Tropical Agricultural Research Vol. 5 1993

Water Use, Soil Water Relations and Yield of Cowpea Under a Minor Irrigation Tank

N. Liyanage, K.G.A. Goonasekera[1] and K. Koga[2]

University of Ruhuna
Wellamadama, Matara

ABSTRACT. *A rice field area under a minor irrigation tank in the south eastern dry zone of Sri Lanka was studied with the objective of investigating the feasibility of growing an inter-seasonal crop using residual moisture. Three soil management practices were assessed for profile soil moisture variation, water use by the crop, yield and dry matter production.*

After harvesting the rice crop, the moisture content of the top soil layer showed a rapid decrease in comparison to the deeper layers. The soil moisture content of the top soil layer was not sufficient for the successful germination of seeds. With an initial irrigation to assist germination, the result of this study indicate that the plants could survive and produce an economic yield by making use of the residual moisture in the rice fields. The apparent moisture requirement of cowpea was 175mm and the estimated water requirement was 288mm. The ground water contribution was also estimated to be about 30mm for the growing season.

An average yield of 2.14 mt/ha was obtained under the no till and straw mulched treatments. This was higher than the yields obtained under irrigated conditions (1.8 kg/ha). However, the surface tilled treatment produced a considerably lower yield in comparison to the above treatments.

The study demonstrates the potential for growing an inter-seasonal crop using residual soil moisture under a minor irrigation tank. However, it is necessary to study the market and other social constraints limiting such practices before further recommendations can be made.

---

[1] Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya.

[2] Iwate University, Japan.

INTRODUCTION

The economy of Sri Lanka is predominantly based on agriculture. The largest part of the country, 2/3 of the total land area, is confined to the dry zone. The major agricultural crop grown in this area is lowland rice.

The rainfall pattern in the dry zone exhibits a bimodal pattern with the major rainy season from late September to mid January (*Maha* season) with an average rainfall amount of 930mm and a minor season from March through May (*Yala* season) with rainfall amount of 380mm. There are 8000 to 10000 active minor irrigation tanks in the dry zone with a total command area of about 104,200 ha of rice land (Fernando *et al.*, 1982).

The predominant soil type in the dry zone is Alfisols (Rhodostalf) with low humic gleys in the valley bottoms. If there is no scarcity of water, these alfisols are the most potential soils for the agricultural development in the country (Panabokke, 1958; Moorman and Breeman, 1978). The soil properties change with the associated drainage characteristics in the catenary sequence of the undulating plains with some rolling portions. Most of the poorly drained and imperfectly drained tracts are cultivated to rice while the well drained portion is about 10-15% of the total paddy tract.

Need for research

It is evident that during most parts of the year, rice lands in the dry zone remain idle because of insufficiency of water for rice cultivation. However, there is a potential for growing other field crops (OFC) using the residual moisture in rice fields.

The unique capacity of the legumes to derive a considerable proportion of their nitrogen requirement from the atmosphere and to enrich the soil is well documented. Having a shorter life cycle and being a cheap source of proteins are the other advantages of grain legumes, when compared among OFCs . Grain legumes have been successfully cultivated between the two major seasons using residual moisture in the dry zone (Sikurajapathi and Jayawardena, 1987; Department of Agriculture, 1989; Jayawardena, 1990). However, these studies were mainly concerned about the agronomic and economic aspects of the problem. The interactions between irrigation schedules, soil plant water relations, and crop evaporation in relation to the dry matter yield are poorly understood for most of the grain legumes (Balyan and Malik, 1979; Wein *et al.*, 1979).

Objectives of the study

This study was undertaken to assess the

i. possibility of growing cowpea as an interseasonal crop in paddy fields, using residual soil moisture,

ii. variations of soil moisture profile during the period,

iii. depletion of ground water table during the period, and

iv. effects of soil surface treatments on moisture retention of soil and on crop yield.

MATERIALS AND METHODS

The study was conducted in the south eastern dry zone (DL4) during the period of February to April in 1992. A suitable site situated 750m downstream of a minor irrigation tank was selected in the Bata Atta farm in the vicinity of Angunakolapelessa Research Station.

The experimental design was a randomized complete block with four replications. The plot size was 8 x 5 m surrounded by a 30 x 30 cm ridge. The study consisted of the following treatments.

T1 = No till (Fallow)
T2 = No till + Straw mulch (4 mt/ha)
T3 = Surface tilled (5-8 cm depth)
T4 = No till + cowpea
T5 = No till + Straw mulch + cowpea
T6 = Surface tilled + cowpea

Plots were prepared and following the planting of cowpea (variety MI 35) seeds, an initial watering was done to assist seed germination since the moisture content of the surface layer was found to be inadequate. Soil moisture was monitored by gravimetric determination in 5 day intervals at

0-25 cm, 25-50 cm, 50-75 cm and 75-100 cm depths. Water table was monitored using 5.0 cm diameter piezometer tubes installed to a depth of 2 m.

Direct measurement of evapotranspiration at early pod filling stage, was done under field conditions using 3 small weighing type lysimeters (plastic buckets) buried in the ground by obtaining the daily difference in weight under favourable water regime.

Meteorological data available at the Angunakolapelessa Research Station were used to estimate the reference crop evapotranspiration by the Modified Penman method (Doorenbos and Pruitte, 1977). Analysis of variance was performed on the parameters measured and comparisons between treatment means were made using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Variation of soil moisture profile

During the period of crop growth showed a rapid decrease in soil moisture in the first 25 cm though the initial moisture level was high 27-28% (Figure 1). Thus the moisture content in the top layer may not be sufficient for the germination of seeds. The soil surface tilled to a depth of 5-8 cm initially showed a high moisture level in the 25-50 cm layer during the first few weeks, but the rate of decrease was higher compared to the straw mulched treatment (Figures 2 and 3). The moisture contents of 50-75cm and 75-100cm layers did not show appreciable variations when compared to the top layers even in cultivated plots (Figures 4, 5 and 6). This may be due to the moisture contribution from the shallow water table.

Water use and evapotranspiration of cowpea

The cumulative water use by the different treatments during the growing period is presented in Table 1. These values were obtained by summing the difference in moisture contents (mm) between selected time periods. Since a contribution from ground water table is a possibility, this may not be a reliable estimate. The water use by no till, straw mulched and surface tilled treatments are about 163mm, 183mm and 180mm respectively, average apparent moisture requirement is about 175mm.

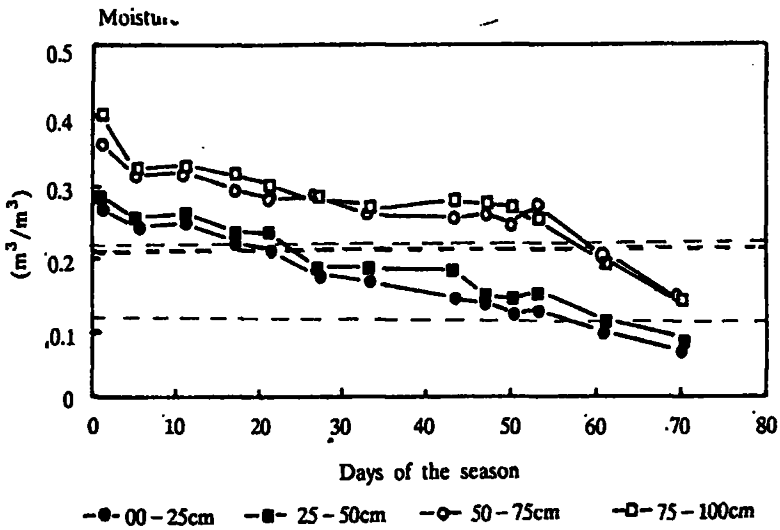

Figure 1. Moisture profile in no till plots.

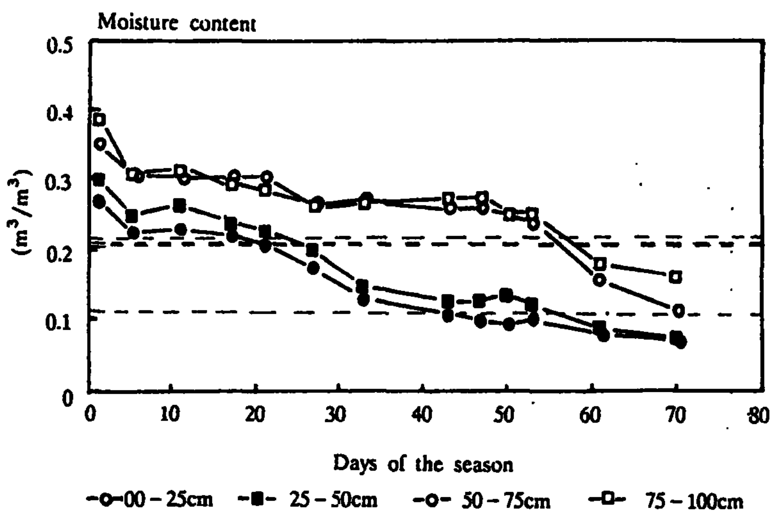

Figure 2. Moisture profiles in no till + cowpea plots

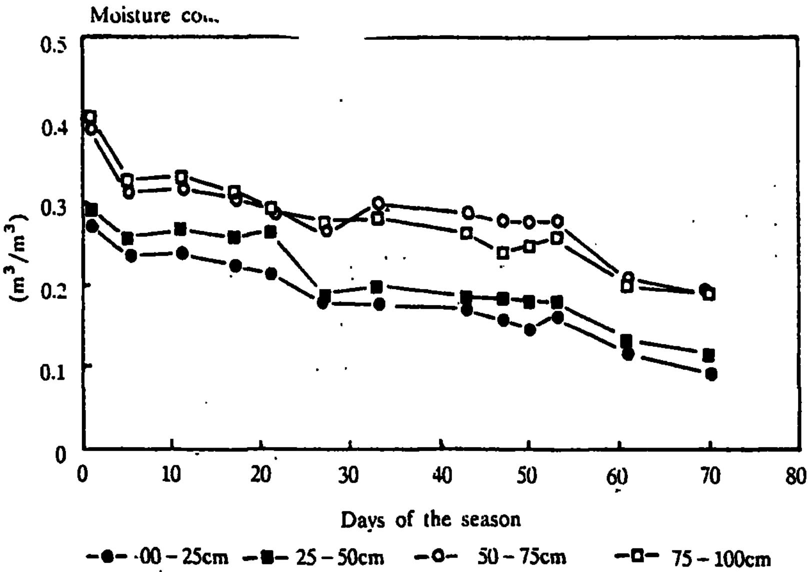

Figure 3. Moisture profile in tilled plots.

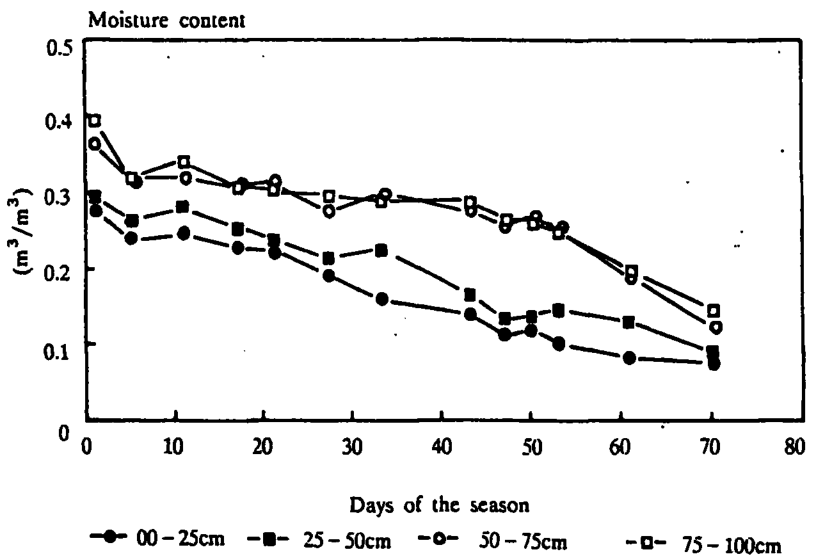

Figure 4. Moisture profile in surface tilled + cowpea plots

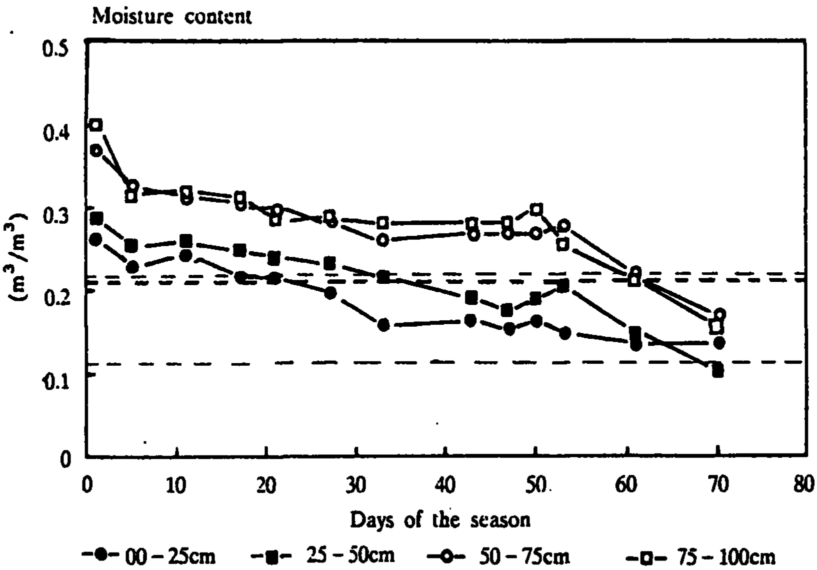

Figure 5. Moisture profile in no till plots.

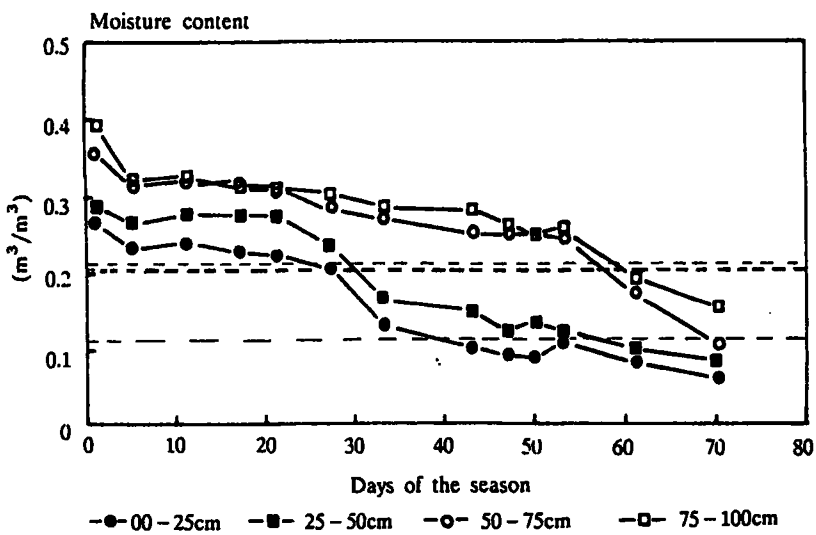

Figure 6. Moisture profile in straw + cowpea plots

Table 1. Water use (mm) throughout the growing season (00-100 cm soil depth).

Time period	No. of days	No till.	Straw	Surface tillage	No til + cow.	Straw + cow.	Surface til. + cowpea
04/3 - 8/3	4	10.1	11.9	07.7 * 13.5	07.1 *13.5	05.0 *13.5	03.8
08/3 -19/3	11	36.8	32.4	29.3	53.2	66.8	27.8
19/3-29/3	10	03.9	01.2	12.8 * 00.7	11.0 *00.7	17.2 *00.7	25.0
29/3-2/4	4	13.6	08.5	10.5	04.3	14.7	26.4
02/4-8/4	6	04.5	-03.6	-03.8	09.6	-02.5	04.1
08/4-16/4	8	54.2	44.3	56.9	52.5	48.9	37.7
16/4-25/4	8	20.8	35.6	15.9	10.6	18.4	41.5
Total	51	143.9	130.3	129.3	162.5	182.4	179.8

* water added as irrigation

The comparison of water use for each treatment was obtained as follows.

Water use by cowpea in no till plots	=	Water use by no till + cowpea plots	-	Water use by no till plots

The water use by crops under no till, straw mulched and surface tilled conditions are 19mm, 52mm and 51mm respectively.

Lysimeters measurements showed a peak daily evapotranspiration of cowpea during early pod filling stage and averaged to be about 8mm (Table 2).

Table 2. Evapotranspiration rate of cowpea (mm/day) measured by small lysimeter tests (average of 3 lysimeters).

Date	mm/day
07/04/92	7.7
08/04/92	7.9
10/04/92	7.9
11/04/92	8.4
12/04/92	8.3
14/04/92	8.3
15/04/92	8.1
16/04/92	7.8
17/04/92	6.7
X	7.9

The reference crop evapotranspiration for the months February, March and April calculated by the modified Penman method were 5.73, 6.8 and 6.52mm per day respectively. Thus the estimated water use by cowpea was about 302mm for the entire growing season. Considering the period given in Table 1. The crop water use by cowpea for the period given in Table 1 is about 288mm which seems to considerably high. This may be due to the use of assumed crop coefficients.

The estimated ground water contribution using soil moisture balance during the crop growth period was 30mm.

Grain yield and dry matter production

Grain yield of cowpea in no till and mulched treatments were significantly higher (2.1 mt/ha) than that of surface tilled (1.1 mt/ha) treatments ($P<0.01$). Comparing with average grain yield (1.8 mt/ha) of variety MI 35 under irrigated conditions (Department of Agriculture, 1993), the grain yields obtained under experimental conditions with a single irrigation for seed germination have exceeded the irrigated yield for no till and straw mulched treatments. Stover yield and total dry matter production also showed similar results (Table 3). Incomplete utilization of nitrogenous fertilizer applied in the dry soil surface of tilled plots may have resulted in a lower yield.

Table 3. Effect of some soil management practices on grain yield, stover yield and total dry matter production.

Treatment	Grain yield mt/ha	Stover yield mt/ha mt/ha	Total dry matter production
No till	2.10 a	3.63 a	6.61 a
Straw mulched	2.17 a	4.04 a	7.16 a
Surface tilled	1.09 b	2.80 b	4.35 b
LSD	0.780	0.883	1.79

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations can be drawn from the results of this study.

The moisture content in the topmost soil layer may not be sufficient for the germination of cowpea. However, with a single supplemental irrigation cowpea can be successfully grown using the residual moisture following the harvesting of the rice crop. It is recommended to plant the inter-seasonal crop immediately after harvesting the rice crop. It is also necessary to study the feasibility of providing at least one supplementary irrigation using the leftover storage of the reservoir.

The observed moisture consumption by plants ranged from 163-183mm with different treatments. The disparity between the observed consumption values and that estimated using climatological data (302mm) illustrates the need to establish appropriate crop coefficients for local conditions.

Mulching with straw produced the highest grain yield of cowpea while surface tilled soil produced the lowest yield. This shows that surface tilling may cause incomplete utilization of nitrogen and added fertilizer due to reduced moisture content.

The study has demonstrated the potential for growing an inter-seasonal crop using residual soil moisture under a minor irrigation tank. However, it is necessary to study the market and other social constraints limiting such practices before furhter recommendations can be made.

ACKNOWLEDGEMENTS

This study was carried out as a partial fulfilment of the degree of Master of Engineering, at Asian Institute of Technology (AIT), Bangkok, Thailand. The authors wish to express their gratitude to the Coordinator and the staff of Irrigation Engineering and Management Programme, AIT and to NORAD for financial assistance.

REFERENCES

Balyan, R.S. and Malik, B.S. (1979). The effect of different soil moisture regimes and straw mulch on the yield quality and water use efficiency of summer cowpea. Indian J. Agron. 24(3): 354.

Department of Agriculture. (1989). Review: Crop Recommendation. Sri Lanka.

Department of Agriculture. (1993). Techno Guide.

Doorenbos, J. and Pruitte, W.O. (1977). Guidelines for predicting crop water requirements. FAO Irrigation and Drainage paper No. 24, pp 12-54.

Fernando, G.W.E., Upasena, S.H., Weerasinghe, S.P.R., Senadheera, D., Senthilanathan. S., Silva, M., and Thieviyanaathan, S. (1982). Cropping pattern testing in Sri Lanka in Cropping pattern research in Asia. IRRI, Philippines: pp 225-236.

Jayawardena, S.N. (1990). Early maturing cowpea and mungbean varieties for fallow paddy lands in the dry zone of Sri Lanka (Un published).

Moorman, R.F. and Breeman, N.V. (1978). Rice, soil water and land. IRRI, Philippines.

Panabokke C.R. (1958). A pedological study of dry zone soils. Trop. Agric., 114: 151-179.

Sikurajapathi, M. and Jayawardena, S.N. (1987). Cropping systems for Mahaweli H area. Annual Report. Department of Agriculture.

Wein, H.C., Littleton, E.T. and Ayanaba A. (1979). Drought stress of cowpea and soyabean under tropical conditions. pp 283-302. *In*: Mussell H. and R.C. Staples (eds), Wiley Inc. New York: