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Tropical Agricultural Research Vol. 1 1989

Drainage Problems in the Sevanagala Sugar Development Project

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ABSTRACT. In the Sevanagala Sugar Development Project, around 10% of the total cultivated area (an extent of 789 ha) appears to be affected by poor soil drainage that has resulted in non productive or under utilized irrigable lands. In fact fifty nine blocks (each with an allotment size of 0.75 ha) have been fully abandoned while around seventy five blocks were in a state of partial abandonment.

Investigations were carried out to determine the nature and causes of the problem, in order to arrive at suitable remedial and preventive measures for the situation. The results of the preliminary studies on the edaphic conditions for sugarcane cultivation in relation to soil drainage are presented in this paper. Studies included climatological analysis, ground water behaviour, soil physical and chemical characteristics and yield response to soil drainage, in areas with and without the problem.

It was observed that the yield reduction in relation to poor drainage to be around 61% in the plant crop. Sprouting of cane appeared to be greatly influenced by surface ponding, rise of the ground water table to critical heights and its extended duration of surface inundation; all been detrimental to the sprouting process. The heavy precipitation experienced during the October/November period greatly contributed to the problem. While salt build up in soils was high in the water logged fields, the crop failure due to soil salinity hazard may account for over twenty five percent decline in cane yield in the worst affected lands.

Adverse effect of improper land development for irrigation and channel construction were also observed during the course of the detailed inspection of the allotment in the project area.

The results of these preliminary investigations have confirmed the fact that facilities for land drainage are inadequate. However, further work is continued to recommend suitable preventive and remedial measures to bring back land productivity.

INTRODUCTION

Sugarcane, in its natural habitat, is a tropical plant with a high potential for rapid growth. Its water requirement is high, but it nevertheless demands a well drained soil for favourable development. The poorly drained sugarcane lands can be easily identified by prolonged soil wetness, stunted yellowish cane with poor stooling and patches of dead cane. Inadequate soil drainage not only affect cane yield but also the quality of cane viz, poor juice quality with higher fibre and non sugar components. However, these unfavourable edaphic conditions can be successfully arrested by improved management through provision of artificial drainage.

In Sri Lanka, reductions in cane yield between 30 to 40 per cent have been recorded due to poor drainage conditions (Somasiri, 1981). The variety Co.775, which remains as the main commercial cultivar since 1967, is drought tolerant, yet does not grow well in water logged soils. Consequently, when this variety was established in the irrigated fields of the Sevanagala Sugar Development Project in 1986, adverse effects due to inadequate drainage were observed even in the first cultivation season.

The C-8 sector of the Sevanagala Sugar Project is fed by the left bank channel of the Uda Walawe Irrigation Scheme. Channel linings were done up to the field level to minimize the conveyance losses of water, but very little attention has been paid to field drainage. The need for drainage facilities in the allotments of this sector was highlighted in the site research meetings during 1986. Therefore, a study was undertaken with the objectives of identifying the causes of poor drainage, to find ways to improve drainage and to recommend suitable remedial and preventive measures. The results of the field investigations which were carried out from November, 1987 to March, 1989 are presented in this paper.

MATERIALS AND METHODS

Preliminary studies

A field reconnaissance of the crops and the ground conditions was carried out on 126 allotments of the C-8 sector planted in September, 1986 to distinguish the poorly drained and well drained blocks. The response of yield on the existing drainage conditions was studied by analyzing the plant crop yields of these allotments. A climatological analysis was done using the data recorded in the meteorological station at Sevanagala for the period between 1981 to 1986. The evapotranspiration of sugarcane was determined using the FAO pan evaporation method (FAO, 1974) and a comparison between rainfall and evapotranspiration was made to identify the critical seasons for drainage design (Kessler and Raad, 1980).

Field drainage investigations

Three representative blocks each of 0.75 ha of the C-8 sector were selected for the surface, water table and soil investigations. Each block included two drainage classes, adequate and inadequate. The adjoining rainfed sugarcane fields immediately above each block were also selected for the water table and soil investigations.

Surface investigation

With a view to find the existing pattern of the drainage problem, the contour maps were superimposed on the maps of allotments and the surface configuration of the representative blocks was determined by taking levels along the greatest slope of each block. The changes in land use pattern and the natural drainage ways due to land development for sugarcane cultivation were examined in order to find information on the nature and development of the drainage problem.

Water table investigation

The variation of the water table was observed from November, 1987 to November, 1988 using piezometers that were laid in a 20 m x 20 m grid in each block. P.V.C. pipes of 2 m in length and 63 cm in diameter were used in preparing the piezometers and the water table was measured by an electronic water level indicator at weekly intervals. Piezometer pipes of 3 m were used in the rainfed sector to monitor the water table and 1 m pipes were installed in the drainage channels to identify the seepage characteristics (Van der Meer and Van de Graff, 1980).

Soil investigation

Soil samples were obtained from several test pits in both irrigated and rainfed sectors. Soil physical properties including hydraulic conductivity, infiltration and deep percolation were studied in both these sectors in order to find the spatial variation of soils. The variation of soil porosity, field capacity and bulk density with soil depth was also examined to determine the drainable pore space using the moisture characteristics of soil (Van Beers, 1979)

The soil saturation extracts were prepared for electrical conductivity (ECe) and pH measurements (Page *et al.*, 1982). The variation of salt concentration with depth, ECe and pH of surface soil layers were analysed to detect the degree of severity of the salinity problem in the sugarcane fields affected by poor drainage.

RESULTS AND DISCUSSION

Preliminary studies

Observations on ground conditions

The depressions were common in most of the affected blocks as a result of improper land levelling practices. The compacted soils in low lying lands and the shoulders created on the sides of the drains were responsible for the ponding effect. Salt crusts that formed on the soil surface due to high evaporation rates were also observed under water logged conditions.

Extent of damage

According to the records of the S.L.S.C. nearly 30 ha of land allotted to the farmers in the C-8 sector (357 ha) was found to be unsuitable for sugarcane cultivation due to inadequate drainage facilities. The field survey carried out in this sector revealed, 31 blocks with drainage problems with 11 of them being severely affected.

Yield response to drainage

The plant crop yield of the well drained areas reached an average of 112 t/ha, compared to 44 t/ha in the imperfectly drained blocks. This accounts for a reduction of 61.1 per cent with respect to the yield under well drained conditions.

Climatological analysis of the area

The periods with excess rainfall were observed to be March to April and October to November in the *Yala* and *Maha* seasons respectively when the rainfall exceeds the amount of crop evapotranspiration (Figure 1). In general, these rainy seasons are accompanied with high intensity showers ranging from 30 to 50 mm/hr. Hence, the rainfall analysis for drainage design can be restricted to that part of the year during which excess rainfall cause damage to the sugarcane lands.

Surface investigation

Impact of present land use pattern on drainage conditions

During the reconnaissance survey of the Uda Walawe Project most of the lands in the left bank which later developed under the Sevanagala Sugar Development Project, were under the native vegetation. The streams and gullies were deeply incised due to excellent surface drainage and the proportion of poorly drained soils was comparatively less in the left bank (Panabokke, 1963).

However, when this area was progressively developed for sugarcane plantations, much of the original natural drainage network and channels were altered. In some locations the roads and irrigation ditches were constructed across natural drainage ways without paying much attention on the removal of excess water from the rainfed area. Thus, there were signs of upstream afflux in these localities where the piezometers showed positive hydrostatic pressures during the rainy seasons.

The existing pattern of the drainage problem

The occurrence of ill drained patches appeared to be closely related to the landscape pattern. Most of the blocks in the low lying areas and those adjacent to natural drains were affected by poor drainage, which is an indication of the insufficient capacity of the drainage channels and unavailability of proper drainage outlets.

The drainage system of the sugarcane fields consists only of several drains connected to the main Habaralu aru, which ultimately joins the Mau aru. It was also observed that over irrigation to be practiced in the fields at higher locations. However, there were no field drains to remove excess water from the cane fields. The main drain and most of

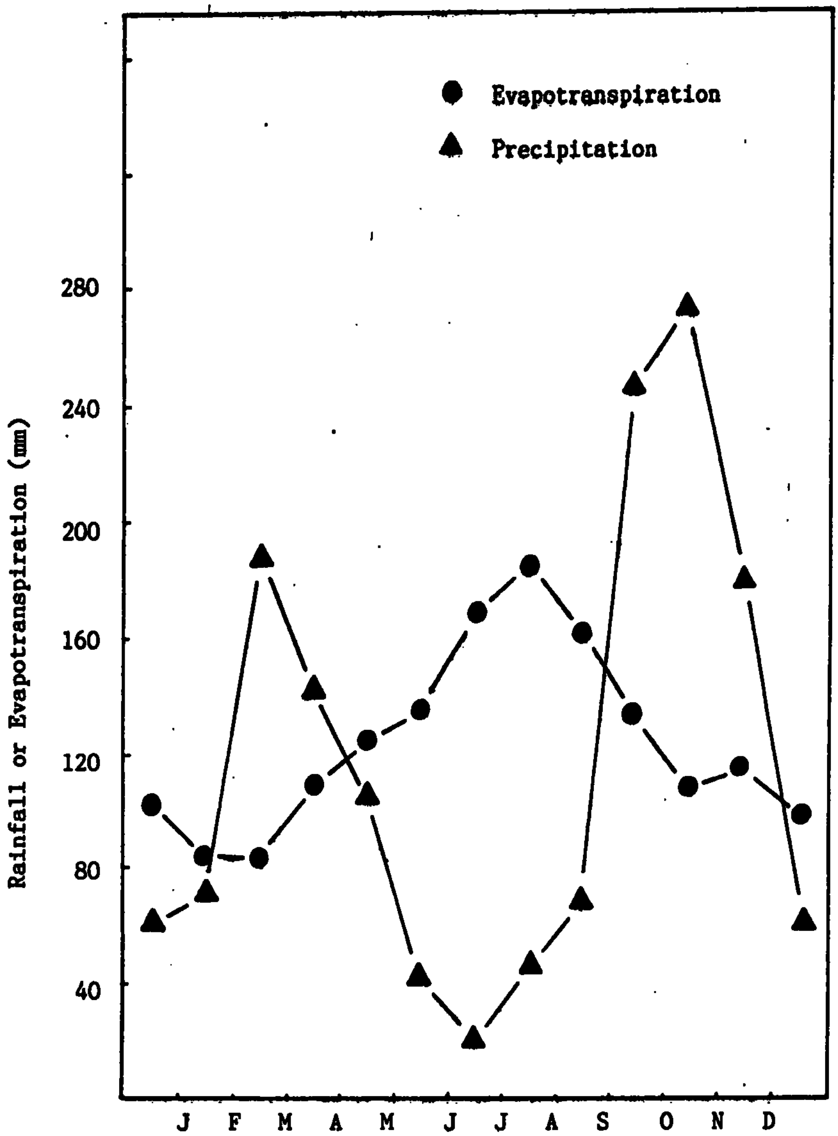

Fig.1. Average monthly precipitation and evapotranspiration from Sugarcane lands (1981 - 1987).

the other natural drains have been silted up over the years and overgrown by a dense cover of grasses. Due to that, in many cases the drains have a depth less than 1 m and not deep enough to take away the sub surface flow. The cross sections of the representative blocks (Figure 2) where the drainage channels are too shallow, indicate that the laterals may not be effective in water table control unless the drainage ways are improved and deepened.

The poor integration of the natural drainage ways is another cause of water table build up. The drainage ways were blocked by the farmers to irrigated the adjoining paddy fields and some drains have been utilized by them to grow paddy in the down stream areas.

Water table investigation

Temporal variation of the ground water table

The purpose of draining sugarcane fields is to allow free drainage of soil to a depth of at least 50 cm (Anon, 1980; Humbert, 1968). The water level in the poorly drained areas remained above this level through out the year but it never reached this critical level in well drained areas. In the moderately drained areas, the water table was above the 50 cm level for 5 to 7 months of the year (Figure 3).

Impact of rainfall on ground water table

The depth to water table had a close relationship with rainfall. the water table rose soon after the rains but days behind the rainfall the decline due to the absence of proper drainage facilities and undesirable internal drainage characteristics of soil (Figure 3).

Seepage characteristics of drains

None of the drains seemed to be efficient in removing the sub surface flow. The piezometers installed indicated a similar depth as in the depth of water in the drain indicates the insufficient drain depth which only served in taking excess water during the rainy seasons.

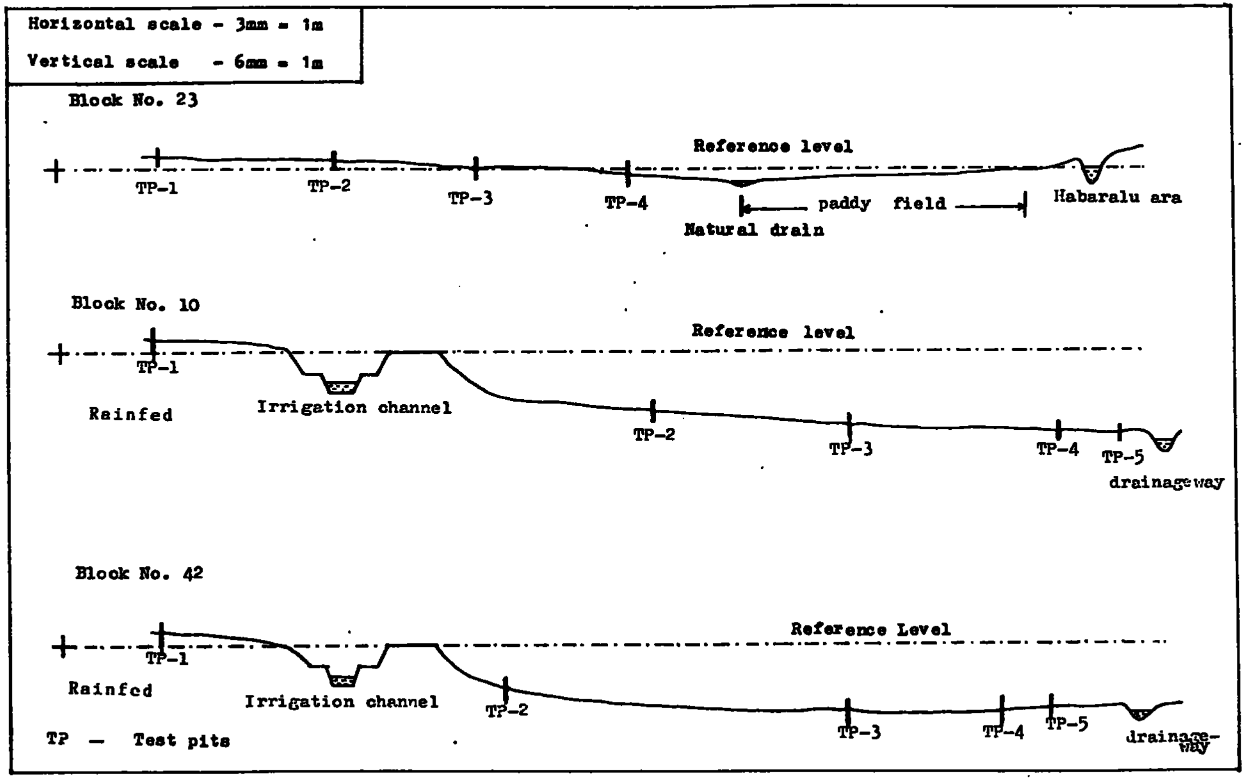

Fig. 2. Hydorlogical Cross Sections and the Locations of Test Pits of the Representative Blocks

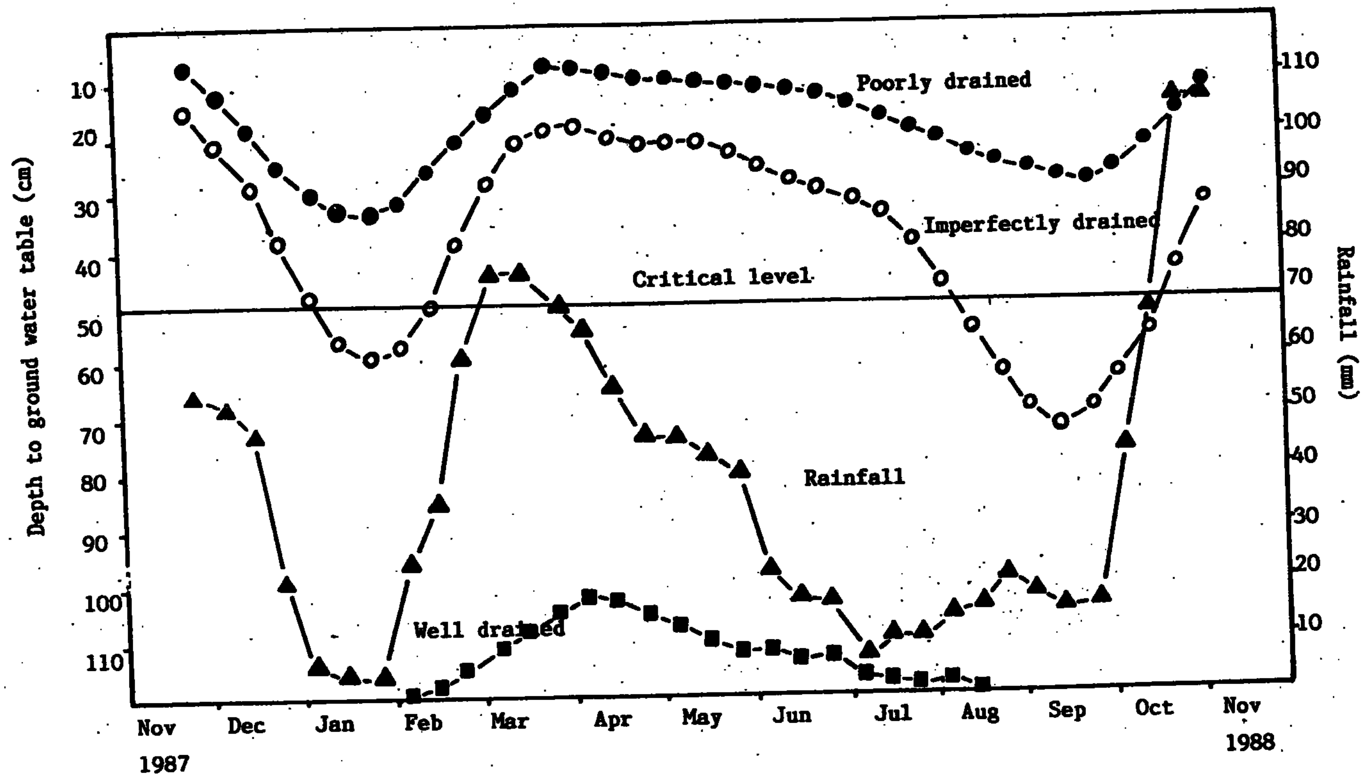

Fig.3. The impact of rainfall and the temporal and spatial variation of ground water table.

Soil investigation

Soil physical properties in relation to drainage

A marked variation of the soil physical properties was observed between irrigated and rainfed conditions (Table 1). The hydraulic conductivity of soils in Block No. 23 as a whole, lower parts of Blocks 10 and 42 are comparatively less pervious than the soils of highland (Near TP – 1 and TP – 2 in both Blocks, 10 and 42).

The infiltration rates also followed a similar pattern with medium values in higher rainfed locations, low values in intermediate locations and very low values in the extreme lowlands. The percolation rates were very close to basic infiltration rates, probably due to the saturated conditions resulting from shallow ground water table (Van der Meer and Van de Graff, 1980). This variation is well connected with the removal of top soil during farm redesign and compaction due to farming operations carried out under unfavourable soil moisture conditions.

The drainable spore space, which is a measure of the aeration status of soil, showed averages of 11.8 and 28.5 per cent in the irrigated and rainfed conditions respectively. Low lying areas had fairly low values averaging about 8 per cent on a volume basis (Figure 4). A drainable pore volume of 15 or more is considered desirable but usually 25 per cent or more is needed for excellent root development of sugarcane (Trouse, 1955; Stakman, 1980). Accordingly, the land strips in the lowlands are not very satisfactory for the root development of sugarcane compared to those in higher locations.

Salinity and drainage

The electrical conductivity measurements had a variation of 0.63 to 6.2 mS/cm, with generally higher value in the lowlands. On the average, a value of 3.2 mS/cm was observed which accompanied by a 10 per cent reduction in yield (Landon, 1984). The soil reaction found to be in the range of 6.3 to 8.2 with an average pH of 7.3. In general, it increased with increasing depth of soil (Table 2), as in the Reddish Brown Earths of the Dryzone (Panabokke, 1967).

The Total Dissolved Salt Concentration (TDS) decreased with soil depth (Table 2). These values in reasonable agreement with the

Table 1. Soil physical properties of the representative blocks.

Block No.	k[1] m/day	Ibas[2] cm/hr	Per. rate[3] cm/hr	Location[4]
Site 1	0.812	2.1	–	Near TP – 1(rainfed)
10	0.487	1.2	1.1	„ TP – 2
	0.051	1.1	0.8	„ TP – 3
	0.029	–	–	„ TP – 4
	0.011	0.1	–	„ TP – 5
Site 2	0.286	0.5	0.4	„ TP – 1
23	0.128	–	–	„ TP – 2
	0.159	–	–	„ TP – 3
	0.132	0.1	–	„ TP – 4
Site 3	0.867	2.2	–	„ TP – 1 (rainfed)
42	0.785	1.8	1.6	„ TP – 2
	0.159	–	–	„ TP – 3
	0.315	0.1	–	„ TP – 4
	0.053	–	–	„ TP – 5

Note:

1. k = Hydraulic conductivity (FAO, 1963)

< 0.2	– very slow	0.2 – 0.5	– slow
0.5 – 1.4	– mod.	1.4 – 1.9	– mod. rapid
1.9 – 3.0	– rapid	> 3.0	– very rapid

2. Ibas = Basic infiltration rate (Rickard and Cossens, 1966)

< 0.25	– very low	0.25 – 1.5	– low
1.5 – 2.80	– medium	2.80 – 5.3	– high
> 5.30	– very high		

3. Per. rate = Percolation rate
4. Locations of test pits (TP) are given in Figure 2.

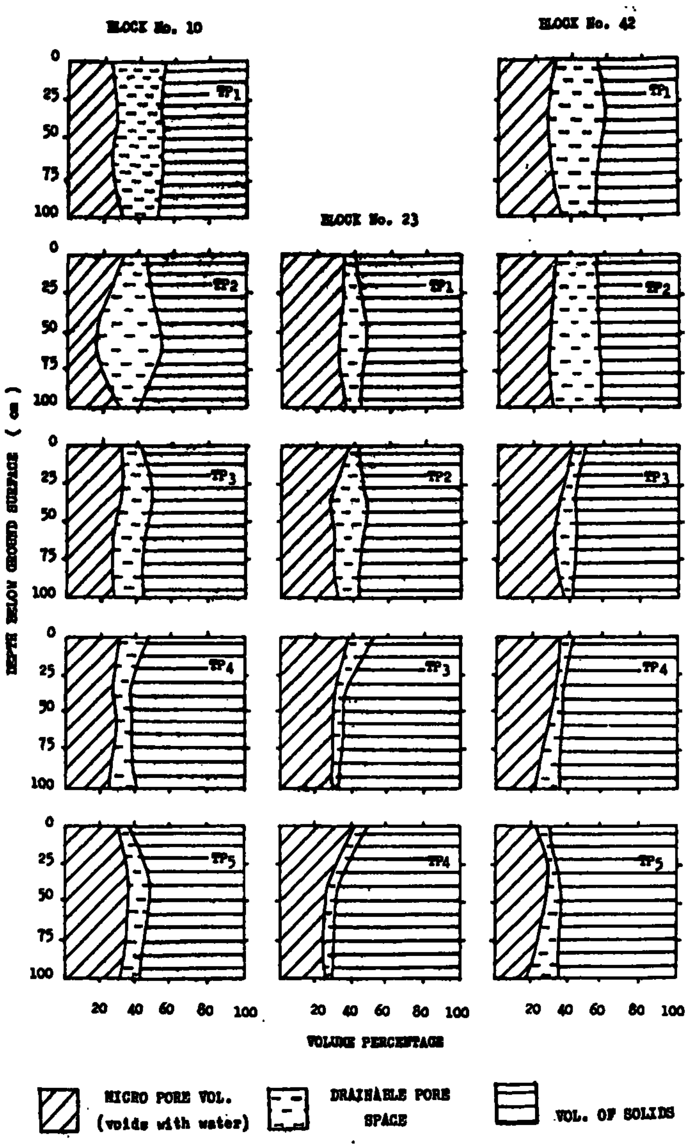

Fig. 4. The Variation of Drainable Pore Space with Soil Depth

Table 2. The variation of total dissolved salt concentration (TDS) and pH with depth.

Depth (cm)	Site 1 TDS (mg/l)	Site 1 pH	Site 2 TDS (mg/l)	Site 2 pH	Site 3 TDS (mg/l)	Site 3 pH
Surface	1790	–	2950	–	2180	–
0 – 25	1020	6.3	900	6.9	1230	6.9
25 – 50	380	6.4	740	7.2	610	6.9
50 – 75	280	6.4	490	7.8	410	7.1
75 – 100	280	6.7	460	7.9	410	7.0
100 – 125	310	7.1	450	7.8	320	7.4
125 – 150	220	7.0	450	7.9	320	7.6
150 – 175	210	7.2	370	8.0	330	7.6
175 – 200	200	7.2	350	8.2	320	8.0

characteristic salt build up of a soil profile in contact with saline ground water, associate with excessive evaporation losses (Van der Meer and Van de Graff, 1980).

CONCLUSIONS

1. The average yield in imperfectly drained soil blocks showed a drastic reduction (61.07%) when compared with well drained blocks.

2. The period of March/April in the *Yala* season and October/November in *Maha* season can be identified as the critical seasons for drainage design where generally high intensity rains are experienced and the rainfall is in excess of the evapotranspiration from the sugarcane lands.

3. A similar trend was observed between rainfall and water table depth in the cane lands. The water table rose up soon after the start of the rainy season but took some time to the fall due to the absence of proper drainage facilities.

4. In the poorly drain areas, the water table was observed above the critical level through out the year, but in the moderately drained areas, it was above the critical level for 5 to 7 months of the year.

5. Most of the affected blocks were observed adjacent to natural drains and in low lying areas indicating the absence of proper drainage outlets and the insufficient capacity of the natural drains.

6. Soil physical properties along the slope of each representative block showed a distinct variation. The morphological and physical characteristics of the typical RBE soils (gravel layer and the reddish brown colour, medium infiltration rates *etc.*) could be found only in the higher locations, indicating the adverse impact of present land use pattern under irrigation on creating problem areas.

7. There is evidence of salinity build up in soil, since the soil salinity accounts for about a 10 percent decrease in sugarcane yield. Thus, proper drainage facilities are important to maintain the water table at a sufficient depth to avoid salinity problems and to make sugarcane lands more productive.

The results of these preliminary investigations have confirmed the fact the facilities for land drainage in this project area are inadequate. However, further research work is continued in order to recommend suitable remedial and preventive measures to bring back land productivity.

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