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WATER BALANCE STUDIES OF SOIL WITH RAINFED CASSAVA IN THE SLOPY FIELDS OF CENTRAL KERALA

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A field experiment was conducted in the lateritic soil of Instructional Farm, Vellanikkara to study and estimate the grain and loss of water in the soil such as rainfall, run-off, evapotranspiration, effective rainfall and deep percolation on rainfed cassava under various cultivation techniques which are common in the State. Profile moisture storage upto 150 cm depth of the soil was determined with neutron scattering method. It is inferred that the maximum water storage capacity of the soil under actual field conditions cannot be taken as its field capasity measured at 0.3 bar pressure. Evaporation from bare land surfaces were much lower than the ET estimated under cultivated plots. An equation was suggested for finding out crop ET based on measurement of surface soil moisture content and potential avapotranspiration.

Next to rice cassava is an important staple food of Kerala. It is grown during the period of abundant rainfall. Cassava is mostly grown in the slopy fields and hence soil erosion and surface run off is a serious problem. Viswambharan and Sasidar (1985) reported that the malady of erosion and run off could be significantly reduced by intercropping the cassava field with peanut In this study, in a lateritic soil of 15.3% slope, attempts were made to quantity run off, evapotranspiration, effective rainfall and deep percolation losses under varying planting techniques and cropping systems on rainfed cassava.

MATERIAL AND METHODS

A field experiment was conducted in the Instructional Farm of the College of Horticulture, Vellanikkara during 1979-80 cropping season, in uniform field run off plots having a length of 24.3 M and width of 2.7 M on 15.3% slope. There were five treatments as detailed below:

T_1 — Cassava alone on mounds,

T_2 — Cassava on mounds with peanut as intercrop,

T_3 — Cassava on ridges across the slope

T_4 — Cassava on ridge across the slope with peanut as intercrop.

T_5 — Uncultivated bare fallow.

The soil of the experimental area is deep, well drained and moderately acidic sandy clay loam of lateritic origin and fairly rich in organic matter. The basic infiltration rate of the experimental area as measured by double cylinder infiltrometer was 14.85 cm/hr. Tapioca cultivar M-4 and

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peanut cultivar TMV-2 were used for the experiment, with all the package of practices recommend by the Kerala Agricultural University (Anon. 1978). The experiment was laid out in Randomised Block Design with four replications. The plot edgings were done with embedded polythene sheets. The run off from each plot was collected directly into water proof polythene lined earthen tanks constructed at the lower end of the plot and measured after the occurence of each rainfall. For the measurement of rainfall, an automatic recording rainguage was installed at the centre of the experimental site. The soil moisture stored at depths of 5 cm, 30 cm, 45 cm, 60 cm 75 cm, 90 cm, 105 cm, 120 cm, 135 cm and 150 cm of the soil profile was measured at fortnightly intervals using neutron scattering probe which was calibrated in the same soil. Apart from these regular measurements, the soil moisture stored in the different soil layers upto 150 cm depth as mentioned above were estimated before and one day after the occurance of each rainfall starting from initial land preparation, for the purpose of estimating effective rainfall and evapotranspiration. From these measurements, actual soil moisture stored in the soil profile upto 150 cm depth was calculated as follows.

$$W = \sum_{i=1}^{n} M_i D_i, \text{ in which,}$$

W = Water storage of soil profile, mm.

n = number of soil layars sampled in the soil profile of depth D.

M_i = Moisture content (volume fraction) of the i th layer.

D_i = depth of the i th layer of the soil, mm

From the measurements of run off, retentive rainfall calculated from the simple relationship.

Retentive rainfall = Rainfall—run off

Estimation of evapotranspiration (ET)

Since the depth of ground water was more than 3 M from the surface, soil moisture depletion method was employed to determine ET. According to Blad (1983). ET is often determined based on the assumption that, gain or loss of water to or from the zone below the maximum root depth is negligible. It involved measurements of soil moisture from various depths upto 150 cm of the soil profile as mentioned earlier in this chapter throughout the study period Consumptive use (Cu) is calculated from the change in soil water content in successive samples from the following equation.

$$u = \sum_{i=1}^{n} (M_{1i} - M_{2i}) D_i \text{ in which,}$$

u = water use from the soil profile for the successive sampling intervals, mm.

n = number of soil layers sampled in the rootzone depth D.

M_{1i} = Soil moisture content (Volume fraction) at the time of first sampling in the ith layer.

M_{2i} = Soil moisture content (Volume fraction) at the time of second sampling in the ith layer.

D_i = depth of the ith layer of the soil, mm.

Seasonal consumptive use ($Cu = \Sigma u$) is calculated by summing up the consumptive use values of each sampling interval. Corrections were also made by adding potential evapotranspiration values (PET) for accelerated water loss for the intervals just after rainfall and soil moisture determinations. For this, PET values were worked out with the impirical formula of Thornthwaite (1948).

Estimation of Effective rainfall

For the purpose of this study, effective rainfall was defined as that part of the total rainfall during the season which is available to meet the consumptive water requirement of the crop From the date of initial land preparation, the moisture losses from the land as ET, run off, deep percolation and the rainfall received daily were monitored. That portion of the retentive rainfall not accounted for by a simultaneous increase in water storage of tha soil profile upto 150 cm depth was considered as lost by deep percolation. The values of deep percolation were deducted from the total retentive rainfall to determine the water that was actually available for crop production from the rainfall received during the period under study. These values were compared with the total ET estimated for the cropping period and were taken as the effective portion of rainfall since the total ET for the cropping period exceeded these values in all cases and hence reported as effective rainfall.

Based on the determinations of soil moisture in the top 20 cm soil and corresponding ET measured after the cessation of rainfall, an attempt was made to find out a method to estimate the actual ET from the values of PET and soil moisture content of the top 20 cm of the soil profile and reported Crop and management practices were ignored in this Multiple regression equation was fitted with the ratio of ET to PET as the 'y' component and moisture volume fraction of the top 20 cm soil as the 'x' component.

To supplement the data, moisture retention including gravel and the bulk density of the soil profile were also determined and reported in table-1. Particle density of the soil was determined and found to be 2.63 Results are presented and discussed below.

RESULTS AND DISCUSSION

Profile wise water content :—

Profile wise moisture contents under different treatments during the three distinct stages (early rainy, middle dry and later rainy periods) of the experiment as measured by the fortnightly determinations and averaged for the different stages are given in Fig. 1, Fig 2 and Fig. 3. The mean moisture contents of the soil profile during the above three different stages of the experiment are also given in table-2. In this context, reader's attention is invited to the soil moisture retention by the soil profile at 0.3 bar pressure which is regarded as the field capacity in table 1. It may be noted that the actual soil moisture content obtained by insitu measurements were much higher than that of the field capacity during all the three stages of the experiment. This cannot be explained as a result

Table 1. Moisture retention including gravel (volume per cent) and bulk density of the soil profile in the experimental site.

Depth (cm)	Moisture retention (volume per cent)		Bulk density (g/cc.)
	0.3 bar	15 bars	
0-30	20.3	16.3	1.25
30-60	22.6	18.3	1.28
60-90	25.4	20.3	1.31
90-120	29.4	23.2	1.29
120-150	21.4	17.4	1.30
Mean	23.8	18.9	1.29

Table-2: Mean moisture content (volume fraction) over 150 cm of soil profile during 3 different stages of experiment

Treatments	Early rainy period (September-November 1979)	Middle dry period (December 1979-March 1980)	Later rainy period (April-May 1980)
T_1	0.394	0.278	0.273
T_2	0.378	0.278	0.276
T_3	0.421	0.315	0.314
T_4	0.401	0.303	0.307
T_5	0.387	0.328	0.319

of the shallow ground water, since the ground water could not be detected within 3 meters depth even during the rainy period. During the early rainy period the maximum moisture content of 0 421 volume fraction was recorded by T_3, while the mean field capacity was only 0 238 volume fraction The increase in moisture content due to a possible rise in ground water table cannot be expected, since, the readings of bulk density and particle density already made in this experiment also do not agree to this. In addition to this, water table could not be detected in a piezometer tube of 3 metre depth. Hence it is inferred that the maximum water retention (storage) capacity of the soil under actual field conditions cannot be taken as its field capacity measured at 0 3 bar pressure.

Water balance in the soil profile:

The results of the water balance study of the experimental site are given in table 3. Storage balance of the soil profile upto 150 cm depth before cropping was 557.51 mm, while the total rainfall received during the period of study was 709.75 mm. Maximum run off was observed in T_5 since the land wasbare fallow and the lowest run off was observed in T_4 since it had maximum protection against run off due to ridges taken across

Table 3 : Water balance of the soil profile (150 cm depth) estimated under various treatments.

Treatments	Storage balance in the soil before cropping (mm)	Total rainfall received during cropping season (mm)	Total run off measured (mm)	Total retentive rainfall (mm)	Deep percolation losses estimated (mm)	Total ET estimated (mm)	Total effective rainfall (mm)
T_1	557 51	709.75	100.43	609.32	19.09	771.81	690.23
T_2	557.51	709.75	54.32	655.43	68.58	754.53	586.85
T_3	557.51	709.75	26.82	682.93	76.96	761.00	605.97
T_4	557.51	709.75	17.54	692.21	84.08	733.81	608.13
T_5	557.51	709.75	193.02	516.73	0.00	657.83*	—

* Evaporation from bare land surface only.

Table 4 : Mean moisture content (volume percentage) in the top 20 cm soil layer under different treatments after cessation of rainfall

Treatments	Days after cessation of rainfall									
	0	14	28	42	56	70	84	98	112	126
T_1	27.01	15.97	11.07	9.01	9.19	8.65	8.52	8.23	8.21	7.94
T_2	29.17	15.36	10.42	9.89	9.11	8.38	8.18	7.47	7.22	6.92
T_3	29 88	16 58	11.93	10.56	10.35	10.00	9.96	9.36	9.35	9.10
T_4	28.73	15 80	11.74	10.75	10.24	9.27	9.24	8.60	8.40	8 41
T_5	26.09	15.73	11.43	10.25	9.44	8.47	8.23	7.43	7.16	6.89

the slope and groundnut intercropping (Viswambharam and Sasidhar, 1985).

Deep percolation was practically nil in bare fallow plots (T_5), while it was lowest (19.09 mm) in T_1. It can be seen that the percolation and run off were inversely related.

Among the cultivated plots, maximum ET was recorded in T_1 (Cassava alone on mounds) while it was least in T_4 (Cassava on ridges across slope with peanut intercrop) as evidenced in Table 3 However, evaporation from bare land surfaces (T_5) was much lower than the ET measured under cultivated plots. This may be, because the roots extract moisture from the deep sub-soil and transpire it through the leaves resulting in greater water losses.

The evapotranspiration rate observed under different treatments after

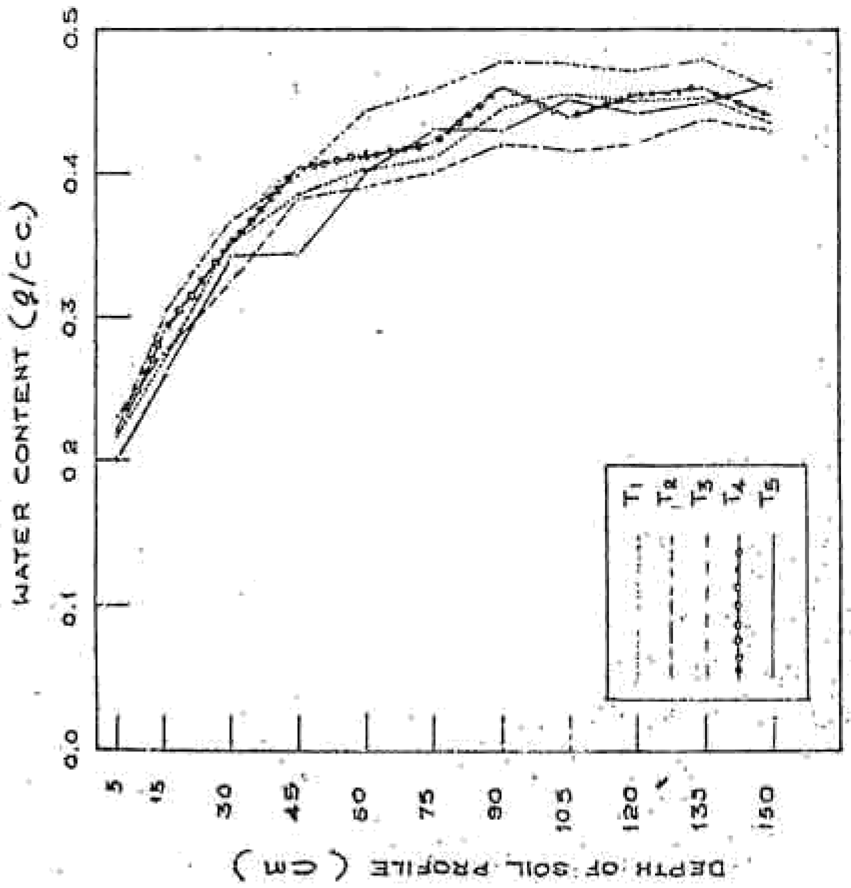

FIG. 1 PROFILEWISE WATER CONTENT DURING INITIAL (RAINY) PERIOD (SEPT.— NOV. 1979)

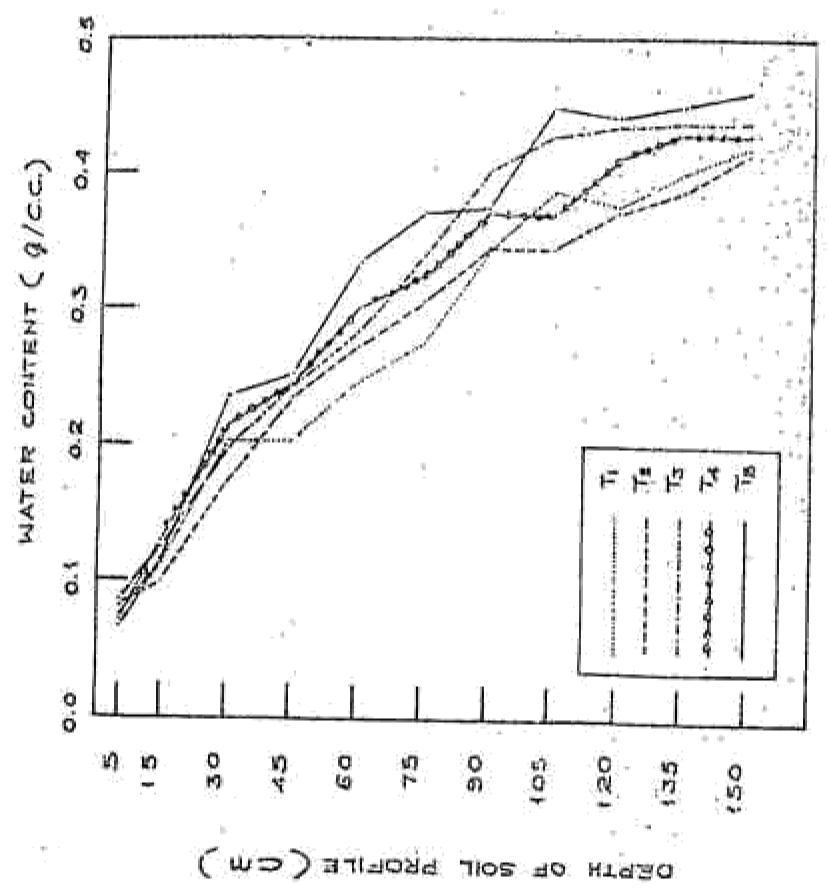

FIG. 2: PROFILE WISE WATER CONTENT DURING MIDDLE (DRY) PERIOD (DEC. 1979 — MARCH 1980)

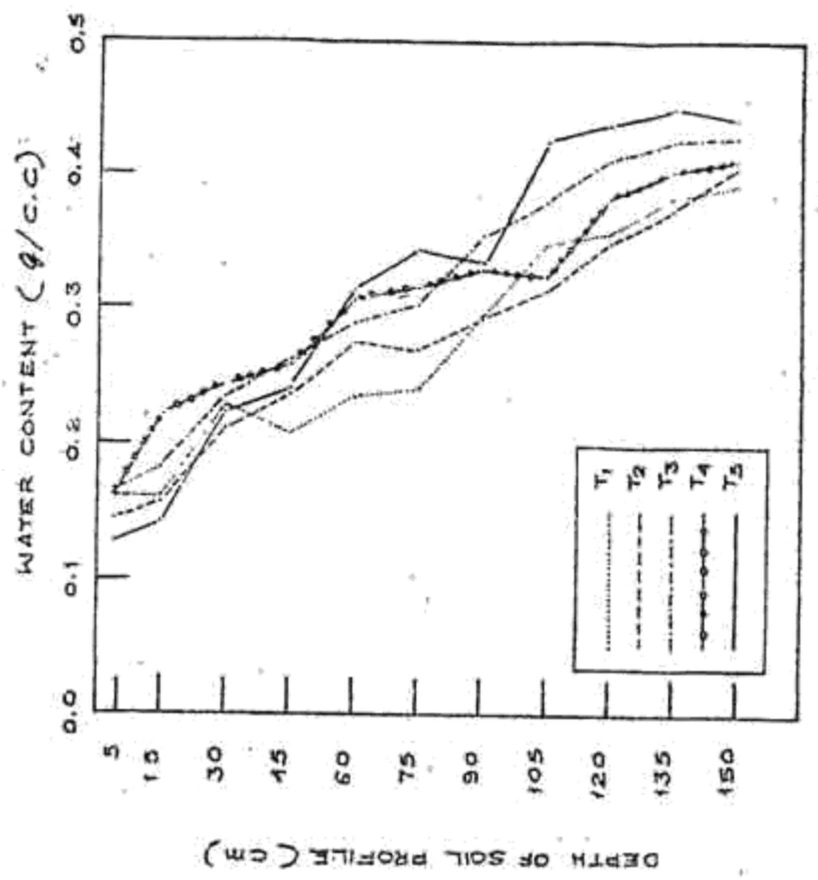

FIG: 3 PROFILEWISE WATER CONTENT DURING LATER (RAINY) PERIOD (APRIL – MAY 1980)

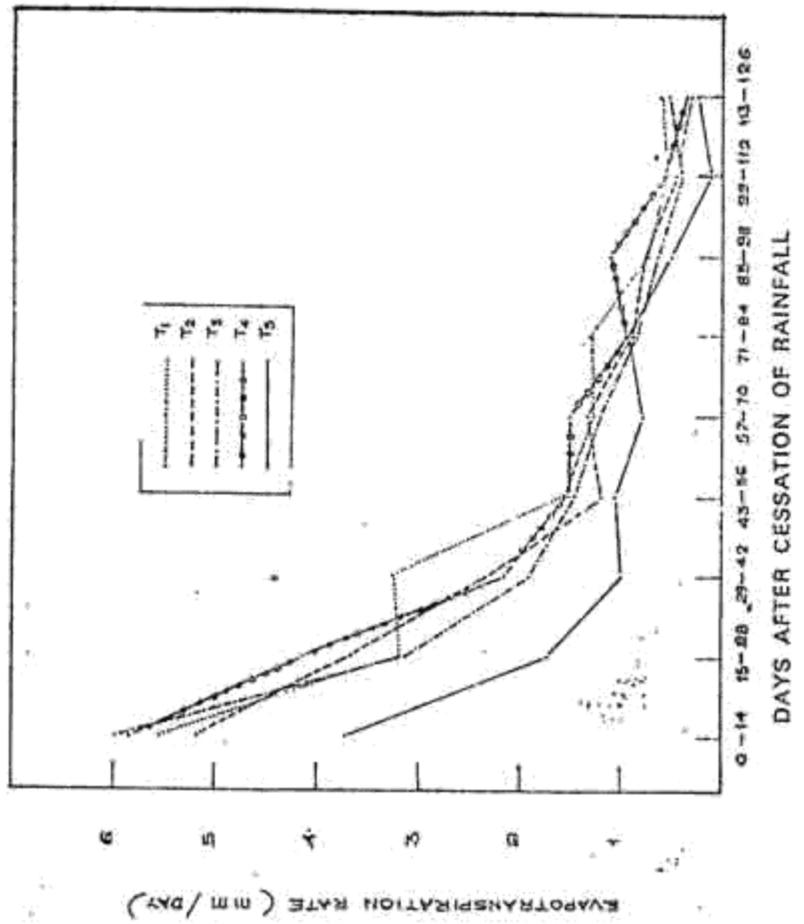

Fig 4. Evapotranspiration rate under different treatments after cessation of rainfall.

cessation of rainfall are shown in Fig. 4. The moisture content (volume per cent) of the top 20 cm of soil profile at the time of each moisture measurements are also given in table-4. It can be seen that the rate of ET decreased abruptly as the days advanced. A simultaneous decreases in moisture contents of the surface soil were also noticed. Relationships were established between ET, PET and sutface soil moisture content and is expressed below.

ET = PET x a in which,

ET = actual evapotranspiration

PET = potential evapotranspiration derived by the Thornthwaite method.

$a = 14.923\, m' \ldots 22.883\, m' - 0.93$

m = moisture volume fraction of the top 20 cm soil.

This equation can be tested for its adaptability to determine ET from other fields where the groundwater contribution in the root zone is negligible and is based on the determinations of surface soil moisture and PET calculated with the Thoruthwaite method. This equation has heen derived with a soil moisture range of 0.08 to 0.23 volume fractions.

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