - low lying area

Map Unit:
Soil Taxonomy: Pachic Haplustoll
A.M.G. Ref:
Air Photo Ref:
Location: Delta Horticultural Research Station, Bowen

Site No: C85
P.P.F.: Uf 6.32

Vegetation: Fallow cultivation

Profile Morphology: Surface - Hard setting.

Ap	0 - 30 cm	Black (10YR 2/1); light clay; strong medium blocky; dry hard. Gradual to -
A_1	30 - 80 cm	Brownish black (10YR 2/2); light clay; strong subangular blocky; dry hard. Clear to -
B_{21}	90 - 110 cm	Black (10YR 2/1); light medium clay; strong subangular blocky; dry hard; trace amounts of manganiferous concretions. Clear to -
B_{22}	110 - 150 cm	Dark brown (10YR 3/3); medium clay; strong subangular blocky; dry hard; small amounts of manganiferous and carbonate concretions.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture %		
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.			A.D.	1/3 bar	15 bar
Ø9476	0-10	6.9	0.04	0.003		2	40	30	28	30	17	10	0.98	0.21	0.099	1.67	0.025	3.6	33	16
Ø9478	20-30	7.2	0.03	0.004		2	49	25	26	30	19	14	0.38	0.31	0.085	1.54	0.017	3.9	33	17
Ø9481	50-60	7.6	0.03	0.002		15	50	19	16	26	17	10	0.13	0.31	0.068	1.29	0.011	3.4	31	13
Ø9484	80-90	8.0	0.03	0.002		28	38	10	20	18	11	7.7	0.08	0.41	0.029	1.33	0.006	2.4	26	10
Ø9487	110-120	8.3	0.03	0.002		26	39	5	28	18	9.1	8.7	0.10	0.61	0.018	1.42	0.006	2.4	24	11
Ø9490	140-150	8.6	0.12	0.002		27	27	14	31									3.7		

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100g	Fe D.T.P.A.	Mn D.T.P.A.	Cu Extr. ppm	Zn Extr. ppm	B ppm
Ø9476	0-10	2.2	0.16	466	98	1.04	171	39	5.0	1.9	
Ø9477	10-20	1.9	0.12	450	73	0.55	138	36	4.5	1.4	

Soil Profile Class: COLET
Great Soil Group: No suitable group
Parent Material: Don River alluvia
Topography: Deltaic deposits - low lying areas

Map Unit:
Soil Taxonomy: Pachic Haplustoll
A.M.G. Ref:
Air Photo Ref:
Location: Delta Horticultural Research Station, Bowen

Site No: C75
P.P.F.: Uf 6.31

Vegetation: Fallow cultivation

Profile Morphology: Surface - Hard setting and very weakly cracking (1 crack per 1.5 m^2).

Ap	0 - 30 cm	Black (10YR 2/1); medium clay; strong medium blocky; dry extremely hard. Clear to -
A_1	30 - 70 cm	Black (10YR 2/1); light medium to medium clay; strong subangular blocky; dry extremely hard. Clear to -
B_{21}	70 - 130 cm	Brown to dark brown (10YR 3/3 to 4/4); medium clay; strong subangular blocky; dry extremely hard; trace amounts of manganiferous and carbonate concretions. Clear to -
B_{22}	130 - 150 cm	Brown (7.5YR 4/4); light medium clay to medium clay; strong subangular blocky; dry extremely hard; trace amounts of manganiferous and carbonate concretions.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture %		
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.			A.D.	1/3 bar	15 bar
Ø9412	0-10	7.4	0.06	0.004		2	35	28	32	31	19	15	0.08	0.52	0.078	1.42	0.016	4.8	32	17
Ø9414	20-30	7.3	0.07	0.003		5	40	26	28	27	17	13	0.05	0.31	0.070	1.47	0.015	4.6	32	16
Ø9417	50-60	7.8	0.04	0.003		13	49	17	21	18	10	8.1	0.04	0.21	0.022	1.23	0.007	3.6	25	12
Ø9420	80-90	8.2	0.05	0.002		9	41	13	40	19	9.9	9.8	0.35	0.01	0.029	1.35	0.010	6.3	30	18
Ø9423	110-120	8.4	0.08	0.002		15	46	9	27	14	7.4	7.3	0.36	0.01	0.044	1.39	0.009	3.3		
Ø9426	140-150	8.5	0.08	0.002		19	47	12	22	12	7.0	5.6	0.17		0.048	1.56	0.007	2.9		

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100g	Fe D.T.P.A.	Mn D.T.P.A.	Cu Extr. ppm	Zn Extr. ppm	B ppm
Ø9412	0-10	1.8	0.09	283	67	0.31	71	31	4.1	1.6	
Ø9413	10-20	1.9	0.10	320	95	0.53	90	56	4.0	2.1	

Soil Profile Class: LAMBER
Great Soil Group: Alluvial soil
Parent Material: Don River alluvia
Topography: Deltaic deposits - low lying areas

Map Unit:
Soil Taxonomy: Mollic Ustifluvents
A.M.G. Ref:
Air Photo Ref:
Location: Delta Horticultural Research Station, Bowen

Site No: C71
P.P.F.: Uf 6

Vegetation: Fallow cultivation

Profile Morphology: Surface - Hard setting.

Ap_1	0 - 10 cm	Black (10YR 1.7/1); sandy clay; strong medium blocky; dry hard. Clear to -
Ap_2	10 - 20 cm	Black (10YR 2/1); light clay; strong medium blocky; dry hard. Clear to -
Ap_3	20 - 30 cm	Black (10YR 2/1); light clay to light medium clay; strong subangular blocky; dry hard. Clear to -
A_1	30 - 40 cm	Brownish black (10YR 3/2); light medium clay; strong subangular blocky; dry hard. Abrupt to -
D_1	40 - 60 cm	Dark brown (10YR 3/3); coarse sandy loam; single grain loose. Abrupt to -
D_2	60 - 100 cm	Brownish black (10YR 3/2); light clay; strong subangular blocky; dry hard. Diffuse to -
D_3	100 - 120 cm	Brownish black (10YR 3/2); medium clay; strong subangular blocky; dry hard. Gradual to -
D_4	120 - 150 cm	Greyish yellow brown (10YR 4/2); medium clay; strong subangular blocky; dry hard; trace amounts of manganiferous and carbonate concretions.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
Ø9444	0-10	7.0	0.07	0.005		25	38	23	15	21	11	7.7	0.41	0.21	0.083	1.59	0.028	2.9	25	11
Ø9446	20-30	8.0	0.09	0.004		8	44	26	26	25	12	7.4	0.21	0.42	0.081	1.58	0.019	3.8	28	12
Ø9449	50-60	8.4	0.03	0.003		53	41	5	3	5	16	9.9	0.03	0.40	0.066	1.55	0.004	0.7	5	3
Ø9452	80-90	9.1	0.13	0.010		10	54	23	16	16	3.3	1.9	0.08	5.0	0.039	1.22	0.007	2.6	28	11
Ø9455	110-120	9.5	0.19	0.012		15	40	12	32	23	8.5	6.4	0.13	10	0.025	1.15	0.014	3.0		
Ø9458	140-150	9.6	0.25	0.011		20	41	13	24	20	2.7	6.8	0.15	9.5	0.030	1.22	0.007	2.8		

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100g	Fe D.T.P.A.	Mn D.T.P.A.	Cu Extr. ppm	Zn Extr. ppm	B ppm
Ø9444	0-10	1.9	0.12	381	49	0.52	105	45	4.2	4.2	
Ø9445	10-20	1.5	0.10	370	41	0.30	78	37	2.9	3.4	

Soil Profile Class: DELTA
Great Soil Group: Alluvial soil
Parent Material: Don River alluvia
Topography: Deltaic plain - infilled channel

Map Unit:
Soil Taxonomy: Mollic Ustifluvent
A.M.G. Ref:
Air Photo Ref:
Location: Delta Horticultural Research Station, Bowen

Site No: C56
P.P.F.: Um 5.52

Vegetation: Mango orchard

Profile Morphology: Surface - Hard setting.

Ap	0 - 20 cm	Black (10YR 2/1); sandy clay loam; weakly structured; loose. Clear to -
A_1	20 - 30 cm	Black (10YR 2/1); light sandy clay loam; weakly structured. Abrupt to -
D_1	30 - 70 cm	Dark brown (10YR 3/3); coarse sand; single grain; loose. Abrupt to -
D_2	70 - 90 cm	Dark brown (10YR 3/3); fine sandy clay loam; weak structure. Abrupt to -
D_3	100 - 120 cm	Dark brown (10YR 3/3); coarse sand; massive. Abrupt to -
D_4	120 - 150 cm	Dark brown (10YR 3/3); fine sandy clay loam; moderate structure.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
Ø9396	0-10	6.2	0.06	0.003		78	15	3	1	10	2.8	1.6	0.35	0.01	0.051	1.98	0.010	0.6	7	3
Ø9398	20-30	6.8	0.02	0.002		81	13	6	1	4	1.5	1.2	0.10	0.01	0.044	1.83	0.006	0.7	5	3
Ø94Ø1	50-60	6.6	0.02	0.002		67	21	10	1	8	3.2	2.1	0.38	0.10	0.061	1.84	0.005	1.3	8	4
Ø94Ø4	80-90	6.8	0.02	0.002		57	28	11	2	10	6.2	3.3	0.66	0.20	0.072	1.73	0.006	1.5	10	5
Ø94Ø7	110-120	7.0	0.02	0.001		84	13	3	1	2	1.5	1.2	0.58	0.20	0.040	1.92	0.002	0.5		
Ø941Ø	140-150	6.9	0.04	0.004		27	45	21	8	14	10	4.3	0.21	0.10	0.078	1.50	0.008	3.0		

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100g	Fe D.T.P.A.	Mn D.T.P.A.	Cu Extr. ppm	Zn Extr. ppm	B ppm
Ø9396	0-10	0.61	0.04	282	22	0.35	32	32	0.7	3.1	
Ø9397	10-20	0.28	0.03	270	20	0.19	24	10	0.6	3.6	

Soil Profile Class: RIO
Great Soil Group: Alluvial soil
Parent Material: Don River alluvia
Topography: Deltaic deposits - infilled channel

Map Unit:
Soil Taxonomy: Mollic Ustifluvent
A.M.G. Ref:
Air Photo Ref:
Location: Delta Horticultural Research Station, Bowen

Site No: 069
P.P.F.: Um 5.52

Vegetation: Mango orchard

Profile Morphology: Surface - Hard setting.

Ap	0 - 30 cm	Black (10YR 2/1); loam with some coarse sand; weak structure. Clear to -
A_1	30 - 50 cm	Black (10YR 2/1); loam with some coarse sand; weak structure. Clear to -
D_1	50 - 70 cm	Dark brown (10YR 3/3); sandy loam (medium sand); massive. Clear to -
D_2	70 - 120 cm	Dark brown (10YR 3/3); coarse sandy loam; massive. Clear to -
D_3	120 - 150 cm	Brownish black (10YR 3/2); fine sandy clay; moderate structure.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mSom^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture %		
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.			A.D.	1/3 bar	15 bar
Ø9460	0-10	6.7	0.04	0.002		49	38	8	4	7	4.0	1.8	0.28	0.10	0.074	1.66	0.012	0.9	10	4
Ø9462	20-30	6.9	0.02	0.002		53	34	8	3	8	5.2	2.3	0.20	0.10	0.068	1.78	0.008	0.9	10	4
Ø9465	50-60	7.3	0.02	0.001		34	58	4	2	5	3.6	1.4	0.08	0.10	0.069	1.48	0.004	0.7	5	3
Ø9468	80-90	7.3	0.02	0.001		81	17	5	1	3	1.5	0.8	0.05	0.10	0.049	1.87	0.002	0.3	2	2
Ø9471	110-120	7.7	0.03	0.002		3	37	30	30	4	2.8	1.4	0.05	0.20	0.058	1.67	0.003	0.5		
Ø9474	140-150	9.0	0.13	0.009		17	52	18	12	16	7.6	5.8	0.09	4.6	0.050	1.33	0.006	2.6		

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb P ppm	Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn D.T.P.A. Extr. ppm	Cu D.T.P.A. Extr. ppm	Zn D.T.P.A. Extr. ppm	B ppm
Ø9460	0-10	0.68	0.03	454	38	0.50	42	24	1.3	2.5	
Ø9461	10-20	0.65	0.04	400	28	0.49	42	17	1.2	2.4	

APPENDIX 2

Conventions Used in the Description of Soil Profile Classes

Frequency of Occurrence — Number of sites classified as a given soil profile class x 100/total number of sites classified.

Principal Profile Form — As in Northcote (1971).

Textures — As in Northcote (1971).

Colours — Colour codes are those of Oyama and Takehara (1967) for moist soil while colour nomenclature is that of McDonald (personal communication), which is based on the Value/Chroma rating system of Northcote (1971) and utilizes the following table:

Value/Chroma 2a = 4/1 - 4/2 to 6/1 - 6/2
Value/Chroma 2b = 5/3 - 5/4 to 6/3 - 6/4

Value/ Chroma	1	2a	2b	4	5
Hue					
5Y	dark	grey	yellow-grey	yellow	olive
2.5Y	dark	grey	yellow-grey	yellow	olive-brown
10YR	dark	grey	yellow-brown	yellow	brown
7.5YR	dark	grey-brown	brown	yellow	brown
5YR	dark	grey-brown	brown	red-brown	red-brown
2.5YR	dark	grey-brown	red-brown	red	red
10R	dark	red-grey	red-brown	red	red

Horizons — As in McDonald (1977).

Profile Morphology — Most common range of morphology encountered in the soil profile class.

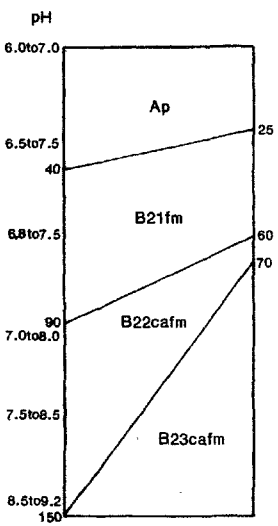
pH — Based on field determinations at 5, 30, 60, 90, 120 and 150 cm.

SOIL PROFILE CLASS: DON

PRINCIPAL PROFILE FORMS: Dd 1.13, Db 1.13, Db 2.13, Dd 2.23

BRIEF DESCRIPTION: Alkaline dark and brown duplex soils formed on alluvium.

SOIL PROFILE MORPHOLOGY



Ap-horizon: dark (10YR 2/1, 3/2) fine sandy clay loam to clay loam, moderately structured. Clear to -

B_{21}fm horizon: dark to brown (10YR 2/1 to 3/4) light medium to medium clay, strongly structured, trace amounts of soft manganiferous patches. Gradual to clear to -

B_{22}cafm horizon: brown (10YR 3/4) medium clay, strongly structured, trace amounts of soft manganiferous patches and concretionary lime. Gradual to -

B_{23}cafm horizon: brown (10YR 4/6) light medium to medium clay, strongly structured, trace amounts of soft manganiferous patches and small amounts of concretionary lime.

Variants: A_1 horizon may occur between 20 to 45 cm with colour and textures of dark (10YR 3/1) clay loam sandy to fine sandy clay loam.

B_3 horizon may occur between 90 to 150 cm with colour and textures of brown clay loam to sandy clay.

B_{21} horizon may occasionally be weakly yellow or darkly mottled.

B_{23} horizon may occasionally have a water table below 130 cm.

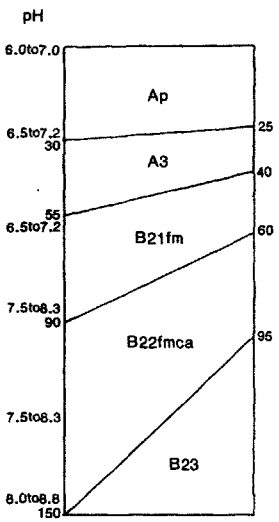
A_2 horizon of dark (10YR 3/2) clay loam may occur between 20-40 cm.

SOIL PROFILE CLASS: STATION

PRINCIPAL PROFILE FORMS: Gn 3.23, Gn 3.43, Gn 3.42

BRIEF DESCRIPTION: Alkaline dark and brown gradational soils formed on alluvium.

SOIL PROFILE MORPHOLOGY



Ap-horizon: dark (10YR 1.7/1, 2/2) clay loam to fine sandy clay loam, moderately structured. Gradual to -

A_3-horizon: dark (10YR 3/1) light clay to sandy clay, moderately structured. Clear to -

B_{21}fm-horizon: dark to brown (10YR 3/1 to 3/3) light clay to medium clay, strongly structured, trace amounts of soft manganiferous patches. Clear to -

B_{22}fmca-horizon: dark to brown (10YR 2/2 to 3/4) light clay to medium clay, strongly structured, trace amounts of soft manganiferous patches and concretionary lime. Gradual to -

B_{23}-horizon: weakly yellow mottled dark to brown (10YR 3/1 to 3/3) sandy clay to light medium clay, strongly structured.

Variants: A_1 horizon may occur between 20 and 60 cm with colours and textures of dark (10YR 2/2) fine sandy clay loam or dark (10YR 2/2) clay loam sandy or dark (10YR 2/1) clay loam or fine sandy clay loam.

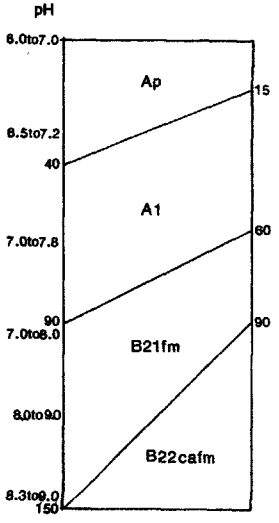
D_1, D_2, D_3, D_4 horizons may occur below the B_{21} with colours and textures of dark brown (10YR 3/3) fine sand, brown (10YR 3/3) fine sandy clay loam, dark (10YR 3/1) clay loam, dark (10YR 3/2) light medium clay.

SOIL PROFILE CLASS: HORTO

PRINCIPAL PROFILE FORMS: Uf 6.32, Uf 6.31

BRIEF DESCRIPTION: Alkaline dark and brown light and light medium non-cracking clays formed on alluvium

SOIL PROFILE MORPHOLOGY



Ap-horizon: dark (10YR 2/1), light clay to light medium clay, strongly structured. Diffuse to -

A_1-horizon: dark (10YR 2/1, 3/2) light clay, strongly structured. Gradual to -

B_{21}fm-horizon: dark brown (10YR 2/1 to 4/4) light clay to light medium clay, strongly structured, trace amounts of soft manganiferous patches. Gradual to -

B_{22}cafm-horizon: brown (10YR 3/3 to 4/6) light clay to medium clay, strongly structured, trace amounts of soft manganiferous patches and lime concretions.

Variants: Uf 3: Sporadically bleached A_2 may occur between 40 and 100 cm.

A_2 horizons may occur between 40 and 100 cm with colours and textures of dark to brown (10YR 3/2 to 3/4) sandy clay to light clay (Uf 4.4 soils).

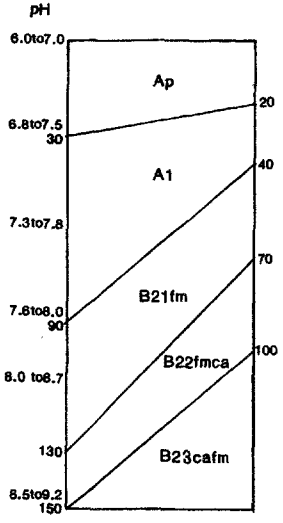
A_3 horizons may occur between 40 and 100 cm with colour and texture of dark (10YR 3/2) sandy clay.

SOIL PROFILE CLASS: COLET

PRINCIPAL PROFILE FORMS: Uf 6.32, Uf 6.31, Ug 5.15, Uf 4.4

BRIEF DESCRIPTION: Alkaline dark and brown light and medium non-cracking and very weakly cracking clays formed on alluvium.

SOIL PROFILE MORPHOLOGY



Ap-horizon: dark (10YR 2/1. 3/2) light clay to medium clay, strongly structured. Gradual to -

A_1-horizon: dark (10YR 3/2) light clay to medium clay, strongly structured. Gradual to -

B_{21}fm-horizon: dark to brown (10YR 2/1 to 4/4) light clay to medium clay, strongly structured, trace soft manganiferous patches. Gradual to -

B_{22}fmca-horizon: dark red to brown (5YR 3/3 to 10YR 4/4) medium clay to medium heavy clay, strongly structured, trace amounts of concretionary lime and soft manganiferous patches and concretions. Gradual to -

B_{23}cafm-horizon: red brown to brown (5YR 3/6 to 10YR 4/4) light medium clay to medium clay, strongly structured, trace amounts of concretionary lime and manganiferous concretions.

Variants: Uf 4.44 - A_2 horizon may occur between 20 to 60 cm with colours and textures of dark (10YR 3/1, 3/2) light clay to light medium clay. A_2 horizon may be sporadically bleached (Uf 3).

Uf 6.42 - B_{21}fm horizon may be weakly mottled or may have a weak sporadic bleach.

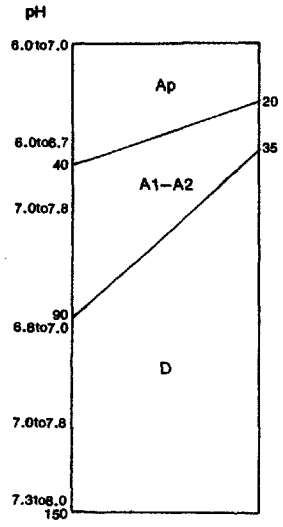
D horizons of brown (10YR 3/3) sandy clay may replace B_{23}cafm horizons.

SOIL PROFILE CLASS: LAMBER

PRINCIPAL PROFILE FORMS: Uf 6, Uf 4

BRIEF DESCRIPTION: Neutral to alkaline dark non-cracking clays overlying variable sandy to clayey D horizons.

SOIL PROFILE MORPHOLOGY



Ap-horizon: dark (10YR 2/1, 2/2) sandy clay to light medium clay, strongly structured. Gradual to clear to -

A_1-A_2-horizon: dark (10YR 2/1, 3/2) light medium clay to medium clay, strongly structured. Clear to abrupt to -

D-horizon: 3 to 5 D horizons may be present. D_1 to D_2 range in colour and texture from dark to brown (10YR 3/2, 4/4) fine sandy loam to fine sandy clay loam. D_3 is normally dark to brown (10YR 3/2, 4/4) clay loam sandy to sandy clay. D_4 and D_5 are normally brown (10YR 4/4) light clay to medium clay.

Variants: Uf 1.23 - Ap horizon directly overlies the D horizons and the Ap horizon is weakly structured.

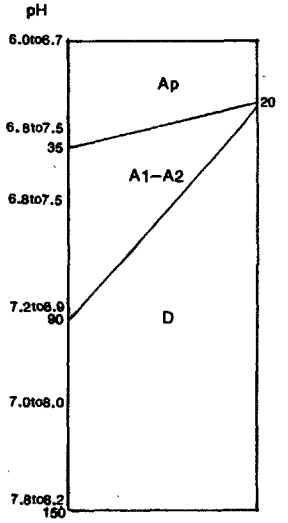
Ap horizon may directly overlie a B_2 horizon of dark to brown (10YR 3/2 to 4/4) medium clay at 30 to 60 cm.

SOIL PROFILE CLASS: DELTA

PRINCIPAL PROFILE FORMS: Um 5.52, Um 6.41, Um 4

BRIEF DESCRIPTION: Neutral to alkaline dark medium textured alluvial soils.

SOIL PROFILE MORPHOLOGY



Ap-horizon: dark (10YR 2/2, 3/2) sandy clay loam to clay loam, weakly to moderately structured. Clear to A_1, sharp to D.

A_1-A_2-horizon: dark (10YR 3/2) loam to fine sandy clay loam, weakly structured. Sharp to -

D-horizon: Up to 7 D horizons may be present. Average thickness of a D horizon is 30 cm with a range of 10 to 50 cm. A wide range of textures is present, however no consistent layering sequence is evident. Textures found were (in order of decreasing frequency): sandy clay loam to fine sandy clay loams, light sandy clay loam to loam fine sandy, coarse sand to coarse sandy loam, sandy clay.

Variants: A_{21} horizon may occur below 20 cm with colour and texture of dark (10YR 2/3) fine sandy clay loam, underlain by 50 cm by A_{22} horizon of brown (10YR 3/3) fine sandy clay loam.

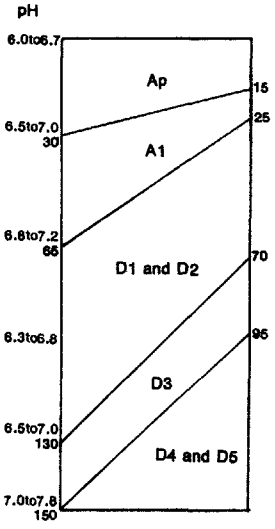
B_2 horizons may occur below 45 cm with a colour and texture of dark to brown (10YR 2/1 to 4/4) sandy clay loam.

SOIL PROFILE CLASS: R10

PRINCIPAL PROFILE FORMS: Um 5.52, Um 6.42, Gn 1.12

BRIEF DESCRIPTION: Neutral to alkaline dark medium textured alluvial soils overlying clayey D horizons below 100 cm

SOIL PROFILE MORPHOLOGY



Ap-horizon: dark (10YR 2/1, 2/2) loam to clay loam, weakly to moderately structured. Gradual to diffuse to -

A_1-horizon: dark (10YR 2/1, 3/2) loam to clay loam, weakly to moderately structured. Clear to -

D_1 and D_2 horizons: these horizons overlie each other in an inconsistent manner. Colours are always brown (10YR 4/4 to 3/3) and common textures are coarse sands to clay loam sandy. Abrupt to -

D_3-horizon: brown (10YR 3/3 to 4/4) clay loam sandy to sandy clay. Abrupt to -

D_4 and D_5 horizons: horizons of dark to dark brown (10YR 2/1 to 3/3) light clay to medium heavy clay with trace amounts of manganiferous concretions and soft patches.

Variants: Um 6.31 - B_1 horizon may occur at 20 to 30 cm with colour and texture of dark (10YR 2/1) clay loam.

Gn 3.42 - B_2 horizons may occur at 25 to 40 cm with colours and textures of dark (10YR 2/2, 3/2) clay loam to sandy clay.

Uc 1.44 - Ap and A_1 horizons may have textures sandier than sandy loam.

Um 4 - A_2 horizon of dark (10YR 3/2) sandy clay loam may occur between 30 and 45 cm.