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Study of Soil Properties and Evaluation of Evapo-transpiration for Wheat by Soil Moisture Depletion Studies

H. M. Rasel[1], B. Ahmed[1*], M. R. Hasan[2] and M. S. U. Miah[1]
[1]Department of Civil Engineering, Rajshahi University of Engineering & Technology
Rajshahi-6204, Bangladesh (hmrruet@yahoo.com, bulbulruet@gmail.com, shafi_ruet@yahoo.com).
[2]Ph.D Fellow, Institute of Environmental Science, University of Rajshahi,
Bangladesh (mrhasanraj@gmail.com).

Abstract

Using available properties of soil an attempt has been made to estimate the evapo-transpiration of water for wheat of four samples at Regional Wheat Research Center (RWRC), Rajshahi and one sample in RUET campus. The different soil properties such as void ratio, porosity, grain size distribution has been determined. The consumptive use of water for wheat is determined by the method of soil moisture depletion studies. The Consumptive use for wheat (mm) at different location such as north, south, east, west side of the RWRC and south side of the Ladies Hall (LH) at RUET was found respectively 337, 354, 341, 417, 288, 355, 313, 452, 265, 399, 328, 449, 350, 365, 319, 396, 210, 301, 255, 346 185, 157, 218, 172 and 140mm.The estimated minimum quantity of evapo-transpiration for wheat is 140mm south side of the LH before harvesting and peak value is 452mm west side of the RWRC. The peak values are obtained after irrigation. Minimum co-efficient of curvature found 1.01 at north side of RWRC and maximum 1.19 at south side of RWRC from grain size distribution curve. The uniformity co-efficient Cu found 3.47 at the south side of the LH and south, north and west side of RWRC was found 3.93, 3.96 and 3.65 respectively. As the uniformity co-efficient Cu lies between 1 to 4 and co-efficient of curvature C_c is nearly unity indicates the soil uniformly well graded and fine grained soil. The soil samples collected from five locations are silty loam according to textural classification of soil.

Keywords: evapo-transpiration, soil property, consumptive use, co-efficient of curvature, uniformity co-efficient, soil moisture depletion studies.

1. Introduction

To grow every crops water is essential. Plant absorbs water from soil by root and this water is used in vegetative growth. Some of this water retains on plant and same of this transpires to the atmospheres. The quantity of water transpired by plants during growth and retained in the plants tissue plus the moisture evaporated from the surface of the soil and vegetation is called consumptive use or evapo-transpiration [1]. Evapo-transpiration represents one of the most important aspects of water loss in the hydrological cycle. It accounts about 75% of the annual precipitation in humid region and nearly 100% in arid region [3]. It is sum of the volumes of water entering plant roots to build plant tissue or bring passed through leaves of the plants in to atmosphere and evaporated from the surfaces of leaves of the plant. From agricultural point of view, the year is divided into two seasons, Rabi season and Kharif season. Normally Rabi start on 1st October and ends on 31st March [4]. Our studied crops wheat lies in Rabi crops. Evaporation, transpiration and consumptive use are important factors in estimating irrigation requirement and planning irrigation systems. The yield from agricultural land depends upon several factors but the most important factor in the crops to get adequate water at the stages growth of the plants. The natural supply of water to the agricultural land for the production of crop is through rain [2]. It is a consideration in irrigation project to provide optimum water to the crops. Lack of water will hampered plant growth and excessive supply will increase cost of irrigation and will bear no benefit and sometimes cause adverse effect to plant growth. So it is essential to provide optimum water supply to the crops. For estimating optimum water supply and various losses we have to know evapo-transpiration. The purpose of this study is to achieve the following specific objectives: Analysis of collected soil sample by laboratory experiment and determination of water content, grain size distribution, void ratio and porosity. Other important assessment is the type of soil in the root zone depth at different locations as well as the seasonal consumptive use and Evapo-transpiration of Wheat.

2. Research methodology

2.1 Auger boring method: Augers are used in cohesive and other soft soils, above water level. Hand augers are used for depths up to about 6m.Mechanically operated augers are used for greater depths & they can also be used in gravely soils. Samples recovered from the soil brought up by augers are badly disturbed and are useful for identification purposes only. Auger boring is fairly satisfactory for highway explorations at shallow depth and for exploring borrow pits. The soil sample has been collected by Hand augers (Post hole auger) [5].

2.2 Water content by Oven-drying method: (1) The container was cleaned and then finding its mass with lid w_1 gm. (2) putting the required quantity of the moist soil sample in the container and replace the lid. Taking the mass w_2 gm. (3). The container was kept in the oven with lid removed and maintained the temperature of oven between 105°c to 110°c, for about 24 hours. (4) Taking out the container, replacing the lid and cooling it and finally taking the mass w_3 gm of the container with lid and dried soil sample.

2.3 Grain size distribution: Grain size distribution of a soil sample can be obtained by conducting sieve analysis and hydrometer analysis. Generally sieve analysis is used for coarse-grained soil and hydrometer analysis is used for fine-grained soil. The particle size distribution for both hydrometer and sieve analysis were conducted in the laboratory. At first 500gm of the soil samples were kept submerged under water for 24 hour. After 24 hour the soil samples were sieved through 200 no. sieves (0.75mm) using water jet [6]. The soil retaining on 200 no. sieves after drying was used for sieves analysis. Soil, which passes the 200 no. sieves, was collected in a large container and was allowed to settle. These settled soils after drying was used in hydrometer analysis.

2.4 Void ratio and porosity of soil: (1) At first collecting the soil sample by using a ring. (2) Finally, take the weight of dried soil sample. (3) After collecting the soil sample is to be planed by using a straight edge. Then take the weight of soil sample (4). Then placing the soil sample into the oven at the temperature of about 105° to110°c for 24 hours.

2.5 Soil moisture studies on plots: This method is usually employed to determine the evapo-transpiration of water in irrigation field plots in which soil is fairly uniform and depth of ground water is such that it does not affect the soil moisture fluctuations within the root zones. Usually a large number of soil samples must be taken at different depths in the roots zone. The moisture content of soil samples is determined by standard laboratory methods and it is expressed as a percentage of the oven dry wt. of the soil. Thus the quantity of water in meter removes from the soil evaporation and transpiration is determined by using the formula, D=PSd/100. In which, P is the moisture percentage by wt; S is the apparent specific gravity of soil; d is depth of soil in meter; and D the depth of water in metros removed from the soil. The total quantity of water removed from the soil during each period is computed which the value of the evapo-transpiration for that period is determined. The values of the 30 days period evapo-transpiration are plotted against time and use of water curve for the crop season is obtained. The average use of water for each month is obtained directly from this curve.

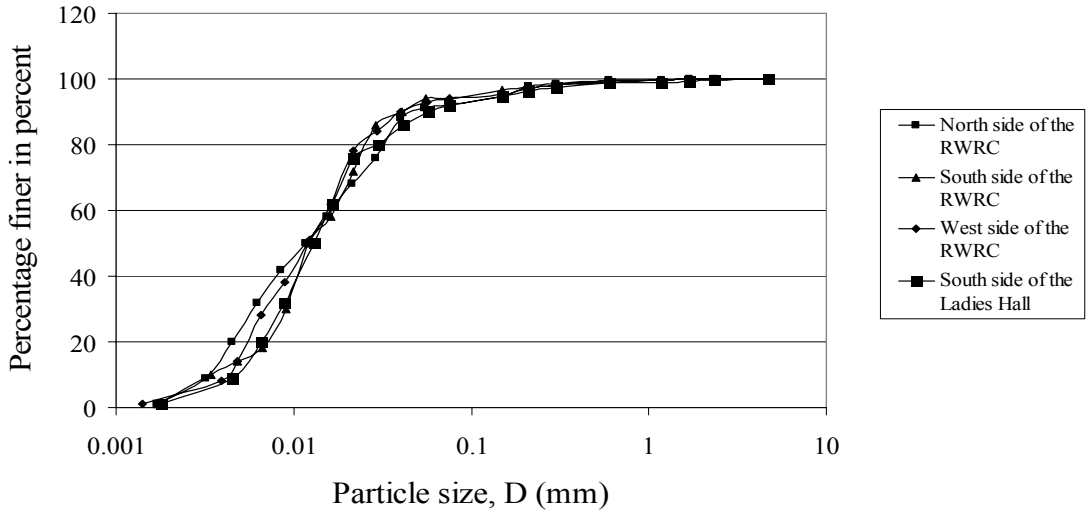

Figure 1: Grain size distribution curve (combined)

3. Results and discussions

The amount of evapo-transpiration of water for the crops of wheat is calculated in RWRC and RUET campus, Rajshahi. The consumptive use for wheat (mm) at different location shown in (Table 3.12 to Table 3.16) south, north, east, west side of the RWRC and south side of the LH, was found respectively 337, 354, 341, 417, 288, 355, 313, 452, 265, 399, 328, 449, 350, 365, 319, 396, 210, 301, 255, 346, 185, 157, 218, 172 and 140mm. The estimated minimum quantity of evapo-transpiration for wheat is 140mm at the south side of the LH before harvesting and peak value is 452mm. Water content in different depth of five locations is shown in table 4.7 to table 3.11 at different period. Porosity at the south, north, east, west side of the RWRC and south side of the LH, it was found 0.30, 0.35, 0.38, 0.37 and 0.41. Void ratio at the south, north, east, west side of the RWRC and south side of the LH, it was found 0.50, 0.55, 0.62, 0.58 and 0.70 which is shown in table 3.6. The estimated minimum quantity of evapo-transpiration for wheat is 140mm at south side of LH before harvesting [Table 3.14] and peak value is 452 mm at west side of the RWRC[Table 3.13]. After irrigation the peak values are obtained. The empirical value (Table 3.1) of consumptive use of water which is lower than the experimental value. The average value of evapo-transpiration shown in table 3.2. The evapo-transpiration curve for wheat is shown in fig. 2. Soil classification according to international soil classification range is shown in table 3.3. Textural classification of soil by using USDA chart and the value of C_u and C_c is shown in table 3.4 and table 3.5.

Table 3.1: Comparison of Consumptive use by different method

Name of the crop	Name of month	Date	Experimental method (mm)	Empirical formula	
				Blaney-Criddle method (mm)	Thornthwaite method (mm)
Wheat	December	1st to 31th December	322.4	52.10	78.80
	January	1st to 31th January	322.4	59.30	83.10
	February	1st to 29th February	361.6	83.45	90.30
	March	1st to 18th March	174.4	93.49	123.25

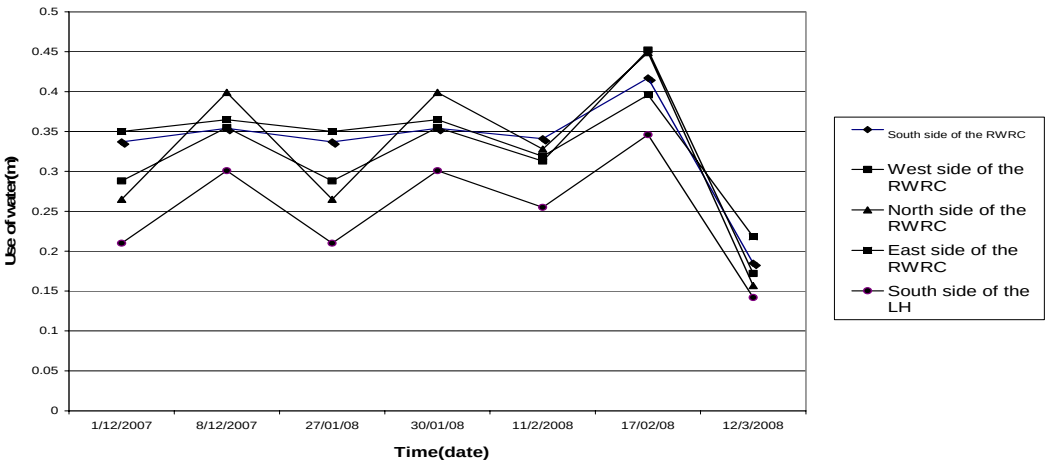

Figure 2: Evapo-transpiration curve for wheat

Table 3.2: Average values for daily, monthly seasonal evapo-transpiration

Location	Average evapo-transpiration		
	Daily (mm)	Monthly (mm)	Seasonal (mm)
South side of the RWRC	3.57	107.03	428.50
West side of the RWRC	4.31	118.83	514.90
East side of the RWRC	3.75	112.59	450.00
North side of the RWRC	4.15	124.57	497.60
South side of the LH	4.68	139.30	536.80

Table 3.3: Soil classification according to International Soil Classification Range

Type of soil	Range of particle diameter in millimeter
Course sand	2-0.2
Fine sand	0.2-0.02
Silt	0.02-0.002
Clay	Less than 0.002

Table 3.4: Textural classification of soil by using USDA chart

Location	Sand (%)	Silt (%)	Clay (%)	Type of soil
South side of the RWRC	28	63	9	Silty loam
West side of the RWRC	22	70	8	Silty loam
East side of the RWRC	26	63	11	Silty loam
North side of the RWRC	28	62	10	Silty loam
South side of the LH	24	67	9	Silty loam

Table 3.5: Soil classification by using the value of C_u and C_c

Location	Uniformity co-efficient C_u	Co-efficient of curvature C_c	Classification of soil
South side of the RWRC	3.93	1.19	Uniformly well graded& fine grained soil
North side of the RWRC	3.96	1.01	Uniformly well graded& fine grained soil
West side of the RWRC	3.65	1.04	Uniformly well graded& fine grained soil
East side of the RWRC	3.89	1.07	Uniformly well graded& fine grained soil
South side of the LH	3.47	1.14	Uniformly well graded& fine grained soil

Table 3.6: Experimental data for void ratio & porosity

Location	Mass of specimen M_1	Volume of mould	$\rho = \frac{M1}{V}$ gm/cm^3	$\gamma_d = \frac{\gamma}{1+w}$	Void ratio $e = \frac{G*\gamma w}{\gamma d} - 1$	Porosity $n = \frac{e}{1+e}$
South side of the RWRC	115.40	56.37	2.05	15.81	0.50	0.30
West side of the RWRC	118.80	56.37	2.11	17.08	0.55	0.35
North side of the RWRC	117.60	56.37	2.08	16.33	0.62	0.38
East side of the RWRC	120.20	56.37	2.13	18.7	0.58	0.37
South side of the LH	116.20	56.37	2.06	17.01	0.70	0.41

Table 3.7: Water content of soil sample at the study area (Collected on 27-01-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	28.90	28.30	27.70	33.40
North side of the RWRC	23.60	24.30	20.20	23.10
East side of the RWRC	24.20	26.170	29.80	31.70
West side of the RWRC	27.70	26.20	23.30	24.70
South side of the LH	25.55	27.72	22.32	25.55

Table 3.8: Water content of soil sample at the study area (Collected on 30-01-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	43.00	24.57	28.80	35.32
North side of the RWRC	48.30	37.72	28.85	35.32
East side of the RWRC	41.00	35.50	30.11	31.00
West side of the RWRC	38.65	33.00	29.35	29.95
South side of the LH	36.66	35.35	30.11	32.11

Table 3.9: Water content of soil sample at the study area (Collected on 11-02-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	32.30	24.00	27.10	34.35
North side of the RWRC	30.30	28.70	26.25	28.15
East side of the RWRC	31.24	27.20	26.32	28.32
West side of the RWRC	30.30	27.15	27.10	26.17
South side of the LH	31.22	28.88	25.66	25.55

Table 3.10: Water content of soil sample at the study area (Collected on 17-02-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	49.80	48.30	33.35	35.62
North side of the RWRC	52.30	48.08	39.80	43.60
East side of the RWRC	49.33	38.42	34.75	32.25
West side of the RWRC	51.33	48.08	35.25	27.50
South side of the LH	50.25	47.88	36.66	26.33

Table 3.11: Water content of soil sample at the study area (Collected on 12-03-08)

Location	Water content (%) At surface	Water content (%) At 30cm depth	Water content (%) At 60cm depth	Water content (%) At 90cm depth
South side of the RWRC	15.40	16.98	16.90	21.45
North side of the RWRC	13.40	14.80	15.40	18.30
East side of the RWRC	13.00	15.35	18.39	20.19
West side of the RWRC	15.42	16.20	17.50	18.29
South side of the LH	14.44	17.78	16.58	22.23

Table 3.12: Determination of evapo-transpiration by soil moisture at the south side of the RWRC

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	28.90	2.51	0	337
	0.3	23.50	2.51	0.177	
	0.6	27.70	2.51	0.417	
	0.9	33.40	2.51	0.755	
2nd Sample					
30-01-08	0	43.00	2.51	0	354
	0.3	24.57	2.51	0.184	
	0.6	28.80	2.51	0.434	
	0.9	35.32	2.51	0.798	
3rd Sample					
11-02-08	0	32.3	2.51	0	341
	0.3	24.00	2.51	0.181	
	0.6	27.1	2.51	0.408	
	0.9	34.35	2.51	0.776	
4th Sample					
17-02-08	0	49.8	2.51	0	417
	0.3	48.3	2.51	0.364	
	0.6	33.3	2.51	0.501	
	0.9	35.62	2.51	0.805	
5th Sample					
12-03-08	0	15.4	2.51	0	185
	0.3	16.98	2.51	0.128	
	0.6	16.90	2.51	0.255	
	0.9	21.45	2.51	0.484	

Table 3.13: Determination of evapo-transpiration by soil moisture at the west side of the RWRC

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	27.70	2.61	0	288
	0.3	26.20	2.61	0.025	
	0.6	23.30	2.61	0.365	
	0.9	24.70	2.61	0.580	
2nd Sample					
30-01-08	0	35.67	2.61	0	355
	0.3	33.00	2.61	0.258	
	0.6	29.30	2.61	0.459	
	0.9	29.90	2.61	0.702	
3rd Sample					
11-02-08	0	30.30	2.61	0	313
	0.3	27.15	2.61	0.213	
	0.6	27.10	2.61	0.424	
	0.9	26.15	2.61	0.615	
4th Sample					
17-02-08	0	51.33	2.61	0	452
	0.3	48.08	2.61	0.376	
	0.6	35.25	2.61	0.552	
	0.9	27.50	2.61	0.881	
5th Sample					
12-03-08	0	13.4	2.61	0	172
	0.3	14.80	2.61	0.115	
	0.6	15.4	2.61	0..241	
	0.9	18.3	2.61	0..429	

Table 3.14: Determination of evapo-transpiration by soil moisture at the north side of the RWRC

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	23.60	2.64	0	365
	0.3	24.30	2.64	0.192	
	0.6	20.20	2.64	0.319	
	0.9	23.10	2.64	0.549	
2nd Sample					
30-01-08	0	41.50	2.64	0	399
	0.3	37.72	2.64	0.299	
	0.6	28.85	2.64	0.457	
	0.9	35.32	2.64	0.839	
3rd Sample					
11-02-08	0	30.30	2.64	0	328
	0.3	28.70	2.64	0.227	
	0.6	26.25	2.64	0.416	
	0.9	28.15	2.64	0.669	
4th Sample					
17-02-08	0	48.08	2.64	0	449
	0.3	46.90	2.64	0.371	
	0.6	34.25	2.64	0.542	
	0.9	37.13	2.64	0.881	
5th Sample					
12-03-08	0	15.42	2.64	0	157
	0.3	16.20	2.64	0.128	
	0.6	17.50	2.64	0277	
	0.9	18.30	2.64	0.435	

Table 3.15: Determination of evapo-transpiration by soil moisture at the east side of the RWRC

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	24.20	2.58	0	350
	0.3	26.17	2.58	0.203	
	0.6	29.80	2.58	0.461	
	0.9	31.70	2.58	0.736	
2nd Sample					
30-01-08	0	41.00	2.58	0	365
	0.3	35.50	2.58	0.275	
	0.6	30.11	2.58	0.466	
	0.9	31.00	2.58	0.719	
3rd Sample					
11-02-08	0	31.24	2.58	0	319
	0.3	27.20	2.58	0.211	
	0.6	26.32	2.58	0.407	
	0.9	28.32	2.58	0.658	
4th Sample					
17-02-08	0	49.33	2.58	0	396
	0.3	38.42	2.58	0.297	
	0.6	34.75	2.58	0.538	
	0.9	32.25	2.58	0.749	
5th Sample					
12-03-08	0	13	2.58	0	218
	0.3	15.35	2.58	0.118	
	0.6	18.39	2.58	0.285	
	0.9	20.19	2.58	0.469	

Table 3.16: Determination of evapo-transpiration by soil moisture at the south side of the LH

1st Sample					
Date	Depth, d (m)	P	S	D=PSd/100(m)	Average, D (mm)
27-01-08	0	19.71	2.60	0	210
	0.3	15.11	2.60	0.118	
	0.6	15.27	2.60	0.238	
	0.9	20.73	2.60	0.485	
2nd Sample					
30-01-08	0	30.6	2.60	0	301
	0.3	29.05	2.60	0.227	
	0.6	23.80	2.60	0.371	
	0.9	25.45	2.60	0.605	
3rd Sample					
11-02-08	0	22.01	2.60	0	255
	0.3	17.35	2.60	0.135	
	0.6	19.54	2.60	0.305	
	0.9	24.73	2.60	0.579	
4th Sample					
17-02-08	0	28.62	2.60	0	346
	0.3	32.19	2.60	0.251	
	0.6	28.13	2.60	0.439	
	0.9	29.57	2.60	0.692	
5th Sample					
12-03-08	0	12.15	2.60	0	140
	0.3	13.25	2.60	0.103	
	0.6	15.20	2.60	0.175	
	0.9	15.35	2.60	0.256	

5. Conclusions

The minimum value of water content is found 13% and the maximum value of water content is 52.30% after irrigation. The uniformity co-efficient of five locations such as south, north, west, east side of the RWRC and south side of the LH, it was found 3.93, 3.96, 3.65, 3.89, 3.47 and the co-efficient of curvature was found 1.19, 1.01, 1.07, 1.04 and 1.14 which suggest to be uniformly well graded fine grained soil. The soil samples collected from five locations are silty loam according to textural classification of soil. Void ratio and porosity for different location varies from 0.50 to 0.70 and 0.30 to 0.41. Porosity indicates the water holding capacity of soil. Therefore, the average values of water content satisfy the porosity limits.

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