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Determination of water needs using the Cropwat and Aquacrop models for some crops in arid regions (Touggourt and Ouargla)

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ABSTRACT:

Background: In the Northern Sahara unfortunately no plant domesticated by man can vegetate without a supply of water.The goal of irrigation is to maintain a moist bulb around the roots of the crop. The use of modeling is one of the most recent and effective means for determining irrigation regimes.
Objective: AquaCrop and Cropwat are FAO models used to calculate water balances, as well as estimate crop water needs and evaluate yields. Given that they present differences in the calculation methodology **Methods:** we opted in this work to compare the water needs provided by these two models for sunflower, wheat, cotton and esparto in Ouargla and Touggourt. The Climwat model is used to obtain climate data.
Results: The results obtained from evapotranspiration and water requirements provided by cropwat are higher than those of aquacrop for sunflower and wheat, and lower for Alfafa and cotton. The evapotranspiration of the sunflower in Touggourt provided by the cropwat is 563.3 mm and that of the AquaCrop is 494.9 mm and in Ouargla respectively, 611.4 mm and 575.6 mm.For Alfafa in Touggourt 1251.6 mm / 1506.7 mm and in Ouargla 1267.5 mm / 1606 mm. For cotton in Ouargla 1040.6 mm / 926.2 mm and in Touggourt 968.5 mm / 852.4 mm.For wheat in Touggourt 881.4 mm / 989.2 mm and in Ouargla 963.6 mm / 1089.8 mm. The results obtained for effective rainfall provided by cropwat are superior to those of aquacrop.
Conclusion: In Ouargla those of cropwat are around 37.1 mm and those of Aquacrop 36.1 mm. Conversely for Touggourt 74.3 mm and 72.7 mm.

Keywords: Climwat ; Cropwat ; Aquacrop ; Evapotranspiration ; Water requirements; Crops.

1. Introduction

In the Saharan zones, water needs are firstly high due to climatic conditions and secondly increasing, particularly in the agricultural sector which accounts for 70% of water consumption in the world [FAO, 2011].Faced with insufficient rainfall, irrigation has emerged as the best way to limit the fluctuation of productivity from one year to the next.
It is essential to provide plants with enough water when they need it most. Generally speaking, the soil must be humidified (irrigation or precipitation) to maintain water dose reception at the desirable level and obtain maximum crop yield.The irrigation water requirements of a crop represent the quantity, time and frequency of water applications necessary to compensate for soil water deficits during its growing period.
Water requirements, as well as the period and quantity of irrigation water vary depending on the stage of development of the crop, climatic factors [Allen et al., 1998], environmental conditions and soil profile.They are evaluated based on climatic demand and the crop coefficient [Tiercelin, 1998].Crop water requirements are defined as the amount of water necessary to satisfy evapotranspiration [Dorrembos and Pruitt, 1977].

There are several processes, formulas or experimental methods for determining watering and irrigation doses. Recently, many authors have moved towards the use of agrometeorological models for the calculation of water balances, as well as the assessment of crop water requirements and yields.
To this end, in all regions of the world, and particularly in arid regions, simulation models are used which relate crop development to water efficiency.These models study crop reactions to environmental stresses to test management practices [Boote et al., 1996; Sinclair and Seligman, 1996] as well as cost-effective irrigation techniques [Lobell and Ortiz-Monasterio, 2006; Heng et al. 2007]. They have been widely developed and also used to simulate the development, production and water requirements of crops at the plot scale.[Zhang and al., 2002].
Modeling is a research tool, which makes it possible to synthesize known information and identify gaps.[Daalen and Shugart 1989]. It can be defined as a means of conceptual formalization of a system, expressed in the form of one or more hypotheses [Van Ittersumand Donatelli, 2003].
The model can therefore be considered as a simplified representation of a real system.It allows the simulation of the impact of future management scenarios before their implementation.It is used in fundamental research to better understand the relationships between plants, soil and the environment, in order to make yield predictions, risk analyzes (e.g. effects of sowing dates) and to develop priorities for research in order to reduce the costs associated with experimentation.
Among these models that can be described as ―agrometeorological‖ or even ―contextual‖, we find the AquaCrop and Cropwat models[Stedutoand al., 2009]. These are developed by the FAO (Food and Agriculture Organization of the United Nations), and are intended for predicting crop production under conditions of water stress.
Semi-empirical agro-meteorological models combine the Monteith equation with some major processes to take into account the main phases of the plant development cycle (emergence, growth and senescence).They have a limited number of formalisms and parameters and, like ―simple‖ models, they are adapted to the study of large areas and specifically designed for cases where input data is limited.[Maas, 1993 ; Liu and al., 2010].
We therefore opted in this study to use these two models to determine the water requirements of crops (sunflower, Alfafa, wheat and cotton) in arid regions (Ouargla and Touggourt).In combination with these models, we also use the Climwat model as a climate database.

2. Material and methods

2.1 Used Models

Cropwat Model

The cropwat model provides an estimate of water needs based on crop species, local climatic and environmental conditions.It used by farmers and planners to better manage water resources.It is an aid for crop irrigation developed in 1992 by the FAO(Food and Agriculture Organisation of the United Nations), based on the calculation of the water balance.He develops water supply schemes.The model calculates the reference evapotranspiration, based on the modified Penman-Monteith equation and based on meteorological data.It also offers the possibility of developing a crop irrigation schedule, evaluating the effects of lack of water on crops, as well as the efficiency of different irrigation practices.[Van Laere, 2003].

AquaCrop model

The AquaCrop model was developed in 2009 by the Land and Water Division of FAO (United Nations Food and Agriculture Organization) [Steduto et al., 2009; Raes et al., 2009] from the crop yield water response algorithm[Doorenbos and Kassam, 1979]. AquaCrop was therefore

developed to increase water use efficiency in food production.[Araya and al. 2010]. To model plant growth.It is based on climatic factors, phenological parameters and soil parameters.It is based on the transfer of water between the soil, the plant and the productivity of the crops.

This model has been verified and tested for several types of crops [ARAYA and al., 2010; ZELEKE and al., 2011; STEDUTO and al., 2012] such as corn [Oiganji, 2016], barley [Abrha et al., 2012], winter wheat [Iqbal et al., 2014], sunflower and sugar beet, market gardening such as cabbage [Wellens and al, 2013] and under several environmental and climatic conditions [Stricevicand al., 2011].

Input data

Both models require climatic data (rain in mm, minimum and maximum temperatures in C°, relative humidity in %, wind speed in m/s and insolation in hours), crop data (date planting and harvesting, phenological stages, rooting depth, crop coefficient Kc, crop height and crop cycle), soil data (the number of horizons, apparent density, saturation hydraulic conductivity, permeability, soil water contents at saturation (ϴsat), at field capacity (ϴFC) and at permanent wilting point (ϴPF) and initial content).These parameters can be obtained using experimental research [Stedutoand al., 2009, Vanuytrechtand al., 2014]. In this study, they are derived from the Climwat software

For its part, AquaCrop requires additional cultivation (zero vegetation, duration of flowering stage, density of plants, type of crop C3 or C4, time of emergence, maximum coverage canopy, harvest index, type of planting method and cultural practices such as fertilization, and salinity).

Output data

Once all the input data has been entered, the AquaCrop and Cropwat models automatically calculate the results and display them either in the form of tables or graphs.The output data for both models are: potential evapotranspiration, effective rainfall, irrigation water requirements, crop water requirements and irrigation schedule.AquaCrop also estimates yield, biomass, water productivity and separately quantifies Evaporation and Transpiration.And Cropwat determines the total gross irrigation, total net irrigation, harvest water deficit, precipitation efficiency and average crop coefficient values for each time step.

Climwat model

Climwat is a joint publication of the FAO Water Development and Management Unit and the

Climate Change and Bioenergy Unit.This model provides agro-climatic data observed from more than 5,000 stations around the world.
The input data are: the country, the study area and the meteorological station closest to the study site. [Debauche and al, 2011]
The output data are long-term monthly average values of seven climate parameters, namely: average daily maximum temperature in °C, average daily minimum temperature in °C, average relative humidity in %, average speed wind in km/day, average sunshine hours per day, average solar radiation in md/m2/day, monthly precipitation in mm/month, and reference evapotranspiration calculated with the Penman-Monteith method in mm/ day. [Raes et al,2012]

2.2Used Crops

The choice of crops focused on crops tolerant to dry conditions, which adapt to all types of soil, particularly sandy and which have often given a good yield in arid regions.

Sunflower

The scientific name of the sunflower, Helianthus annuus Linnaeus, refers to the characteristic shape of its compound inflorescence, the flower head.It comes from the Greek words Helios and Anthos which mean –sun‖ and –flower‖ respectively [Evon Philippe, 2008].
The plant has an erect habit, with a single or slightly branched stem, with a height varying from 1 to 1.2 m, the yellow flowers are grouped in a flower head at the end of the stem.The seeds borne are oval, flat, black or gray in color.If the root system does not encounter any obstacles, it can explore the soil up to 2 meters.The sunflower adapts to all types of soil and grows well in sandy textured soils.The sunflower is an annual plant and is tolerant of hot and dry climates [Morizet, J., Merrien A 1990.] thanks to its root system which allows it to extract water from the soil better than others [Cabelguenne and Debaeke , 1998].But it is resistant to drought, provided that water stress is avoided during flowering (critical phase).[Lecomte Vincent, 2024]
Sunflowers are mainly grown for their oilseeds, the oil content of which varies from 25 to 40% depending on the variety. [ITGC 2013]The whole plant harvested before maturity is used as fodder.
Several studies have shown that the yield gain and profitability of irrigation could be significant in certain economic, climatic and hydraulic contexts [Merrien and Grandin, 1990; Unger, 1990; Goksoiand al., 2004; Demir andal .,2006].
However, the benefit of irrigating sunflowers must not be evaluated only at the scale of the plot but also at the scale of the farm or the collective of irrigators, particularly in a context of limited resources [Jacquin and al., 1993; Lorite et al., 2004; Deumierand al., 2006].Furthermore, the insertion of sunflowers into the irrigable soil, whether or not with a view to irrigation, can meet other imperatives, particularly organizational or agronomic.

Alfalfa

Alfalfa is a member of the Leguminosae or Fabaceae family [Cumo, 2013]. It is also known under the name Alfalfa [Botineau, 2010].
Alfalfa or alfalfa is a perennial herbaceous plant with an erect stem from the base, branched and angular, which can reach 60 to 70 cm in height**.**The alternate petiolate leaves with 3 oblong leaflets, denticulate at the top, are obtuse and a little notched at the top with a mucron towards the middle of the notch.It resists drought particularly well [Lemaire, 2006] and adapts to sandy soils.Its greatest development is found in warm temperate zones where it finds its greatest development.[Mazoyerand al, 2002]. It can be sown in the fall or in the spring. It is a plant grown mainly for livestock feed or other purposes. [Rita A. and al 2017]. Its durability gives it the ability to contribute to the sustainability of rainwater systems [Volaire and Norton, 2006]. Alfalfa, a covering plant, limits water loss through evaporation.
In arid Mediterranean areas, alfalfa is often irrigated and faces salt stress. The search for cultivars better adapted to this situation is a priority [Ibriz and al, 2004].

Cotton

The cotton plant is a perennial plant that grows in arid tropical or subtropical climates. It is present on five continents with different varieties as well as cultural practices. It needs warmth, sun and water. [Ezan Marc and al. 1998] It requires a loamy or clay-sandy or sandy soil in which it can sink its strong pivot roots deeply and thus develop in the best conditions. The leaves of the cotton plant are webbed and measure between 12cm and 15cm long and wide and are placed in a spiral every 5cm to 8cm, along the main stem. The height is 1.3m Its particularly developed root system (its length can sometimes reach double the height of the plant). The first leaves appear between a week and a month after sowing. Flowering appears after a month and a half to two months and continues regularly over several weeks. The harvest is done once the cotton has reached maturity, between 6 and 9 months after sowing. [OECD/FAO, 2023].
We can obtain from the seeds of the cotton plant a good quality edible oil, practically odorless, rich in polyunsaturated fatty acids and without cholesterol. It constitutes the sixth vegetable oil in the world. [Cretenet M and Dessauw D, 2006]

Wheat

Cereals are cultivated in Algeria over large areas of the country mainly in the high plains and high plateaus due to their strategic interest in the territory, with an average of 3.3 million hectares sown each year with durum wheat, soft wheat and barley (not including fallow), i.e. 29% of the UAA, including 62% cultivated only in wheat [DSASI, 2018]. Wheat is found mainly in the countries of the Mediterranean basin with arid and semi-arid climates. [Abeledo L.G, and al; 2008]. In Algeria, durum wheat (Triticum durum Desf.) has acquired a true symbolic value over the centuries, due to its importance in agriculture and human nutrition. Wheat is a plant that belongs to the class of monocots, of the family Poaceae (graminaceae) [Feillet, 2000].
Its grain constitutes a basic product in the Algerian diet (couscous, bread, etc.), it is also considered a very large resource of proteins and carbohydrates. It also contains amino acids, lipids and vitamins. In addition, its by-products (straw) are used as livestock feed [Godon, 1985].

Drained and deep soils [Doorenbos and Kassam, 1979], loamy, clay-limestone soils and clay-siliceous soils and with fine elements are best suited to wheat.[Soltner, 2000)] Wheat also gives good yields in sandy soils.

Wheat requirements are generally between 550 to 600 mm. Wheat needs 4 to 5mm per day during the bolting, a period which sees the development of a main component for yield [Moule, 1980].

3. Results and Interpretation

The needs of the plant vary depending on the climatic conditions, the stages of development and the biology of the plant, its place in the cultivation of the palm grove, the nature of the soil and the state of its filling [Toutan, 1979].

Climatic factors

Climatic synthesis is an essential step for irrigation and determining water needs. It consists of determining climate indices in order to arrive at climate trends, its characteristics and describe these variations [Allam Salah,2014] Meteorological parameters are key factors in the seasonal distribution of irrigation and evapotranspiration. And some of them are found in all the formulas for determining water needs. The climate data determined by the Climwat model mainly concern precipitation, maximum and minimum temperatures, winds, insolation, air humidity, solar radiation and reference evapotranspiration calculated with the Penman-Monteith method. The climatic factors provided by the Climwat model are summarized in Table 1 for Touggourt and in Table 2 for Ouargla.

Table 1: Climatic factors provided by the Touggourt Climwat model

Months	Tmin	Tmax	H	Wind	I	Ray.	Rain	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm	mm/day
January	3,3	16,7	79	164	6,6	11,2	15	1,5
February	5,6	19,4	75	216	8,2	15,1	3	2,32
March	8,9	23,3	69	251	8,5	18,6	7	3,52
April	12,8	28,3	67	251	9	21,8	4	4,75
May	17,2	32,8	61	251	10,3	25	12	6,17
June	22,8	37,8	59	251	10,1	25,1	1	7,18
July	25	41,7	46	156	11,4	26,7	1	7,58
August	23,9	40,5	59	156	10,9	24,9	0	6,86
September	21,1	36,1	60	147	9,6	20,8	4	5,42
October	15	28,9	71	164	7,9	15,6	4	3,53
November	8,9	22,2	85	147	6,6	11,7	8	1,91
Décember	4,4	17,2	87	138	6,6	10,5	18	1,29
Average	14,1	28,7	68	191	8,8	18,9	77	4,34

Table 2: Climatic factors provided by the Ouargla Climwat model

Months	Tmin	Tmax	H	Wind	I	Ray.	Rain	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm	mm/day
January	4,4	17,2	62	181	6,8	11,8	7	2,04
February	6,7	20	57	199	8	15,3	5	2,87
March	9,4	23,3	43	181	8,9	19,3	8	4,04
April	13,9	28,9	50	216	9,4	22,5	1	5,38
May	17,8	32,8	42	216	9,6	24,1	1	6,56
June	23,3	39,4	36	207	9,5	24,3	0	7,74
July	25,5	42,8	39	173	11,2	26,5	0	8,05
August	25	41,7	41	181	10,3	24,1	0	7,62
September	22,2	37,2	50	190	9	20,2	4	6,17
October	16,1	30,5	58	207	8,1	16,2	3	4,48
November	10	23,3	77	181	7	12,4	6	2,38
Décember	6,1	18,3	73	181	6,7	11	5	1,82
Moyenne	15	29,6	52	193	8,7	19	40	4,93

Tmin: Minimum monthly temperature in °C. Tmax: Maximum monthly temperature in °C. H: Air humidity in %. Wind: Average wind speed in km/day. I: Insolation in hours per month Ray: Average solar radiation in mj/m2/day P: Monthly precipitation in mm/month, Eo: Reference evapotranspiration calculated with the Penman-Monteith method in mm/day

Minimum monthly temperatures vary in Touggourt from 3.3 to 25°C with an average of 14.1° and that of Ouargla from 4.4 to 25.5°C with an average of 15°. Maximum monthly temperatures vary in Touggourt from 16.7 to 41.7 °C with an average of 28.7 and that of Ouargla from 17.2 to 42.8 °C with an average of 29.6. Air humidity varies in Touggourt from 71 to 87% with an average of 68% and that of Ouargla from 36 to 77% with an average of 52%. Wind speeds vary in Touggourt from 138 to 251 km/day with an average of 191 and that of Ouargla from 181 to 216 km/day with an average of 193 km/day.

Sunstroke varies in Touggourt from 6.6 to 11.4 hours with an average of 8.8 hours and that of Ouargla from 6.7 to 11.2 hours with an average of 8.7 hours. Solar radiation varies in Touggourt from 11.2 to 25.1 with an average of 18.9 MJ/m²/day and that of Ouargla from 11 to 26.5 MJ/m²/day with an average of 19 MJ/m²/day . Monthly precipitation varies in Touggourt from 0 to 15 mm with a cumulative of 77mm and that of Ouargla from 0 to 8 mm with a cumulative of 40mm. The reference evapotranspirations vary in Touggourt from 1.5 to 7.58 with an average of

4.34mm/d and that of Ouargla from 2.04 to 8.05mm/d with an average of 4.93mm/d.

Effective rain

Effective precipitation plays an important role in irrigation and irrigation depends on its quantities. For agricultural production, effective precipitation refers to the fraction of precipitation that can be effectively used by crops. Interannual variations in total effective rainfall for Ouargla are shown in Figure 1 for Ouargla and in Figure 2 for Touggourt.

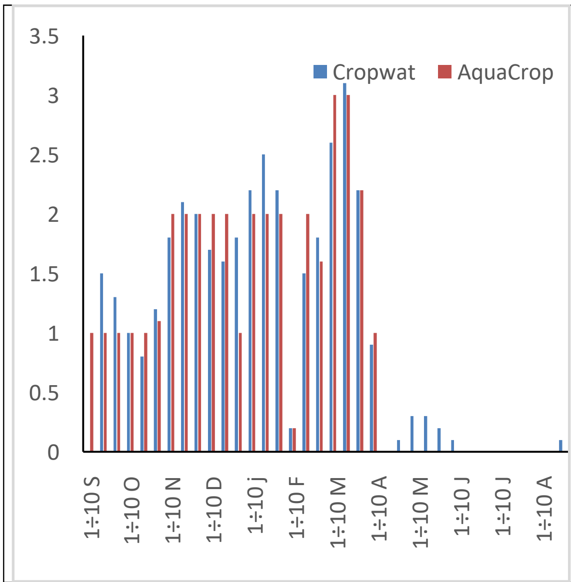

Figure 1: Effective rainfall from Ouargla

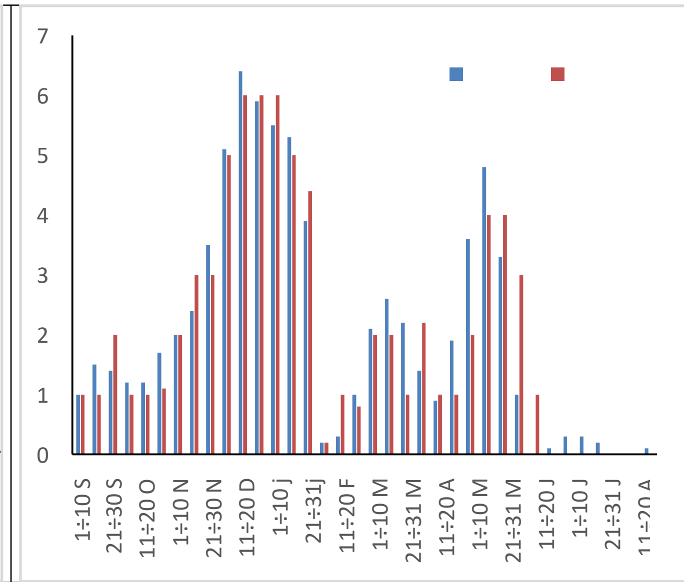

Figure 2: Effective rainfall from Touggourt

The graphs show the effective rainfall determined using cropwat at Ouargla is of the order of 37.1 mm, and fluctuates between a minimum 00 mm and a maximum 3.1 mm in March. And that of Touggourt is of the order of 74.3 mm, and fluctuates between a minimum 00 mm in and a maximum 6.4 mm in December.

For that determined using Aquacrop in Ouargla is of the order of 36.1 mm, and fluctuates between a minimum 00 mm and a maximum 3 mm in March. And that of Touggourt is of the order of 72.7 mm, and fluctuates between a minimum 00 mm and a maximum 6 mm December.

Evapotranspiration

Evapotranspiration is an important parameter for determining the dose and irrigation programs, planning and management of irrigation water in agriculture. [Xu and Singh, 1998]. It corresponds to the total quantity of water transferred by evaporation from soil surfaces and physiological transpiration of plants and plants from the soil/plant complex to the atmosphere. The evapotranspirations of sunflower, alfafa, wheat and cotton in Touggourt and Ouargla provided by the Cropwat and Aquacrop models are represented in the figures (from 3 to 10).

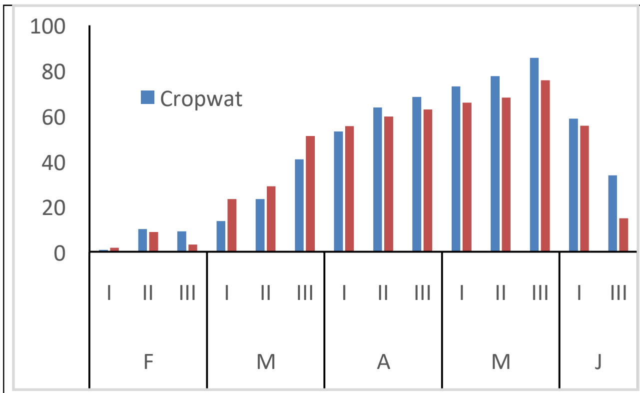

Figure 3 : Evapotranspiration Ouargla

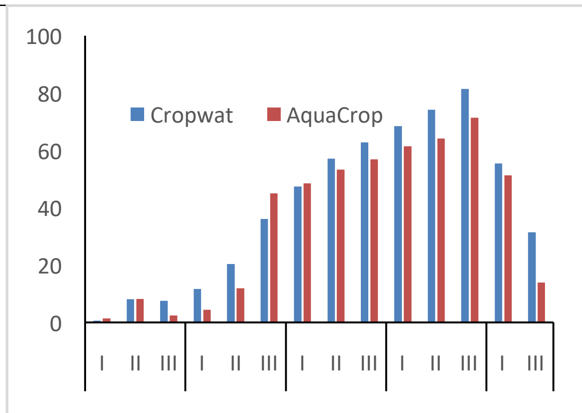

Figure 4 : Evapotranspiration

SunFlower

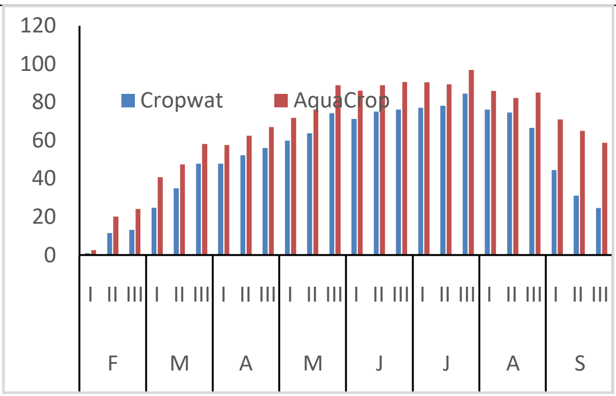

Figure5 : Evapotranspiration Ouargla Alfafa

Touggourt SunFlower

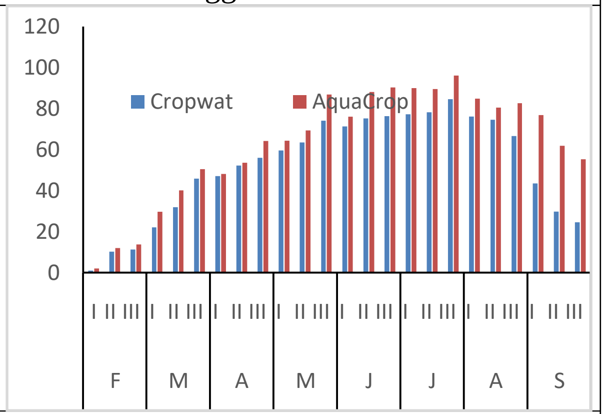

Figure 6 : Evapotranspiration Touggourt Alfafa

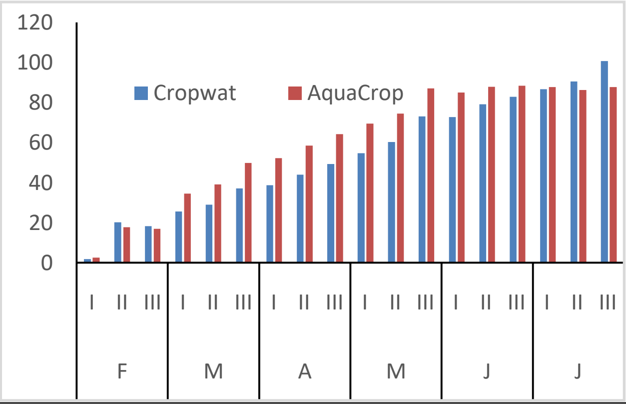

Figure 7: Evapotranspiration Ouargla Wheat

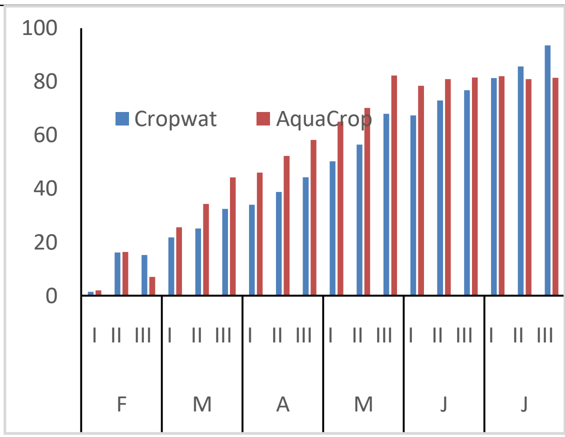

Figure 8 : Evapotranspiration TouggourtWheat

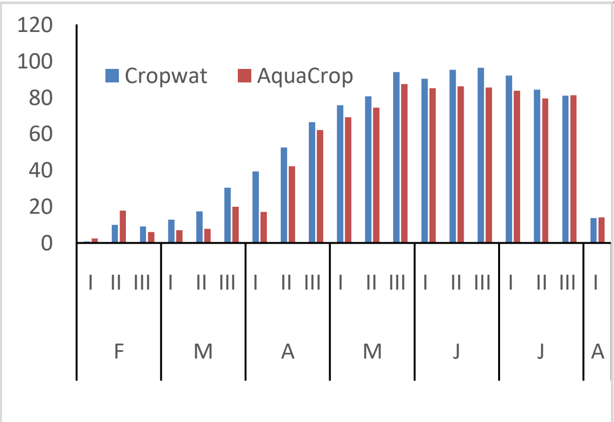

Figure 9: Evapotranspiration Ouargla Cotton

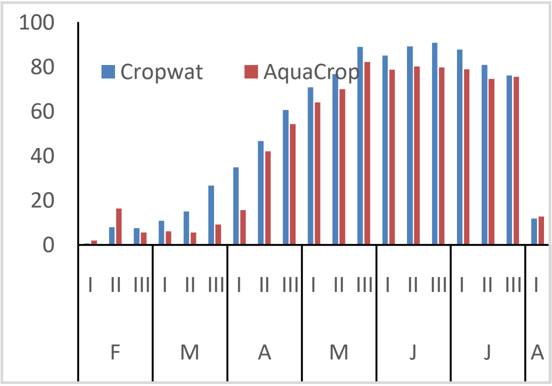

Figure 10 : Evapotranspiration Touggourt Cotton

Case of the sunflower

For cropwat, evapotranspiration at Touggourt equal to 563.3 mm varies from 0.7 to 81.5 mm. And for the AquaCrop equal to 494.9 mm, varies from 1.5mm to 71.4mm.

For Ouargla, the evapotranspiration provided by the cropwat is equal to 611.4 mm and varies from 0.9 to 85.6 mm. And for the AquaCrop equal to 575.6 mm, varies from 1.9mm to 75.7 mm. For both regions, the minimum values are in February and the maximum in May.

Case of Alfalfa

For cropwat, evapotranspiration at Touggourt equal to 1251.6 mm varies from 1 to 84.5 mm for cropwat. And for the AquaCrop equal to 1506.7 mm, varies from 2 mm to 96.1 mm

For Ouargla, the evapotranspiration provided by the cropwat is equal to 1267.5 mm and varies from 1 mm to 84.5 mm. And for the AquaCrop equal to 1606 mm, varies from 2.5 mm to 96.9

mm

Case of cotton

For both regions, the minimum values are in February and the maximums are in June for cropwat and in May for aquacrop.

For cropwat, evapotranspiration at Ouargla equal to 1040.6 mm varies from 0.9 to 96.2 mm. And for AquaCrop equal to 926.2 mm and varies from 2.5 mm to 87.2 mm.

For Touggourt, the evapotranspiration provided by the cropwat is equal to 968.5 mm and varies from 0.7 to 90.7 mm. And for AquaCrop equal to 852.4 mm, varies from 2 mm to 82.1 mm

For wheat

The minimum values are in February and the maximum in July for cropwat and June for aquacrop

For cropwat, evapotranspiration at Touggourt equal to 881.4 mm varies from 1.4 to 93.6 mm. And for the AquaCrop equal to 989.2 mm, varies from 2 mm to 82.3 mm.

For Ouargla, the evapotranspiration provided by the cropwat is equal to 963.6 mm and varies from 1.8 to 100.7 mm. And for the AquaCrop equal to 1089.8mm, varies from 2.5 mm to 88.4 mm.

Water requirements

The water requirement is defined as the volume of water that must be provided by watering in addition to rainfall.

To calculate irrigation water requirements at field level for a given crop, it is necessary to establish a water balance, which is carried out by measuring all natural inputs or water inflows and any water losses or outflows made to the field. scale of a cultivated plot [Zella, 2015].

The water requirements of sunflower, esparto, wheat and cotton in Touggourt and Ouargla provided by the Cropwat and Aquacrop models are shown in figures (11 to 18).

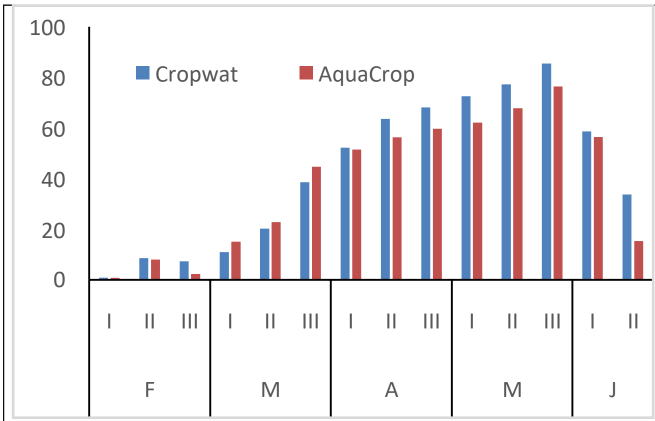

Figure 11: Sunflower needs in Ouargla

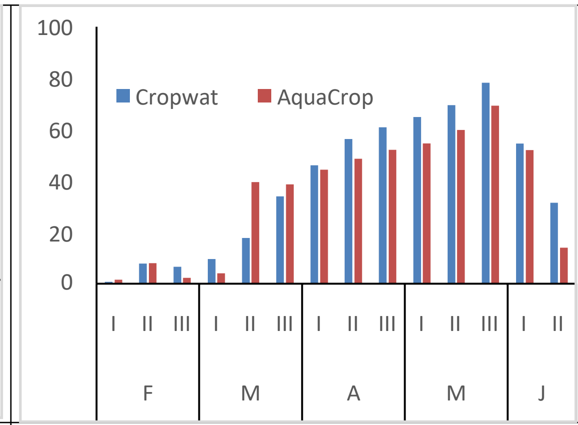

Figure 12: Sunflower needs in Touggourt

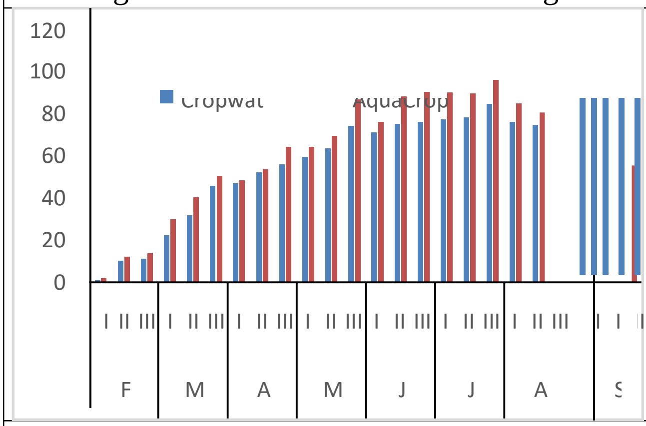

Figure 13 :Needs of Alfalfa in Ouargla

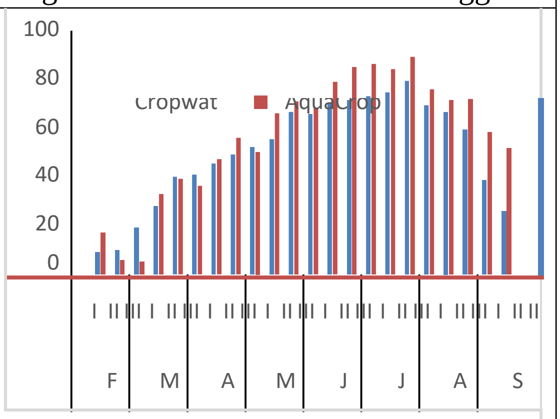

Figure 14 :Needs of Alfalfa in Touggourt

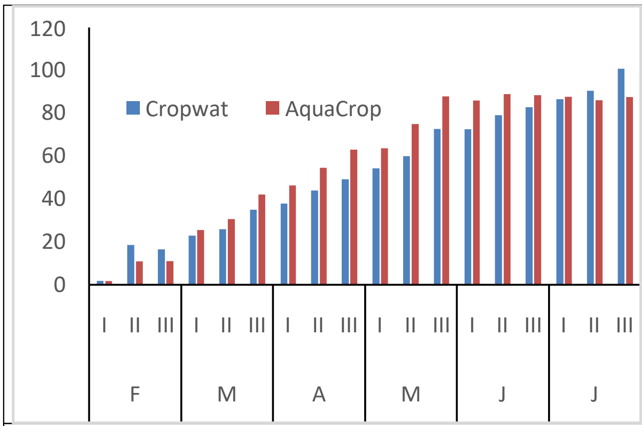

Figure 15 :Wheat needs in Ouargla

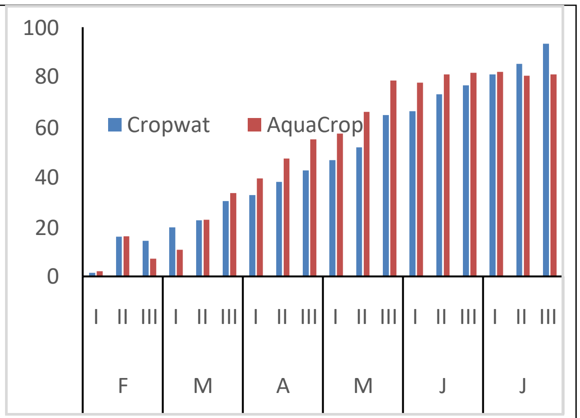

Figure 16 :Wheat needs in Touggourt

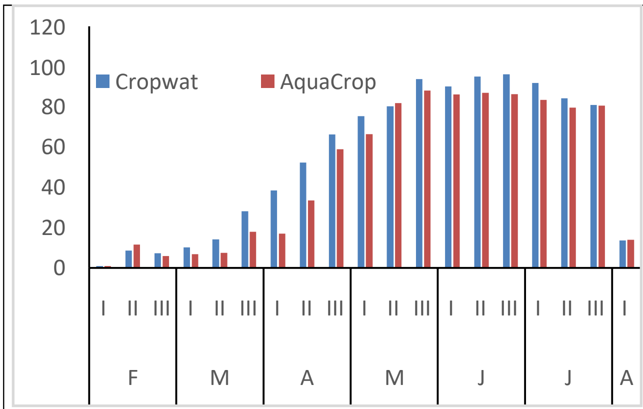

Figure 17 :Cotton needs in Ouargla

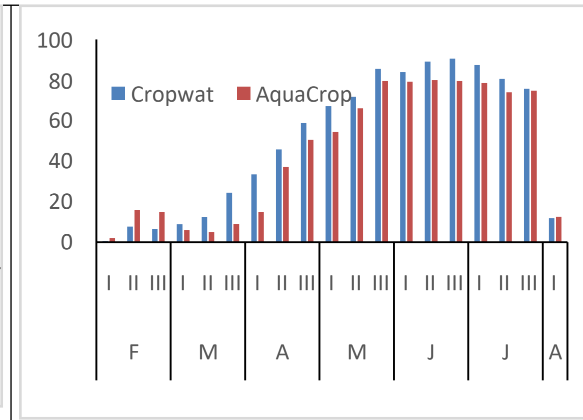

Figure 18 :Cotton needs in Touggourt

Case of the Sunflower

The requirements for the entire growing period in Touggourt are 538.4 mm for cropwat and 488.2 mm for AquaCrop. The values vary from 0.7 to 78.2 mm for the first model, and from 1.5 mm to 69.2 mm for the second

The requirements for the entire growing period in Ouargla are 598.2 mm for cropwat and 538.4 mm for AquaCrop. The values vary from 0.9 to 85.4 mm for the first model, and from 0.7 mm to 76.3 mm for the second.

For both regions, the minimum values are in February and the maximum in May.

Caseof theAlfafa

The requirements for the entire growing period in Touggourt are 1135.6 mm for cropwat and 1295.4 mm for AquaCrop. The values vary from 0.8 mm to 79.4 mm for the first model, and from 2 mm to 89.3 mm for the second

The requirements for the entire growing period in Ouargla are 1251.6 mm for cropwat and 1506.7 mm for AquaCrop. The values vary from 1mm to 84.5mm for the first model, and from 2mm to 96.1mm for the second

Case of Cotton

The requirements for the entire growing period in Touggourt are 942.3 mm for cropwat and 834.1 mm for AquaCrop. The values vary from 0.7 to 90.6 mm for the first model, and from 2 mm to 80 mm for the second

The requirements for the entire growing period in Ouargla are 1027.4 mm for cropwat and 914 mm for AquaCrop. The values vary from 0.9 to 96.2 mm for the first model, and from 1 mm to 88.1 mm for the second

For both regions, the minimum values are in February and the maximums are in June for cropwat and in May for aquacrop.

Case of Wheat

The requirements for the entire growing period in Touggourt are 855.5 mm for cropwat and 918.8 mm for the second. The values vary from 1.4 to 93.3 mm for the first model, and from 2 mm to 81 mm for the second

The requirements for the entire growing period in Ouargla are 950.3 mm for cropwat and 1037.1 mm for AquaCrop. The values vary from 1.8 to 100.7 mm for the first model, and from 1.8 mm to 88.9 mm for the second.

The minimum values are in February and the maximum in July for cropwat and June for aquacrop

4.Conclusion

Both models are specialized in analyzing crop water requirements. But the difference between the results may come from the fact that the AquaCrop model provides more precise and detailed estimates while the Cropwat provides more general and simplified estimates. Differences in local environmental and climatic conditions may also affect the results of the two models.

The results of the climatic factors provided by the Climwat model show that the minimum and maximum temperatures of Touggourt are slightly lower than those of Ouargla. The air humidity of Touggourt is higher than that of Ouargla. The wind speeds, insolation and solar radiation of Touggourt and Ouargla are almost equal. Precipitation in Touggourt is almost double that of Ouargla. The reference evapotranspiration of Touggourt is lower than those of Ouargla.

The effective rainfall determined with the Cropwat model is slightly higher than that provided by the Aquacrop model. The effective rainfall of Touggourt is almost double that of Ouargla. In Ouargla those of cropwat are around 37.1 mm and those of Aquacrop 36.1 mm. Conversely for Touggourt 74.3 mm and 72.7 mm.

The evapotranspiration of the sunflower in Touggourt provided by the cropwat is 563.3 mm and that of the AquaCrop is 494.9 mm and in Ouargla respectively, 611.4 mm and 575.6 mm. For Alfafa in Touggourt 1251.6 mm / 1506.7 mm and in Ouargla 1267.5 mm / 1606 mm. For cotton in Ouargla 1040.6 mm / 926.2 mm and in Touggourt 968.5 mm / 852.4 mm. For wheat in Touggourt 881.4 mm / 989.2 mm and in Ouargla 963.6 mm / 1089.8 mm

The water needs of crops are conditioned by Evapotranspiration. The cropwat model gives higher values of evapotranspiration and water requirements for the entire growing period compared to those provided by the AquaCrop model for sunflower and wheat and lower for Alfafa and cotton. According to both models, the minimum values are in February for both regions.

For both regions, both models provide maximum values in May for sunflower. For cotton the maximums are in June for cropwat and in May for aquacrop. For wheat the maximums are in July for cropwat and in June for aquacrop. For alfafa, the two models provide the maximum values in July for the two regions.

The cropwat combines the advantages of being easy to handle and displaying comprehensive results. It adapts to various agricultural conditions, which may provide more appropriate estimates in some cases. It requires little input data and provides a wide range of results. However, using AquaCrop may require a higher level of training and experience for best results.

In general, choosing the best program depends on the user's needs and the level of specialization required, and a personal comparison of the results of each program can help make the appropriate decision.

Although the AquaCrop and CropWat models provide reasonable estimates of evapotranspiration, effective rainfall and water requirements, they must be calibrated in the context of the study areas..

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