IRRIGATION CHARACTERISTICS OF SOILS IN THE MAREEBA-DIMBULAH AREA OF NORTH QUEENSLAND

1. SOIL MOISTURE CHARACTERISTICS OF THREE MAJOR SOIL TYPES

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SUMMARY

Data on the field capacity, wilting point, bulk density, available soil moisture and texture of three important tobacco soils are presented.

A general description of the soils is included together with some comments on their behaviour under irrigation.

I. INTRODUCTION

The Mareeba-Dimbulah area in North Queensland is being developed as a major irrigation area.

This paper discusses basic studies on the soil moisture characteristics of three major soil types on which tobacco is being grown under irrigation. The investigations reported were conducted in conjunction with field investigations of infiltration capacity which will be reported in a subsequent paper.

II. SOIL DESCRIPTIONS

The soil types examined were originally described by officers of the Queensland Department of Agriculture and Stock in unpublished Departmental reports. They were designated:

(*a*) Walsh Sandy Clay Loam (Type 43)
(*b*) Algoma Loamy Sand (Type 32)
(*c*) Dimbulah Sandy Loam (Type 41).

These soils occupy considerable areas on the left bank of the Walsh River. In general terms, the area can be described as a fairly narrow strip running east-west and bounded on the north by the Walsh River and on the south by a range of mountains and hills. Closely related soil types occur in other sections of the irrigation scheme.

To study irrigation characteristics, representative virgin areas were selected either on or adjacent to Parada Tobacco Experiment Station. In locating these sites, the original soil survey reports were consulted. The type profile descriptions from these reports have been included in Appendix 1 for purposes of comparison.

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Field descriptions of the profiles at the selected sites are given below, together with general features of each soil type.

(a) Walsh Sandy Clay Loam (Type 43)

This alluvium forms the levee bank of the Walsh River and occupies approximately 970 ac. It gradually falls away from the river, merging into a drainage line of depression-type soils. The slope ranges from 0·5 to 1·0 per cent.

The vegetation is predominantly long-leafed box (*Eucalyptus leptophleba*) and bloodwood (*E. intermedia*), with a slight preponderance of the former. Beefwood (*Grevillea glauca*), ironwood (*Erythrophloeum chlorostachys*) and quinine berry (*Petalostigma pubescens*) also occur. Poplar (*Eucalyptus alba*) is common along the lower slopes where this soil merges into the depression soils. The principal grasses are kangaroo grass (*Themeda australis*), giant spear grass (*Heteropogon triticeus*) and bunch spear grass (*H. contortus*). Figure 1 shows typical vegetation.

Fig. 1.—Vegetation on Walsh Sandy Clay Loam. Large long-leafed box in right foreground.

PROFILE DESCRIPTION (Figure 2)

Horizon	Depth (in.)	
A1	0–12	light brown sandy loam
B1	12–54	reddish yellow clay loam—loam
B2	54–72	reddish gritty clay loam

Horizon boundaries are diffuse. Concretionary material up to ½ in. in diameter is commonly found in the surface foot.

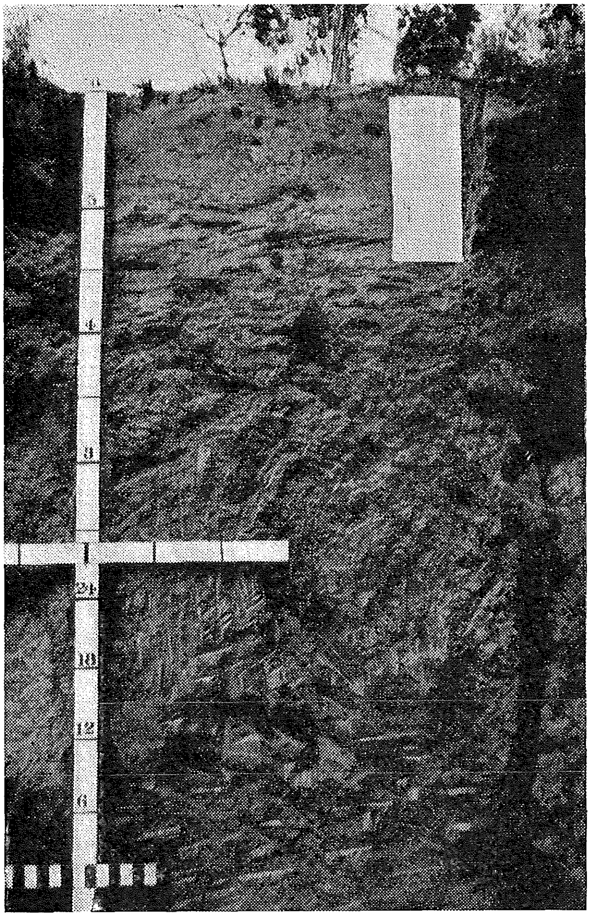

Fig. 2.—Soil Profile—Walsh Sandy Clay Loam.

This fine-textured soil becomes hard on drying, particularly at a depth of 12–15 in., where there is a compacted layer which tends to restrict water penetration.

A type profile description is given in the Appendix.

(b) Algoma Loamy Sand (Type 32)

This soil occupies some 4,200 ac in the Left Bank Walsh area. It is a coarse sandy regosol formed from granitic material conveyed from mountains to the south and deposited in the "fill" area between the mountains and the Walsh River. The "fill" area is dissected by many minor streams and drainage lines and the Algoma soil type is associated in a complex pattern with other less desirable alluvial soils. It occurs on gentle slopes of up to 1·0 per cent.

Fig. 3.—Vegetation on Algoma Loamy Sand. Bloodwood in right foreground; pandanus and tea-tree in background.

The general area of this soil type has a very slight surface accumulation of organic matter and a very small amount of silt and clay throughout the profile. It supports a mixed open forest vegetation, chiefly bloodwood and broad-leafed tea-tree (*Melaleuca nervosa*). Beefwood, long-leafed box and quinine berry also occur and the grass cover is predominantly spear grasses.

Throughout areas of this general soil type are narrow localized ridges which have a coarse gravelly surface and support a growth of pandanus (*Pandanus* spp.) (Figure 3). On these ridges there is little or no grass cover.

PROFILE DESCRIPTION (Figure 4)

Horizon	Depth (in.)	
A1	0–4	light grey loamy sand
A2	4–10	very light grey coarse loamy sand
B1	10–72	very light grey coarse sand and gravel

The soil is extremely variable below 3 ft, with a sandy clay being the heaviest texture encountered. At the site selected, a sandy clay band approximately 4–6 in. thick occurs at a depth of 6 ft. Water movement through this layer is restricted and leads to the build-up of a perched water table.

A type profile description appears in the Appendix.

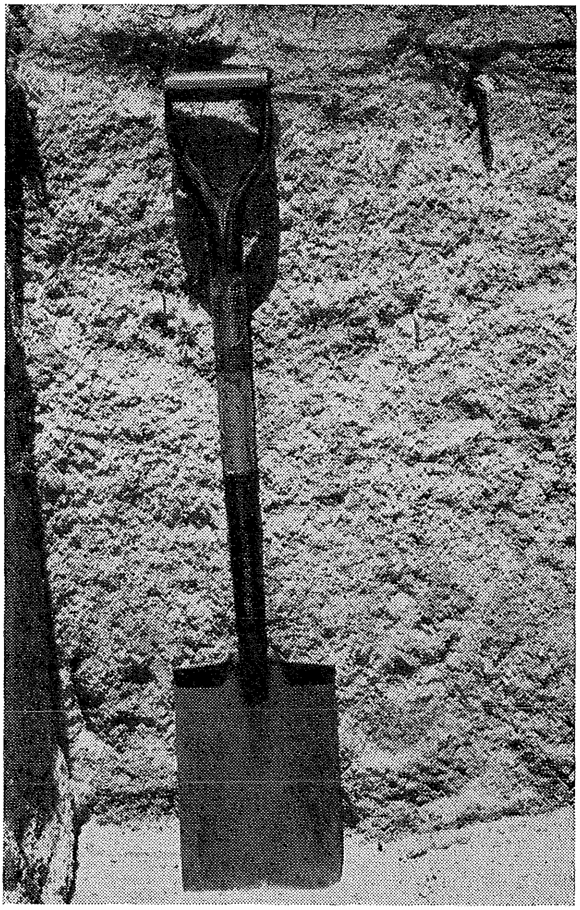

Fig. 4.— Soil profile of Algoma Loamy Sand.

(c) Dimbulah Sandy Loam (Type 41)

Of the three soils, the Dimbulah Sandy Loam occurs furthest from the Walsh River and is always confined to elevated regions. In the Left Bank Walsh area, Type 41 occupies some 5,000 ac and has a slope varying from 1·0 to 2·5 per cent.

Ironwood is characteristic of the Dimbulah Sandy Loam. Long-leafed box, bloodwood, flame tree (*Brachychiton paradoxum*) beefwood and red ash (*Alphitonia excelsa*) also occur. There is a good coverage of grass (Figure 5).

PROFILE DESCRIPTION (Figure 6)

Horizon	Depth (in.)	
A1	0–4	light brown coarse sandy loam
A2	4–15	light brown coarse sandy loam
B1	15–21	red gritty clay loam
B2	21–48	red gritty clay loam

Fig. 5.—Vegetation on Dimbulah Sandy Loam. Ironwood in right foreground.

Fig. 6.—Soil profile of Dimbulah Sandy Loam.

At the selected site, the soil profile was examined to 9 ft, at which depth rock was encountered. Some red and yellow mottling was found below 5 ft and a thin pallid zone occurred at 8 ft 6 in., above free water resting on the rock material. Quartz fragments were present below 18 in.

The soil becomes sticky when wet, particularly in the B2 horizon where there is a comparatively high clay content (25 per cent.). Below 48 in. the soil is lighter in texture where increased amounts of sand and gravel occur, giving rise to sandy and gravelly clay loams.

III. METHODS

Investigations were confined to an area of 1 square chain on the representative virgin sites already described. A limited area was chosen in order to obtain some measure of the degree of variability to be expected from the various observations.

(1) *Field Capacity.*—From March to August 1959, a series of infiltration tests was conducted on the three soil types. Unbuffered ring infiltrometers were used. An area 2 ft square was cultivated to a depth of 3 in. and a 12 in. dia. ring driven through the cultivated layer to an overall depth of 5 in. Six tests (hereinafter referred to as a trial) were run simultaneously on a particular date. On completion of each trial, the rings were left in position and the surface within each ring covered by means of polythene film and a rubber band to prevent evaporation.

Field capacity is not an equilibrium value but one on a time-drainage curve (Veihmeyer and Hendrickson 1949). From preliminary trials it was decided that samples for field capacity determination should be taken at 24 hr on the Algoma, 48 hr on the Dimbulah and 72 hr on the Walsh soil types.

A tube-type soil sampler was used to collect soil samples at 6 in. intervals down the wetted profile within each ring. Soil moisture was determined gravimetrically.

(2) *Wilting Point.*—On each representative area, 24 sampling sites were chosen (6 rows each of 4 sites). Samples were collected from within the main soil horizons at each site with a 4 in. Jarret head auger. The four sub-samples per row were bulked and the composite sample ground to pass a 2 mm sieve.

Duplicate determinations were carried out on each composite sample. The method used for measuring wilting point was essentially the same as the sunflower technique described by Piper (1950).

(3) *Bulk Density.*—In these studies, bulk density was measured by the auger method (Stirk 1957). A 4 in. Jarret head auger was used to excavate soil in 8 in. intervals to a depth of 24 in. The volume of excavated soil was taken as being equivalent to the volume of the hole, dimensions of which were measured with a rule and calipers. Bulk density was obtained by dividing the oven-dry weight of soil by the field volume and the result expressed in g/c.c.

(4) *Soil Texture*.—The mineral fractions of the soils were determined by the Bouyoucos hydrometer method (Piper 1950). The silt and clay fractions were obtained from the hydrometer readings, the coarse sand fraction by sieving and weighing and the fine sand fraction by difference.

IV. RESULTS

(a) Field Capacity

The values obtained for field capacity are presented in Table 1. On the Algoma Loamy Sand, samplings below the surface foot were made at 12 in. intervals instead of the normal 6 in. intervals as there was little textural differentiation below this depth and the water applied frequently penetrated to at least 5 ft.

The infiltration trials were conducted over a range of antecedent soil moistures and for varying lengths of time, so the depth of penetration varied from trial to trial. Colman (1944) discussed field capacity as affected by depth of wetting and considered that only samples 12 in. above the wetted front are at field capacity. The figures incorporated in Table 1 were selected on comparison with antecedent soil moistures. For all three soils these figures represent samples at least 12 in. above the wetted front.

The relatively higher field capacity of the surface layer is probably due to organic matter content, particularly in the Walsh and Algoma soils.

TABLE 1

MOISTURE PERCENTAGE AT FIELD CAPACITY

Soil Type	Sampling Depth (in.)	Moisture at Field Capacity (%)	No. of Samples
(*a*) Walsh Sandy Clay Loam	0–6	19·0	55
	6–12	15·1	53
	12–18	15·5	30
	18–24	15·7	20
(*b*) Algoma Loamy Sand	0–6	10·3	69
	6–12	7·4	68
	12–24	6·6	67
	24–36	6·1	22
	36–48	6·5	15
(*c*) Dimbulah Sandy Loam	0–6	10·4	58
	6–12	9·3	57
	12–18	10·4	51
	18–24	14·5	40
	24–30	16·7	25
	30–36	16·6	20

Mean S.D. : (*a*) 1·5, (*b*) and (*c*) 1·1.

(b) Wilting Point

The results of the determination of the lower limit of available soil moisture have been summarized in Table 2.

For the Walsh and Dimbulah soils the percentage moisture at wilting point increases down the profile as the texture becomes heavier. In the case of the Algoma Loamy Sand the wilting point remains virtually unchanged below the surface horizon. The presence of a small amount of organic matter in the surface few inches would account for the higher moisture percentage in this layer.

TABLE 2

MOISTURE PERCENTAGE AT WILTING POINT

Soil Type	Sampling Depth (in.)	Wilting Point* (%)
(*a*) Walsh Sandy Clay Loam	3–6	4·5
	14–18	7·9
	24–27	10·4
(*b*) Algoma Loamy Sand	0–3	2·2
	6–9	1·6
	21–24	1·5
(*c*) Dimbulah Sandy Loam	0–3	2·6
	6–9	2·5
	15–18	4·9
	21–24	10·9

Mean S.D. : (*a*) 0·4, (*b*) 0·2, (*c*) 0·5.
* Mean of 12 determinations.

(c) Bulk Density

For this measurement the auger method was adopted. Although this method tends to give slightly higher results than the more conventional methods (Tisdall 1951), it was considered to be sufficiently accurate for these investigations. Stirk (1957) stated that "reasonable accuracy is obtained provided that depth intervals of not less than about 15 cms are used". In measuring the bulk density of these three soils, increments of approximately 8 in. were taken. The results (Table 3) are the means of six determinations per depth.

TABLE 3

BULK DENSITY MEASUREMENTS
(g/c.c.)

Soil Type	0–8 in.	8–16 in.	16–24 in.
(*a*) Walsh Sandy Clay Loam ..	1·34	1·66	1·76
(*b*) Algoma Loamy Sand ..	1·43	1·63	1·69
(*c*) Dimbulah Sandy Loam ..	1·55	1·58	1·52

Mean S.D. : (*a*) 0·04, (*b*) 0·11, (*c*) 0·05.

(d) Available Soil Moisture

The results from Tables 1–3 are summarized in Table 4 at depths corresponding to the different soil horizons.

TABLE 4

AVAILABLE SOIL MOISTURE AND MECHANICAL ANALYSES

Soil Type	Horizon	Depth (in.)	Available Soil Moisture					Mechanical Analyses				Texture
			Field Capacity (%)	Wilting Point (%)	Available Soil Moisture (%)	Bulk Density (g/c.c.)	Available Soil Moisture (in./ft)	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	
(*a*) Walsh Sandy Clay Loam ..	A1	0–12	17·0	4·5	12·5	1·34	2·01	13	59	19	9	LS
	B1	12–24	15·6	7·9	7·7	1·71	1·58	9	53	17	21	L
(*b*) Algoma Loamy Sand	A1	0–4	10·3	2·2	8·1	1·43	1·39	79	14	4	3	S
	A2	4–10	7·4	1·6	5·8	1·43	0·99	79	15	4	2	S
	B1	10–72	6·4	1·5	4·9	1·66	0·98	73	20	4	3	S
(*c*) Dimbulah Sandy Loam ..	A1	0–4	10·4	2·6	7·8	1·55	1·45	54	38	5	3	LS
	A2	4–15	9·8	2·5	7·3	1·58	1·38	47	44	4	5	LS
	B1	15–21	12·4	4·9	7·5	1·52	1·37	46	35	5	14	SL
	B2	21–48	16·6	10·9	5·7	1·52	1·04	36	31	8	25	SCL

Included in this table is the distribution of the mineral fractions down the soil profile. Clay content increases with depth in both the Dimbulah and Walsh soils, while the percentage clay of the Algoma is relatively small and constant. The Walsh soil type is composed mainly of fine material (less than 0·2 mm dia.), whereas coarse sand predominates in the Algoma. Fine and coarse sand fractions of the Dimbulah Sandy Loam are relatively evenly distributed and tend to decrease with depth. The type locality of the Walsh Sandy Clay Loam, which occurs nearer the headwaters of the river, tends to be heavier in texture than at the selected site.

V. DISCUSSION

Data on mechanical analysis and available moisture per foot of soil are given in Table 4. For all three soils the surface horizon has the highest available soil moisture. In the case of the Algoma soil type this is probably due entirely to the accumulation of organic matter in the surface 4 in. In the case of the other two soil types it is probably the result of the combined effect of texture and organic matter content.

It will be noted that while increasing clay content raises the field capacity, it increases wilting point to an even greater degree, thereby reducing the storage potential for available moisture. A comparison of the B1 and B2 horizons of the Dimbulah Sandy Loam reveals this point clearly.

An increase in the proportion of silt and fine sand has a more marked effect on the storage potential for available moisture, as these two fractions raise the field capacity appreciably without affecting the wilting point to any extent.

The amount of available water necessary to ensure economic utilization of a soil is dependent to a large extent upon the climatic conditions which prevail during the irrigation season. The U.S. Bureau of Reclamation (1947) considers that soils require at least 0·75 in. of available water per foot for economic management in comparatively arid environments. In more humid environments, irrigation may be practicable with reserves of approximately 0·5 in. per ft. The soils examined occur in a region with an average annual rainfall of 27 to 35 in., of which approximately 81 per cent. falls from December to March. It would appear that these soils fill the above requirements adequately.

Of the three soil types, the Algoma Loamy Sand has the lowest range of available moisture and would require frequent light applications of irrigation water. A sandy clay layer is often encountered on this soil type at depths below 3 ft. The soil horizons above this layer are very permeable and there is a danger of waterlogging if inefficient irrigation practices are employed.

The Dimbulah Sandy Loam and Walsh Sandy Clay Loam have favourable moisture-retaining properties and are well-drained.

The potential under continued irrigation of these three soils is sound provided attention is given to efficient irrigation techniques and farming practices.

VI. ACKNOWLEDGEMENTS

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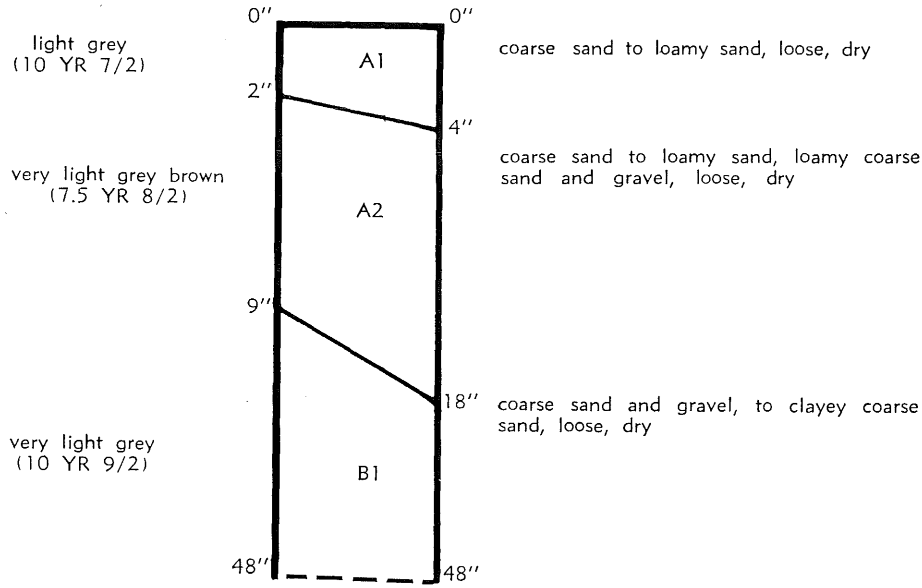
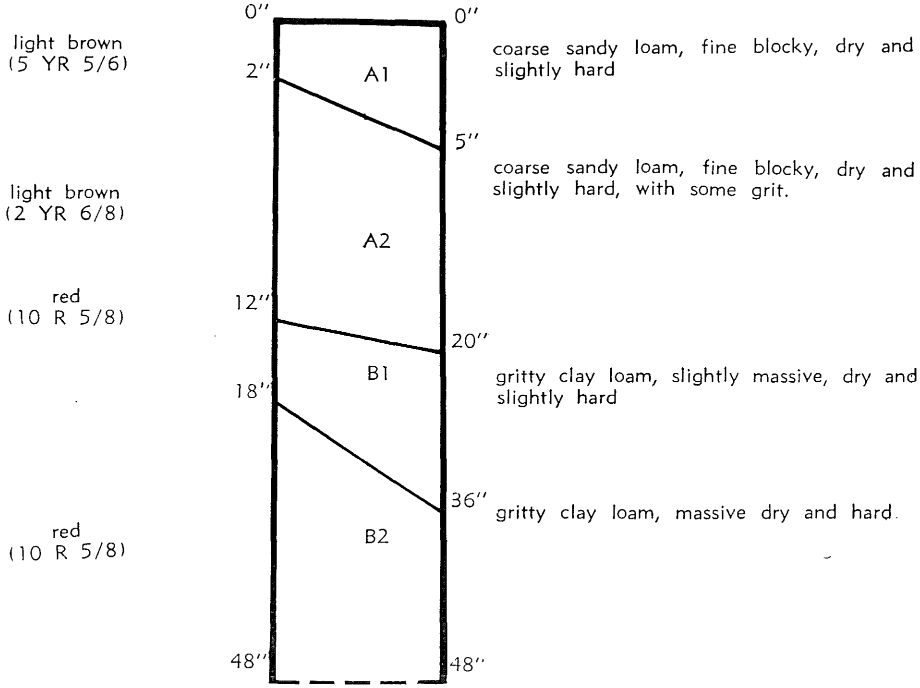
APPENDIX

The type profile descriptions of Walsh Sandy Clay Loam, Algoma Sandy Loam, and Dimbulah Sandy Loam, taken from unpublished Soil Survey Reports of the Queensland Department of Agriculture and Stock, are given below.

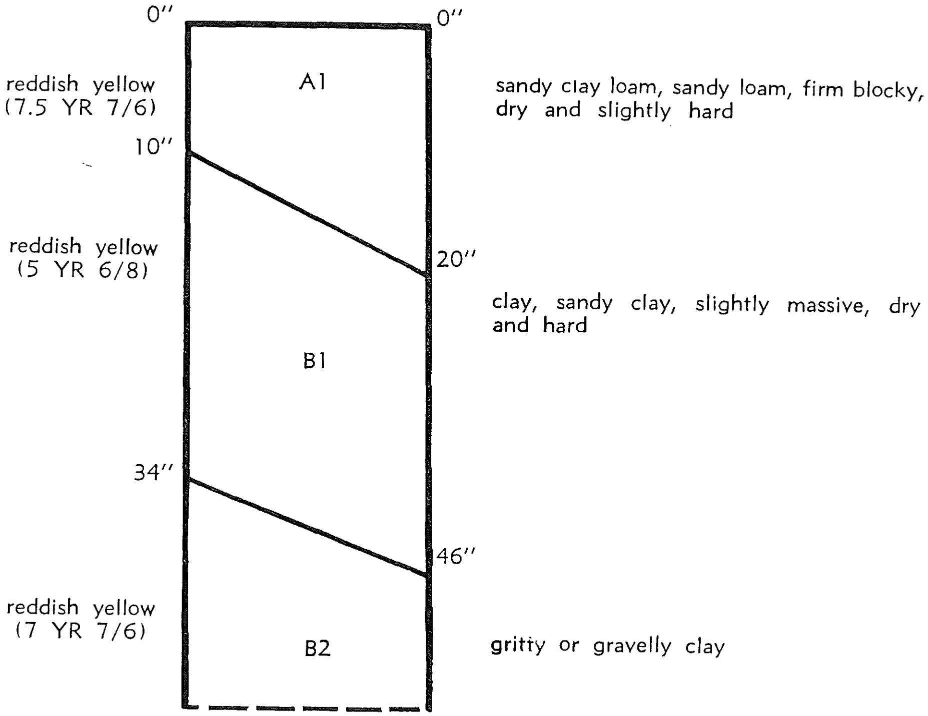
Type 32—Algoma Loamy Sand



Type 41—Dimbulah Sandy Loam



Type 43—Walsh Sandy Clay Loam



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