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Article

Water requirement analysis of three strawberry cultivars by using bucket-type lysimeter and its comparative study

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Abstract: An experiment was carried out from November, 2014 to February, 2015 at Dinajpur, Bangladesh to quantify the total water requirement of Strawberry for three indigenous cultivars RU-1, RU-2 and RU-3by using 12" × 11.5" Bucket-Type Lysimeter. Water requirement in zero evaporation condition for RU-1, RU-2 and RU-3 were 86.25 ± 0.23, 49.22 ± 0.31 and 73.42 ± 0.42mm respectively, which were significantly different ($p< 0.01$). After adding field evaporation total water requirement RU-1, RU-2 and RU-3 were 351.45 ± 0.23, 324.42 ± 0.31 and 338.61 ± 0.42mm respectively.ET_0(Potential evapotranspiration)value ranged between3.21-4.56 (mm/day) while seasonal ET_0 was approximately 457 (mm/season).ET_c (Evapotranspiration) value measured by using K_c (Crop coefficient) value and equations provided by FAO, (2016a, b) viz. 324.24 (mm/season). As plant only uses less than 1% of its total water uptake for metabolic use, Crop water requirement (CWR) can be easily represented by ET_c. However our CWR value is in line with the theoretical ET_c which clearly indicates level of accuracy. Therefore, it is highly recommendable for the local Commercial Strawberry growers to get robust yield.

Keywords: crop water requirement; lysimeter; potential evapotranspiration; crop coefficient; strawberry; Bangladesh

1. Introduction

Water for Agriculture is becoming rare due to rise of water necessity from numerous areas and currently global water requirement has increased six times than the last century (IWMI, 2011). Irrigation is probably the most important use of water all over the world. Water uptake for irrigation are nearly 70% of the total withdrawn for human uses followed by industrial use (20%) and municipal (10%) use (Cosgrove, 2014). Inadequate knowledge for specific Crop Water Requirement (CWR) may lead to inappropriate use of water and higher input cost for growers. CWR is defined as the total amount of water that is lost via Evapotranspiration (ET) process. CWR analysis is essential for the design and operation of soil and water management policies (Igbadun 2012). For decades lysimeters have been used to measure ET, CWR and Crop co-efficient (K_c) for a cultivar of crops. Different designs for lysimeter has been invented to achieve maximum accuracy as well as Cost efficiency (Howell *et al.*, 1985; Marek *et al.*, 1988; Bergstrom, 1990; Allen and Fisher, 1990; Young *et al.*, 1996; Yang *et al.*, 2000). Hence the reasons behind selecting Bucket type Lysimeter are portability, easy access and Cost efficiency.

Strawberry (*Fragaria ananassa* Duch.) is one of the most delicious and fragrantly sweet flavoured fruits of the world, very popular in many countries (Sharma and Sharma, 2004). Strawberry is becoming a popular crop among Bangladeshi growers after its successful field performance and higher market value for its consumers

(Rahman *et al.,* 2013). Still Bangladeshi growers is quite unknown to its cultivation technique especially irrigation schedule and eventually there is only a handful research on CWR analysis for strawberry in the context of Bangladesh. Besides, commercials are facing several problems such as less sweetness, short shelf-life and damage during transportation. Efficient irrigation for optimum fruit quality is really necessary (Fallahi *et al.,* 2010) for commercial strawberry production in Bangladesh. Especially strawberry is very much sensitive to water stress (Lozano *et al*., 2016). Thus the objectives of the study is to determine CWR of strawberry and its comparison with Theoretical value.

2. Materials and Methods

The experiment was carried out at Faculty of Engineering, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh; 25.63° North latitude, 88.64° East longitude during November, 2014 to February, 2015.The climatic conditions of the study area were characterized by an annual rainfall of 1979 mm (77.9 inch) and the mean annual temperature of 25°C(77°F) and monthly means varying between 18°C (64°F) in January and 29 °C (84°F) in August (Table 1). All weather data were collected from Dinajpur weather Station, Bangladesh.

2.1. Lysimeter preparation and experimental design

A non-weighing bucket type lysimeter was designed by using a bucket of 12 inch height & 11.5 inch diameter. Four holes were made at the bottom of the bucket to collect the percolated water. The percolated water was collected by a pot which has a strong covering. From the farm field of HSTU the sandy loam soil was collected and standard fertilizer doses applied for strawberry cultivation (BARC 2012) i.e. 40gm Urea, TSP and MOP in every bucket. Large size gravels, small size gravels and sand were placed respectively from bottom of the each bucket followed by proper Soil Mixture. The soil of the studied area is classified as sandy loam (USDA classification), with 60% sand, 27% silt and 13% clay. The arrangement of soil in the bucket was gravel (both small and moderate), sand, sandy loam & then sand respectively (Figure 1). A plastic funnel was attached to the bottom of bucket with the help of sugar glue. Seven days old healthy and disease free strawberry plants of RU-1, RU-2 and RU-3 were collected from the Rajshahi University, Bangladesh. With great care planting have completed through making 2-3 cm deep hole manually. Mulching has done to prevent capillary raise of water and polythene cover was used to create zero evaporation condition and to control entry of rain water into pot. This plastic covering was fastened tightly with a rope to the bucket Other Intercultural Operations weeding alone with pesticide application were done accordingly. 50 WP Carbendazim @ 200 mm/plant were applied on 30 December, 2014. Drip irrigation system was applied by using pipe with regulator to control water movement. Irrigation continued from 20th December, 2014 to 24th February through changing water flow as required.

As stated in the objectives, the main purpose of this study was to investigate the ET_c, ET_0andto compare. Nine buckets were used for3replication of each cultivars. Single plant was planted in every single bucket and all strawberry plant quality were similar. The seasonal water requirement is computed by adding measured quantities of irrigation water, effective rainfall received during the season and the contribution of moisture from the soil. Field water balanced may be expressed by the following relationship.

$$WR = IR + ER + \sum_{i=1}^{n} \frac{Mbi-Mei}{100} \times Ai \times Di - P \text{.....[1]}$$

Where,

WR = seasonal water requirement (mm); IR = total irrigation water applied(mm); ER = seasonal effective rainfall (mm); Mbi = moisture percentage of the beginning of the season in the ith layer of the soil; Mei = moisture percentage at the end of the season in the ith layer of the soil; Ai = apparent specific gravity of the ith layer of the soil; Di = depth of ith layer of the soil with in the root zone (mm); n = number of soil layer in the root zone D; P = percolation;

2.2. Seasonal Crop Coefficient Calculation

The Blaney–Criddle equation is a relatively simplistic method for calculating potential evapotranspiration.

ET_0 can be determined by following equations (FAO, 2016a)

$ET_0 = P*(0.46\ T_{mean}+8)$…… [2]

Where, ET_0 = Potential Evapotranspiration (mm of water per day); P = monthly percentage of total day time hours of year; T_{mean} = mean daily temperature (°C)

$ETc = K_c*ETo$…… [3]

Where, K_c = crop coefficient; ETc = Evapotranspiration or Consumptive use of water.
SPSS and Microsoft Excel program 2013 were used to process and analyze the data. DMRT was done to test was done to check the level of significance.

3. Results and Discussion

3.1. Total supplied and percolated water

Growers of the study area perceive that strawberry is very sensitive to water stress. The water was supplied to every reference crop according to their need. Amount of water of the soil surface have been checked regularly. So water was supplied only if the soil found dry. Total supplied water and Percolated water varied from plant to plant because of growth and cultivar (Table 2). Maximum water was supplied in R1 of RU-3 (7430 ml) whereas minimum was found in R3 of RU-1(6510 ml). Similar data was observed in case of percolation.

3.2. Corp water requirement (CWR)

From equation [1] average water requirement for RU-1, RU-2 and RU-3 were found as follows; 86.25, 49.22 and 73.42mm (Table 4). Significant difference were found among the varieties. The soil surface of the plant were covered with polyethylene. So amount of evaporation was tends to zero. But in field level evaporated water must take into account to calculate total crop water requirement. Total water requirement for RU-1, RU-2 and RU-3 (Figure 2) were estimated 351.45 ± 0.23, 324.42 ± 0.31 and 338.61 ± 0.42mm respectively. Previous scientific research shows a wide range of water requirement analysis, ranging between 300 and 787 mm (Serrano *et al.,* 1992; Trout and Gartung, 2004; Hanson and Bendixen, 2004; Strand, 2008). Lozano *et al.* (2016) used drainage lysimeters in *Sabrina* trial and seasonal crop evapotranspiration ranged from 430 to 453 mm, whereas in *Antilla* it reached 352 mm. The reason behind this slight difference with our experiment is may be because geological, climatic and cultivar difference.

3.3. ET_0 (Potential evapotranspiration)

ET_0 was measured by using Blaney–Criddle equation [2] where p value for 25° North latitude was obtained from FAO, (2016c). ET_0 (mm/season) was approximately 457 mm/season. Clark *et al., (*1996*)* reported that for three consecutive years 1988-1991 ET_0 values of strawberry ranged between 457-537 (mm/season) in Drip irrigation system. Lozano *et al.* (2016) concluded that estimated ET_o over the course of the growing season was523 (mm/season).

3.4. ET_c (Crop evapotranspiration)

ET_c value was measured by using [3] equation and K_c value of strawberry at different stages. FAO, (2016b) shows a wide range of $K_c$values for non-stressed, well-managed strawberry cultivation in sub humid climates i.e. 0.45(Init. stage), 0.80 (Dev. stage), 0.80(mid. stage) and 0.75 (late stage). Using these values for 4 different month November to February the estimated ET_c was 324.24 (mm/ season). As plant only uses less than 1% of its total water uptake for metabolic use, Crop water requirement (CWR) can be easily represented by ET_c. The acquired CWR (351.45 ± 0.23, 324.42 ± 0.31 and 338.61 ± 0.42mm/season) values were compared with calculated ET_c value (324.24 mm/ season) which clearly indicates that our findings is in line with the theoretical ET_c estimation. However the reason behind this slight difference maybe be because subtropical environment and difference between Cultivars.

Table 1. Weather parameters, ET_0 and ET_c in four months.

Month	Weather parameters						ET_0 (mm/day)	ET_C (mm/day)
	Rainfall (mm)	Mean maximum air temperature (^oC)	Mean minimum air temperature (^oC)	Mean average relative humidity (%)	Mean evaporation (mm)/day	Mean sun shine (hrs)		
November	00.00	13.50	09.85	79.64	02.32	06.02	3.21	1.44
December	41.00	9.98	07.02	81.87	1.980	5.820	3.10	2.48
January	0.10	16.24	11.68	82.02	1.09	4.20	3.89	3.12
February	12	20.31	13.33	76.19	03.01	06.83	4.56	3.42

Table 2. Total Amount of Supplied Water (in mm) and percolated water (in mm).

Cultivar	Replication	Area of Bucket (in m^2)	Supplied Water (in m^3)	Supplied Water(in mm) Water/Area	Percolated Water (in m^3)	Percolated Water(in mm) Water/Area
	R1	0.27	0.00654	24.222	0.000396	1.467
RU-1	R2	0.27	0.00652	24.148	0.000393	1.456
	R3	0.27	0.00651	24.111	0.00039	1.444
	R1	0.27	0.0054	20.000	0.000826	3.059
RU-2	R2	0.27	0.0052	19.259	0.000822	3.044
	R3	0.27	0.0053	19.630	0.000823	3.048
	R1	0.27	0.00743	27.519	0.001251	4.633
RU-3	R2	0.27	0.00741	27.444	0.001259	4.663
	R3	0.27	0.00743	27.519	0.001247	4.619

Table 3. Soil Moisture Content, Depth of root zone, Effective Rainfall analysis.

Cultivar	Replication	Initial Moisture Content (%)	Final Moisture Content (%)	Depth of soil root zone (mm)	Apparent Specific Gravity	Effective Rainfall (mm)
	R1	2.83	23.87	63.21	2.6	0
RU-1	R2	2.87	23.96	62.85	2.6	0
	R3	2.84	23.92	62.92	2.6	0
	R1	2.74	22.49	42.09	2.6	0
RU-2	R2	2.72	22.41	42.46	2.6	0
	R3	2.73	22.35	41.84	2.6	0
	R1	2.83	24.07	49.49	2.6	0
RU-3	R2	2.81	24.28	50.34	2.6	0
	R3	2.82	24.21	50.18	2.6	0

Table 4. Water Requirement analysis.

Cultivar	water requirement(mm)	Evaporation(mm/season)	Standard Deviation
RU-1	86.25**	265.2	0.23
RU-2	59.22**	265.2	0.31
RU-3	73.41**	265.2	0.42

(**) Indicates significantly different at 1% level of probability by DMRT.

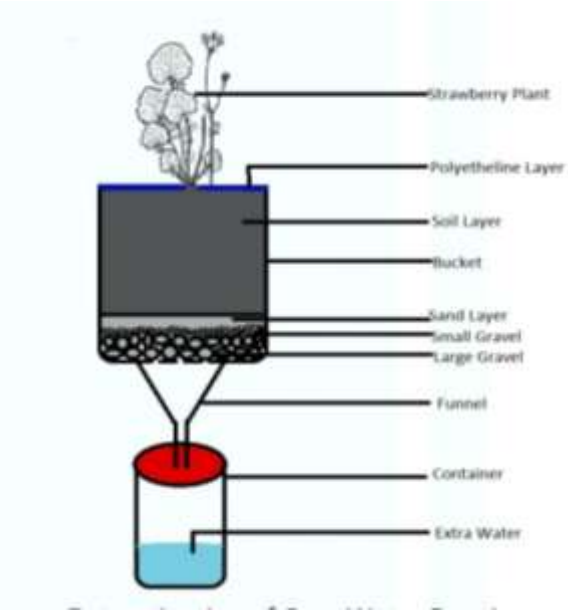

Figure 1. Direct method for computing seasonal crop water requirement.

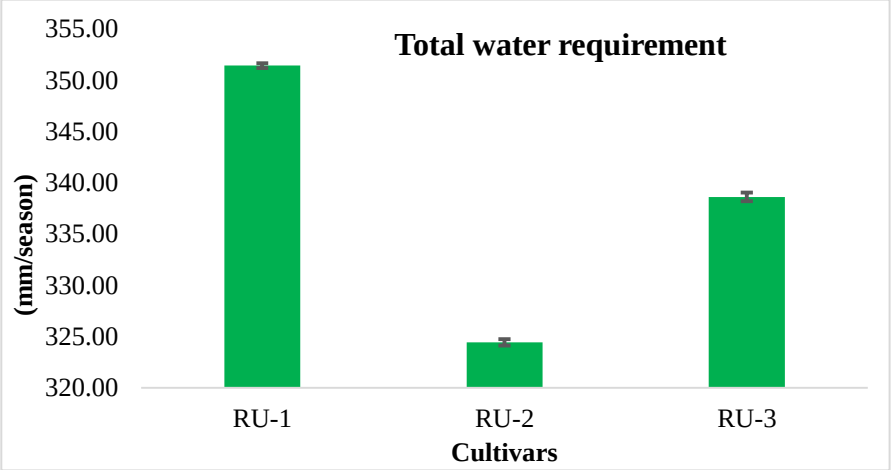

Figure 2. Total Water requirement of RU-1, RU-2, RU-3 cultivars.

4. Conclusions

This experiment presents the amount of water requirement for strawberry in drip irrigation system for three different cultivar. The irrigation was supplied locally made and very cheap irrigation system. With the use of such lysimeter, fundamental information could be acquired with a relatively economical system and a minimum of maintenance. The system was able to measure the soil water content mean values between the established ranges throughout the total growing period. Evaporation of soil surface was controlled and entry of rain water into the plant was totally controlled. With supplying the irrigation, others operation like weeding, application of fertilizers, herbicides, pesticides etc. were done properly. Since the crop water requirement values were determined matching the local conditions of soil, plant, and environment, they are more accurate than the standard ones. Therefore, it is highly recommendable for the local Commercial Strawberry growers to get robust yield.

Conflict of interest

None to declare.

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