5. ON-FARM SUPPLEMENTARY IRRIGATION REQUIREMENT FOR RICE IN THE DRY ZONE OF SRI LANKA

J. A. LEWIS*

Introdction

Recently water has become the chief factor limiting rice production in the dry zone of Sri Lanka. This situation came about, mainly because an unnecessary large amount of water from the storage tanks is used during the main rainfall reason, or the wet season. Consequently there is a lack of water during the dry period. According to census figures, about 135,000 hectares of irrigable paddy land in the dry zone is not cultivated during the dry period largely due to inadequate water supply. Therefore, water in the tanks should be used only to supplement rain in the wet season. In order to implement this programme, a study of the plant-water and soil-water requirement for rice production should be made.

In this paper, measurements of irrigation issued to a rice crop grown in standing water are given. On the results of these measurements an attempt is made to estimate the supplementary irrigation requirement for rice when cultivated in soils with varying drainage properties.

Consumptive use

(Murakami) in the wet season of 1966, made a detail study of consumptive use of the rice plant in the dry zone. The data obtained from his experiments are given in Table 1. The total consumptive use is given as 10 inches for a 4 month crop. This value is presently used for the estimation of water supply requirement. However, this is not quite acceptable because of the following reasons:–

1. The experiments were conducted in small isolated plots.
2. The estmiate was computed from parameters such as transpiration ratio and dry matter production.

Table 1. Calculation of 'Water Required in Field'

Period	Description	Wet Season
Preparation of field	Water required for tilling, puddling, levelling and maintaining	For 25 days 6.7″
From sowing to heading	Evapotranspiration	0.13″×20 days 2.6″
From transplanting to harvest	Evaporation	0.13″×100 days×0.54 7.0″
	Transpiration	70 bushel/Ac. 9.4″
From sowing to harvest	Percolation	0.28″×120 days 33.6″
	Total	59.3″=4.9″

* Research Officer, Irrigation Agronomy, Agricultural Research Station, Maha-Illuppallama, Sri Lanka.

(Sivanayagam) carried out lysimetry studies to determine consumptive use in the wet season of 1971. He reported 20.4 inches for a 4 months crop. His observations were that the evapotranspiration rates were highly erratic during the wet season, but it co-related almost exactly with fluctuations of pan evaporation. Therefore, in the absence of other data, (Sivanayagam's) determination of 20.4 inches may be accepted for the computation of supplementary irrigation requirement.

Soil-water Requirement

To maintain standing water in the paddies, the percolation losses should be replaced by either rainfall or irrigation (The percolation losses here means seepage losses plus deep percolation losses). The rate of percolation depends on the soil physical properties, the ground water table conditions, the slope of the land, and the nature of the terrace bunds. Measurements of percolation were computed by (Murakami) from number of field plot trials during the wet season of 1966. He estimated the losses to be 33.6″, from the time of sowing to harvest. These trials however, were conducted in small plots on the poorly drained soils of the dry zone. Therefore, the estimated value of 33.6″ may not be applicable on the well drained soils on the upper slopes. However in the absence of other data this value could be used for the computation of water requirement.

Using (Sivanayagam's) consumptive use of 20.4″ and (Murakami's) percolation losses of 33.6″ the total (from sowing to harvest) requirement is 33.6+20.3″=53.9″−4.5′.

Soils

The greatest extent of the land surface in the dry zone, is occupied by the reddish brown earths. The 'A' horizon is moderately textured with variable proportion of quartz grit. These soils are comparatively well drained, mostly confined to the upper slopes of the land scape, while as the mid and lower slopes are occupied by its associates, the imperfectly and poorly drained soils. In the upper slopes, the soil is well drained mainly because the ground water table rarely reaches the 'B' horizon while as in the poorly drained soils the water table is at or above the 'B' horizon for a considerable part of the year.

Rainfall

In the dry zone the annual rainfall is well defined into two seasons. The 'Maha' or the wet season is the major rainy period and 'Yala' the minor rainy period. The wet season commences in mid October and tails off in mid January.

A knowledge of the distribution and quantity of the rainfall is necessary for the provision of water to supplement rain. The mean monthly rainfall is unreliable for the purpose of estimating the contribution by rain. (Panabokke and Walgama) for agricultural purposes have computed 75% confidence limits of rainfall for most of the districts in the dry zone for e.g. according to the computation, 3 out of 4 years, the minimum expected rainfall at Maha Illuppallama for the months:

December	5. 1″
January	2. 3″
February	0. 3″
March	0. 6″
Total	8. 3″

The measured rainfall for the above months during 1972/73 wet season, are given in Table II Col. 5. For the provision of adequate water supply, the minimum expected rain 3 out of 4 years is considered.

Method and Material

In the wet season of 1972/73 the quantity of supplementary irrigation, required to grow a crop of rice, was measured in a farmer's field. The main objective was to study the percolation losses in the rice fields. The farm was part of a pilot project in the Dry Zone, initiated by the State in 1969. One of the purposes of the project was to educate the farmers in the efficient use of water for rice production. At this project 20 farmers with their families were settled. Each farmer was given 2 acres to cultivate rice during the wet season, making maximum use of the rain water. However, when rains failed to occur, at the desired time, irrigation was given to the crop.

A ground plan of the farm selected for the irrigation measurement is given in Figure 1(a). The farm is bounded on the north by the main channel, on the south by the main drainage ditch, on the east a lateral drainage ditch and on the west a cement lined field chanel. Because of the irrigation channels and drainage ditches, the farm was isolated of seepage influence from neighbouring fields.

The farm-land is typical of a large part of the dry zone. The upper slopes, ranging from 2 to 3 per cent, is mainly reddish brown well-drained soil. The mid slopes consists of the imperfectly drained soil and lower slopes, ranging from 0.5 to 1 per cent, consist of the poorly drained soil. In this soil, during the wet season the ground-water table is close to the surface, hence it is poorly drained.

Bench Terraces

Since the land was sloping, bench terraces were constructed with a motor grader. On the terraced land rice was grown in standing water. The cross slopes of the terraces were levelled out. At right angles to the cross slopes the land was slightly graded to facilitate water to spread quickly to the remotest part of the terrace. This was done, in order to shorten the time of opportunity for the water to infiltrate.

A longitudinal section showing the elevation of each terrace is given in Fig. 1(b). The vertical drops from terrace to terrace in the well and imperfectly drained lands are greater than in the poorly drained land. It is desirable, for better control of water, to construct wide terraces with small vertical drops. However, this would involve deep cutting and in this instance it was not possible to do so because of the shallow depth of the soil.

The terrace bunds, on all sides were constructed high, in order to trap all the rain water. No water was allowed to flow as run-off.

Irrigation

Since, in this investigation, it was decided to grow the rice crop in standing water, at each irrigation, the fields were flooded to a height of 2″. At the centre of each terrace a perforated stilling well was installed. A mark was inscribed on the inside wall of the well to denote the 2″ height above the ground. As the height of the water inside the well reduced to zero level, irrigation water was siphoned out from the cement lined field channels. The discharge of each syphon was held constant by maintaining the pressure head differences between the standing water in the channel and discharge level in the field. The syphon operation time was recorded. Knowing the discharge, the total quantities of water delivered to each terrace were computed.

Drainage

Since all the rain water was trapped, the main drain and the field drain merely conducted the sub-surface percolation flow of the terraced paddies. The rain storm during the wet season are generally low in intensity, therefore, on no occasion the water

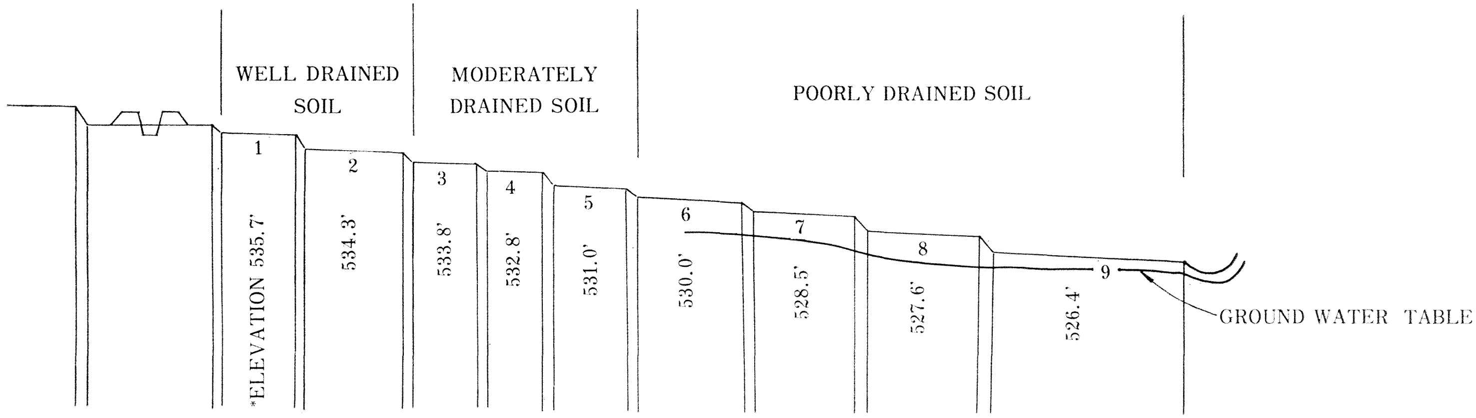

Fig. 1 (b). L.S. of the Farm

*ELEVATION ABOVE MEAN SEA LEVEL IN FEET

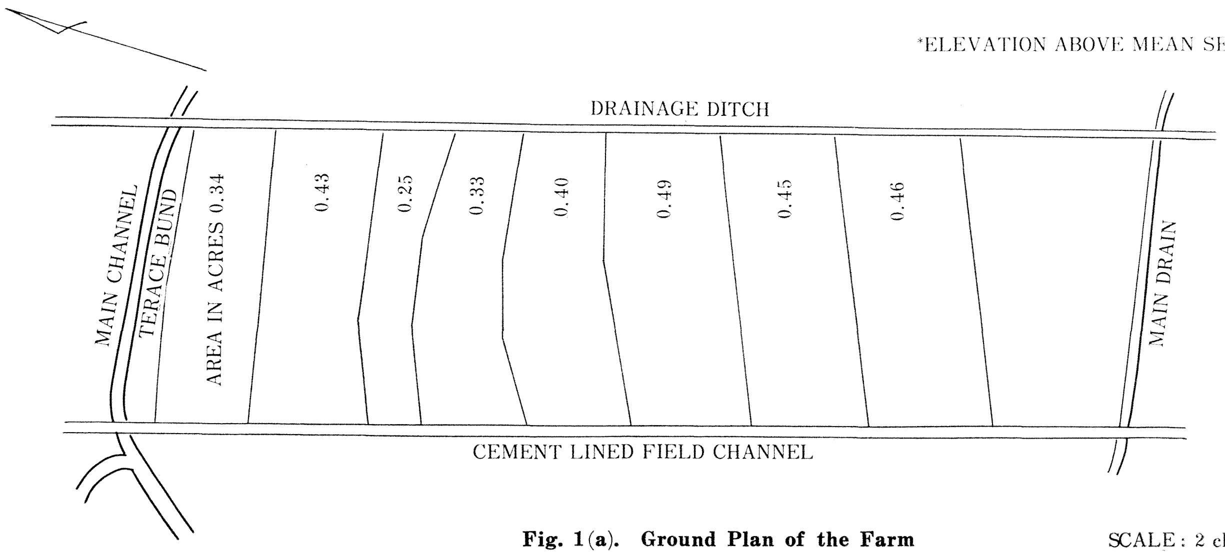

Fig. 1 (a). Ground Plan of the Farm

SCALE : 2 chains to an Inch

inside the terraces breached the bunds.

Cultivation

The land was ploughed and puddled during mid October before the onset of the monsoon. This was done purposefully, with a view to determine the maximum amount of water for land preparation.

Seed paddy of a 3½ months variety (BG. 34–8) was broadcasted. The sowing commenced by the beginning of December. Weeds were controlled with a pre-emergence weedicide and satisfactory puddling operation. Other cultural practices were according to the recommendations of the department of Agriculture.

The paddy crop was harvested 115 days after sowing. The crop matured almost the same time on all the terraces. The protential yield of this variety is **110** bushels per acre. The yields obtained from each terrace is given in Table II, Col. **11.**

Table 2. Water Inputs to each Terrace

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11
Terrace Number	Irrigation for land preparation in Ac. ft/ac. *	No. of Irrigations from sowing to harvest.	Irrigation from sowing to harvest in Ac. ft/ac.	Rainfall from sowing to harvest in Ac. ft/ac.	Total input of water from sowing to harvest. Col. 4+5	Irrigation from sowing to harvest by experiment in Ac. ft/ac.	Net loss or gain in Ac. ft/ac. Col. 7– Col. 6	Total supplementary irrigation Requirement in Ac. ft/ac. Col. 2+ Col. 4	Soil type and Slope	Yield in bushels/ac.
1	0. 9	34	5. 92	0. 9	6. 82	4. 5	– 2. 32	5. 74	Average for well drained soils upper slopes	60. 5
2	0. 9	25	3. 77	0. 9	4. 67	4. 5	– 0. 17			62. 0
3	0. 6	23	3. 64	0. 9	4. 54	4. 5	– 0. 04	3. 54	Average for moderately drained soils mid slopes	65. 0
4	0. 6	20	3. 33	0. 9	4. 23	4. 5	+ 0. 27			66. 7
5	0. 5	17	1. 95	0. 9	2. 85	4. 5	+ 1. 65			64. 8
6	0. 35	9	0. 68	0. 9	1. 58	4. 5	+ 2. 92	0. 79	Average for poorly drained soils lower slopes	60. 8
7	0. 33	6	0. 30	0. 4	1. 20	4. 5	+ 3. 30			68. 0
8	0. 3	9	0. 30	0. 9	1. 20	4. 5	+ 3. 30			65. 3
9	0. 5	7	0. 40	0. 9	1. 30	4. 5	+ 3. 20			63. 4
				Total	28. 39	Total	+12. 11			
				Average	3. 15					

* 1 Acre Ft=1, 200 m³.

Discussion

In Table II all water inputs are given in acre feet per acre.

1. The amount of water required for land preparation (Table II Col. 2) does not agree with the estimate of (Murakami) as in Table I. On the well drained soil about twice

the amount is required than on the poorly drained. This is understandable because the farmer normally uses the excess water from the higher terraces to wet the lower terraces.

2. The total input of water from sowing to harvest i.e. irrigation plus rain is given in (Col. 4). The poorly drained soil require about 1–2 times less water than the well drained. This is due to ground water influence in the poorly drained area.

3. The average number of irrigations in the well drained is 29 and progressively decreases to 8 in the poorly drained. Therefore, it is desirable to design field channels to meet these variable frequencies.

4. The quantity of rain during the growing period of the crop (December 1972 to March 1973) was 0.9 feet. This is equivalent to a quantity of 0.9 acre feet per acre (Col. 5). Incidentally this amount of rain fall is quite close to the minimum expected three out of four years (refer page 3). Therefore, the irrigation issue (Col. 9) to supplement the rain could be considered as the maximum requireemnt.

5. The experimental results of (Murakami and Sivanayagam) as discussed earlier in this paper is equivalent to a quantity of 4.5 acre feet per acre. If an assumption is made that this is the maximum requirement then 4.5—total input, (Col. 7—Col. 6) results in either net loss or net gain (Col. 8). Since the arithmetic sum is a net gain it could be concluded that the original estimate of 4.5 acre feet is too excessive for the poorly drained soils, while as, inadequate for the well drained soils.

The supplementary irrigation requirement given in Table II, is applicable only to the slopes and soils as found in this farm.

6. There were no significant differences in the yields obtained from each terrace.

Conclusion:

1. In order to estimate the irrigation requirement on farm, there is a need to recognize the soil and slopes of the land scape. They effect the seepage and percolation losses.

2. Rice cultivation in standing water on the well drained upper slopes of the dry zone require large quantity of water. Therefore, an intermittent irrigation system, where water is applied only at a pre-determined soil moisture stress, should be adopted. Hence, more studies should be undertaken to determine the response of rice plant to such regimes of irrigation.

Acknowledgement

The authors wishes to express his gratitude to the staff at Pelwihara pilot project, in particular to Mr. H. S. Fernando Agricultural Instructor for the help in carrying out this investigation.

References:

1. Murakami, T. (1966) Report on Rice plant-water relation studies at Agricultural Research Station Maha Illupalama, unpublished.
2. Panabokke, C. R. & Walgama, A. (1974) The application of rainfall confidence limits to crop water requirements in dry zone agriculture in Sri Lanka, J-Natn. Sci. Council. Sri Lanka 1974 2(2): 95–113.
3. Silvanayagam, T. Report on lysimetry studies conducted at Agricultural Research Station, Maha Illuppalama, Sri Lanka, unpublished.

Question and Answer

T. Saito, Japan: As an irrigation engineer I am of opinion that the improvement of infra-structure in paddy fields in the dry zone of Sri Lanka should receive special attention.

Because there are much difference in amount between designed water requirement and observed requirement in existing project area.

Answer: Engineering point of view the infra structures to deliver the water to the field at the land preparation, serving and at other time is very important. However in Sri Lanka unless water at there particular time should be assured. This will depend the availabiilty of water in irrigation tanks. If the water supply is assured at these particular times thus the infrastructure will be of great importance.

H. K. Pande, India: 1. Whether it is possible to find some alternative crop for rice in upper slope land. 2. Possibility of trying sub-surface barrier to stop high percolation losses using bitumen etc.

Answer: 1. We are growing alternate crops in the upper slopes in dry season. However we still have to grow rice on a larger extent ever in the upper slopes. The only alternation is to improved and modify the system of irrigation in upper slopes during the wet season.

S. **Okabe,** Japan: I would like to know the economic aspects on supply of supplementary water to paddy fields. Do you think that the supply of supplementary water to the higher slope lands could be economically viable in the dry zone is Sri Lanka? I wonder to what extent the results of this experiment could be applicable to any reasonable size of the dry area.

Answer: Economic evaluation depends largely on the yields. I must admit that we have not conducted enough investigations to estimate the yields under supplementary irrigation. Some experiments carried out with HYV 71/72 wet season showed that with 3 to 5 supplementary irrigation in addition to rainfall has given yields comparable to growing rice under wet land condition. However more studies will have to carried as to the interaction of fertilizer uptake in *standing* water and without *standing* water.

C. C. Lim, Malaysia: I would like to seek some clarification from the Author with regard to the figures under Col. 6 and Col. 7 in Table 2. The total for "input" under Col. 6 is less than the total for "irigation by experiment". Could you please explain how this is possible?

Answer: The Col. 6 is not the result of water budget but simply given the net loss or gain from what was actually applied in the field and what was computed values of W.R. according to Murakami.

T. Murakami, Japan: What kind of the intermittent irrigation is most suitable to the paddy field such as terrace number 1 or number 2 in your experiment?

Answer: It is known as broad bottom furrow, 1 meter width or 2 meters could be constructed with a two wheel tractor and rotary implement. The paddy is sown in lines. However, the length of the broad furrow, the gradient and furrow stream size should be desired to suit the soil and depth of irrigation requirement for rice. The same furrows could be modified for other crops.

T. Saito, Japan: I think the determining of the rate of percolation in each block of project area in the dry zone so Sri Lanka should receive sufficient attention because this varies greatly, even within the selected area, depending on the soil condition (permeability) and the hydraulic conditions, while evapotranspiration generally remains about constant. We should ascertain that the exact relationship during Maha as well as Yala, between the rate of percolation and the ground-water level.

Answer: It is admitted that during the Yala season or dry season the percolation rates are being much higher in the upper slopes. However we are recommending diversification of crops on these lands.