#7475 CROP WATER REQUIREMENTS, BIOMASS AND GRAIN YIELDS ESTIMATION FOR SULLA (HEDYSARUM CORONARIUM L.) USING CROP WAT IN SEMI-ARID REGION OF TUNISIA

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ABSTRACT

Dwindling water resources and increasing food requirements require greater efficiency in water use, both in rainfed and in irrigated agriculture. Regulated deficit irrigation provides a means of reducing water consumption while minimizing adverse effects on yield. With the current water shortage in Africa improving crop water use is vital especially in the arid and semi-arid regions. Models can play a useful role in developing practical recommendations for optimizing crop production under conditions of scarce water supply. To determine the optimal irrigation levels for maximum *Hedysarum coronarium* L. production and to assess the effect of limited water supply on field grown *Hedysarum coronarium* L. yield under different irrigation regimes, we tested the FAO CROPWAT model version 8.0 during the cropping seasons of 2017 and 2018 at the station of Centre de Formation Professionnelle Agricole de Sidi Bourouis in northern Tunisia. Three irrigation scheduling levels such as 70 % of crop water requirement (ETc), 50% ETc, 30% ETc and finally rainfed regime were replicated three times. We found that the crop water requirement (CWR) were estimated for the seedling emergence stage (5.4 mm), vegetative growth stage to flowering stage (118.3 mm), flowering stage (170.1 mm) and reproductive growth stage (48.2 mm). The results of data analysis showed that use of various irrigation regimes brought a significant effect ($P<0.01$) effect on the grain yield and biomass parameters of Sulla. The rainfed regime produced the lowest fresh and dry forage biomass with 18.45 t / ha of fresh matter compared to the three irrigated regimes (70% ETc, 50% ETc and 30% ETc), which had respectively, 28 t / ha and 30.6 t / ha and 31.97 t/ ha. CROPWAT performed excellently and could be used to efficiently estimate water requirements and reference evapotranspiration.

Keywords: CROPWAT, ET_O, irrigation regime, yield response

INTRODUCTION

Global climate change has led to irreversible phenomena that have significantly affected agriculture of many countries of the world (CCUNCC, 2018), especially developing countries. With an average of 410 m³ of water per inhabitant per year, Tunisia is clearly below the water scarcity threshold. This situation is all the more worrying as climate change will lead to a 28% drop in conventional water resources by 2030 and decrease in surface water resources will also be recorded (CCUNCC, 2018). Tunisia is classified among 17 countries least endowed with fresh water on the planet.

In Tunisia, agriculture is the largest (80%) consumer of water and hence more efficient use of water in agriculture needs to be top most priority (ONAGRI, 2011). Thus, efficient water use and management are currently major concerns (FAO, 2015). There appears to be a consensus that irrigated agriculture, in general, is up against a future with less water. This consequently, calls for increased efficiency in the utilization of scarce water resources. A better understanding of the intricate interactions between climate, water and crop growth needs to be a priority area in Tunisia.

Crop simulation models such as DSSAT, CROPWAT 8 and FASSET can play a useful role in developing practical recommendations for optimizing crop production under conditions of scarce water supply (De Wit et *al*., 2019; Halimi et *al*., 2019). Crop water requirement simulation models compute effective rainfall, reference evapotranspiration (ETo), crop evapotranspiration (ETc), net irrigation water requirement (NIWR), gross irrigation water requirement (GIWR), irrigation scheduling and crop growth. Several methods are used for ETo calculation such as mass transferbased methods, radiation-based methods and temperature-based methods, etc. (Adarsh et al., 2018). The Penman–Monteith method (Allen et al., 1998) is proved as one of the most reliable and comprehensive methods for estimation of evapotranspiration and crop water requirements, and it is widely used. CROPWAT 8 model developed by FAO is used for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns (FAO, 2020).

Forage Fabaceae, such as Sulla (*Hedysarum coronarium* L.) play a fundamental floristic and agronomic role. The specie is commonly used to enhance the productivity and sustainability of cereal-based systems because of its excellent adaptability to marginal and drought-prone environments (Amato et *al*., 2016). Annicchiarico et *al.* (2008) highlighted the particular value of genetic resources of Sulla for severely drought-prone environments, whose extent in the Mediterranean Basin is expected to rise as a consequence of climate change and foreseeable reduction of water available for irrigation (CCUNCC, 2018). Forage of Sulla is a versatile crop which can be used for silage production, grazing and hay making. It has a high biomass yield and is one of the more productive legume crops with high protein content in rainfed environments. It is a perennial species that require less energy to plant and fertilize, reduce the risk of soil erosion, and increase soil carbon (Schwartz et al., 2013). Moreover, it has several nonagricultural uses; for example, it can be planted to protect soil (Amato et *al*., 2016) and revegetate disturbed land or used for honey production and landscape architecture (Annicchiarico et *al.* 2008).

There is a lack of information with respect to Sulla on crop water requirements in general and in Tunisia. Hence, in this study an attempt has been made to compute the crop water requirements of Sulla in semi arid regions at the station of Centre de Formation Professionnelle Agricole de Sidi Bourouis in northern Tunisia using FAO CROPWAT model version 8.0. Also, FAO CROPWAT 8.0 was used to determine of optimal irrigation levels for higher Sulla (*Hedysarum coronarium* L.) forage production under four irrigation regimes (Three irrigation regimes of 70 % of crop water requirement (ETc), 50% Etc–, 30% ETc and rainfed treatments).

MATERIALS AND METHODS

Experimental Location, Design, Treatments and Cultural Practices

Trials were conducted during the cropping seasons of 2017 and 2018 at the station of Centre de Formation Professionnelle Agricole of Sidi Bourouis in northern Tunisia. The research station is located about seven kilometers north of Siliana. It is in the east of the State between north latitudes 36.10 ′ and east longitudes 9.07, at an elevation of 406 m above sea level. The climate of the area is semi-arid Mediterranean climate, with a dry period that can reach 5 months. The rainfall in the order of 350 to 400 mm per year. Soils at the station are coarse textured sandy clay loam type. The design of the experiment was randomized plot with three replicates. The subplot size was 3 ×6 m. The main plots comprised three irrigation four irrigation regimes (Three irrigation regimes of 70 % of crop water requirement (ETc), 50% Etc, 30% ETc and rainfed treatment). The subplots were cultivated with *Hedysarum coronarium* cv. Bikra 21. The seeds were sown on 28 October 2017.

Soil, Crop and Meteorological Data

The Data of soil physical parameters, such as soil texture, depth, infiltration rate, the available soil moisture, and bulk density, are required to estimate the total available water in the area of root zone and the irrigation plan. The parameters derived from this search are presented in Table 1.

Table 1. Soil parameters.

Parameter	Value
Total plant available moisture (mm/m)	120
Maximum rain infiltration rate (mm/day)	36
Maximum rooting depth (cm)	80
Initial soil moisture depletion (as % TAM)	90
Initial available soil moisture (mm/m)	12

Crop coefficient (Kc) curves of variation of the seasonal/annual for the studied crops were taken according to Allen et al, (1998). Maximum and minimum temperature (^{o}C), humidity (%), wind speed (m/S) and sunshine (hours) were collected from the Meteoblue website (Meteoblue, 2018). Daily rainfall (mm) was collected from Sidi Bourouis station.

RESULTS AND DISCUSSION

Reference Evapotranspiration, Water Requirement

The estimate of the Reference Evapotranspiration (ET0) for the study area is presented in Figure 1. The results show that the highest average daily evapotranspiration ET_0 values are attained in May (5.13 mm/day) and in April (4.76 mm / day), it is a critical phase with regard of Sulla. If we multiply these values by the number of days of each month, you can have the amount of water that has been evapotranspired, respectively during the month of May (156.03 mm) and April (142.8 mm). Consequently and in the absence of rains during this period must be applied to net irrigation dose during March of 1560 m ^{3} /ha and during the month of April 1428 m^{3}/ha.

The total water requirements of Sulla (CWR) are equal to 343 mm. We found that the crop water requirement were estimated for the seedling emergence stage (5.4 mm), vegetative growth stage to flowering stage (118.3 mm), flowering stage (170.1 mm) and reproductive growth stage (48.2 mm) (Fig. 2).

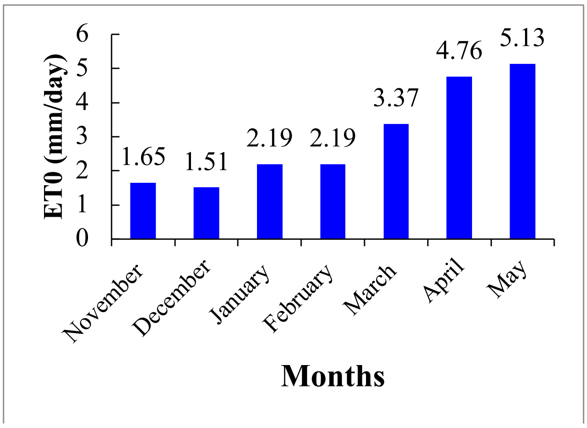

Figure 1. Reference Evapotranspiration (ET_0).

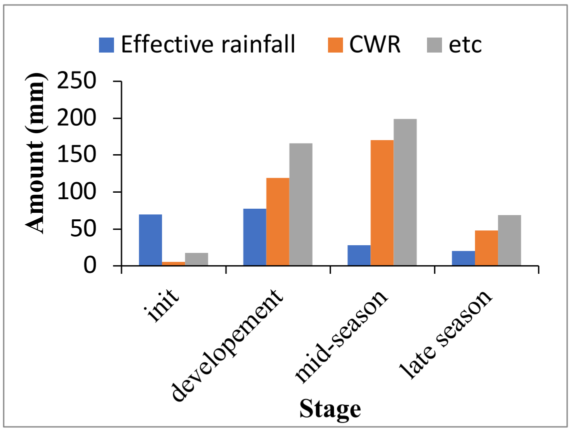

Figure 2. Crop water requirements of Sulla.

The results of data analysis showed that use of various irrigation regimes brought a significant effect ($P<0.01$) effect on the grain yield and biomass parameters of Sulla. The rainfed regime produced the lowest fresh and dry forage biomass with 18.45 t / ha of fresh matter compared to the three irrigated regimes (70% ETc, 50% ETc and 30% ETc), which had respectively, 28 t/ha, 30.6 t/ha and 31.97 t/ha (Table 2).

Table 2. Effects of water supply on fresh and dry forage and grain yields (t ha^{-1}) of Sulla under four water regimes.

Parameters	**Rainfed Regime**	**70% ETc**	**50% ETc**	**30% ETc**
Fresh forage yield (t ha^{-1})	18.45c	28b	30.6a	31.97a
Dry forage yield (t ha^{-1})	6.40c	10.74b	12.22a	13.22a
Grain yield (Kg)	706.33c	935c	1148.67b	2024.67a

CONCLUSIONS

The Sustainable Water Management helps ensure a more stable production. Improving irrigation efficiency is very important for farmers to have a more correct use of water and for this reason, before thinking of irrigation as a water source, they must establish whether irrigation is really necessary or not in their specific environmental conditions. For this purpose, a preliminary analysis is very useful. CROPWAT performed excellently and could be used to efficiently estimate water requirements and reference evapotranspiration.

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