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Impact of Alternative Wetting and Drying on the Soil Surface Organic Matter in a Lowland Paddy Field

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Abstract: Ponded water in lowland paddy cultivation has a role on soil biomass accumulation, decomposition, and nutrient availability. However, alternative wetting and drying (AWD) is a common phenomenon under minor irrigation systems due to scarcity of water. The AWD process may have an effect on the soil organic matter (SOM). Therefore, the effect of several cycles of varying length of AWD conditions on SOM content at the soil surface was investigated by using Lysimeter for a period of 98 days. The experiment design was complete randomized design with 4 treatments; i.e. 4 days dry spell (T_1), 12 days dry spell (T_2), 20 days dry spell (T_3) and 4 days dry spell with paddy (T_4). Soil samples from the surface were collected at 14 days interval and the SOM contents were measured. Results show significant differences among the treatment combinations. The accumulation of SOM after AWD water management practices is higher for T_1 followed by T_2, T_3 and T_4. The surface SOM content has reduced by 19 %, 53 %, 86 % and 49 % of the initial SOM content for T_1, T_2, T_3 and T_4, respectively. Shorter dry spells enhance the organic matter accumulation compared to longer dry spells by creating anaerobic condition. On the other hand, organic matter degradation is higher in longer dry spells due to aerobic condition. This finding may help to take decisions on correct water management practices to optimize organic matter dynamics in lowland paddy fields.

Keywords: AWD, Decomposition, Low land paddy, SOM, Water management

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1. Introduction

Ponded water in lowland paddy cultivation plays a crucial role in soil biomass accumulation, decomposition, nutrient availability, weed control, crop growth and ultimately the yield. However, water availability underminor irrigation systems are not reliable to have continuous ponded water in the fields due to high rainfall variability and less water storage capacity of the tanks. Alternative wetting and drying is therefore a common phenomenon under minor irrigation systems. An extension of a dry spell will cause irregular and extreme water stresses for soil organisms and plants. Accumulation of organic matter (OM) in soils is controlled by environmental and pedogenic processes. Soil organic matter (SOM) content is a function of climate, parent material, time, organisms and topography (Jenny, 1941). It was shown that SOM content varies with fertilizer application and age of the crop in lowland paddy cultivation (Sellathurai *et al.*, 2015). The rate and products of OM was different in flooded and non-flooded soils (Alexander, 1961).The alternate wetting and drying (AWD) process, which creates anaerobic and aerobic conditions, may have an effect on the SOM content and its bio-availability. Therefore, a study was conducted to identify the effect of several cycles of AWD at varying lengths on surface SOM content in lowland paddy field.

2. Materials and Methods

Plastic containers, each with 54 cm length, 36 cm width and 30 cm depth were used as Lysimeter to simulate the field condition in the laboratory at Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Sri Lanka. Soil was collected from lowland paddy fields of the Bayawa minor irrigation system located in Kurunegala district. The soil was air dried, sieved (2 mm) and analyzed for texture, OM content (%), ammonium-N, nitrate-N and saturated hydraulic conductivity. A 3 cm depth from bottom of the Lysimeter was filled with aggregates to facilitate the drainage. Then, the Lysimeter was filled with sieved soil up to 15 cm. A piezometer was installed in order to monitor the water level in the Lysimeter. The Lysimeter were allowed to settle by adding water from the bottom. Then the experiment was conducted with the following treatment combinations for 98 days from 2nd September to 8th December, 2014.

T_1 - 4 days dry spell without paddy
T_2 - 12 days dry spell without paddy
T_3 - 20 days dry spell without paddy
T_4 - 4 days dry spell with paddy

The periods for dry spells were selected based on the probability analysis of rainfall for the period from 1981 to 2010 in this study area. The probabilities for 4, 12 and 20 days dry spells were 90, 70 and 50 %, respectively. Each treatment received an artificial rainfall (6 mm) to break the dry spell; which was the most frequent rainfall event in the study area during the 2013/2014 *Maha* season. A10 cm depth of irrigation was provided at 0, 15, 30, 75 days and urea fertilizer was also applied on the same days at the rate of 125 kg/ha (Department of Agriculture Sri Lanka, 2006) to simulate the field condition. The experimental design adopted was factorial complete randomized design with three replicates.

Soil samples at the surface were collected at 14 days interval. The SOM content was estimated by modified Walkley and Black method (1934). The temperature data for the study period was obtained from nearby meteorological station in Wariyapola. Statistical analyses were performed using the SAS statistical software at 95% probability level.

3. Results and Discussions

The Lysimeter were subjected to several cycles of varying length of alternate wetting and drying condition. Figures 1 -3 show the management practices; irrigation and fertilizer application and climatic condition for T_1, T_2, T_3 and T_4, respectively.

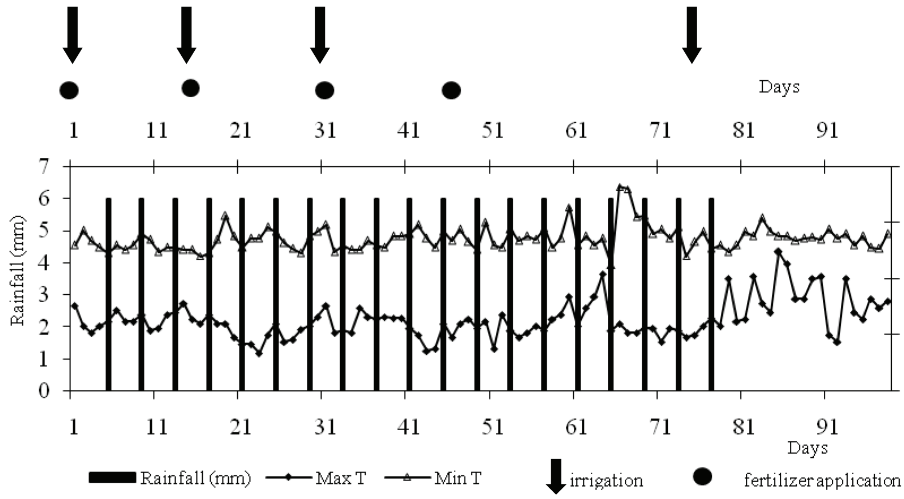

Figure 1: The climatic conditions and management practices for T_1

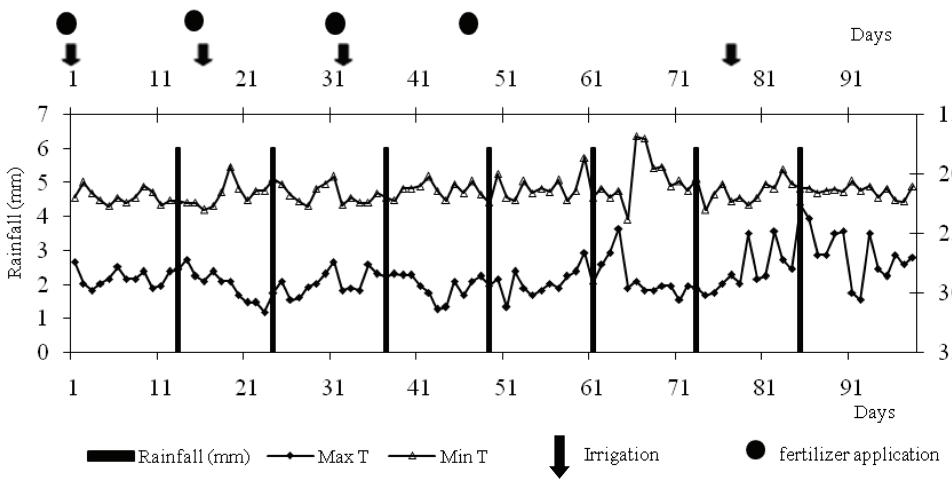

Figure 2: The climatic conditions and management practices for T_2

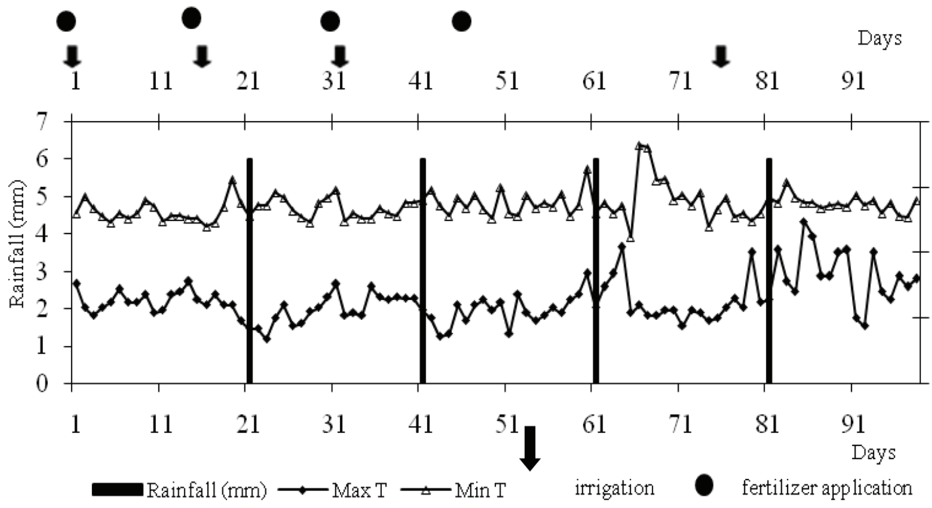

Figure 3: The climatic conditions and management practices for T_3

Table 1: The variation of surface SOM content with time (days)

T	Days							
	0	15	29	43	57	71	85	91
T_1	0.80 ±0.13[bc]	1.02 ±0.31[ab]	0.55 ±0.16[c]	0.56 ±0.36[c]	0.90 ±0.26[bc]	1.02 ±0.48[ab]	1.02 ±0.3[ab]	1.29 ±0.00[ab]
T_2	0.64 ±0.47[bc]	0.92 ±0.46[abc]	0.81 ±0.13[bc]	1.01 ±0.61[abc]	0.49 ±0.30 [c]	0.84 ±0.04[abc]	1.19 ±0.11[ab]	0.64 ±0.00[c]
T_3	0.88 ±0.81[bc]	0.93 ±0.04[bc]	0.41 ±0.44[c]	0.61 ±0.56[bc]	0.67 ±0.24[bc]	0.85 ±0.40[bc]	1.20 ±0.32 [b]	0.49 ±0.00[c]
T_4	1.07 ±0.09[ab]	1.20 ±0.52[a]	0.70 ±0.31[bcd]	0.71 ±0.13[bcd]	0.63 ±0.44[bcd]	0.51 ± 0.11[cd]	070 ±0.14[bcd]	0.48 ±0.00[d]

T: treatments; the means with same letters are not significantly differ at α=0.05 the mean comparison is in row vise.

Table 1 show how SOM temporally varied for each treatment. There are significant differences observed within the treatment with time. The results also show a significant difference among the treatment combination ($p<0.0001$). The AWD creates anaerobic and aerobic conditions that will effect on SOM accumulation and decomposition, respectively resulting significant differences among treatments.

The cumulative surface SOM content for various treatments is shown in Figure 4. According to Brich (1958) the carbon mineralization rate generally increases for a few days following rewetting of a dry soil. All treatments show a reduced surface SOM content after application of irrigation water. The T_1 has higher SOM than T_4, but two values were not significantly differed (P=0.07). The SOM content increases in the latter part after the cessation of irrigation in T_1, but it decreases for T_4 (Table 1 and Figure 4).

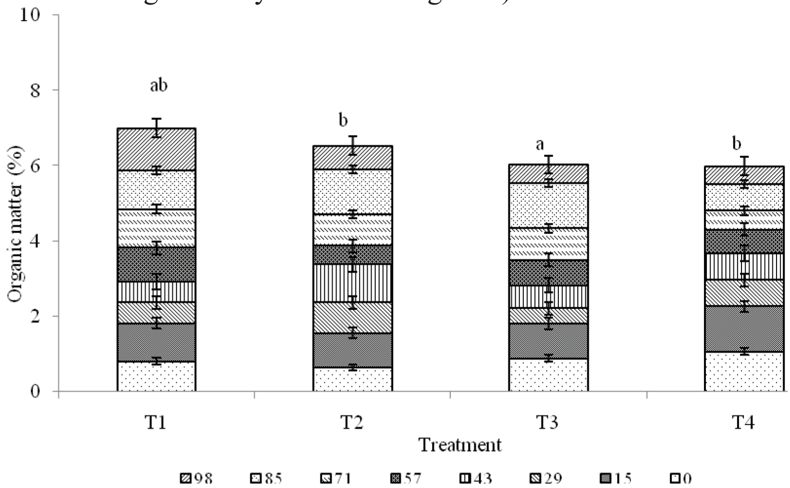

Figure 4: The surface SOM contents for various treatments

The cumulative organic matter accumulation after water application is higher for T_1 followed by T_2, T_3 and finally T_4. This may be due to the aerobic and anaerobic conditions and relevant microbial activity in the soil. Under the aerobic conditions, the mineralization process is high and therefore the T_3 condition shows the least amount of SOM. Because, the interval between the two wetting cycle was high and it received only four rainfall events that creates favorable conditions for the microbial growth. The Figure 5 shows the box and Whisker diagram for the SOM content for each treatment. There are no mild out layers and extreme out layers found.

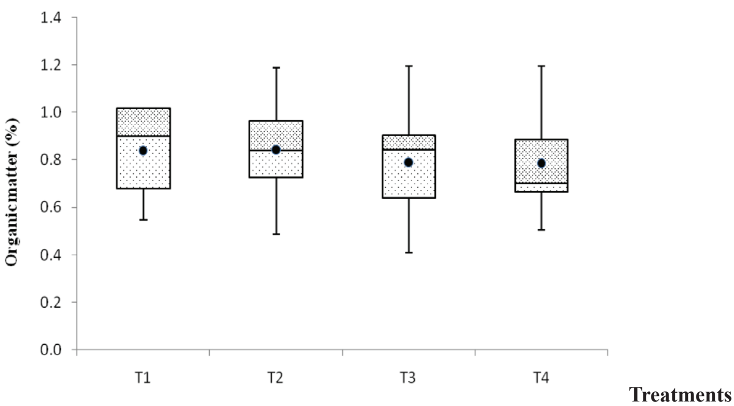

Figure 5: The Box and Whisker diagram for each treatment

4. Conclusions

Surface SOM content fluctuates with time as well as with wetting and drying cycles. The shorter dry spells (T_1) have high amount of surface SOM accumulation compared to other treatments. Longer dry spells have aerobic degradation resulting in less SOM accumulation. There is no significant difference among the measured SOM at 4 days dry spell with plant and without plant. This finding may help to decide on correct water management practices to optimize organic matter dynamics in lowland paddy fields.

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