

OPTIMUM UTILIZATION OF THE STORAGE IN VILLAGE TANKS

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ABSTRACT

Storage requirements were studied for the command area of a village tank, Paidikulama (Anuradhapura). The nature of catchment yield and tank water losses were assessed through a tank water balance study. It was found that delaying cultivation results in a high irrigation requirement and reduces the contribution of rainfall to the crop water requirement, forcing the cultivable extent to be smaller. An analysis of 41 years rainfall data shows that the probability of receiving adequate water to the crop decreases with delay in cultivation. Thus, a split cultivation model has been suggested to optimize the water use in village tanks.

KEY WORDS: Cultivation probability, Split cultivation, Village tank, Water budgeting

INTRODUCTION

Village tanks in the dry zone have been designed to supply water to the command area during the maha season (October to February; North-east monsoon). Any water remaining in a reservoir at the end of a maha crop may be utilized for a second crop. However, with the present management of tank water, second crops are seldom cultivated. Farmers start maha cultivation after sufficient water has been stored, since rainfall is uncertain and highly variable.

Water stored in a tank is lost not only through evaporation but also due to seepage and percolation. Cultivation of the entire command area is not frequent due to shortage of water, and the farmers have to resort to *chena* (slash and burn) cultivation as the main source of income. Most village tanks are not capable of feeding their entire command area. This may probably be due to one or more of the following constraints: (a) limitation of the catchment area; (b) high tank water losses; (c) initial delay in cultivation; (d) failure to make the best use of effective rainfall; (e) incorrect water management practices.

Therefore, it is extremely important to undertake research studies to develop a strategy to achieve efficient utilization of water, the most scarce resource in the village tank farming system. Presently, there is no information to support the assumption that the agricultural potential of the village tank is fully realized (Somasiri, 1979). A tank water balance study, carried out at Paindikulama (Anuradhapura) during 1984 to 1988 was used to determine how the cultivable extent is governed by some of the above constraints. Results of this study are discussed in this paper.

MATERIALS AND METHODS

Experimental site

The Paindikulama tank has a catchment of 123 ha and is capable of storing 299,000 cu . m of water. The command area is 54 ha. Usually, maha cultivation takes place in November, December or January, depending on the seasonal storage status of the tank.

The Paindikulama catchment has the general ecological and topographical features of Anuradhapura district. The land slope ranges from 1 to 6 % and more than 90 % of the area is composed of the well-drained Alfisols (Udic Rhodustalf). The forest has been cleared for *chena* from time to time in 70 % of the area but only about 10 % is presently being cultivated leaving rest of the chena land fallow for different periods.

Components of the tank water balance were measured or computed from measurable parameters. The existing water management was observed without interfering with farmers' activities, and records were maintained for analysis.

Rainfall analysis

Daily rainfall data of 41 years at Maha Illuppallama were used to obtain cumulative monthly totals from October to May for the period 1945 to 1985. The Paindikulama area is only 6 km away from the Regional Agricultural Research Centre, Maha Illuppallama where long term weather records are available. An attempt was made to establish a relationship between monthly rainfall totals of the two locations (Paindikulama and Maha Illuppallama) by using data observed during the study period.

Monthly rainfall values at 75% probability were computed to determine monthly storage status which was used subsequently in the estimation of tank water losses. The effective rainfall was calculated for each month by

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using the following formula recommended for lowlands in Sri Lanka (Ponrajah, 1984):

$$Re = 0.67 (R - 25),$$

where Re is the effective monthly rainfall in mm and R is the average monthly rainfall in mm.

Water yield of the catchment

Runoff values were computed from the tank water balance equation as described by Somasiri (1979). Rainfall-runoff relationships were developed separately for yala and maha seasons using seasonal total values obtained from 1985 to 1989.

Tank water loss

The usual losses (evaporation, seepage and deep percolation) from the tank storage were considered as a single parameter and measured during periods with no irrigation and inflow (Somasiri, 1979). The storage-loss relationship was then established (Dharmasena, 1985) to prepare tank water budgets.

Irrigation requirement

Irrigation requirements for short-aged rice varieties (3.5 months) were calculated separately for cultivations commencing in October, November, December and January to irrigate various extents of the command area. The following equation was used to calculate the monthly irrigation requirement (Joshua, 1977):

$$I = \frac{(ET_o \times C - Re) + FL}{\text{Conveyance Efficiency}}$$

where ET_o is reference crop evapo-transpiration (mm), C is crop factor, Re is effective rainfall (mm) and FL is farm losses (mm).

The modified Penman method was used to calculate ET_o values for different months using data available for Maha Illuppallama. Crop factors for different periods of growth were selected according to Ponrajah (1984). Farm losses (FL) which consist of runoff, percolation and leakage from dyke (liyadda) were assumed as 100 mm per month for lowland conditions of Sri Lanka (Khepar, Personal communication, 1984).

Tank water budgeting

Tank water budgets were prepared for different command catchment ratios with cultivations done in October, November, December and January. The equation used for a monthly tank water budget runs as follows:

$$S_f = S_i + R_o + R_d - UNL - I$$

where S_f is storage at the end, S_i is initial storage, R_o is catchment runoff, R_d is direct rainfall to the tank, UNL is usual net loss of the storage and I is irrigation (units of all components are in cu. m).

The minimum rainfall requirement under each condition was derived from tank water budgets and compared with actual rainfall figures of 41 years. The success of cultivation was judged on the basis that rainfall of each month should exceed the minimum requirement of the month.

A flow diagram showing the methodology is given in Fig. 1.

RESULTS AND DISCUSSION

Regression analysis shows that the monthly rainfalls of Maha Illuppallama and Paindikulama differ only by 15 mm and this was considered negligible in cultivation probability analysis.

During the period of study, the extent of land cultivated was always below 60% of the available command area (Table 1). Cultivations were delayed in all observed seasons. Irrespective of the amount of seasonal rainfall received in yala season, farmers confined the farming extent to 4% for growing chilli on *bethma** basis. According to observations, the farmer practice in relation to water management in this field is wasteful. More than half the storage in each season was lost without its direct utilization to the crop.

* *bethma* — (division): A cultivation practice followed when the available water is not adequate to cultivate the entire paddy tract. A portion of land is divided equitably among all farmers temporarily for the season.

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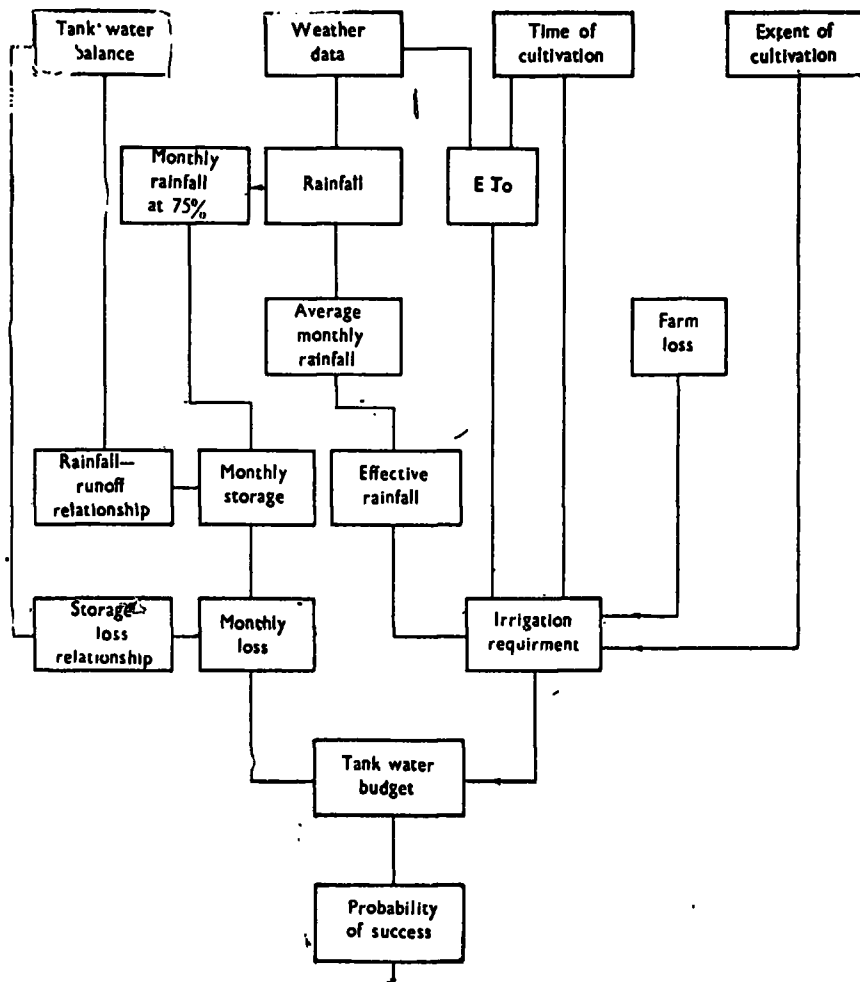


Fig. 1. Flow diagram showing the procedure for cultivation probability analysis

Table 1. Cultivation status at Paidikulama

Season	maha 84/85	yala 85	maha 85/86	yala 86	maha 86/87	yala 87	maha 87/88
Rainfall (mm)	656	108	821	508	418	412	854
% land cultivated	50	4	32	4	0	0	59
Crop	rice	chilli	rice	chilli	—	—	rice
Commencement of cultivation	Jan.	May	Dec.	May	—	—	Nov.
Total outflow (in 1000 cu. m)	115	62	143	98	49	29	235
% outflow as irrigation	45	37	32	30	0	0	49
Irrigation (mm)	192	1062	265	1355	—	—	359

Rainfall -runoff relationship

The following rainfall-runoff relationships were developed for Paidikulama catchment separately for yala and maha seasons:

yala season

$$\text{Runoff} = 0.15 (\text{Rainfall}) - 21, r^2 = 0.99^{**}$$

(mm) (mm)

maha season

$$\text{Runoff} = 0.20 (\text{Rainfall}) - 44, r^2 = 0.93^{**}$$

(mm) (mm)

These equations show that a considerable amount of rainfall is required initially in both seasons before any runoff begins to occur. This amount is 140 mm in yala and 220 mm in maha season. Once this "ineffective rainfall" has occurred, 15% of the successive rainfalls in yala and 20% in maha season flow into the tank.

Storage — loss relationship

The usual net loss (UNL) of the tank (evaporation, seepage and percolation) shows the following relationship with its instant storage (Fig. 2):

$$\text{UNL} = 1.31 \ln S - 0.85, r^2 = 0.90^{**}$$

where S is storage in 1000 cu.m and UNL is usual net loss in 1000 cu.m/week.

****Significant at 1% level**

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Using results obtained from above calculations, tank water budgeting was carried out considering different farming extents and commencing times. The rainfall requirements under different conditions were compared with observed rainfall data of 41 years and the success of the cultivation was evaluated for different commencing times of cultivation and farming extents. The summary of results is given in Fig. 3. The probability of success decreases as the extent under cultivation increases. If the entire command area is cropped, even early in the season (in October), the probability of meeting the total irrigation requirement is very low (22%). The level of 75% probability of success can only be achieved by restricting the extent under cultivation to 35% of the command area. A shift in the commencing time from October to November reduces the cultivable extent from 35% to 19%. This decreases to 13%, if cultivation starts in December or January.

The relative proportions of effective rainfall and irrigation, together meeting the crop water requirement depend on the commencing time of cultivation (Fig. 4). If the commencement of cultivation shifts from October to November, irrigation requirements may go up by 65% and the use of effective rainfall may decrease by 15%. Delaying the cultivation till December will cause an increase of the irrigation requirement by 155% and lower the use of effective rainfall by 35%. The situation becomes further aggravated if the farmers attempt to postpone the sowing beyond December.

A cultivation model

The results of this study suggest that the cultivation should commence as early as possible, but the extent must be decided at a high cultivation probability level such as 85—90 %. A cultivation pattern may hence be attempted by splitting the programme into two phases of time and space. One objective of this model is to provide definite return to the farmer who receives nothing from paddy fields in low rainfall seasons. The possible two phases are given below:

First phase : An early cultivation is to be scheduled at the onset of monsoonal rains (October) in a part of the command area. Size of this extent would be the extent which has 85-90 % probability of success. An area equivalent to one tenth of the catchment area is suggested for this phase (see Fig. 3).

Second phase: A late cultivation may be possible at the end of December. The extent must depend entirely on the additional potentiality of the storage in the concerned season.

In low rainfall seasons farmers will do only the first phase. Most probably due to land fragmentation, the first phase may require the *bethma* management system which is presently acceptable to the dry zone farmer.

Farmers' involvement in upland farming as well as the nature of land ownership are the main constraints in implementing the proposed split cultivation model. As this is a conceptual approach, an evaluation programme is required to assess its applicability and effectiveness for village tank irrigated farming.

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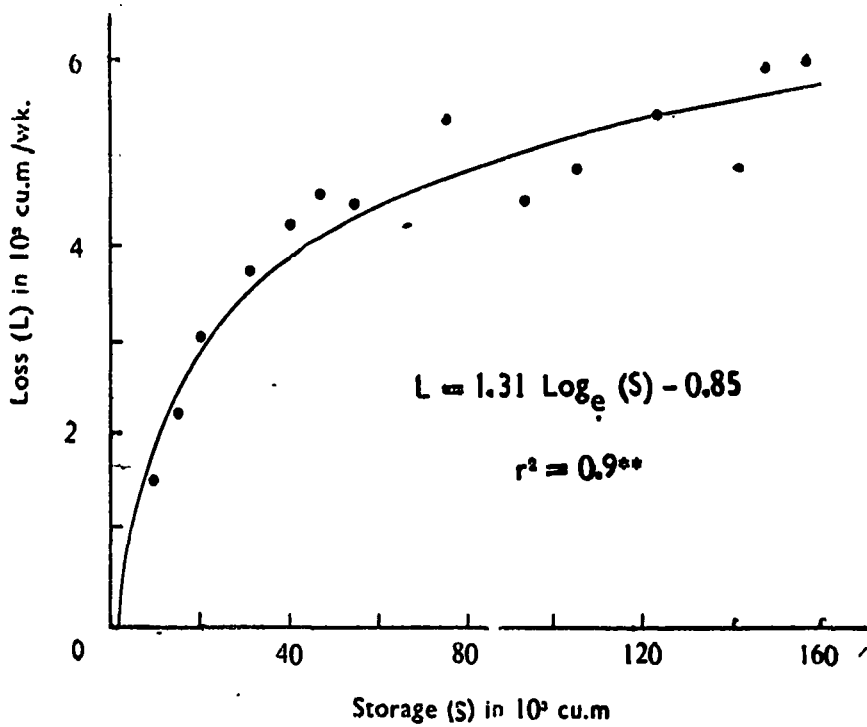


Fig. 2. Variation of the usual net loss with storage (Paindakulama Tank, 1985-1987)

**Significant at 1% level

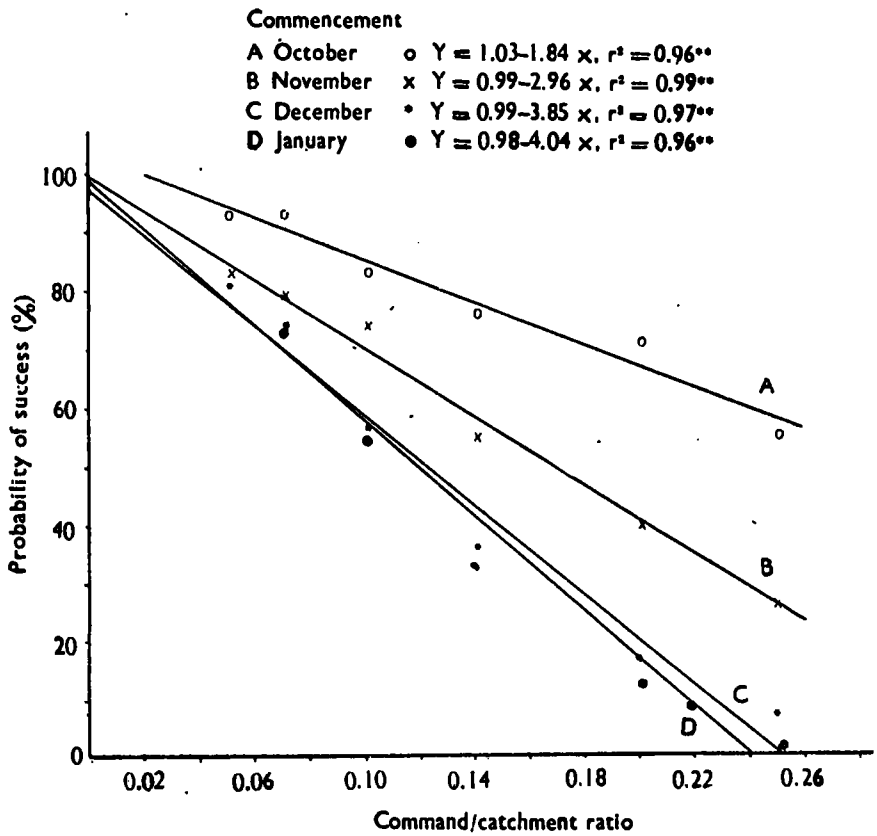


Fig. 3. Cultivation probability analysis (Paindikulama)

****Significant at 1% level**

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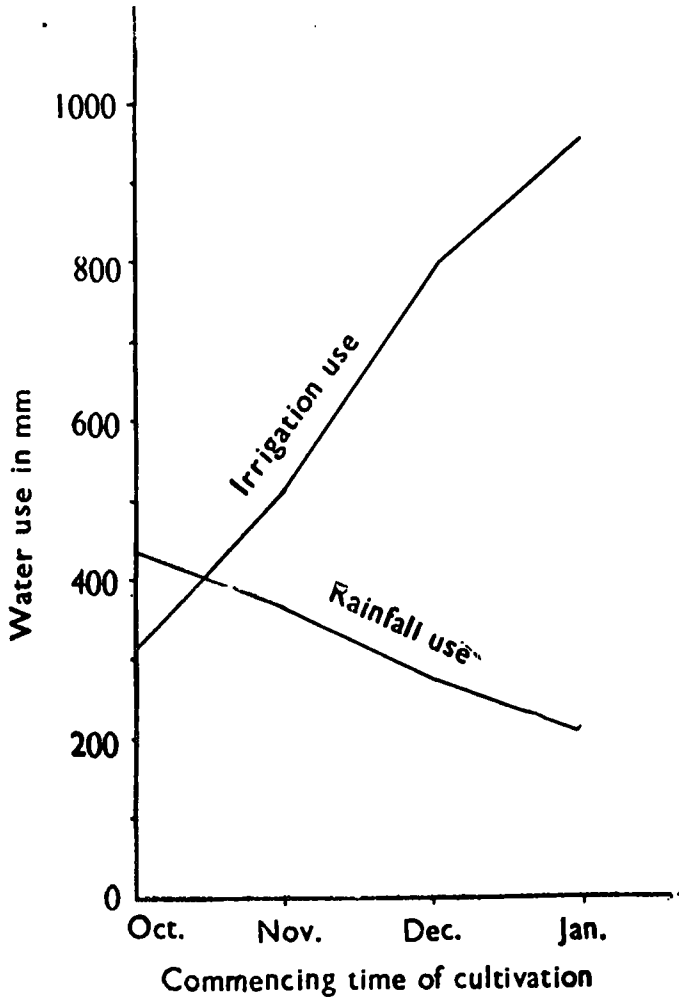


Fig. 4. Variation of irrigation and rainfall use with the change of commencing time of cultivation