Soil water dynamics in a grassland of the mid country intermediate zone of Sri Lanka

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Accepted 30 September 1999

ABSTRACT

Temporal and spatial variability of soil water content (SWC) in a catchment affects surface and sub-surface runoff, modulates evapotranspiration and determines the degree of ground water recharge. The present understanding of soil water dynamics in different land uses in Sri Lanka is poor. An experiment was conducted to study the soil water dynamics in a grassland of mid country of Sri Lanka. Rainfall, runoff and SWC were monitored for two years in an experimental plot of 525 m^2. SWC was monitored up to decomposing parent material using neutron moisture meter. Data showed that the temporal variability of SWC at 15 and 30 cm depths was very high. The variability of SWC in depths below 30 cm was low and showed gradual change with time. The SWC in the profile remained below field capacity most of the time, showing the capacity of the profile to absorb rain water. The runoff from the plot was negligible.

Keywords: grassland, ground water, rainfall, runoff, soil water content,

INTRODUCTION

Very low water levels in perennial streams and rivers during dry weather and peak flows following rain storms are frequently observed at present in Sri Lanka. Maddumabandara and Kuruppuarachchi (1989) showed that the discharge in the river *Mahaweli* at Peradeniya during dry months of the year has been decreasing over the last several decades. They also showed an increasing trend of flow in rainy months. It has also been shown that in several drainage basins of the island, runoff: rainfall ratio was increasing by about 1-2% annually (NARESA 1981). This behavior of rivers and streams has been mainly attributed to land use changes taking place in the country. The changes in the stream and river flow can seriously affect the human life through its implications on water availability for agricultural, domestic and industrial purposes.

Land use practices influence many aspects of the land which affect the hydrologic processes. Vegetation, which determines the land use is the most important factor influencing the hydrology in a given area. The integrated effect of vegetation on the hydrology of an area is comprised of its effects on interception, evapotranspiration and soil water dynamics.

Abbreviations : SWC - soil water content, IBC - immation brown coams, FC - field capacity

Understanding of land use effects on hydrologic processes is a prerequisite for implementation of any watershed management program to achieve sustained water yields from catchments. Temporal and spatial variability of soil water content in a catchment affects surface and sub-surface runoff, modulates evapotranspiration, determines the extent of ground water recharge and initiates and sustains feed back between land surface and atmosphere (Geogakakos and Bamner 1996). Information on soil water behavior in response to rainfall is not available for many land uses in Sri Lanka. The objective of the research presented here was to determine the behavior of soil water storage in relation to rainfall in a grassland in the mid country intermediate zone of Sri Lanka.

MATERIALS AND METHODS

The study was conducted during March, 1995 to December, 1996 at the farm of School of Agriculture, Kundasale, Kandy. A plot of 525 m^2 was isolated (on surface) at the crest of a land of 9% slope of the rolling terrain using an earth bund of about 30 cm high. This bund was covered with same vegetation of the plot. The land consisted of naturally growing grass, Guinea A (*Panicum maximum*). The ground was completely covered by the vegetation. A runoff water collecting tank system was built at the lower end of the plot (Fig. 1). All runoff water from the plot was directed to this tank for measurement. Rainfall was measured at a meteorological station located within a 50 m radius of the experimental site. Ten year average rainfall data was also obtained from the same station for comparison. Four aluminum neutron probe access tubes were installed at random to reach the decomposing parent material below the soil. Soil water was measured using neutron moisture meter (Hydroprobe model CPN 506) at 30 cm intervals down to 150 cm once a week. The meter was calibrated for the sight. Soil water at 15 cm depth was determined by gravimetric method. Infiltration rate was measured using double ring infiltrometer. The grass was harvested at regular intervals. Soil texture of different layers was determined by pipet method. Root penetration depth was observed in 3 pits dug in the plot at the end of the experiment.

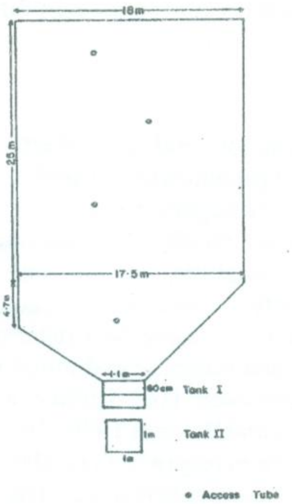

Fig.1. Lay out of the experimental plot.

RESULTS AND DISCUSSION

Site characteristics

The experimental site falls within the mid country intermediate zone of Sri Lanka (Land Use Division 1979). The soils of the experimental site were Immature Brown Loams (IBL) (Moorman and Panabokke 1961), classified as Dystropepts according soil taxonomy (USDA 1975). The soil profile was 150 cm deep from surface to decomposing hard bed rock. The depths of A, B and C horizons were 0-15, 15-45 and 45-150 cm respectively. The soil texture was loamy sand in A and B horizons and sandy in C (Table 1). The grass was not grazed but periodically cut and removed. Grass was completely rain-fed.

Table 1: Particle size distribution in different horizons of the soil profile at the experimental site

Horizon	Depth (Cm)	% Sand	% Silt	% Clay	Textural class
A	0-15	80.1	15.8	4.1	Loamy sand
B	15-45	80.7	13.2	6.2	Loamy sand
C	45-150	94.5	4.0	1.5	Sand

Neutron probe calibration was done for each layer. As the slope of the curve for each layer was similar, data were pooled. The calibration curve is given in Figure 2.

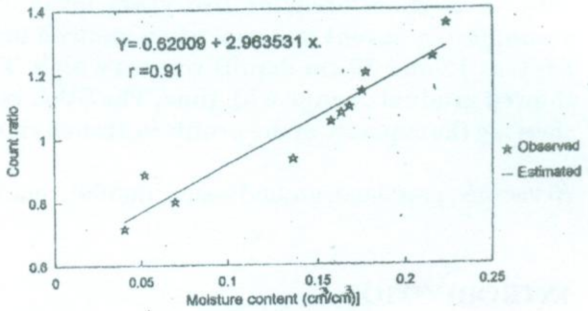

Fig. 2. Calibration curve of the neutron moisture meter for Kundasale.

Correlation coefficient of 0.91 shows that there is a high correlation between count ratio and the soil water content.

The vegetation and topography of the site suggest that it represents the naturally growing grasslands on IBL soils in the intermediate zone of Sri Lanka.

Rainfall and runoff

Monthly rainfall, ten year average rainfall in the area and runoff from the experimental plot are given in Table 2. The distribution of rainfall of the two years deviated from the 10 year average rainfall to some extent. However, the mean annual rainfall remained more or less the same. The runoff was negligible at the site and was evident only in November following substantial rainfall. Even in these months runoff was produced only by storms of high rainfall. The two rainstorms which resulted in runoff amounted to 92.3 mm (12th November, 1995) and 198.5 mm (28th November, 1996). Runoff from a catchment depends on rainfall and catchment characteristics. The rainfall intensity and the duration are two important rainfall characteristics. Soil water content, infiltration and topography are the important catchment characteristics (Ward 1975). The intensities of the

Table 2: Monthly and ten year average rainfall at the site And runoff from the experimental plot in 1995 & 1996

Month	Rainfall, mm 1995	Runoff, mm 1995	Rainfall, mm 1996	Runoff, mm 1996	10 yr. avg. rainfall, mm
Jan	NA	NA	65.6	0	89.4
Feb	NA	NA	82.3	0	59
Mar	25.4	0	7.4	0	66.9
Apr	216.4	0	156.9	0	96.9
May	263.7	0	31.0	0	104.2
Jun	66.9	0	103.2	0	104.2
Jul	32.4	0	112.7	0	97.1
Aug	64.8	0	52.5	0	67.7
Sep	95.2	0	176.5	0	106
Oct	246.5	0	164.9	0	193.6
Nov	282.7	8.71	335.7	0	218.9
Dec	58.1	0	81.2	0	148.9

NA : Data not available

Rainfall in the area are generally low. Nayakkorala and Maddumabandara (1996) showed that 60% of the rainstorms of the area were with maximum intensities (measured during 7.5 minute periods) below 18mm h^{-1}.

If the infiltration rates of the soil is lower than the rainfall intensity, then runoff will be the result. The basic infiltration rates at the site ranged between 44-140 mm h^{-1}, which is higher than the maximum intensities reported above. As the soil was covered by grass, there was no sudden reduction of infiltration rate following rainfall. Therefore, infiltration rate in grassland remained at a higher rate. The soil water content at the site was at its maximum (75% - 80% of the total storage) during the months of October and November (Fig. 3) which also helped in generation of runoff during this month. Further, the Fig. 3 shows that the SWC was below field capacity (FC) (personal communication, R.B. Mapa) throughout the year showing soil water deficit.

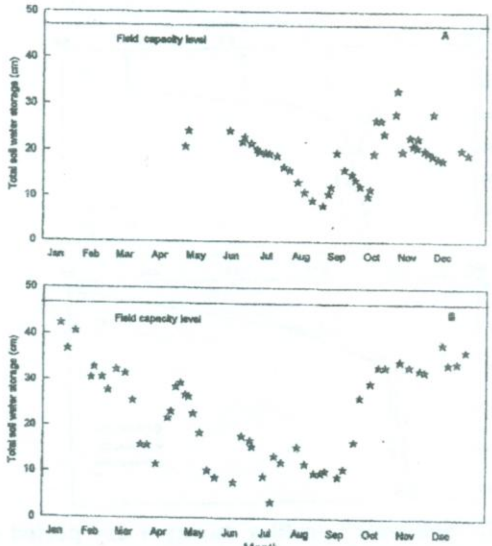

Fig. 3. Variability of total soil water storage in the profile during 1995 and 1996 (B)

Runoff data from grasslands in Sri Lanka are very limited. Gunawardena (1988) who compared runoff from small catchments in the wet zone of Sri Lanka where annual rainfall amounted to 5320 mm reported that runoff from a catchment with patana grass was 36% of the rainfall. Nayakakorale & Maddumabandara (1996) reported that in the mid country intermediate zone of Sri Lanka, runoff from natural forest was negligible. They attributed the low runoff to high infiltration rates of the forest land and to high soil water deficit (difference between FC and SWC at a given time) shown in the profile. Similarly, the low runoff from the grassland in this experiment also can be attributed to high infiltration rates of the soil.

Soil water dynamics

Temporal variability of SWC at the experimental site for 1995 and 1996 are given in Figs. 4 & 5.

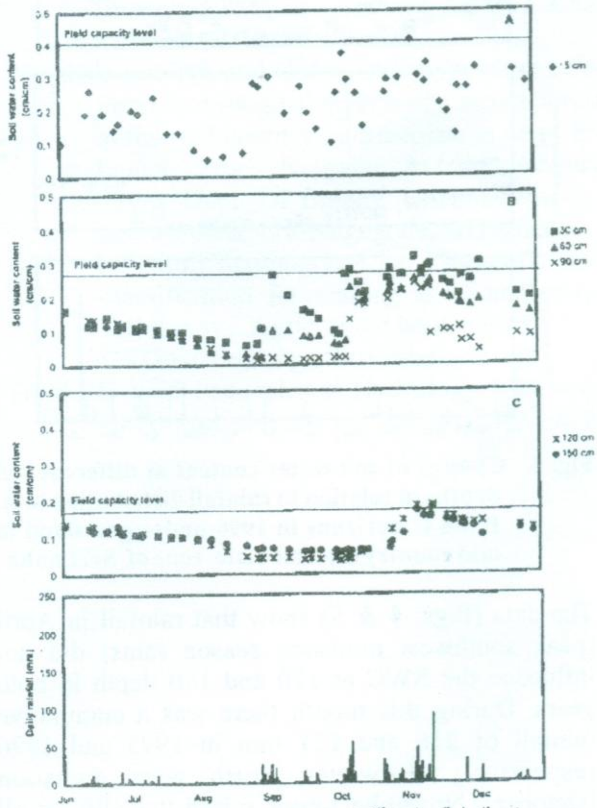

Fig. 4. Change of soil water content at different soil depths in relation to rainfall distribution in A, B andChorizons in 1995, under grassland in mid country intermediate zone of Sri Lanka

Comparison of SWC among different depths show that the variability is highest at 15 cm followed by 30 cm. The variability at depths below is lower. It is also seen that at 15 and 30 cm depths the change of SWC is sudden, but at depths below, the change is gradual.

These differences can be expected because direct contact of the rainfall is with the surface layer. The effect of rainfall on deeper depths depends on the amount of rainfall and antecedent SWC. When antecedent SWC is high, even lighter rains can influence SWC at deeper depths. On the other hand if rainfall is higher, even at low SWC it can influence soil layers at deeper depths. Accordingly during dry periods it can be seen that fairly high rainfall did not change SWC at depths below 30 cm (Figs. 4 & 5).

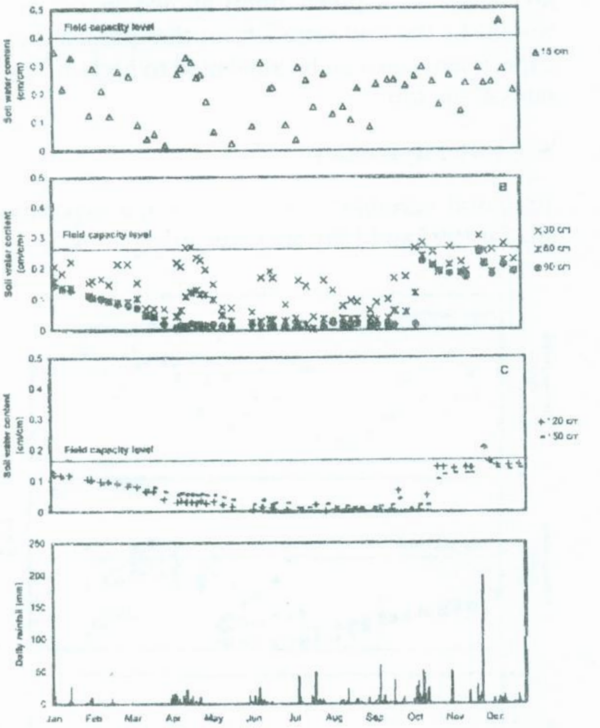

Fig. 5. Change of soil water content at different soil depths in relation to rainfall distribution in A, Band C horizons in 1996 under grassland in mid country intermediate zone of Sri Lanka

The data (Figs. 4 & 5) show that rainfall in April (peak southwest monsoon season rains) did not influence the SWC at 120 and 150 depth in both years. During this month there was a cumulative rainfall of 216 and 157 mm in 1995 and 1996 respectively. However, north west monsoon (October - November) rains raised the SWC at all soil layers. The SWC at 120 & 150 cm reached highest levels during both years following there rains. The rainfall in October and November was 529 and 535 mm for 1995 and 1996 respectively. The visual observation of soil profile at the experimental site revealed that the roots had penetrated to about 110 - 120 cm depth. Soil water depletion pattern (Fig. 7) shows that significant depletion did not take place below 120 cm depth. Due to coarser nature of the soil in this layer, upwards movement of water from below 120 cm depths by capillary action is not anticipated. Therefore, it can be expected that grass extracted water from 1 to 110 - 120 cm depth.

Fig. 6 shows the replenishment (filling) of soil with rain water during a wet period. With progression of the rainy period, the moisture content in the profile increased gradually from surface to lower profiles. Similarly, depletion of SWC during a dry period is shown in Fig. 7. It can be seen that depletion first occurred in top layers as usual. It is noteworthy that depletion takes place only down to 120 cm depth. This is because, as stated above, the roots had penetrated only up to 110- 120 cm depth and probably no extraction took place from layers below.

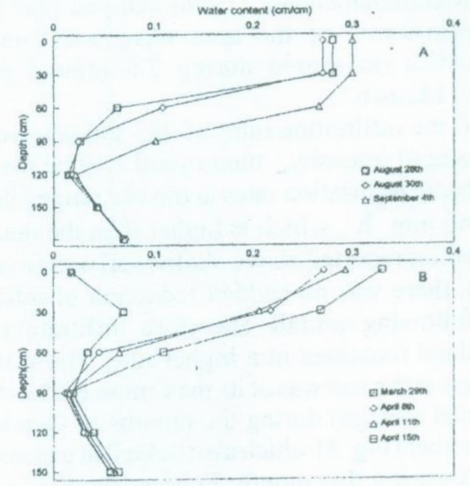

Fig. 6. Soil water profiles during a wet period in a grassland 1995 (A) and 1996 (B) (means of 4 reading)

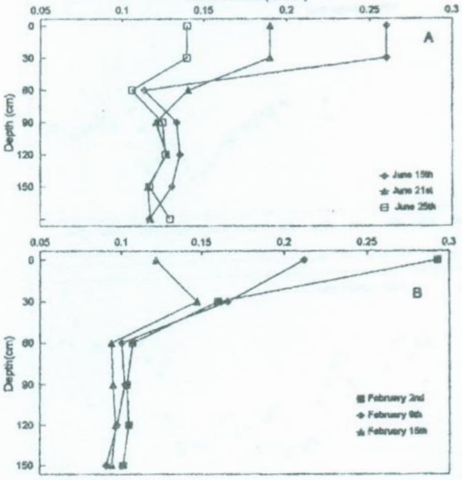

Fig. 7. Soil water profiles during a dry period in a grassland 1995 (A) and 1996 (B) (means of 4 reading)

CONCLUSION

The results showed that the rainfall, except in October and November did not influence SWC at depths below 60 cm during the two years of the experiment. In October and November rainfall increased the SWC up to 150 cm depth which is the depth of the

soil profile down to decomposing rock. Total soil water storage was highest during Maha season following continuous rainfall. The soil water contents at depth below 15 cm remained above FC only in April, May, October and November. The soil profile showed a deficit (bellow FC level) in SWC during most of the time. The high infiltration rates of the soil under grass and the soil water deficit did not allow significant runoff out of the experimental plot. Further, the SWC at deeper depths remained at low levels during most of the time which suggested that chances for lateral movement or deep percolation of water were very rare.

ACKNOWLEDGEMENT

The project was partly funded by a contract research grant (number 12/215/177) by the Council for Agricultural Research Policy. Mr. K.M. Karunaratna and Mr. G.B.S. Samaranayake, research assistants, Natural Resources Management Center, Peradeniya, helped in data collection.

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