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Estimation of Water Requirement, Evaporation and Potential Transpiration of Brassica Napus L Plant in Ahwaz Town Using CROWPWAT Model

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Abstract

In present world, inequality and uncertainty is high in section of agriculture production and food security of a great amount of people in developing countries is not supplied. Based on studies of international organizations, about a third of produced food for human consumption in worldwide is lost or wasted. While in developing countries, there is price enhancement, decrease in access to healthy food and unhealthy nutrition of a great number of people due to weak infrastructure such as weak in food storage process and package method. Therefore, investment in agriculture sector is too important. We can help to food security by investment in agriculture sector and support and development of education and health in community so all the world can be beneficial. In this research, at the first, ecologic data (temperature and rainfall, sunshine hours, wind speed, relative humidity) are used using a 54 years long term average from 1951-2005 to estimating amount of evaporation and transpiration and water requirement of *Brassica napus L* for Ahwaz town. Then dry and wet durations were determined for the station. In addition, dry duration in this area, which takes a long from early spring to mid autumn, is accommodated with time of crop growth and its sensitivity to water shortage, hence, complementary irrigation is needed in this time of the year. Then, we calculated real transpiration and evaporation of *Brassica napus L* crop and water requirement and irrigation of this important crop in studied area using CROPWAT model. For this purpose, ecologic data average (maximum and minimum of temperature, monthly rainfall, wind speed, relative humidity and daily sunshine), crop cultivation pattern (implant date, coefficient amount of each stage of growth days, depth of root, depth of penetration), soil type, total accessible humidity, early humidity of the soil (in percentage from total humidity) and others are inserted in the model. Its results in each stage are presented as graphs and diagrams. Finally, based on these diagrams and graphs, the amount of net irrigation is estimated 2117.4 mm and amount of gross irrigation is estimated 1482.2 mm.

Key words: Food security, Potential transpiration and evaporation, Brassica napus L, Ahwaz, CROPWAT

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Introduction:

Food security is one of the most important strategies of different countries of the world, especially in present uncertain condition. Food security is a multifaceted natural, political and economic phenomenon. The importance of its natural issues depends on effective factors in production of fertile soil, qualitative and suitable quantitative water and suitable ecologic conditions. Population growth, effort on increasing social justice and welfare and healthy human as the base and objectives of developing requirement and access to food security has a special place, which some countries use it as a fatal weapon. In our country, Iran, reaching to food security is a priority for planners and managers especially by forward-looking approach due to establishing this country in a dry and semi-dry ecologic region with unstable condition and low confidence level of water resource and ecologic elements. According to emphasis on population growth and increasing demand in regarding food and condition of the country in water sources, Increasing need to food shows importance of water as the most fundamental agricultural element from point of evaluating determination of cultivation pattern and increasing efficiency in water source. Therefore, estimation of required water and evaluating establishment of irrigation networks is very important (Osamu et al, 2005:18).

More than 90 percentages of domestic consumption of edible oil in country is supplied through imports. Hence, it is deniable to make a long-term and coherent with objective of achieving self-sufficiency in producing edible oil. It is a while that *Brassica napus L* plant is considered as a suitable oil plant for cultivation in climatic condition of the country. So that nowadays, *Brassica napus L* is the center of plans of increasing production of oil seeds. According to condition of temperature and humidity, autumn cultivation of this plant is easily possible in most regions of the country. *Brassica napus* L is placed alternatively with other cultural crops especially cereals and it is effective in controlling diseases, pests and weeds of farms. Seed oil of all kinds of edible *Brassica napus L* has a very favorable quality. Finally, after oil extraction, remained meal is protein-rich and it is appropriate for using in livestock nutrition as fresh, silage and even dry feed. Palatability and high potential in producing dry and green feed (Aghaalijani, 1382) leads to considering this plant as future feed (Rezapour, 1387). It is one of most dominant oil seeds of the world in recent decades by having more than 40 percentages seed oil and protein-rich meal (FAO, 2007). Nowadays, this product is cultivated in many countries and its most producers are china, India, Canada, Germany, France and England. Under cultivation land of *Brassica napus* L in the world was 8.2 million hectares in 1970 and it reached to more than 30.2 million hectares in 2007 (Zhang, G,et.2006). . *Brassica napus L* oil seed in imported to the country from past years and 1993 is the base year of cultivating *Brassica napus L*. in this year 94.5 hectares *Brassica napus L* were caltivated in Iran and 51.2 tones. *Brassica napus L* were produced. By multiple researches on this product, under cultivation area of it had a considerable increase, so that about 8 years after, 2001, its cultivation reached to 70 thousands hectares by producing more than 65000 tones and in cultivation year of 2007-2008, this area is 230000 hectares and it is increasing every year (statistical journal of agriculture, 2007). This figure is increasing every year due to the place which *Brassica napus L* finds in Iran.

Oil seeds are the second food supply of the world after cereals. These productions have protein in addition to fatty acid-rich supplements. *Brassica napus L* is from *cruciferae* branch, which is a kind of natural *amphi-diploid* resulting from coincidence of oil kind of *B.rapa* with *B.oleracea* and doubling hybrid chromosomes. . *Brassica napus* L is considered as one of the most important oil seed in the world and it supplies 13 percentages of edible oil of the world. Its cultivation area is increasing all the time due to requirement of the country to oilseeds (Kakaei et al, 2009-a).

Our country requirement to food supplies especially to oilseeds is always one of stress of agriculture authorities and its policy makers. Agriculture activists advise Brassica napus L plant as a suitable product due to its unique properties in regarding product of feed and supplying edible oil and low water requirement and compatibility with the climate. This product attracted a various investigations about good culturing and inbreeding (Amin et al, 2002).
Dedicated portion of water to agriculture sector is decreasing rapidly due to increasing demands for urban and industrial water. Therefore, one of fundamental managements in agriculture sector is preparing conditions to maximizing product against consuming water (Ramezani Etedali et al, 1387). In recent decades, scientists and professionals of agriculture science and ecology conducted a broad research on agriculture ecology and tried to indentifying and detecting connection of ecologic factors and elements with cultivating and stages of product growth by offering different methods (Zare' Abiane, 1392).
Because of Special climatic condition of Iran which its dryness and inappropriate spatial and temporal distribution of rainfall is a undeniable reality, any kind of food production and agriculture depend on proper and logic use of water resources of the country (Ebrahimi Pak 1381). In this regard, we can say that irrigation water is the most important production element of agriculture production. It is reasonable that in a country such as Iran, which is located in an arid and semi-arid region of the world, economic productivity of water, is considered; because it is possible to reach to water acceptable productivity by a proper management method (Sepahvand, 1388). Non-optimal use of irrigation water, limitation of water sources and increasing need of human beings to more, varied and more appropriate food make a situation that irrigation engineers be thrifty in water consumption and increase irrigation efficiency by using modern management methods. This work is not possible without precise estimation of water requirement of the plant and adaptation of irrigation based on durative requirements of plants to water (in time and adequate irrigation) (3).
Evaluation of water requirement and proper and optimal condition for each plant product especially those, which are not native of the region, is a key step. CROPWAT model is one of efforts in this regard. Marica (2003) used this method in Romania for estimation and anticipation of main components of soil humidity equilibrium based on climatic seasonal anticipation in that country and he estimated soil storage condition 3 to 4 months ahead. Yarahmadi Kharajou et al (2003) used ASTER satellite images to determining type and area of cultivated crops and they used CROPWAT model to calculating evaporation and transpiration and water requirement of available plants in Salmas and Tasouj regions. The results of this research showed that balance in both plains especially in Tasouj region was completely negative and there is no reasonable relationship between available water source potential and amount of using it. Esmaeili (1385) used this model for management of low irrigation of corn in 2 regions of Shahrekord and Ghazvin. He concluded that estimation of the model in determining irrigation requirement is better than performance of dry matter. In addition, performance of dry matter is better than seed performance. Lashkari et al (1387) used WATERCAP and estimated amount of evaporation and transpiration and water requirement of wheat for west towns of Kermanshah province during a 18 years statistical duration from 1988-2005. Based on obtained results from estimation of the model, 2 or 3 irrigations are needed to preparing the crop for harvest. Ramezani Etedali et al (1387) used CROPWAT to estimating performance of two products of heat and grain under low irrigation management in Karaj climate through comparison of model results with obtained results from desert studies. They concluded that efficiency of water consumption in studied plants is obtained in range of 1.3 to 2.3 kilograms per meter and the maximum amounts are related to caring low irrigation of 20 percentages water requirement.
The objective of this research is evaluating CROPWAT model in estimation of water requirement and potential evaporation and transpiration of *Brassica napus L* product in Ahwaz in Khouzestan is one of agriculture pole of the country (first rank in under cultivation lands) and third rank of production volume

and efficiency. This town has an important place for developing agriculture and strategic production of the country.

Properties of study area:

Brassica napus L should be cultivated in advised date to producing maximum seed. This date is different in various regions. According to agriculture ministry research in 1386-87, the cultivation date of *Brassica napus L* in Khouzestan is first to 25^{th} of Aban.this seed is cultivated in towns of Omidieh, Andimeshk, Ahwaz, Izeh, Baghmalek, Behbahan, Dezfoul, Dasht-e-Azadegan, Ramshir, Ramhormoz, Sshadegan, Hendijan, Shoush, Shoushtar, Gatvand, Lali, Masjed Soleiman, Mahshahr and Haftgel (Agriculture ministry, 1387). In this research, Ahwaz station is investigated as a testifier.

Data and research method:

Data:

Used data in this research are Ahwaz synoptic station data. Table 2 shows properties of Ahwaz climatic station. Based on this table, the station average rainfall is 213 millimeter; minimum temperature and maximum temperature are respectively 17.6 and 23 centigrade.

Table 1: geographical position and calculated climatic parameters in study station during statistical years (1951-2005)

Station	Longitude	Latitude	Height	Average minimum Temperature	Average Maximum Temperature	Average Rainfall (Mm)	Average Relative humidity (percent)	Average Wind Speed (Knot)	Average annual sunshine hours
Ahvaz	48.4	32.1	22.5	17.6	22.9	213.4	43	5.0	3049

In addition, ambrotermic climate gram of the station is drawn as determining indicator of monthly time distribution of the region. Based on Ambrotermic diagram (diagram 1), Ahwaz station has two dry and wet climatic durations and wet duration started from late march and continues to late October (maximum water requirement of the plant). The wet duration started from early November and continues to march (minimum water requirement of the plant). Diagram 1: amberotermic diagram of Ahwaz town

Research method:

CROPWAT model is a supportive system, which is developed by water and land development section of FAO organization for planning and irrigation management. CROPWAT is a common application that meteorologists, agriculture professionals, and irrigation engineers use it for estimating standard calculation of evaporation and transpiration of water requirement source and crop irrigation. In addition, about management and management planning plans, this tool acts as a guide to improving irrigation operation and its time schedule when we are faced with water shortage (FAO, 1992:46). On the other words, it is a simple water balance model, which makes it possible to simulating humidity stress on the plant and calculating crop decrease based on developed methods of estimation of evaporation and transpiration and plant reaction to water stress. On the other words, this model can estimate amount of crop decrease due to low irrigation (Smith, 2004). To calculating amount of potential transpiration and evaporation (ETO), meteorology data including statistics of average temperature, averages of minimum and maximum temperature, average of relative humidity, average of wind speed and sunny hours. To calculating amount of effective rainfall (ER), average rainfall data are used. In addition, to calculating amount of absorbed water by plant root, information about texture, type and salt of the soil and penetration depth, this model is used. in addition, this model is used to irrigation scheduling from cultivation pattern including cultivation date, crop coefficient data and cultivated area (0-100 percentages of total area). Finally, amounts of net irrigation requirement (IR) are obtained by deducting effective rainfall amount (ETC).

Discussion:

According to structure of CROPWAT model, quantities of potential transpiration and evaporation are calculated based on penman-monteith method, effective rainfall, effective sunshine and wind speed. These calculations are described in following.

1) Potential transpiration and evaporation

Calculation of amounts of potential transpiration and evaporation are applied in calculation of requirement of consuming water (ETC) for different plants and designing draining, water storage and irrigation systems in addition to showing properties of a region climate (Mojarrad et al, 1383). It depends on many factors such as temperature, effective rainfall, wind speed, sunny hours, soil type, total available humidity in soil, maximum root depth, early humidity which penetrates in soil (in percent of total humidity) and reaches to its maximum if evaporation and transpiration water exists.

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

$$\text{ETo}=\frac{0/408(R_n-T)+\lambda\frac{900}{T+273}U_2(e_a-e_d)}{\Delta+\lambda(1+0/34u_2)}$$

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 (ea-ed),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: estimation of potential transpiration and evaporation for study station during statistical duration 1951-2005 using CROPWAT model

Station	Jan	feb	mar	apr	may	jun	jul	Aug	sep	oct	nov	dec	Aannual
Ahwaz	1.51	2.21	3.44	4.58	6.47	7.49	6.70	6.30	4.80	4.34	2.23	1.41	4.29

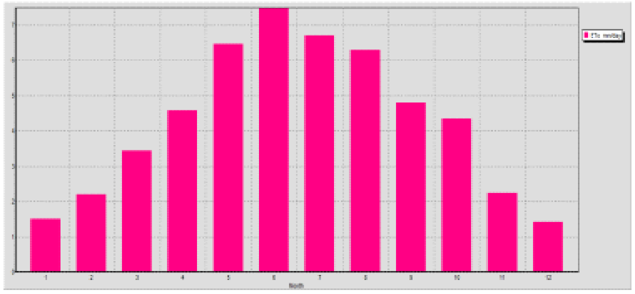

Diagram 2: diagram of obtained potential transpiration and evaporation using the model for Ahwaz town

2) Effective rainfall

Various field professionals and professionals of a unit field interpret the effective rainfall term differently. From engineers' viewpoint, irrigation that is reached to the storage directly or plane water-smooth from surroundings indirectly, is the effective part. Agriculture professionals consider a part of whole rain as effective rain, which is directly responsible to water requirement of the plant, and plane water-smooth, which can be pumped from lake or shaft to the farm (Dastin, 1362, pp 8-9). Effective raining is a very important indicator in agriculture crop production and it plays a vital role in growth stages of the plant. In this research, CROPWAT model calculates amount of effective rainfall based on USDA method. In this method, it is supposed that crops can use 60 to 80 percentages of rainfall higher than 250 millimeters. In higher than 250 millimeters in month, the amount of using crops from whole raining is only 10 percentages. In other words, when raining increases, its efficiency decreases (Yarahmadi, 2003:32).

Relation 2: Ptot<250mm when

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

Where here PEFF is presentation of effective rainfall in mm in month, PTOT is total rainfall in mm in each month. Table 3 shows the amount of effective rainfall of the station in order to cultivating *Brassica napus L* crop.

Table 3 : estimation of effective rainfall for study station during statistical duration 1951-2005 using CROPWAT model

Station	Jan	feb	mar	apr	may	jun	jul	Aug	sep	Oct	nov	dec	Aannual
Ahwaz	45.8	26.4	27.0	14.9	4.8	0.4	0.1	0.0	0.1	6.5	30.3	44.7	201.1

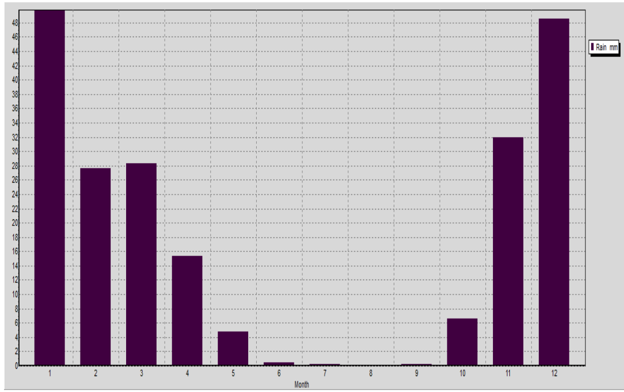

Diagram 3: diagram of effective rainfall for Ahwaz town

Effective radiation:

Table 4: estimation of effective radiation for study station during statistical duration 1951-2005 using CROPWAT model

Station	Jan	feb	mar	apr	may	jun	jul	Aug	sep	oct	nov	dec	Aannual
Ahwaz	20.5	23.8	28.6	31.2	40.8	45.6	38.0	35.3	30.1	34.9	23.1	19.0	30.9

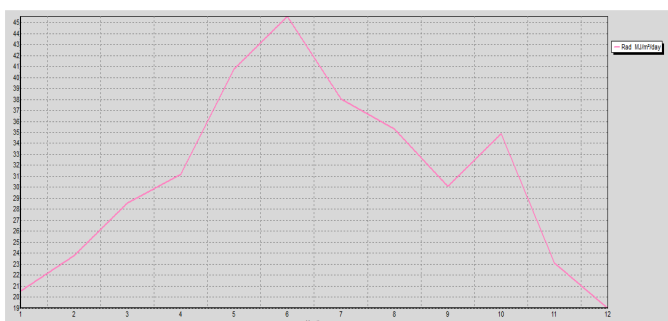

Diagram 4: diagram of effective radiation for Ahwaz town

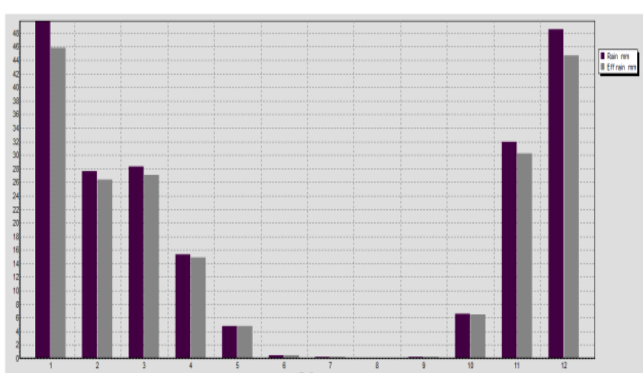

Diagram 5: diagram of comparison between potential transpiration and evaporation with effective rainfall for Ahwaz town using CROPWAT model

Wind speed:

Table 5: wind speed in terms of knat in Ahwaz town:

Station	Jan	feb	mar	apr	may	jun	jul	Aug	sep	Oct	nov	dec	Aannual
Ahwaz	3.8	4.3	5.2	5.6	6.1	7.2	6.5	5.7	4.7	3.7	3.6	3.5	5.0

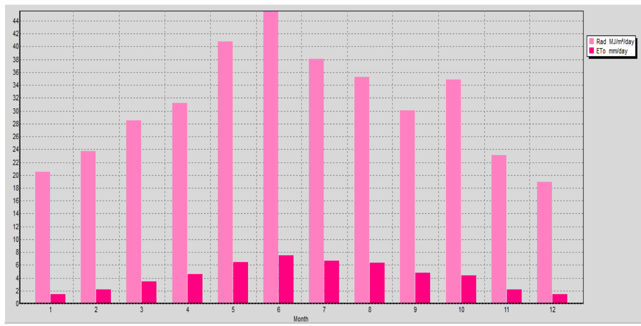

Diagram 6: diagram of comparison between potential transpiration and evaporation and estimated radiation using the model in Ahwaz town

Diagram 2 is diagram of potential transpiration and evaporation obtained by CROPWAT model during statistical duration 1951-2005 shows a normal distribution; in such a way, that amount of evaporation and transpiration trended to increase gradually from March and it reached to its maximum amount in Juan (7.49); and it showed its minimal amount in November(1.4). According to table 3, amounts of effective rainfall, which are obtained from the model, are presented. Based on figures in this table, in duration of plant growth, effective rainfall decreases gradually from April, May, Juan, July, August and September and it even reaches to zero. From October, November and December which in, the plant passed its growth duration, effective rainfall shows an increasing trend. It indicates shortage of water and irrigation and need to complementary irrigation in plant growth duration. Based on table 4 which presents obtained effective radiation for the study station, we can see that temperature increased gradually from February and reached to its maximum during April, May, Juan, July and August. This matter approves above subject. Based on diagram 5, which is a comparison between potential transpiration and evaporation with obtained effective rainfall, by the model, we can see that effective rainfall amount decreases along with months which in, evaporation and transpiration increase and water requirement supply of the plant faces with fundamental problem during vital growth duration. According to diagram 6, based on comparison between potential transpiration and evaporation with estimated radiation by the model, it is indicated this relationship that during those months which in evaporation and transpiration increase, radiation is increase, too and water requirement of the plant enhances.

CROPWAT model calculates crop water requirement vased on below equation: (Faures et al, 2002:43)

Relation 4 CWR=ETo*Kc*cultivated area

Where ETO is amount of evaporation and transpiration of the reference crop in terms of millimeter per day, KC is average of crop coefficient for each time stage and CRW is water requirement of the crop in terms of millimeter per day.

Table 6: estimation of water requirement and irrigation of Brassica napus L in Ahwaz town using CROPWAT model

Crop Water Requirements

ETo station: Ahwaz   Crop: CANOLA

Rain station: Awaz   Planting date: 28/04

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Apr	3	Init	1.00	5.21	15.6	1.1	15.6
May	1	Init	1.00	5.84	58.4	2.6	55.9
May	2	Deve	1.06	6.87	68.7	1.3	67.3
May	3	Deve	1.28	8.74	96.2	0.9	95.2
Jun	1	Deve	1.51	11.02	110.2	0.5	109.7
Jun	2	Deve	1.73	13.31	133.1	0.0	133.1
Jun	3	Mid	1.93	14.18	141.8	0.0	141.8
Jul	1	Mid	1.96	13.64	136.4	0.1	136.4
Jul	2	Mid	1.96	13.13	131.3	0.0	131.2
Jul	3	Mid	1.96	12.86	141.5	0.0	141.5
Aug	1	Late	1.93	12.54	125.4	0.0	125.4
Aug	2	Late	1.75	11.20	112.0	0.0	112.0
Aug	3	Late	1.54	9.04	99.5	0.0	99.5
Sep	1	Late	1.33	6.98	69.8	0.0	69.7
Sep	2	Late	1.13	5.33	53.3	0.0	53.3
Sep	3	Late	1.00	4.56	18.2	0.1	18.1
					1511.4	6.7	1505.8

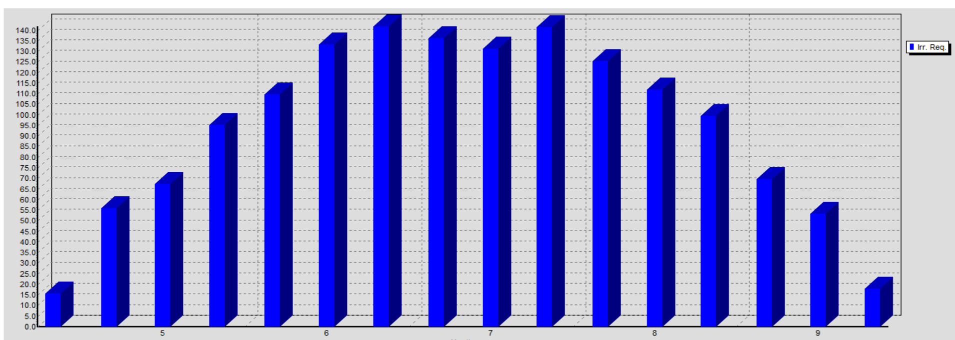

Diagram 7: diagram of estimation of water requirement of *Brassica napus L* plant for Ahwaz town using the model

According to table 6 and diagram 7 which show water requirement of plant during growth duration, it indicates that amount of evaporation and transpiration is increased during the season, which in plant is passing its fundamental stages of growth and this time, amount of effective rainfall decreases while plant requirement for rainfall and irrigation is so intensive and essential. Therefore, we should supply the plant requirements in these seasons by irrigation methods.

Conclusion:

Realistic cultivation of the crop depends on proper understanding of ecologic conditions. Awareness from amount of annual rainfall, growth duration, effective rainfall and amounts of water requirement for agricultural planners helps considerably to reducing risks of product processing and optimal use from limited water sources. Usually, potential transpiration and evaporation are used as one of required

important parameters for agricultural planning especially in calculating amounts of water requirements for agro products. Proper estimation of evaporation and transpiration amounts enables planners to prepare other water requirements from other sources such as rivers, dams and shafts by determining top of water requirement, in addition to supplying a part of requirement through rainfall and finally effective rainfall.
In this research, amounts of net irrigation requirement in Ahwaz town is calculated based on effective rainfall, water consumption requirement of plant and amount of absorbed water by root and related diagrams are presented. In such a way, that water requirements of *Brassica napus* L product, which is obtained, based on amount of effective rainfall using the model in the station was 6.7 mm per day. Its irrigation requirement was 1505.8 mm per growth duration; while amount of evaporation and transpiration is estimated 1511.4 mm in this station during growth duration of *Brassica napus L*. therefore, it faces with rain shortage and dryness. According to a matter that *Brassica napus* L needs a high water requirement for completion of physiological processes during fundamental stages, hence, beginning of growth season of the plant in this region is along with evaporation and transpiration increase and radiation and dryness increase and decreasing rainfall. Therefore, soil loses its early humidity due to evaporation and weather heat and the plant gives dry stress and hurts if it will not be irrigated in this stage and its required water will not be supplied. Hence, according to amount of soil humidity shortage, which is obtained using the model for the station, net amount of irrigation is 2117.4 mm and gross amount of irrigation is estimated 1482.2mm.

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