Research article

A Study on Field Water Tube's Effectiveness as a Practical Indicator to Irrigate SRI

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Received 19 December 2010 Accepted 21 February 2011

Abstract Rice, the staple food of 2.7 billion people as well as prolific user of water, are at risk of severe water shortage and hence food insecurity. To cope with looming water crisis, we must sought water saving technologies to maintain and to increase rice production for meeting world's food needs with less water. A new strategy is the use of field water tube in SRI with AWDI application. A lysimeter scale experiment was conducted at Tokyo University to find out the effectiveness of Field Water Tube for monitoring the depth of ponded water, determining the right irrigation timing. The experimental layout was Demonstration Strip Design with twice replication where 5 different diameters PVC Tube (viz. 5 cm, 7.5 cm, 10 cm, 12.5 cm and 15 cm) were treatment and Hioki meter, tensiometer, moisture sensor, temperature sensor, data logger were used as instrument. When the water level went to 10 cm below the soil surface level then irrigation was applied in the drying cycle of AWDI. Throughout the study period, ponded depth/water level, moisture percentage, pressure, temperature was measured. The study revealed that all the treatments measured the water level perfectly and determined the appropriate time of irrigation in drying cycle of AWDI. The study disclosed that in measuring water depth all the water tube exhibited good relationship (in same diameter maximum r^2 value 0.9955 and minimum r^2 value 0.9876, in different diameter maximum r^2 value 0.995 and minimum r^2 value 0.965) to each other. It is demonstrated that water tube measurement has strong relationship with water level sensor measurement (Hioki Meter) and tensiometer. Field Water Tube proved that it is a water saving technology where AWDI done in SRI based on water requirement of the field not by predetermined interval approach.

Keywords field water tube, ponded depth, diameter of water tube, alternate wetting and drying irrigation, SRI, soil crack

INTRODUCTION

Rice cultivation in system of rice intensification (SRI) with alternate wet-dry irrigation (AWDI) management is generally practiced with 5/7/10 days interval irrigation but the idea of predetermined day's interval approach cannot be treated as the demand driven technology perfectly. Moreover, success of AWDI depends largely on irrigation to the field at the right time when needs water for the rice plant. But determination of right irrigation timing during the dry cycles of AWDI is very hard due to different soil physical properties such as soil structure/ texture, bulk density of soil; soil pore space etc and different soil have different hydraulic conductivity like movement of water, infiltration/percolation rate, and water retaining capacity. Therefore, farmers fail to decide the appropriate time for irrigation and pay penalty as yield reduction for saving irrigated water. To solve the crucial problem of yield reduction, International Rice Research Institute (IRRI), Philippine Rice Research Institute (Phil Rice) and Bangladesh Rice Research Institute (BRRI) recommended 15 cm, 12 cm and 7-10 cm diameter water tube, respectively. The three designated institutions also suggested different re-irrigation timing in drying cycle of AWDI such as based on varied water ponded depth viz.15 cm or 20 cm below the soil surface re-irrigation time is prescribed by the institutions. In this context, more study is required on Field Water Tube and its diameter size to uncover the effectiveness, accuracy, durability of the instrument as a good practical indicator of irrigation in AWDI management regime.

MATERIALS AND METHODS

Climatic Features and Description of the Study Area

Japan is under temperate climatic region and the climate of the area was warm oceanic that is mild in winter and relatively cools in summer and the climatic data in the experimental site was collected during the rice –season (April to August). Table1 summarized the weather data.

Table 1 Meteorological data from April to August, 2010

Month	Rainfall (mm)		Temperature (hrs)			Sun (hrs)
	Total	Daily Max.	Ave.	Daily Max.	Daily Min.	
April	194.5	48.0	10.9	16.3	6.4	135.7
May	109.5	24.5	17.6	22.7	13.0	213.2
June	109.5	26.5	22.0	27.0	18.1	167.3
July	77.0	21.5	26.6	31.7	22.9	199.9
Aug	8.5	4.5	28.3	33.7	24.6	253.3
Ave.	99.8	25.0	21.1	26.3	17.0	193.9

Source: Abiko Meteorological Station, Chiba

This study was conducted at the roof top lysimeter of the environmental building in Kashiwa Campus, University of Tokyo, which is in Kashiwa city, Chiba, Japan, during the rice season of 2010 (April to August). The experimental site was situated at 35^0 54' North latitude and 139^o 56' East longitude, and at an altitude of 55 m above mean sea level.

Fig.1 Lysimeter utilized in the study installed at the roof top

The size of the lysimeter was 500*160*60 cm^3 (Fig.1) and soil depth was 30 cm. The soil of the experimental site was sandy loam and homogeneous with fairly good soil fertility. Mochigome cultivar, the second major rice variety (sticky rice) in Japan, was used in the experiment.

Experimental Details

Apparatus

5 different sized (diameter) field observation water tubes: 5 cm, 7.5 cm, 10 cm, 12.5 cm and 15 cm diameter tube were used, which height was 25cm, having perforated holes space-2 cm apart and perforated holes diameter was 3mm. The thickness of the tube was 0.5 cm, 0.4 cm, 0.3 cm, 0.25 cm and 0.2 cm for 15 cm, 12.5 cm, 10 cm, 7.5 cm and 5 cm diameter Tubes, respectively. The other instruments are 1 Hioki meter (Water Level Sensor), 4 ECH2O Soil Moisture Sensors, 4 Temperature Sensors, 4 Tensiometers (5 cm, 10 cm, 15 cm and 20 cm), 2 Data Logger, Lysimeter (Reinforce Cement Concrete-RCC Size-500*160 cm^2), Leaf Color Chart and a ruler.

Detailed Area Plan

The lysimeter of 500 x 160 cm^2 or $8m^2$ was divided into 5 columns and 17 rows (Fig.3). The distance between each column and row was 30 cm (square shape). The distance from corner of lysimeter to corner column and row were 20 cm and 10 cm respectively. In the experiment, 5 different diameters field water tube were used as treatment and it replicated twice by placing between 2nd-3rd column and 3rd-4th column. The water tubes were installed vertically as its 5 cm remain over the soil surface and 20 cm remain under the soil.

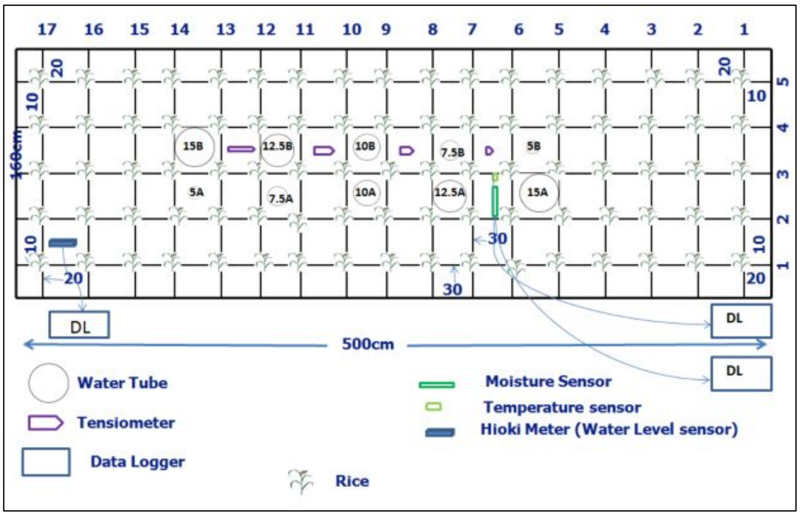

Fig. 2 Detailed area plan of lysimeter scale experiment

There were 4 tensiometers installed between water tubes of line B. 4 moisture sensors and 4 temperature sensors were installed between tubes 12.5A and 15A at the following depth 5 cm, 10 cm, 15 cm and 20 cm. One Hioki meter (water level sensor) was installed in-20 cm depth which soil was taken away. At every joint of column and row, 2 rice plants were planted, or totally, 170 rice plants were transplanted at 85points (17*5).

Irrigation Management

This was one of the most important features of the experiment. When determining the irrigation schedule, major emphasis was laid on critical stages of water requirement in the given climatic situation. AWD irrigation was applied after 1 day of transplanting and continues up to whole experiment period (102 days). AWD Irrigation management was divided into two regimes:

a. Irrigation for 10 days after transplantation (1 Day Interval AWDI)
b. Irrigation for 11 days to 102 days after transplantation (AWDI with Field Water Tube)

The methodology of irrigation (with Field Water Tube) was when water level would go to 15 cm depth of 15-A water tube then re-irrigated the field but due to the climatic conditions and to fulfill the main objective (Effectiveness of Field Water Tube) of the experiment, AWD irrigation was done.

Parameter observed

Field water tube, moisture sensor, temperature sensor, tensiometer was observed at 12 hours interval (9 am and 9 pm) and Plant growth was observed at 7 days interval throughout the experiment period. Each Field water Tube was attached with a ruler to measures the water Level in the field and data collection was started at DAT1 and it continued up to DAT102.

RESULTS AND DISCUSSION

Comparison among water tubes

It was indicated that water depth of all water tube is similar with some small difference when water remains around soil surface but when water goes to under the soil surface. When water level goes to 10 cm below the soil surface then water level difference among the water tube varies greatly (Fig. 3). It is also observed that among the five different diameter water tubes, the narrower diameter water tube shows lower ponded depth than the wider diameter Water Tube.

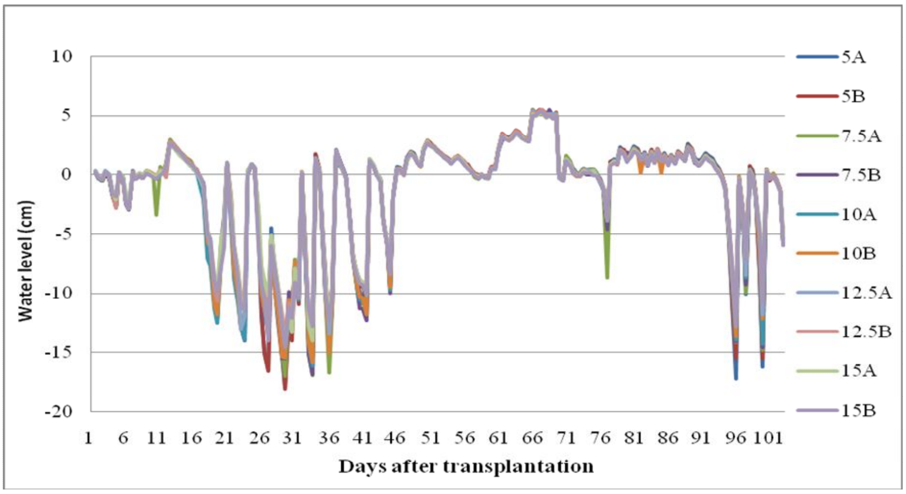

Fig. 3 Ponded depth of all water tubes in the experiment period

The lowest or extreme ponded depth is shown by 5B and that is -18.1 cm below the surface level and minimum lowest ponded depth is -13.5 cm in 12.5B. The difference between these two water level points is 4.6 cm and it is very significant for AWD irrigation management in rice field.

It is found that AWD irrigation after long days, the decreasing trend of water level is very high. It is observed that water level decreasing rate is maximized in small diameter water tube than larger diameter tube. Highest water level reduction is happened in 5B Tube and that is -8.2 cm and lowest reduction in 15A and that is 7.1 cm. It is observed that the highest maximum water level reduction in 24 hours is happened in 7.5B Water Tube (-15.4 cm) and less maximum water level reduction in 15B tube (-11.5 cm). It is found that all the tubes show good relationship to measure ponded depth.

Comparing in same diameter water tube, maximum and minimum relationship is shown by 10 cm and 15 cm diameter water tube which are 0.9955 and 0.9876 (r^2 value) respectively. In different diameter water tube, maximum and minimum relationship is exhibited by 12.5B-15B and 5A-15A water tube which are 0.995 and 0.965 (r^2 value) respectively. From these findings it can be said that if variation of diameter of the tube is small then measuring water level is close and vice versa.

Water tube and Hioki meter

It is found that Hioki meter (Water Level Sensor) measurement goes side by side with water tube ponded depth measurement (Fig.4) and proved that it is very accurate.

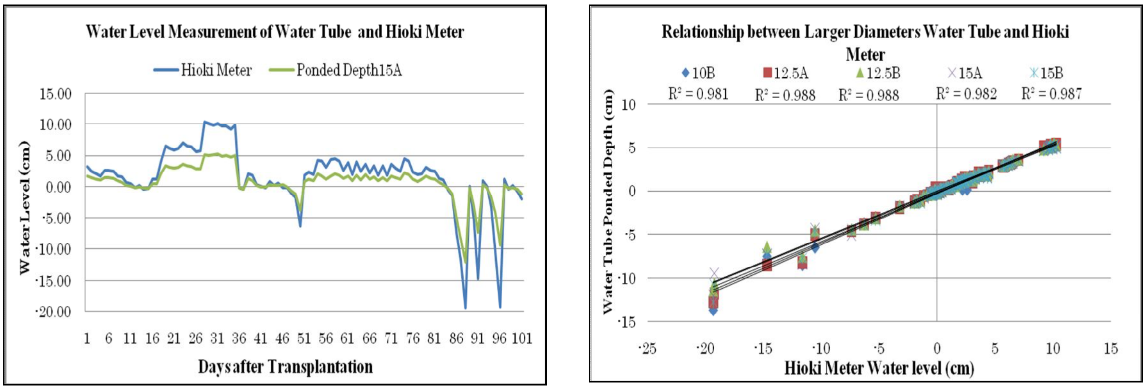

Fig. 4 Water level measurement by water tube and Hioki meter and their relationship

It is found that water tube measurement has strong relationship with Hioki meter measurement and especially larger diameter water tube has better relationship with Hioki meter (Fig.4). Maximum relationship between water tube and hioki meter is 0.9884 (r^2 value) by 12.5B tube and minimum relationship is 0.9575 (r^2 value) by 5A tube.

Water tube and tensiometer

Relationship between soil pressure and different diameter water tube has been investigated and it is found that maximum relation (r^2=0.547) prevails between soil pressure at 5 cm depth tensiometer and 5B water tube and minimum relation (r^2=0.4594) is identified in 15B water tube. It is also observed that no pressure prevailed above -4.3 cm (15A Tube) depth of the soil and maximum pressure (-14 kPa) is found on DAT 35 by 5 cm depth tensiometer.

Water tube, moisture sensor and temperature sensor

In the experiment, it is not found that moisture presence has relationship with ponded water depth measured by water tube. Only 20 cm depth moisture sensor has shown 0.21 relationships with water tube measurement and others has shown very much insignificant result which is less than 0.1.

It is investigated that there is very insignificant relationship between temperature sensor and water tube by using water level decreasing data of drying cycle of AWDI and temperature data on that particular observation. 15 observations data on maximum decreasing of ponded depth has been counted and considers temperature on that time and find that there are less than 0.2 relationships between temperature and ponded depth. Therefore, from this investigation it is not found that higher temperature increases more transpiration and decreasing water level rapidly.

Water requirement and soil physical condition

Total water applied in the field is 77.8 cm of which 45.8 cm comes from irrigation and 32 cm water comes from rainfall which is 59% and 41% of total irrigation. It is investigated that soil crack has relationship with water level. When water level goes to under the soil then soil crack shows maximum width. It is observed that first soil crack is formed on DAT 6 and the maximum size of the crack is 3.5 cm on DAT29.

Crop measurement

It is identified that plant growth curve is S-shaped and number of tiller/shoot growth and leaf growth shows exponential growth curve in this experiment. The number of effective tiller is 27.54 which is very good phonological result for rice plant.

Merits and demerits of water tube

It is investigated that the cost of the 25centimetr PVC water tube is comparatively cheap and available at local market in Japan. There is no carrying, installation and maintenance cost. Installation, observation, maintenance is not hard laborious job for using water tube and it does not consume time. Water tube with PVC pipe is not perishable instrument and not affected by heavy rain fall, flooding, high sun shine and its durability is very high. Water tube is also environment friendly and there is no chance of damaging this instrument by other animals. As the water tube technology is very simple, farmer can adopt and apply this in SRI rice field easily due to its high trial-ability.

CONCLUSION

Water tube showed significant performance to measure the water availability as well as water requirement by the plant. It exhibited right timing of irrigation. All the water tubes monitored the depth of the ponded water very successfully in the drying period of AWDI and show the requirement of water in field.

To increase productivity and to produce rice in water-wise way, water tube technology can be very good option for sustainable rice farming which can save valuable water resource and reduce production cost.

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