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Estimation of Evaporation and Transpiration of Wheat Plant in Zaraghan Station Using CROPWAT Model

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Abstract

In this research, amount of evaporation and transpiration and water requirement of wheat plant for Marvdasht town (representation station: Zaraghan) during 17-years statistical duration from 1989-2005 and properties of plant and soil are calculated using CROPWAT software. At the first, trends of dry and wet periods for mentioned station were determined using long-term average of climatic data (temperature and rainfall). In this town, 8 month from middle of the year is dry period. Hence, complementary irrigation is needed this time and most parts of these areas, which are cultivated as dry farming had to use underground waters inevitably. Decrease in rainfall in recent years intensified this issue and therefore, it resulted in intensive decline in level of underground waters and sinking of plains. Then, real transpiration and evaporation and irrigation requirement of wheat crop in the region is calculated using CROPWAT model. Based on obtained results from irrigation schedule in the station and according to dominance of dryness and humidity lack of soil, two or three complementary irrigation is required to preparing crops for harvest.

Key words: Evaporation, Transpiration, Water requirement, Marvdasht town, CROPWAT

Introduction:

Food production is one of main tasks of agriculture section. If agriculture section can provide enough and required food of the country by appropriate speed with population growth, rare sources can be used for technology absorption and development process would be accelerated. In other wise, production resources, especially currency will be spent for food import and therefore, development procedure will be drowsed and chronic under development will continue. Nowadays, wheat is the most vital stuff in consumption pattern of the world households and it is used as a political tool in international relations even for exerting dominance and political pressure on needful third world countries (Falahi et al). Nowadays, cereals are considered as the most important crops and among the cereals, wheat is regarded as a strategic crop in the world. In Iran, wheat and its bread are considered as the most important food source and major part of required calorie and protein is obtained through this crop. Wheat is a one-year

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plant from cereal branch and triticum breed with various species. Wheat is the most important crop, which has the most under-cultivation area, and highest production rate among different agronomic plants of the world (Masoudifar and Mahkaran, 1384). Wheat has a special importance as one of essential agriculture crops and supplying this crop, for communities such as Iran which in, wheat has a special place in nutrition pattern, means to establishing food security, and social welfare of middle and poor classes is affected intensively by this crop. Shortage of this crop and consequently, its price increase resulted in intensive social tensions and global strikes all over the world including Egypt and El Salvador (Kalafarti, 2000). Average performance of irrigated wheat per area unit of Iran is 3.890 hectares. Mild climate of the country is one of important wheat producing climates in the country; this climate includes vast parts of provinces of Razavi Khorasan, Markazi, Semnan, Tehran, Isfahan, Yazd, Fars, Kerman, Kermanshah and Lorestan. This climate allocated near 30 percentages of wheat cultivation area to itself by having 682 thousands area. Records of wheat production are reported mostly from mild regions. In order to importance of these regions, it is enough to point to the role of Fars, Khorasan, Kermanshah and Isfahan provinces in producing wheat. The average performance of irrigated wheat in these regions is limited and sometimes, decline in dams' water resulted in wasting a considerable percent of downward cultivations due to lack of irrigation in some provinces such as Isfahan and Fars (Binam, 1388). Due to special climatic conditions of Iran, which its dryness and inappropriate temporal and spatial distribution of rainfall is an undeniable reality of it, any stable agro or food production depends on proper and logic use of limited sources of water in the country (Ebrahimi Pak, 1381). In this regard, we can say that irrigation water is the most input of agro production. Due to limitation of water resources, 7.8 million hectares lands from about 37 million hectares of agricultural fertile lands of the country are cultivated as irrigation method (Karimi, Sedighi et al, 1381).

Wheat is one of the most important cereals of the country and it has a considerable performance and cultivation land area in Fars province, while this province faced with shortage of water and drought all the time and its underground and surface water resources are declining. Therefore, it is necessary to determine required water for wheat in each region of this province in critical conditions- low rainfall and high transpiration and evaporation-(Fouladmand, 1388). The amount of wheat production in Iran in agro year of 1388-89 is estimated 13484.47 million tons and Fars province is in first rank of production by 1396.65 million tons (10.35 percentages) (Statistical journal of agriculture, 1390). Shortage of water and therefore, decreasing production of agriculture crops endangers lives of people in dry regions of the world and the country. Appropriate management in using rainwater is one of methods, which by them we can effectively counter with this threat. Agronomic plants in arid and semi-arid regions need extra water in addition to natural rain. This water can be accumulated from side lands and would be used for plant use in dry period (Oweis, 1999). Increasing efficiency of water is one of strategies in management of water consumption in agriculture sector and increasing its consumption output. To improving efficiency of water consumption in irrigation networks, it is necessary to precise determining of plants' water requirement and precise estimation of amount of transpiration-evaporation. We can improve management of water consumption in agriculture using this method (Ghaemi Bayegi et al, 1392). The topic of improving water efficiency in producing food is one of essential issues in different countries, especially low-water kind of them such as Iran. Hard competition between industry, potation and agriculture sections for water consumption and dryness and drought events in the country makes it necessary to obtain more production from each consuming unit. Average Annual rainfall height of the world is about 0.25 and it is less than half of rainfall in Asia. According to arid and semi-arid climate of Iran, water crisis is a more serious threat for us than other countries. Water, soil and plant management has a considerable effect on efficiency of water consumption due to its high effect on intensity of transpiration and evaporation. Precise determination of plants' water requirement and precise estimation of transpiration-evaporation is an essential issue to improving efficiency of water consumption. According to limitation of water resources in the country and investments which are conducted on supply and transfer of water, precise planning is essential to optimal use from present water sources which are important factors of farming irrigation management. Determination of water requirement of the plants in different regions of the country is necessary to achieving this objective. The amount of evaporation and transpiration depends on meteorological parameters and atmospheric conditions, soil texture and method of planting (Niazi et al, 1384).

CROPWAT is a supportive system, which is developed by land and water development section of FAO organization. CROPWAT is a common application, which helps to meteorologists, agricultural professionals and irrigation engineers to estimating standard calculation of reference evaporation and transpiration, water requirement and crop irrigation. In addition, about special management plans and irrigation planning, when we are faced with water shortage it acts as a guide for improving irrigation operation and scheduling. Finally, it anticipates amount of production in dry farming condition or water shortage. CROPWAT databases include data for 6 climatic regions and 14 countries (FAO, 1992:46). Hence, according to the matter that Marvdasht town is one of agricultural poles of the country by having 150 thousands hectares under-cultivated lands, development and growth of agriculture section in this town plays an important role in development and growth of whole town (falahi and Chizari, 1386). The main objective of this research is determining water requirement of wheat in different levels in Marvdasht town.

Location

Marvdasht is one of towns of Iran and it is located in Fars province. This town is located in 35 kilometers from north of Shiraz and its weather is mountainous and temperate. Marvdasht is one of northern towns of Fars province with height of 1620 meters from sea level and 4649 square kilometers area. This land was in focus of attention from the past due to its excellent geographical position and its temperate weather and having plentiful water and suitable soil, and due to natural properties, developed quickly and now, it is considered as the second town of Fars province. This town is developing day by day due to its very appropriate business and commerce position and suitable life condition.

Methods and materials:

Based on ambrotermic diagram, dry period of the year in Zaraghan station begins in middle of March and continues to middle of November. Properties of the station and average of some important climatic parameters, which are applied in the model, are presented in table 1.

Table 1: geographical location and annual average of climatic parameters in study station during statistical duration (1989-2005).

Station name	Altitude from sea level(m)	Longitude	Latitude	Average minimum temperatures	Average maximum temperature	Relative humidity(percent)	Average Rainfall	Average wind speed (KNOT)	Sunshine hours per year
Zaraghan	96	52.4 3	29.47	7.8	24.7	38	360.6	2.5	3304.4

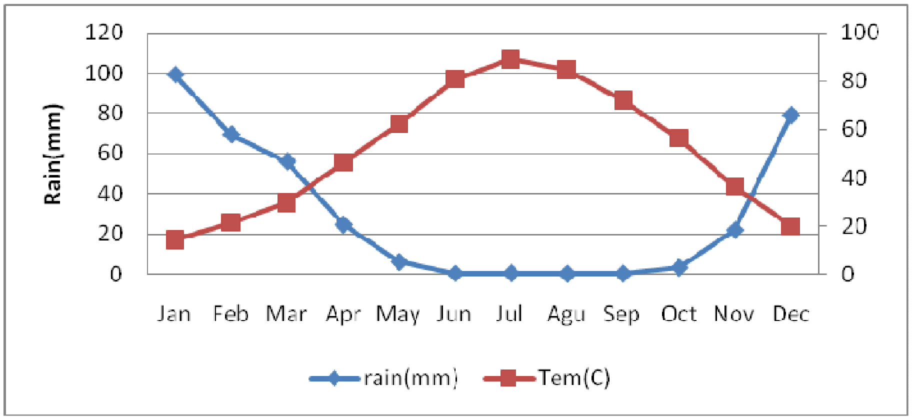

Diagram 1: ambrotermic diagram of Zaraghan station

Method

To calculating water requirement (CWR) and irrigation water requirement (IWC), model needs to crop, climatic and soil data, therefore:

1. Evaporation and transpiration of reference plant (ETO) which its amount is based in climatic data of maximum and minimum temperature degree of weather, relative humidity, radiation length and wind speed using CROPWAT.

2. Rainfall data

3. the pattern of cultivation including cultivation date, crop coefficient data and cultivated area (0-100 percentages of total area) in addition, model requires to following data to scheduling irrigation:

Soil type, total available humidity for soil, maximum depth of root, early humidity that penetrates in soil (in percent from total humidity)

Penman-Monteith equation is used to calculating potential transpiration and evaporation as follow: (yarahmadi, 2003:31):

$$ETo=\frac{0/408(R_n - T) + \lambda \frac{900}{T+273} U_2 (e_a - e_d)}{\Delta + \lambda(1+0/34u_2)}$$ Equation 1 Where λ is pisometric constant, ETO is evaporation and transpiration of reference plant in terms of mm per day. Rn is net radiation on area of crop in terms of (mj/day). G is stream of soil heat in terms of (mj/day). T is average of temperature degree (C°). u2 is wind speed in 2 meters height n terms of meter per second $(e_a - e_d)$,Δ deficit of water pressure in terms of (kpa), curve slope of water vapor pressure in terms of (kpa c), 900 is coefficient factor of conversion based on daily calculation.

Table 2: potential evaporation and transpiration which is obtained using the model for Zaraghan station

	JAN	Feb	M ar	apr	may	jun	Jul	A ug	S ep	oct	nov	D ec	A ve
Station	1.72	2.63	4.16	5.74	6.53	6.85	7.06	6.55	5.39	3.85	2.39	1.64	4.54

Effective rainfall, which is a part of total rainfall, is suitable for producing crops. In this research, CROPWAT model calculates effective rainfall amount using (USDA) method. In this method, it is supposed that crops can use 60 to 80 percentages of rainfall higher than 250 millimeters. Rainfall, which is higher than 250 millimeters in month, reaches use of crops from total rainfall to 10 percentages. In the other word, when rainfall increases, efficiency decreases (Yarahmadi, 2003:32).

Relation 2: Ptot<250mm when $Peff = \frac{Ptot(125-.2Ptot)}{125}$

Relation 3: Ptot<250mm when Peff = 125 +0.1Ptot

Where Peff is representation of effective rainfall in millimeter per month and Ptot is total rainfall in millimeter per month.

Table 3: estimation of effective rainfall in the station using CROPWAT model

	JAN	Feb	mar	apr	may	jun	Jul	A ug	S ep	oct	N ov	D ec	A ve
Station	63.3	53.9	42.5	37.9	12.3	0.6	0.3	0.4	0.3	1.9	18.5	60.1	292.1

Table 4: estimation of effective radiation using the model for Zaraghan station

	JAN	Feb	M ar	apr	may	jun	J ul	A ug	sep	oct	N ov	dec	A ve
Station	25.3	31.4	38.8	44.0	45.6	45.8	45.5	44.3	41.3	36.3	30.3	24.0	37.7

Table 5: wind speed in terms of knot

	JAN	Feb	mar	apr	may	jun	J ul	A ug	sep	oct	nov	dec	A ve
Station	2	3	4	3	3	3	3	2	2	2	2	2	3

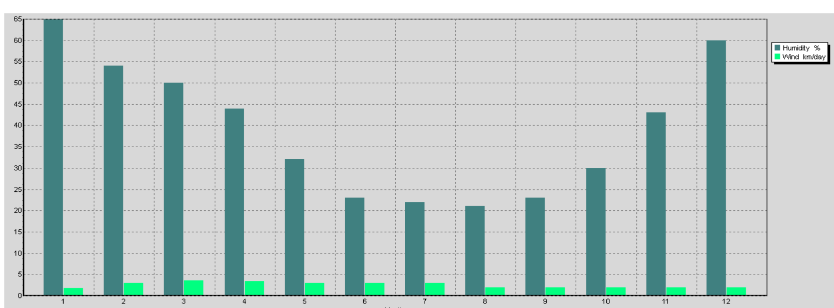

Diagram 2: wind and humidity

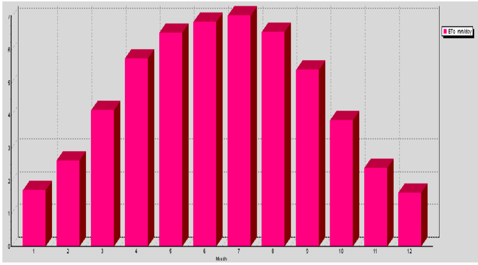

Diagram 3: diagram of evaporation and transpiration

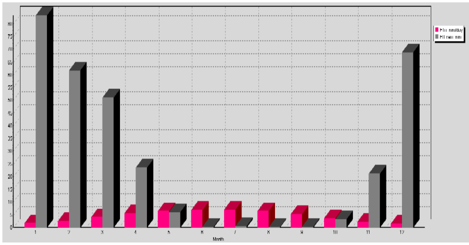

Diagram 4: comparison between amount of evaporation and transpiration and amount of effective rainfall

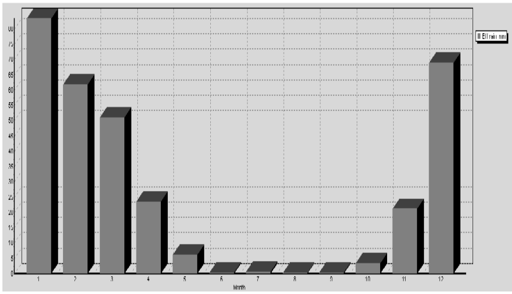

Diagram 5 :estimation of amount of effective rainfall

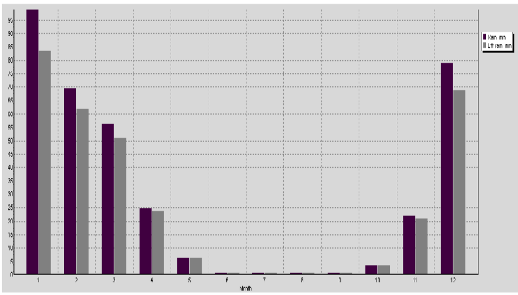

Diagram 6: comparison between amount of rainfall and amount of effective rainfall

The model calculates water requirements of the crop mased on folloing equation: (Faures J., et al, 2002:43)

Relation 4: CWR=ETo*Kc*cultivated area

ETo (mm/period): evaporation and transpiration of the reference

Kc: average of amount of crop coefficient for each time stage

CWR (mm/period): crop water requirement

Discussion and results:

Diagram 2 shows amount of humidity among different months of year and first 4 months of the year, last 2 months have high humidity, and during 6 months, humidity is low in the station. In addition, wind speed in terms of knot show that wind speed has a stable and slow process in all seasons of the year. Diagram 4 shows estimation of effective rainfall and in first 3 months and last 2 month there is effective rainfall in the town but in other 8 months, effective rainfall is so little and it reaches to zero in some months. According to diagram 3 which shows potential transpiration and evaporation process during seasons of the year, this process is normal and first and last months of the year have less evaporation and transpiration and middle of the year shows increase in evaporation and transpiration.

Table 6: estimation of water requirement and wheat irrigation using CROPWAT model in Zaraghan station

ETo station: Marvdasht — Crop: Wheat f.f.

Rain station: MARVDASHT — Planting date: 05/06/2014

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
May	1	Init	0.40	2.51	12.5	1.8	10.7
May	2	Init	0.40	2.61	26.1	1.5	24.7
May	3	Deve	0.41	2.73	30.0	1.0	29.0
Jun	1	Deve	0.43	2.91	29.1	0.5	28.6
Jun	2	Deve	0.45	3.08	30.8	0.0	30.8
Jun	3	Deve	0.47	3.24	32.4	0.1	32.4
Jul	1	Deve	0.49	3.41	34.1	0.2	33.9
Jul	2	Deve	0.51	3.57	35.7	0.2	35.6
Jul	3	Deve	0.53	3.62	39.9	0.1	39.7
Aug	1	Deve	0.55	3.67	36.7	0.1	36.6
Aug	2	Deve	0.57	3.70	37.0	0.1	36.9
Aug	3	Mid	0.58	3.60	39.6	0.1	39.5
Sep	1	Mid	0.59	3.40	34.0	0.1	34.0
Sep	2	Mid	0.59	3.17	31.7	0.0	31.7
Sep	3	Mid	0.59	2.87	28.7	0.4	28.4
Oct	1	Mid	0.59	2.57	25.7	0.3	25.4
Oct	2	Mid	0.59	2.27	22.7	0.4	22.2
Oct	3	Late	0.59	1.98	21.7	2.6	19.1
Nov	1	Late	0.51	1.47	14.7	4.1	10.5
Nov	2	Late	0.39	0.93	9.3	5.6	3.6
Nov	3	Late	0.29	0.61	4.3	8.0	0.0
					576.8	27.1	553.4

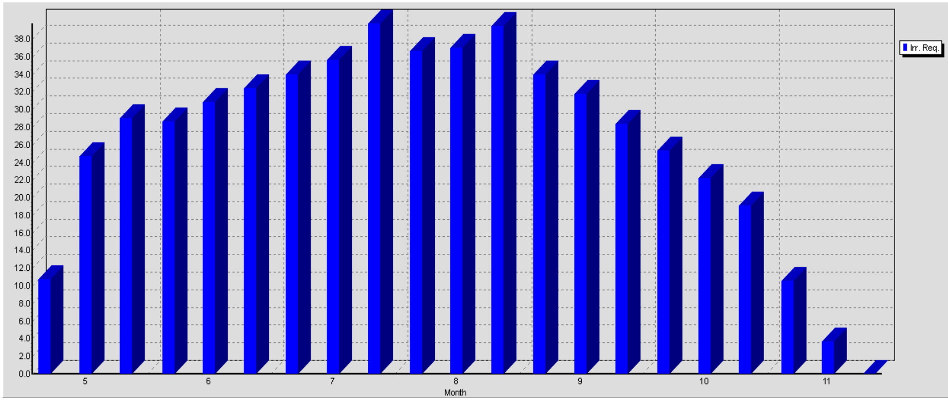

Diagram 6: estimation of water requirement and wheat irrigation using CROPWAT model in Zaraghan station

According to table 7 and diagram 6 which show amount of water requirement for wheat based on growth stages during season of the year, it is indicated that water requirement of wheat increases based on its growth stages and its water requirement decreases during last stages of its growth gradually. However, according to the table that shows amount of effective rainfall, we see increase in water requirement and decrease in effective rainfall. It means that rainfall amount decreases intensively as water requirement of the plant increases.

Conclusion

Based on obtained results, Abadeh station shows high figures regarding water requirement and irrigation for wheat crop due to low rainfall and high temperature during the year and longer dominance of dryness period. In such a way, that water requirement of wheat crop, which is obtained, based on amount of effective rainfall is 27.1 millimeters in this station during growth period and its water requirement is 553.4 mm during its growth period; while amount of potential transpiration and evaporation during wheat growth period is estimated 576.8 mm in this station. Based on the matter that main stages of wheat growth, which has a high water requirement, is coincidence with beginning of dry season of the year in this region, in such a way that 8 months of the year, weather is dry and there is water requirement and rainfall is not enough for farming. It means that amount of potential transpiration and evaporation is more than real transpiration and evaporation, soil is faced with humidity shortage and continuing this process results in stress on crop and lack of growth and its immaturity. Therefore, according to amount of shortage in soil humidity, which is obtained using the model for the station, gross amount of irrigation is estimated 872.7 mm and net amount of irrigation is estimated 610.4 mm and complementary irrigation is necessary during growth stages of the crop.

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