

# Significance of relief and hydrology on the land use pattern of the lower order valleys of the dry zone

J. HANDAWELA

*Regional Research Station, Maha Illuppallama*

## SUMMARY

In the lower order valleys of the dry zone landscape the soil profiles were studied with special emphasis on subsoil colour which changed from reddish to yellowish and greyish with increasing profile wetness. Mottles were absent, prominent and secondary to grey in the well drained, imperfectly drained and poorly drained land classes respectively. Electrical conductivity and pH of soil and distribution of iron-manganese glauco-basils indicate operation of leaching in the well drained lands and eutrophication in the lower slopes.

Field experiments with lowland rice demonstrate the need for more fertilizer nitrogen in the well drained land class, moderate amounts in the imperfectly drained soils, and the dominance of other problems outside nitrogen in the poorly drained soils.

The primary feature that has to be considered in designing land use practices for these soils is whether a particular soil is undergoing leaching or eutrophication.

## INTRODUCTION

In the dry zone the drainage system is made of primary and lower order valleys arranged in a dendritic pattern converging into main streams that radiate from inland to the sea. The main rivers with narrow and incised beds do not have broad valleys and the total extent of land in such valleys is very limited in extent. Therefore it is the primary and lower order valleys that offer most land for agricultural operations and have been the subject of investigation in soil science studies.

Abeyratne (1956) reporting on dryland farming explained the traditional system of land use practised in these valleys as consisting of distinct upland and lowland cultivation centered round a surface reservoir for collection and conservation of water for domestic and agricultural use. He attributed the development of such a system of land use to undulating terrain, narrowness of the valleys, presence of an impervious rock basement and absence of perennial streams.

Studying the soils of these valleys Panabokke (1959) demonstrated that moving down the toposequence from the watershed towards the valley bottom the soil environment became more and more wet. He distinguished three land classes namely, well drained upper slopes, imperfectly drained middle slopes and poorly drained bottomlands. The form of iron oxide, hematite in the well drained soil and goethite in the poorly drained soil closely followed the drainage status.

Moorman and Panabokke (1961) presenting a classification of the most important great soil groups of Ceylon, encountered the Reddish Brown Earths (Rhodustalfs) in the better drained part and Low Humic Gleys (Ochraqualfs) in the poorly drained portion of the land surface.

Tokutome (1970) classifying the paddy soils of these lands based on hydromorphology of soil profiles distinguished three main groups of paddy soil; surface water gleylike, intermediate gleylike and ground water gleyed which corresponded with the three drainage members of Panabokke.

The present study was undertaken to further elucidate the significance of relief and hydrology on soil characteristics and agricultural potential of the land association found in the typical dry zone catchment system in the context of current requirements.

#### MATERIALS AND METHODS

The studies reported here were conducted in the primary and secondary valleys at the Agriculture Research Station at Maha Illupallama and in the Kagama Katiyawa irrigation project. Both locations come within the Kalaoya drainage basin.

Soil profiles to represent the three drainage members were studied. The colour of the soil and of mottles and gley formations and relative abundance of mottles and gleys were recorded in order to express the degree of oxidation - reduction and hydration at different depths in the profile for each land class. Electrical conductivity, pH and abundance of iron manganese glaeboles were recorded to illustrate the degree of leaching or eutrophication the land classes have undergone.

The quality of irrigation, runoff and drainage, and ground water expressed as electrical conductivity was measured for use as another yardstick in studying leaching and eutrophication within the confines of the valley system.

In each drainage member a field experiment was conducted to estimate the response of lowland rice to applied nitrogen and organic manure. The trials in the well drained and imperfectly drained members were done during 1976/77 October-February season with medium-aged transplanted rice, while in the poorly drained land a short-aged variety was broadcast sown in 1977 April-July season.

#### RESULTS AND DISCUSSION

The most characteristic feature of a soil profile which identifies itself with the land class to which it belongs is subsoil colour (Tables 1, 2 and 3). The well drained profile is predominantly reddish brown 5 YR with no mottles and gley formations. Yellow and grey colours are encountered only in the decomposing parent material where it is primarily inherited from the original rock. In the imperfectly drained profile the overall colour of the soil turns brown 7.5 YR and mottles occupying a dominant position in the upper metex and resulting from wetting and drying are reddish in colour 10 R — 5 YR. The subsoil of the poorly drained profile is characteristically grey with a higher hue 10 YR or above and the mottles found there are in a lower state of oxidation, brown to olive brown 7.5 YR — 2.5 Y.

The well drained soil profile is shallow when compared to the profiles lower down. Erosion in the upper slopes and colluviation and

alluviation in the lower slopes may have contributed to this difference. In contrast to this observation the weathering zone of the well drained profile is thicker than in the other two profiles. This may be attributed to alternate wetting and drying of the soil-rock interphase in the well drained profile as opposed to the other two profiles where the soil - rock interphase is almost always wet. Another factor may be that water reaching the rock surface has a lower pH in the well drained profile, and hence acts as a better solvent.

A study of pH and electrical conductivity of soil (Fig 1 and 2) show that the well drained soil has been losing bases and salts from its profile while the profiles lower down have been gaining them. The electrical conductivity of various forms of water found within the catchment system (Table 4) confirms this observation.

The distribution of iron and manganese glaeboles (Fig 3) shows that the conditions in the well drained land class are not conducive for their formation except in the horizons close to the weathering rock. In view of low pH and electrical conductivity it is likely that the well drained profile is losing iron and manganese in solution to the lower land classes. The greatest abundance of iron-manganese glaeboles and even mottles are found in the upper horizons of the imperfectly drained profile. Therefore it may be inferred that these horizons receive good supplies of dissolved iron and manganese and have ideal conditions for their precipitation.

The results of the field experiments conducted in the three land classes show that in the well drained land there is a clear response to fertilizer nitrogen particularly to the first increment. In the imperfectly drained land class the response to nitrogen over high control yield is not significant. The poorly drained lands showed no response to applied nitrogen and organic manure over the poor control yields. From these observations it may be inferred that nitrogen fertilizer application is a necessary practice in the well drained land class where signs of leaching have been clearly evident. In the imperfectly drained soil where eutrophication is taking place inherent soil fertility with regard to nitrogen is expected to be high requiring little fertilizer nitrogen. In the poorly drained lands there appear to be other problems which seem to affect rice yields which are quite unrelated to nitrogen and organic manure.

#### CONCLUSIONS

The three main land classes encountered in the dry zone catchment system appear to have resulted from draining of water and leaching of ions in solution from the upper slopes and accumulation of water and concentration of dissolved ions leading to their saturation of the exchange complex and precipitation in the slopes lower down. These two processes of leaching and eutrophication are permanent features and they determine the properties and potential of the dry zone catchment soils. Therefore it is imperative that the management practices of these lands have to greatly depend on the degree of leaching or eutrophication they undergo.

In the well drained soils the objective should be to arrest and counter the process of leaching. This can be done by application of more

fertilizer, avoiding standing water in bench terraces, cultivation of deep rooted crops and maintenance of a permanent plant stand to lock up plant nutrients in live biomass as a reserve not prone to leaching.

The imperfectly drained soils do not call for special precautions and can be cropped at moderate levels of nitrogen fertilizer application.

Collection of more water and concentration of salts particularly during dry weather in poorly drained soils have to be countered by improving drainage and avoiding evaporation from a wet soil surface. The latter can be accomplished by keeping standing water while cropping and drying the upper soil layers during the off seasons. Therefore the best adapted method of land use for the Low Humic Gley soils is lowland rice cultivation.

#### REFERENCES

1. Abeyratne, E. L. F., Dryland Farming in Ceylon. *Trop. Agric.* 112, 1956.
2. Panabokke C. R., A Study of Some Soils in the Dry Zone of Ceylon. *Soil Sci.* 87, 1959.
3. Moorman, F. R. and Panabokke, C. R. Soils of Ceylon. *Trop. Agric.* 117, 1961.
4. Tokutoine, S. Survey and Classification of Paddy Soils of Ceylon, Department of Agriculture, Peradeniya, 1970.

Table 1: Profile Characteristics reflecting Surface Hydrology Phenomena in Well - drained Profile<sub>9</sub>

Horizon	Depth cm.	Texture	Soil colour	Mottles	Gley formations
Ap	0—20	Sandy clay loam	Brown 7.5 YR 4/3	—	—
B2t	20—80	Sandy clay loam	Dark reddish brown 5 YR 3/4	—	—
B3t	80—140	Sandy clay loam	Reddish brown 5 YR 4/6	—	—
C1	140—180	Gravelly sandy loam	Brown 10 YR 4/6 and light grey 10 YR 8/1	—	—
C2	180—200	Clay loam	Light grey 7.5 YR 8/2	—	—
C3	200—245	Fine sandy loam	Pale yellow 5 Y 8/3	—	—
C4	245—280	Weathered rock	Orange 7.5 YR 6/6	—	—
C5	280—310	Semiweathered hard feldspathic rock with clay in crevices	Light grey 10 Y 8/1	—	—
C6	310—350	Semiweathered soft rock	Yellowish brown 10 YR 5/6 and Orange 7.5 YR 6/8	—	—
R	350+	Slightly weathered rock			

Maximum height of water table; 300 cm below ground

Table 2: Profile Characteristics reflecting Surface Hydrology Phenomena in Imperfectly-drained Profile

Horizon	Depth cm	Texture	Soil colour	Mottles	Gley formations
Apg	0—15	Sandy clay loam	Dark brown 10 YR 3/3	Bright brown 7.5 YR 5/8 fine tubular, common	Present
A12g	15—45	Sandy clay loam	Brown 7.5 YR 4/4	Red 10 R 4/6 and reddish brown 2.5 YR 4/6 tubular and cloudy, common	Brownish grey 5 YR 4/1, common
B1g	45—115	Sandy clay loam	Brown 7.5 YR 4/4	Reddish brown 10 R 4/6 dull reddish brown 5 YR 4/4, cloudy, common	Brownish grey 5 YR 4/1 and 7.5 YR 4/1, common
B2g	115—165	Sandy clay	Brown 7.5 YR 4/4	Not clear	Brownish grey 10 YR 6/1, common
B3g	165—215	Clay loam	Dull reddish brown 5 YR 4/4		Light grey 7.5 Y 7/1
C1	215—265	Decomposing gravelly material	Light grey 10 R 8/1 and light yellow 2.5 Y 8/4		
C2	265—325	Decomposing gravelly material	Dark brown 7.5 YR 3/3 to light grey 2.5 Y 8/1		
R	325+	Rock			

Maximum height of water table; 175 cm below ground

Table 3: Profile Characteristics reflecting Surface Hydrology Phenomena in Poorly-drained Profile

Horizon	Depth cm	Texture	Soil colour	Mottles	Gley formations
Apg	0—16	Sandy clay loam	Dark brown 10 YR 3/3 — dark greyish yellow 2.5 Y 4/2	Brown 10 YR 4/6 to olive brown 2.5 Y 4/6, cloudy, common and bright brown 7.5 YR 5/8, tubular, some	Common contributes to general soil colour
A12g	16—30	Sandy clay loam	Olive brown 10 YR 5/4	Yellowish brown 10 YR 5/6	Common, contributes to general soil colour
B1g	30—70	Sandy clay	Grey 5 Y 5/1	Brown to olive brown 10 YR 4/6—2.5 Y 4/6 cloudy, few	Dominant, grey 5 Y 5/1
B2g	70—170	Sandy clay	Dull yellowish brown 10 YR 4/3	Brown 7.5 YR 4/4— 4/6, cloudy, common	Grey 2.5 Y 5/1— 5 Y 5/1
B3g	170—220	Coarse gravelly sandy clay	Light yellow to light yellowish brown 2.5 Y 7/4—7/6 and bluish grey 5 B 5/1— 5 PB 5/1	—	Bluish grey 5 B 5/1— 5 PB 5/1
C1	220—280	Alternating bands of gravelly and sandy clay	Dull yellowish orange 10 YR 7/3 gravel, dark bluish grey 10 BG 4/1 clay	—	Dark bluish grey 10 BG 4/1
R	280+	Rock			

Maximum height of water table; 75 cm below ground level.

**Table 4: Quality of water at different landscape positions**

Form of Water	Electrical conductivity mmhos/cm.		
	Well drained land	Imperfectly drained land	Poorly drained land
Runoff and drainage from land under irrigated upland agriculture			
Wet weather — December	nd	0.69	0.72
End of wet weather — January	nd	0.91	1.08
Mild dry weather — February	—	—	1.16
Very dry weather — June	—	—	1.28
Surface water in irrigated lowland rice — dry weather	0.42	0.53	0.65
Ground water in dry weather			
Lowland rice valley under continuously flowing supply canal	0.45	0.65	0.78
Upland crop valley fed by controlled supply canal	0.49	0.93	1.03
nd.	Not determined.		

**Table 5. Effect of fertilizer nitrogen and organic manure on the grain yield of rice under different land classes.**

Treat. No	Treat./Fert.		Land class	Well drained 76/77M Bg 11-11 Transplant	Imperfectly drained 76/77M Bg 11-11 Transplant	Poorly drained 77Y Bg 34-8 Broadcast
	Nitrogen fertilizer kg/ha	Organic manure kg/ha				
			Season Variety Planting	Grain Yield (kg/ha)		
1.	0	0		5899	7006	2420
2.	0	10		6562	7577	2884
3.	0	20		7032	7919	3493
4.	50	0		6713	7771	2977
5.	50	10		7376	7809	3486
6.	50	20		7684	8365	3692
7.	100	0		7443	8002	3396
8.	100	10		7842	8324	3455
9.	100	20		7762	8393	3810
	Grand mean			7146	7907	3290
	Nitrogen means		N 1	6497	7501	2932
			N 2	7258	7982	3385
			N 3	7682	8240	3554
	Organic manure means		OM 1	6685	7593	2931
			OM 2	7260	7903	3275
			OM 3	7493	8226	3665
	C.V.			6.01	6.08	32.68
	LSD 5% for treatments			611	1016	1530
	LSD 5% for N and OM			894	1424	2440

RELIEF AND HYDROLOGY OF THE LOWER ORDER VALLEYS OF THE DRY ZONE

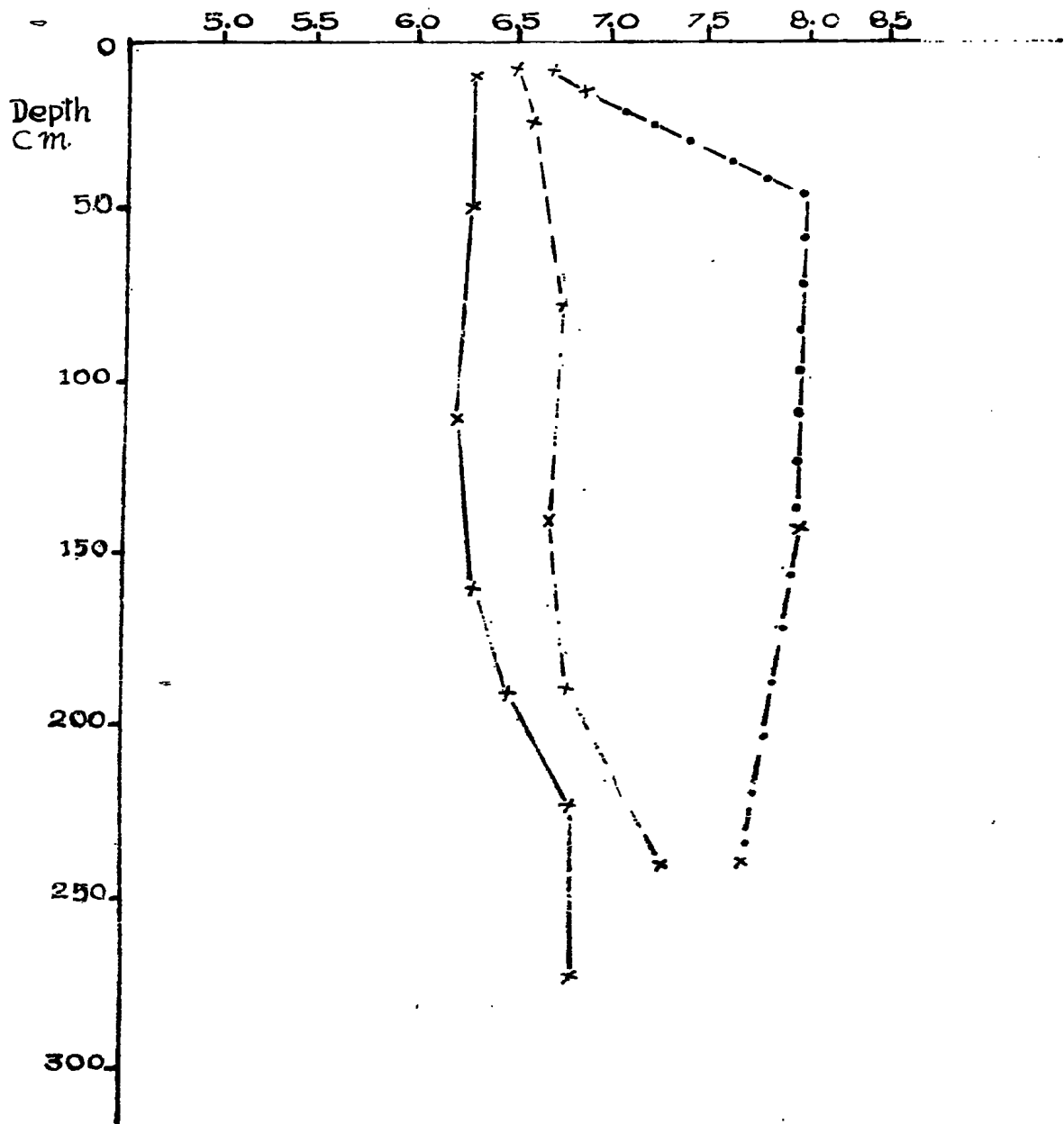


Fig. 1. Change in pH of soil with land class and depth in profile (pH = 1:2 water)

— Well drained      - - - Imperfectly drained      - . . . - Poorly drained

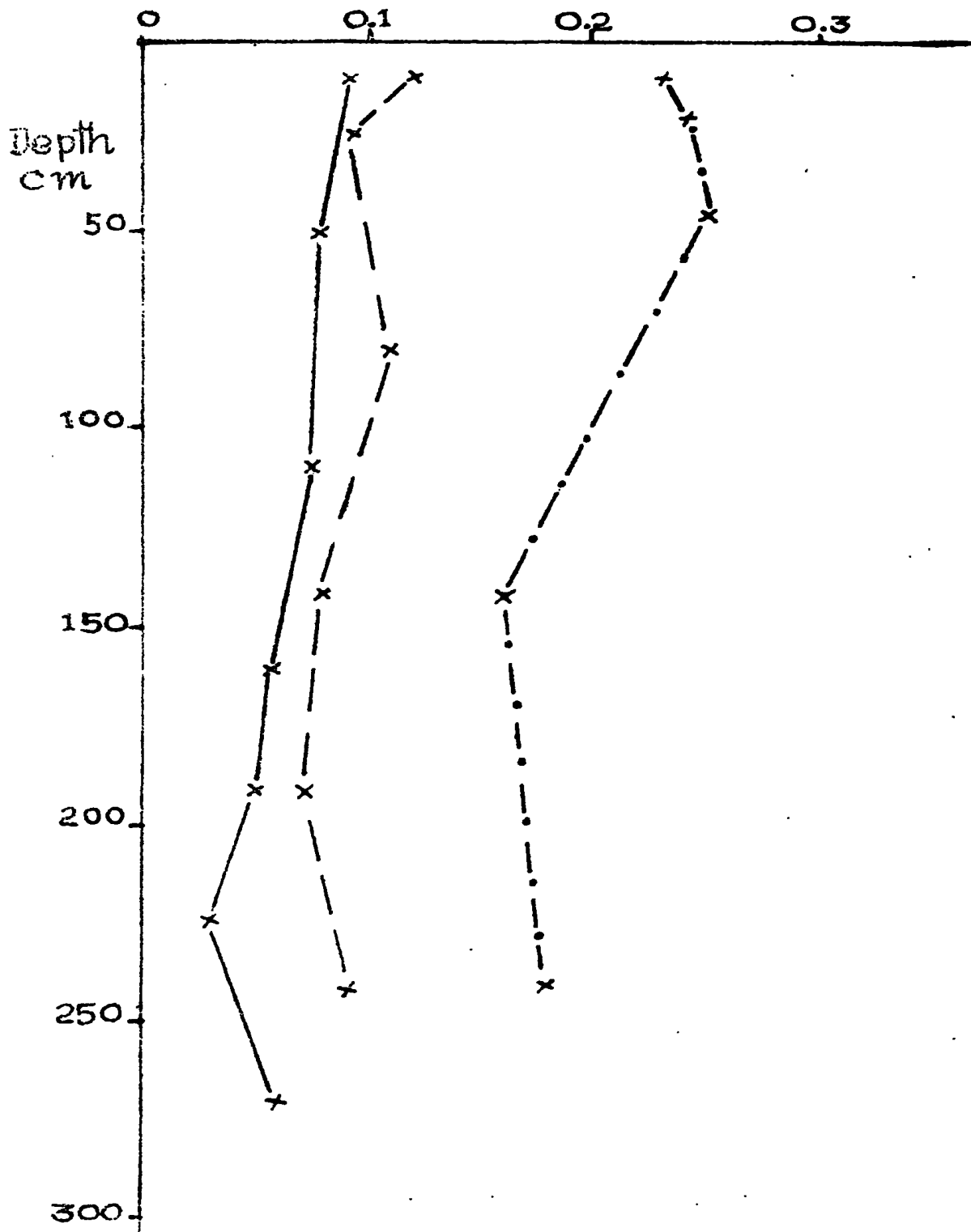


Fig. 2. Change in electrical conductivity of soil with land class and depth in profile (Electrical Conductivity (1 : 5) mmhos/cm)

— Well drained      - - - Imperfectly drained      - · · · · Poorly drained

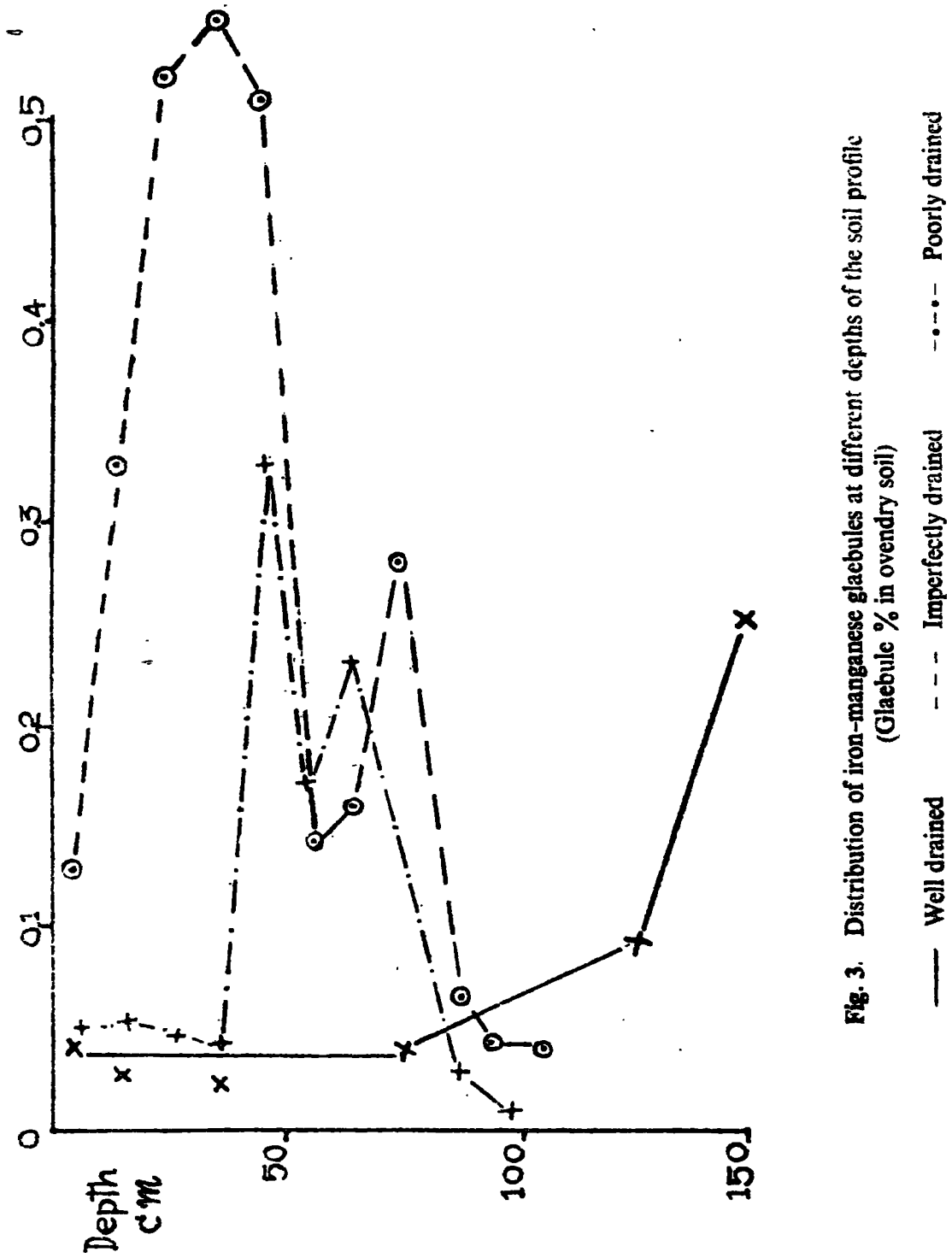


Fig. 3. Distribution of iron-manganese glaebules at different depths of the soil profile (Glaebule % in oven-dry soil)

— Well drained      - - - Imperfectly drained      - · - · - Poorly drained