Rice Soils of Hewagam Korale

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INTRODUCTION

A survey of the rice soils in Hewagam Korale was made to determine some of the factors that limit productivity, and a provisional map prepared in 1958 (8). The present paper embodies descriptions of the principal soil series encountered in the Korale.

Hewagam Korale which is a Revenue Division of Colombo District covers an area of approximately 90,000 acres of which approximately 11,000 acres is paddy land. It is bound in the north by the Kelani Ganga and in the west and south-west by Colombo Mudaliyar's Division and Salpiti Korale respectively. In the south it extends up to Rayigam Korale, while in the east it is bound by the Atulugam and Panawal, and the Kuruwita Korales.

Climatological Data

The annual precipitation in the greater portion of the Korale is 100-125 inches of which 60-80 inches fall during the south-west monsoon. At higher elevations in the Korale the annual precipitation is a approximately 150 inches (6). Average monthly precipitation at several stations in the Korale is presented in Table I.

The mean annual temperature in the shade remains approximately at 80°F in most parts of the Korale while the mean relative humidity fluctuates between 63 and 84 percent (6).

Geology, Physiography and Drainage

The solid foundation of the entire Korale is crystalline rock of Archaean age and include biotite gneisses (with or without garnet) and charnokite which are heavily intruded in certain areas by pink granite.

Over the eroded and undulating surface of these solid rocks is a mantle of superficial deposits. These deposits are of recent geological age and include laterite, alluvial sands and clays, and peat.

TABLE I.—Average Monthly Precipitation at Several Stations in Hewagam Korale

Station	Elevation ft.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for the Hear (ins.)
1. Hanwella	40	6.11	3.83	7.39	8.14	7.11	14.30	0.57	5.08	10.69	19.22	13.32	10.47	106.23
2. Panagoda	60	3.30	5.84	13.73	13.09	4.26	8.60	4.71	3.95	10.80	18.86	11.84	7.83	106.81
3. Avissawella	100	5.39	1.11	11.78	11.26	7.58	14.90	0.95	7.96	15.48	26.11	18.39	4.51	125.42
4. Labugama	380	8.11	2.25	20.26	14.15	9.36	14.56	1.48	7.53	14.76	20.06	18.32	9.77	140.61

Most of the area in this Korale forms part of the coastal peneplain of the Island, at elevations between 0-100 ft. above sea level. The land is almost devoid of relief except for erosion remnants such as Nawagama 430 ft., Liyanwila 491 ft. and others of lower elevation formed of hard crystalline rocks, sometimes bare or covered by lateritic soils. The intervening valleys are buried by recent deposits, mainly of alluvium with some admixture of colluvium.

The major portion of the Korale is drained by streams flowing northwards into the Kelani Ganga, the important tributaries being Pallewela, Pusweli and Wak Oya, while the rest of the streams flow into Bolgoda Ganga.

FIELD STUDIES

The greater portion of the rice soils of Hewagam Korale are located on recent alluvial deposits in the flood plain of the Kelani Ganga and its tributaries. Thus most of the ground occupied by rice is lowland, and these lowlands generally merge into each other forming a pattern which simulates valleys belonging to a natural drainage system in an advanced stage of maturity. Two such drainage systems that can be traced belong to the Kelani and Bolgoda catchments.

The parent material of the major portion of rice soils are of alluvial origin with some admixture of colluvium, and are highly weathered, strongly acid in reaction and low in exchangeable bases.

Thirteen soil types were identified and mapped, where each unit has the same succession of master horizons and similar texture of the surface soil.

The soils were classified into five series on the basis of the degree of hydromorphism. Table II presents the series and their approximate acreage in the Korale. In addition to these azonal and boggy soils have been recognised.

TABLE II. The Predominant Series of Rice Soils in Hewagam Korale and their Approximate Extents

Series	*Approximate Extent (acres)*
1. Homagama (very poorly drained)	400
2. Oruwela (Poorly drained)	3,700
3. Panagoda (Imperfectly drained)	5,200
4. Morapitiya (Moderately well drained)	100
5. Poregedera (Well drained)	100

Typical profiles are shown graphically in Figure 1 (*a-d*). The profile characteristics of typical members of each series are given below. The letter designations of the soil horizons are based on the scheme outlined by Kanno (3). All colours described are Munsell notations on moist soils.

1. *Homagama series—very poorly drained*

These occur in positions of concave relief in the lower aspects of the topography, and in small narrow tongues of large yayas. Hence they are very poorly drained and the water-table remains at the surface for the greater part of the year. They are very dark coloured and are high in organic matter. Root development is very poor.

Horizon	*Depth (inches)*	*Description*
Ap. G	.. 0–24 ..	Dark gray (10YR 3/1) ; (humic) sandy clay ; no mottles gradual change to
G	.. 24#+ ..	Light gray (7·5YR 7/0) ; sandy clay loam ; no mottles

Two soil types of this series were identified and mapped.

2. *Oruwela series—poorly drained*

Soils of this series are found in positions of slightly concave relief or at the foot of hills. The water-table is approximately 2 feet from the surface in dry weather, although during other periods of the year it remains at the surface. The content of organic matter is not as high as in soils of the Homagama series. Root development is poor.

Horizon	*Depth (inches)*	*Description*
A_1pg	.. 0–6 ..	Gray (5Y 5/1) ; clay ; few prominent dark brown mottles around root channels ; abrupt change to
$A_{11}G$	.. 6–10 ..	Dark gray (5Y 4/1) ; clay ; no mottles ; clear change to
$A_{12}G$	.. 10–20 ..	Gray (2·5Y 6/0) ; clay ; few distinct light brown mottle along root channels ; very sticky and very plastic gradual change to
G_1	.. 20–22 ..	Black (2·5Y 2/0) ; clay ; no mottles ; very sticky and very plastic ; clear change to
G_2	.. 22#+ ..	Very dark gray brown (10YR 3/2); humic clay ; no mottles sticky and plastic

Four soil types of this series were identified and mapped.

3. *Panagoda series—imperfectly drained*

Approximately 5,200 acres of rice soils in the Korale belong to this series. The soils are moderately fine-textured, strongly acid and lateritic. The B horizon exhibits evidence of oxidation as shown by the reddish-brown iron mottles on a matrix of gleyed soil. This is due probably to the recedence of the water-table which falls below 3 feet during the dry season. The development of a plowsole is observed.

A typical profile is as follows:

Horizon	*Depth (inches)*	*Description*
A_1pg	0–8	Very dark gray (10YR 3/1); clay loam; common distinct reddish-brown iron mottles in verticle streaks spreading into films; abrupt change to
$A_{12}g$	8–13	Very dark gray (10YR 3/1); clay loam; few prominent reddish-brown mottles in narrow streaks along root channels; abrupt change to
$B_{21}G$	13–29	Dark gray (10YR 4/1); clay loam; many prominent brown mottles along root channels spreading along rootlets; very sticky and very plastic; gradual change to
$B_{22}G$	29–37	Pinkish gray (5YR 6/2); clay; common prominent brown mottles along root channels; gradual change to
G_1	37–50	Very dark gray (7·5YR 3/0); clay; no mottles; gradual change to
G_2	50#+	Light gray (2·5Y 7/2) loamy sand; no mottles.

Three soil types of this series were identified and mapped.

4. *Morapitiya series—moderately well drained*

The extent of this soil series in the Korale is comparatively small, being approximately 100 acres. These soils occur in large flat yayas usually on the slopes or in elevated regions of smaller yayas. The soils are generally dark-brown in colour, lateritic and moderately well drained with a strong acid reaction. The water-table may fall to below 5 feet from the surface during dry weather. The A and B horizons show prominent reddish-brown patches and streaks along root channels. A plowsole is present.

The profile is as described below:

Horizon	*Depth (inches)*	*Description*
A_1pg	0–5	Dark brown (10YR 3/3); sandy clay; common prominent strong reddish-brown mottles along root channels and on the surface of clods; abrupt change to
$A_{12}g$	5–8	Very dark gray brown (2·5Y 6/4); loamy sand; few distinct reddish-yellow medium sized mottles along root channels; abrupt change to
$B_{21}g$	8–10	Light yellowish brown (2·5Y 6/4); loamy sand; few faint brownish-yellow mottles along root channels; abrupt change to
$B_{22}g$	10–11	Gray brown (2·5Y 5/2); sandy loam; common distinct reddish-yellow mottles along root channels; abrupt change to
$B_{23}g$	11–22	Light gray (2·5Y 7/2) sandy loam; very prominent reddish-yellow mottles; many thick verticle streaks; gradual change to
$B_{24}g$	22–40	Light gray (2·5Y 7/2); sandy clay; many prominent brownish-yellow mottles along root channels; gradual change to
BG	40#+	Gray (2·5Y 6/0); sandy loam; common distinct light olive-brown mottles in large diffuse films.

Two soil types of this series were identified and mapped.

5. *Poregedera—well drained*

The rice soils in locations of higher elevation, as for example on the higher terraces, are well drained. These soils are usually formed in *situ* and non-alluvial in origin although they may have some admixture of colluvium. Due to their topographical characteristics the water-table is usually low during the major portion of the year. Soils of this nature were encountered in small areas (Poregedera, Kosgama and Arukwatta) and as such detailed profile studies were not made.

In the limited extent of this series two soil types were recognised.

LABORATORY STUDIES

Analytical Procedure

Soil samples were transported to the laboratory in polythene bags and a sub-sample with a field moisture content was utilized for determining soil pH in the wet state. The remaining soil was air dried, crushed and passed through a 2-mm sieve before using for particle size and chemical analyses.

Particle size analysis was made according to the Hydrometer method of Bouyoucos (2). Measurement of pH was made with a glass electrode-potentiometer system using soil-water ratio of approximately 1: 1. Organic matter was estimated by the method of Walkley and Black (9) and total nitrogen by the Kjeldahl method. Available phosphorus was estimated according to the method of Olsen *et al.* (4).

Exchangeable cations and cation exchange capacity were determined after extraction with 1 N ammonium acetate at pH 7.0 (5).

Free iron oxide was estimated by the biological reduction procedure described by Allison and Scarseth (1), while easily reducible manganese was determined according to the method of Sherman *et al.* (7).

Analytical data of representative soil profiles are presented in Table III.

TABLE III.—Particle Size distribution and Chemical Properties of Representative Soil Profiles

Horizon	Depth in inches	*Particle Size Distribution* Sand % 2000–0020 mm	Silt % 0.020–0.002 mm	Clay % 0.002 mm	*Chemical Properties* pH	C. E. C. NH_4OAc m.e./100g.	Exch. Bases m.e./100g.	Organic Matter %	Total N %	Easily Reducible Mn. ppm.	Free Iron Oxide ppm.
Homagama Series :											
ApG	0—24	57·0	6.0	37.0	5.1	23.14	2.20	19.55	0.32	1.6	620
G	24+	62·0	6.0	31.5	5.3	25.64	2.60	12.77	0.02	1.9	230
Oruwela Series :											
A_1PG	0—6	32·5	8.0	59.5	4.9	32.12	1.63	10.67	0.39	1.9	920
$A_{11}G$	6—10	26·0	3.0	70.0	4.9	26.56	1.28	7.79	0.22	1.4	1100
$A_{12}G$	10—20	27·0	0.5	72.0	4.9	33.40	0.29	6.20	0.01	1.4	520
G_1	20—22	28·0	2.0	69.5	5.0	31.76	0.23	29.20	0.20	1.5	420
G_2	22+	38·0	10.8	51.0	4.4	17.56	0.23	31.12	0.20	1.9	640
Panagoda Series :											
A_1pg	0—8	66·5	14.0	19.0	4.2	16.10	1.20	9.73	0.31	0.6	1200
$A_{12}g$	8—13	88·5	5.5	5.5	4.4	12.80	0.85	12.96	0.29	1.1	1100
$B_{21}G$	13—29	63·5	9.0	27.0	4.0	23.10	0.50	9.12	0.20	1.7	570
$B_{22}G$	29—37	53·0	5.5	41.0	4.1	12.60	0.98	2.25	0.05	1.4	540
G_1	37—50	55·5	3.0	41.0	5.0	9.30	1.30	8.51	0.01	1.8	480
G_2	50+	89·5	0.5	9.0	5.2	2.00	1.20	9.72	0.02	1.4	185
Morapitiya Series :											
A_1pg	0—5	62·5	8.0	26.5	4.4	16.30	0.62	8.75	0.25	1.9	1420
$A_{12}g$	5—8	67·0	7.5	24.5	4.6	14.50	0.50	4.44	0.19	2.1	1120
$B_{21}g$	8—10	85·0	7.0	7.5	4.3	14.40	0.48	1.64	0.07	1.7	200
$B_{22}g$	10—11	60·0	21.0	18.5	4.3	4.92	0.77	4.25	0.06	1.1	600
$B_{23}g$	11—22	50·0	6.0	43.5	4.4	29.37	0.99	4.34	0.05	0.8	1400
$B_{24}g$	22—40	61·0	4.5	33.5	4.0	35.74	0.95	1.28	0.03	1.8	540
BG	40+	61·0	5.0	33.5	5.9	11.70	0.54	1.52	0.02	0.8	600

DISCUSSION

Field Studies

Drainage conditions have a profound influence on the nature and properties of rice soils. Hence the degree of hydromorphism was used as the basis to differentiate the soil series in the present survey.

It should be noted that the drainage classes of this study are widely different from those of highland soils in the normal systems of soil classification. This is primarily because the water regime is an important factor in the genesis of rice soils. It should be noted, however, that natural or deliberate alteration of the drainage conditions will consequently result in the change of the status of a soil in this classification.

Degree of mottling

In these studies the presence of verticle reddish-yellow and brownish-black mottlings along root channels has been used as a reliable criterion for evaluating the degree of drainage and aeration of the horizon in particular, and the profile in general. While mottlings are absent in the very poorly drained soils of the Homagama series, the few mottles in the poorly drained Oruwela series indicate the relatively better drained conditions of the latter. The subscript " g " was used to indicate the presence of mottles, both ferric iron and manganese. In the better drained soils reddish-yellow ferric iron mottles occur above brownish-yellow and olive-brown manganese mottles. This is due to the relative ease of reduction and solubilization of manganese.

Laboratory Studies

Analytical data of representative soil profiles are presented in Table III.

Particle Size Distribution

With the exception of very poorly drained Homagama series it is observed that as the sand fraction increases the profiles tend to improve in drainage. As expected better drainage is associated with a decrease in the proportion of clay in the profiles. The silt fraction shows little variation in the profiles.

The relatively large sand fraction in the soils of the very poorly drained Homagama series when compared with those of the better drained Oruwela series may probably be due to the fact that soils of the former series are situated in small, narrow tongues surrounded by the highland, where some admixture of colluvium is likely to occur.

Soil Reaction

Generally under the field conditions these rice soils are very strongly acidic to strongly acidic where pH ranges between 4.0 to 5.5. The soils of the very poorly drained member (Homagama series) have a higher pH value. It is also seen that surface soils tend to be more acidic as drainage improves. The variations in pH througout the soil profiles are generally not conspicuous.

Cation Exchange Capacity

Cation exchange capacity varies between 16.10 to 32.12 m.e./100 gm in the surface soils, the better drained soils having a lower capacity for cation exchange and therefore of cation retention. Conversely cation exchange capacity tends to increase as drainage becomes poorer. The relatively low cation exchange capacity of the soils point to the Kaolinitic character of the clay fraction.

The greater cation exchange capacity may be associated with the texture of the soils. However, the contribution to cation exchange capacity by the organic matter content cannot be overlooked.

Exchangeable Bases

The percentage exchangeable bases are generally low in all soils. Among these the very poorly drained Homagama series showed the highest values.

Organic Matter

As expected the organic matter content of the plowed layer is highest in the very poorly drained series. In this series the organic matter content is high in the first 24 inches and below, and confirm the field observations on the humic nature of the clay. In the Oruwela series a decrease is observed up to 20 inches, after which it increases to almost thrice its value in the surface soil. Field observations showed gleying below 20 inches in the profile, the colour ranging from black to very dark gray brown with no mottles.

Total Nitrogen

The content of total nitrogen usually ranges between 0.31 to 0.39 per cent. in the surface soils of the Homagama, Oruwela and Panagoda series. The relatively low value of 0.25 per cent. in the Morapitiya series is probably associated with better drainage and lower organic matter content.

Easily Reducible Manganese

The content of easily reducible manganese generally ranges between 0.8 and 2.1 ppm in the profiles. No general pattern of distribution can be seen in any of the four series.

Free Iron Oxide

The content of free iron oxide is low in the very poorly drained Homagama series and high in moderately well drained Morapitiya series. The general tendency is for the free iron oxide content of the plowed layer to be higher than that of the lower horizons, and for the value to decrease with depth.

The surface soils of the Morapitiya series had a content of free iron oxide that ranged from approximately 800 to 1450 ppm while those of the Panagoda series ranged between 1200 to 1350 ppm.

SUMMARY

The rice soils of the Hewagam Korale are classified into five series based on the degree of hydromorphism.

Descriptions of profiles are made in relation to location, depth of water-table and characteristics of horizons.

Analytical data on particle-size distribution and chemical characteristics of representative profiles are presented.

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REFERENCES

1. Allison, L. E. and Scarseth, G. D., 1942. Biological reduction method for removing free iron oxides from soils and colloidal clays. *Jour. Amer. Soc. Agron.* 34 ; 616-623.

2. Bouyoucos, G. J., 1951. A recalibration of the hydrometer method for making mechanical analysis of soils. *Jour. Amer. Soc. Agron* 43 ; 434-438.

3. Kanno, I. A., Scheme for soil classification for paddy fields in Japan with special reference to mineral paddy soils *Soil and Plant Food* 2 ; 148-157.

4. Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A., 1954. Estimation of available phosphrous in soils by extraction with Sodium bicarbonate. U. S. D. A. *Circular* No. 939.

5. Peach, M., Alexander, L. T., Dean, L. A., and Reed, J. F. 1947. Methods of soil analysis for soil-fertility investigation. *U. S. D. A. Circular* No. 757.

6. Report on the Colombo Observatory for 1956. *Government Press,* Colombo.

7. Sherman, G. D., McHargue, J. S. and Hodgkiss, W. S., 1942. Determination of active manganese in soil. *Soil. Sci.* 54 ; 253-257.

8. Thenabadu, M. W., Gunasekara, B. C. G. and Fernando, B. L., 1958. Preliminary report on the survey of the paddy soils of Hewagam Korale. *Proc. Ceylon. Assoc. for the Advancement of Science.* 1 : 21.

9. Walkely, A. and Black, I. A. 1934. An examination of the Detjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* 37 ; 29-38.

Olsen S. R.

Fig. 1. Schematic diagrams of representative soil profites