Research

iMedPub Journals
www.imedpub.com

Journal of Plant Breeding and Agriculture

2018
Vol.2 No.1:1

Evaluation of Radiation Methods for Calculating the Water Requirement of Grass in Two Different Climates Using REF-ET Software

Saeid Eslamian[1], Masoume Najafi[1], Mohammad Salariyan[2], Kaveh Ostad-Ali-Askari[3*] and Vijay P Singh[4]

[1]Department of Water Engineering, Isfahan University of Technology, Isfahan, Iran

[2]Department of Water Engineering, Ferdowsi University of Mashhad, Mashhad, Iran

[3]Department of Civil Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran

[4]Department of Biological and Agricultural Engineering, Zachry Department of Civil Engineering, Texas A&M University, Texas, USA

[*]**Corresponding author**: Dr. Kaveh Ostad-Ali-Askari, Department of Civil Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran, Tel: +9831353540019; E-mail: Koa.askari@khuisf.ac.ir

Received: April 17, 2018; **Accepted:** August 1, 2018; **Published:** August 7, 2018

Citation: Eslamian S, Najafi M, Salariyan M, Ostad-Ali-Askari K, Singh VP (2018) Evaluation of Radiation Methods for Calculating the Water Requirement of Grass in Two Different Climates Using REF-ET Software. J Plant breed Agric vol: 2 No.1: 1

Abstract

Evapotranspiration plays a fundamental role in agricultural water management. Its calculation requires weather data, such as radiation, which are often not available and should be estimated indirectly. This study employed the Ref-ET software for estimating radiation for the period of 1970-2011 under two different climates of Rasht and Isfahan. Results showed that for Isfahan, the first method (minimum and maximum temperature difference) was satisfied with K_{RS}=0.17, indicating good results. For Rasht, radiation was estimated using the third method (K_{RS}) assuming K_{RS}=0/44, and the evapotranspiration relative to the values of evapotranspiration in the presence of data was acceptable. Also, results of evapotranspiration derived from the Torque equation in Isfahan and results of the Penman-Monteith FAO relation for Rasht were more acceptable.

Keywords: Radiation; Rapid evaporation; REF-ET

Introduction

The supply of water needed for maximum crop growth, total water consumption, and the determination of capacity of canals and reservoirs constitute the important parts of an irrigation and drainage project. The Penman-Monteith method, approved by the FAO, is the standard for calculating the evapotranspiration of reference crop. This method requires a large amount of climate data, but sometimes a number of meteorological parameters, such as radiation, temperature, and precipitation, are not available. It may be noted that the sensitivity of evapotranspiration to meteorological parameters is not the same in different regions; hence it may be necessary to more precisely estimate some of the parameters [1]. While estimating evapotranspiration by the Penman-Monteith FAO-56 model and the fuzzy inference system [1] found that solar radiation was the most effective parameter. Sabzi Parvar evaluated the sensitivity of the Penman-Monteith FAO-56, Jensen-Hayes, and Hargreaves models to weather parameters and found that evapotranspiration was most sensitive to solar radiation parameters and air temperature [2]. On estimating evapotranspiration by the Penman-Monteith method for 64 stations from different climatic regions of China, Thomas found that solar radiation had the highest impact in the south, and wind speed, relative humidity, and maximum temperature were the main factors in the northeast, the center, and northwest of China [3].

Some of the weather parameters can be estimated and some measured. Erfanian and Babaii compared three models for estimating radiation, including hybrid models, modified Daneshyar and Sabbagh in a study on evapotranspiration in Tabriz, Iran, and found that the hybrid model had a higher accuracy than the two other models [4]. Comparing hybrid and Angstrom-Prescott models at 14 stations in Japan concluded that the hybrid model performed better than did the Angstrom-Prescott model. In another study on a number of U.S., Japan and Saudi stations, Yang concluded that the hybrid model was able to accurately estimate solar radiation at daily and hourly scales than were the FAO and Angstrom-Prescat models with global coefficients [5-12].

Materials and Methods

Statistics of the synoptic weather stations at Isfahan and Rasht for the statistical period of 1970-2011 were used. Meteorological information used included minimum and maximum temperatures, minimum and maximum humidity, wind speed, and sunshine hours. The average meteorological parameters and geographical location of the studied areas are presented in **Table 1** and **Figure 1**.

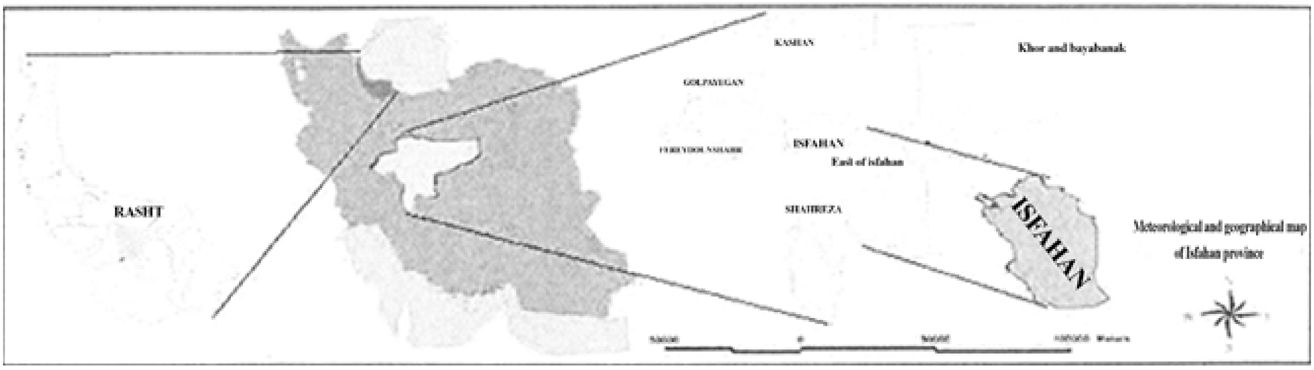

Figure 1 Isfahan, Sep. 2015 Geographical location of the city of Isfahan and Rasht.

Table 1 Geographic and meteorological parameters of stations for statistical period (1970-2011).

Wind speed meter in seconds	The number of sunny hours	Maximum humidity	Minimum humidity	Maximum temperature	Minimum temperature	Above sea level	latitude	Longitude	Station
1.21	4.52	96.06	66.41	20.56	11.64	-6.9	37.25	49.6	--
7.74	9.09	56.1	22.21	23.46	9.5	1550.4	32.61	51.66	--

REF-ET software was used to estimate the radiation parameter. First, using the values of wind speed, number of sunshine hours, minimum and maximum temperatures for Rasht and Isfahan, reference evapotranspiration was calculated [5] **(Figure 2).** Then, by removing solar radiation and using the methods present in the software for estimating this parameter, evapotranspiration was calculated again and evapotranspiration was compared at each step [8].

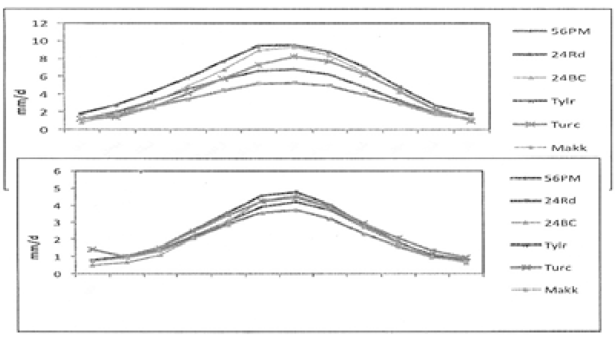

Figure 2 Evapotranspiration chart of reference crop using REF-ET software for Rasht (1970-2011).

Comparison of diagrams show that in the Rasht region differences in the results of equations were negligible and the lines were closer, but in the Isfahan region, these differences were increasing in warm months, but these disparities are negligible in cold months [13-15]. The three methods used in the software were used to estimate the brightness or radiation parameter. The methods were as follows:

Method 1: This method is influenced by minimum and maximum temperatures. If R_n is not available, R_s is estimated using equation (1), which is moderated by hermaphrodite variation as proposed by Samani and Hargreaves

$$1982 - 1985 R_s = K_{RS} \times R_a \times \sqrt{(T\max - T\min}$$

Where R_a is the outer radiation ($MJm^{-2}\ d^{-1}$); T (max) is the maximum air temperature (°C); T(min) is the minimum air temperature (°C); and K_{RS} is the correction factor of climate (c). In the first method, the K_{RS} value varied between 0/16 and 0/19, varying in coastal and non-coastal areas. According to the FAO-56 model and the publication for non-coastal areas, the correction factor K_{RS} is 0.16 accordingly, in this study, the values of 0.16, 0.17, 0.18, and 0.19 were considered for the K_{RS} coefficient.

Method 2 (Island): According to R_s=0.7R_a, radiation estimated islands can be applied.

Method 3 (Kg): According to R_s=K_r.R_a, radiation can be estimated by choosing an appropriate value of Kr. The Kr coefficient was determined based on the climate and region and it was suggested to be between 0-1-1. For the Isfahan region, the coefficient was 0.25 and it was 0.25, 0.41, and 0.61 for the racetrack. (Proposed by the Authorizing Officers). To compare the relationships, results of the six equations, including Radiation, Blanie-Cradle, Prestley Taylor, McCurve, Torque, and FAO Penman-Monteith, for estimating evapotranspiration were used [7] These equations are as follows:

FAO Penman-Monteith Method

This method has been introduced by the International Commission on Irrigation and Drainage and the World Food Organization (FAO) as a standard method for calculating potential evapotranspiration. It is assumed that the total surface area of vegetation is a large leaf with its apertures [9]. That is why the Penman-Monteith method is called the (Big Leaf). Its equation is as follows:

$$ETo = \frac{0.4*8\Delta(R_n - G) + \gamma[\frac{890}{T+273}]U_2(e_a - e_d)}{\Delta + \gamma(1 + 0.34u_2)}$$

where R_n is the radiation for the vegetation cover ($MJm^{-2}d^{-1}$); T average air temperature at a height of 2 m from the ground; (°C); U_2 wind speed at 2 meters above the ground (ms^{-1}); (e_a-e_d) vapor pressure deficiency at 2 meters' height ($KPa°C^{-1}$); Δ curve vapor pressure curve ($KPa°C^{-1}$); γ moisture factor ($KPa°C^{-1}$); G flame inside the inside soil (MJm^{-2} d^{-1}).

Radiation Method –FAO

This relationship is presented by Durenbus (1977) as follows:

$$ETo = c\,[ER_S + (1 - W)0.27\,(1 + 0.01U2)\,(e_a - e_d)]$$

where c is the factor that depends on the relative humidity of air and daily wind speed: w is the weight factor that indicates the effect of temperature in relation to altitude. Rs solar radiation * wind speed 2 meters above ground level (ms^{-1}); (e_a-e_d) vapor pressure shortage at 2 meters (mb).

Method Blunni-Kerry Dell 1950

Its equation is as follows: One of the oldest methods for estimating ETo of the grass reference crop, which was investigated at the University of California, is as follows [13]:

$$ETo = a + b[p(0.46T + 8.13]$$

where a and b are climate factors, depending on the relative humidity of the air; actual sunshine, and daily wind speed; t is the average monthly temperature (c); P is the coefficient of the day or the annual percentage of sunlight in the month, described on a daily basis (average light hours each day per month divided by total light year multiplied by 100).

Prestley-Taylor Method 1972

The Prestley-Taylor method is based on solar radiation and the degree of heat. Its equation is:

$$ETo = 1.26\Delta/(\Delta + \gamma)(R_n - G)/\gamma$$

in which R_n is radiation; G flux of heat into the soil ($MJm^{-2}d^{-1}$); λ the heat of evaporation; ($MJkg^{-1}$); Δ the slope of the vapor pressure curve ($MJkg^{-1}$); and is the humidity coefficient ($KPa°C^{-1}$).

Macking 1957

The Macking method is based on solar radiation and temperature. This method was first developed in the Netherlands and then in Australia. In general, it's more applicable to Western Europe, and its equation is as follows:

$$ETo = 0.61\frac{\Delta}{\Delta + \gamma}\frac{R_s}{2.45} - 0.12$$

In which R_S is solar radiation ($MJm^{-2}d^{-1}$); Δ the slope of the steam pressure curve ($KPa°C^{-1}$); γ the humidity coefficient 2.45; and the latent heat of evaporation at approximately 20°C ($KPa°C^{-1}$).

Table 2 Evapotranspiration of reference crop using REF-ET software in Isfahan city.

T	RSME	MBE	MAE	Equation	Value	Method	Parameter
5.61	0.11	0.08	0.08	PM65	K_{RS}=6v5	ONE	
6.87	0.35	0.28	0.28	Rd42			
6.16	0.22	0.17	0.17	BC42			
5.79	0.15	0.11	0.11	Tylr			
7.27	0.2	0.16	0.16	Makk			
6.3	0.26	0.2	0.2	Turc			
2.21	0.04	-0.02	0.03	PM65	K_{RS}=6v0		
2.62	0.14	-0.07	0.1	Rd42			
2.49	0.08	-0.04	0.05	BC42			
2.22	0.06	-0.03	0.04	Tylr			
2.76	0.08	-0.04	0.06	Makk			
2.18	0.09	-0.04	0.06	Turc			

© Copyright iMedPub

7.77	0.14	-0.12	0.12	PM65	K_{RS}=6v0		
8.74	0.46	-0.41	0.41	Rd42			
8.48	0.28	-0.24	0.24	BC42			
7.45	0.2	-0.17	0.17	Tylr			
9.18	0.27	-0.24	0.24	Makk			
8.42	0.31	-0.28	0.28	Turc			
7.75	0.26	-0.22	0.22	PM65	K_{RS}=6v0		
8.53	0.84	-0.76	0.76	Rd42			
8.25	0.49	-0.43	0.43	BC42			
7.63	0.37	-0.31	0.31	Tylr			
9.19	0.48	-0.44	0.44	Makk			
8.23	0.58	-0.51	0.51	Turc			
5.84	0.2	0.15	0.15	PM65	Ra=4	TWO	
6.88	0.7	0.57	0.59	Rd42			
6.39	0.44	0.34	0.35	BC42			
5.98	0.28	0.21	0.22	Tylr			
7.38	0.4	0.33	0.34	Makk			
6.29	0.53	0.4	0.41	Turc			
6.32	1.23	1.01	1.01	PM65	K_{RS}=6146	THREE	
-3.84	3.98	3.55	3.55	Rd42			
3.02	2.61	2.21	2.21	BC42			
5.39	1.74	1.43	1.43	Tylr			
4.83	2.26	2.05	2.05	Makk			
1.96	2.88	2.44	2.44	Turc			

Torque Method 1961

The torque method is based on solar radiation and temperature, as in the Macking method. The use of this method was also developed in the Netherlands and then in Australia.

$$ETo = a_T 0.013 \frac{T_{mean}}{T_{mean} + 15} \frac{23.8856 R_s + 50}{\lambda}$$

These indicators are as follows: in which R_s of solar radiation ($MJm^{-2}d^{-1}$); T is the average temperature of heat (°C) and λ the latent heat of evaporation ($MJkg^{-1}$). a_T the coefficient, when the average daily relative humidity is more than 50%, is considered to be 0.1, and when the average daily relative humidity is less than 50%, the relation is [11]:

$$a_T = 1 + \frac{50 - RH_{meam}}{70}$$

Where relative humidity is in percent. The torque B equation will only apply when Tmean >-10°C. In this study, we used the tests proposed by Jacquids (1997) to evaluate the accuracy of models and compare the results of estimated methods with measured radiation values; wind speed and relative humidity. Jacques showed that the use of RMSE, MBE, MAE alone causing an error in choosing the best model. Therefore, it is recommended that along with these two indicators, the criterion T, which is a combination of them, is also used.

$$1982 - 1985 R_s = K_{RS} \times R_a \times \sqrt{T_{\max} - T_{\min}}$$

$$RMSE = \sqrt{\sum_1^n (p_i - o_i)^2}$$

$$MAE = \sum_{1=1}^{n} ABS(p_i - o_i)/n$$

$$t = \sqrt{\frac{(n-1)\, MBE^2}{RMS_{E^2} - MBE^2}}$$

These equations are the estimated values of the parameters; O_i is the measured value of the parameter, and n is the number of observations [10]. Results of this test for the radiation parameter for two regions of Isfahan and Rasht are presented in **Tables 2 and 3**, respectively. Comparison of results indicates that if the radiation parameter is not available for Isfahan, the first method with coefficient K_{RS}=0.17 and for the Rasht method using the third method with coefficient K_{RS}=0.44 will produce results closer to reality. Also, for the Isfahan region, results of the Torque equation and for Rasht equal the results of the Penman-Monteith equation, as well as other empirical equations. For Isfahan, results of the Penman-Monteith-FAO and Torque equation had little difference in comparison with other equations.

Comparison of results showed that if there was no radiation parameter, using the third method (Kg) and assuming Kr=0.44, the best estimate would be for Rasht area. Because RMSE and T coefficient, which is a composite index, are less for the studied methods; this indicates a high accuracy in the estimation of parameters.

Table 3 Evapotranspiration chart of reference plant using software REF-ET in Rasht (1970-2011).

T	RSME	MBE	MAE	Equation	Value	Method	Parameter
0.3	0.2	0.1	0.1	PM65			
6.14	0.28	-0.21	0.23	Rd42			
5.79	0.14	-0.1	0.12	BC42			
4.33	0.19	-0.12	0.14	Tylr			
6.22	0.22	-0.16	0.18	Makk			
6.23	0.21	-0.16	0.18	Turc			
7.29	0.22	-0.18	0.18	PM65	K_{RS}=6v0		
8.9	0.44	-0.4	0.4	Rd42			
8.99	0.22	-0.2	0.2	BC42			
7.2	0.3	-0.25	0.25	Tylr			
9.01	0.34	-0.31	0.31	Makk			
9	0.34	0.21	0.31	Turc			
7.75	0.32	-0.27	0.27	PM65	K_{RS}=6v0		
9.31	0.62	-0.58	0.58	Rd42			
9.29	0.22	-0.3	0.3	BC42			
7.6	0.45	-0.28	0.28	Tylr			
9.5	0.48	-0.45	0.45	Makk			
9.41	0.48	-0.45	0.45	Turc			
7.6	0.44	-0.37	0.37	PM65	K_{RS}=6v0		
9.17	0.82	-0.77	0.77	Rd42			
9.13	0.43	-0.39	0.39	BC42			
7.5	0.6	-0.51	0.51	Tylr			
9.45	0.63	-0.59	0.59	Makk			
9.31	0.64	-0.6	0.6	Turc			
7.05	0.48	-0.39	0.39	PM65	R_a=4	TWO	
7.75	0.85	-0.74	0.74	Rd42			
7.81	0.45	-0.29	0.29	BC42			
6.9	0.66	-0.53	0.53	Tylr			
8.02	0.65	-0.57	0.57	Makk			
7.85	0.66	-0.75	0.57	Turc			
5.69	0.87	0.65	0.65	PM65	Kr=6146	THREE	

© Copyright iMedPub

6.43	1.44	1.22	1.22	Rd42			
6.65	0.84	0.68	0.68	BC42			
5.42	1.18	0.89	0.89	Tylr			
7.14	1.1	0.94	0.94	Makk			
6.83	1.15	0.97	0.97	Turc			
0.39	0.16	-0.62	0.11	PM65	Kr=6122	FOUR	
0.01	0.28	-0.01	0.22	Rd42			
0.09	0.015	0.01	0.12	BC42			
0.33	0.21	0.04	0.15	Tylr			
0.02	0.21	-0.01	0.17	Makk			
0	0.21	0	0.17	Turc			
7.43	0.74	-0.62	0.62	PM65	Kr=6155	FIVE	
8.32	1.36	-1.3	1.3	Rd42			
8.87	0.72	-0.66	0.66	BC42			
7.13	1.01	-0.86	0.86	Tylr			
9.05	1.05	-1	1	Makk			
8.87	1.07	-1.01	1.01	Turc			

Result and Discussion

Evapotranspiration presents a vital impress in agronomic water management. Possible evapotranspiration (PET) is a significant gnomon of hydrologic budgets at several spatial criterions and is an exigent changed for comprehension territorial biological activities [6]. It is mostly a main changing in computing real evapotranspiration in rainfall-runoff and ecosystem modeling [16]. However, PET is determined in various procedures in the work and quantitative assessment of PET with available statistical formulas generates incompatible consequences. Multivariate statistical trials, as regards, demonstrated that PET values from various procedures were notably various from one another. Higher diversities were found among the temperature relying PET ways than radiation relying PET ways. In common, the Turc, and Penman-Monteith procedures made better than the other PET procedures. However, Turc's equation likely an attractive substitute to the more intricate Penman-Monteith procedure. Referral crop evapotranspiration is a crucial changed in methods appointed for approximation of evapotranspiration rates of agricultural products. Component analysis also showed that wind speed become clears to be an essential uncertain in the dry climate, while sunshine hours become clear to be more prevailing in sub humid and humid weathers. Consequences of component analysis more or less followed the consequences of the statistical analogies and prepared a statistical explanation for the classify of substitute procedures depended on efficiency indexes. The consequences prepare a base for impartially evaluating the relative implement of resource ET equations in a diversity of weather conditions. Methods to assess absent information were traced when restricted weather inputs were existent. The systematize sample was wanted to clarify and clear the showing and usage of the procedure; as regards, it needs multiple inputs that often are not existent at most weather stations. Precise assessment of territorial evapotranspiration (ET) is vital for extremely agricultural water dependent studies. In inclusion, all procedures want to be further experienced under a diversity of plants area concord, crop growth step, environmental and climatological situations.

Conclusion

This study showed that in the region of Rasht for the radiation parameter, the third method (K_{RS}) has the best estimate if Kr=0.41. For the Isfahan region, for the radiation parameter, the third method (K_{RS}) has the best estimate if the value of Kr=0.44. For the Isfahan region, for the radiation parameter; in the first method (the difference between minimum and maximum temperature), if K_{RS}=0/17, the result is better. Results also showed that the evapotranspiration values obtained from the Penman-Monteith relation for Rasht and the evapotranspiration values obtained from the Turque relation for Isfahan with the reconstruction of the radiation parameter are closer to the evapotranspiration obtained from measured parameters. With the reconstruction of the radiation parameter for Isfahan, results of the Penman-Monteith-FAO and Torque (Turc) equations are slightly different from those of other equations.

References

1. Ansari H, Moradi H (2010) A fuzzy model for estimating hourly reference evapotranspiration using minimum meteorological data. J Water and Soil 2: 286-275.
2. Erfanian, Baba'I (2013) Estimation of hybrid model in solar radiation estimation and preparation of seasonal maps of radiation for Urmia lake. 5th International Congress of Geographers of Islamic World, Tabriz.
3. Ren T, Modest MF, Haworth DC (2018) Simulating turbulence–radiation interactions using a presumed probability density function method. Int J Heat Mass Transfer 121: 911-923.
4. Lu J, Sun Ge, McNulty SG, Amatya DM (2007) A comparison of six potential evapotranspiration methods for regional use in the Southeastern United States. J Am Water Resour Assoc 41: 621-633.
5. Yoder RE, Odhiambo LO, Wright WC (2005) Evaluation of methods for estimating daily reference crop evapotranspiration at a site in the humid southeast United States. Appl Eng Agric 21: 197-202.
6. Fernández MD, Bonachela S, Orgaz F, Thompson R, López JC, et al. (2010) Measurement and estimation of plastic greenhouse reference evapotranspiration in a Mediterranean climate 28: 497–509.
7. Kovoor NL(2006) Performance evaluation of reference evapotranspiration equations across a range of Indian climates. J Irrig Drain Eng 132: 238-249.
8. Itenfisu D, Elliott RL, Allen RG, Walter IA (2003) Comparison of reference evapotranspiration calculations as part of the ASCE standardization effort. J Irrig Drain Eng Vol 129: 440-448.
9. Rojas JP, Sheffield RE (2013) Evaluation of daily reference evapotranspiration methods as compared with the ASCE-EWRI Penman-Monteith Equation using limited weather data in Northeast Louisiana. J Irrig Drain Eng 139: 285-292.
10. Zhai L, Feng Q, Li Q, Xu C (2009) Comparison and modification of equations for calculating evapotranspiration (ET) with data from Gansu Province, Northwest China. Irrig Drain 59: 477- 490.
11. Jensen NE, Allen RG (2016) Evaporation, evapotranspiration, and irrigation water requirements. Crops, Energy methods, Evapotranspiration, Hydro power, Water surface, Irrigation water, Water resources, North America, United States.
12. Sufen Ye, Zhang L, Feng H (2017) Marine ecological risk assessment methods for radiation accidents. J Environ Radioact 180: 65-76.
13. Dinpashoh Y (2006) Study of reference crop evapotranspiration in I.R. of Iran. Agric Water Manag 84: 123-129.
14. Ravazzani G, Corbari C, Morella S, Gianoli P (2012) Modified Hargreaves-Samani Equation for the assessment of reference evapotranspiration in Alpine River Basins. J Irrig Drain Eng 138: 592-599.
15. Chávez JL, Neale CMU, Prueger JH, Kustas WP (2008) Daily evapotranspiration estimates from extrapolating instantaneous airborne remote sensing ET values. Irrigation Sci 27: 67-81.
16. Ye S, Zhang L, Feng H (2017) Marine ecological risk assessment methods for radiation accidents. Journal of Environmental Radioactivity 180: 65-76.

© Copyright iMedPub