

Simulating Crop Water Requirements of Potato in Arid Conditions in South Algeria of Different Scenarios Using AquaCrop Model

M Amirouche^{1*}, D Smadhi² and L Zella³

¹Department of Rural Engineering, Agricultural National High School, Algeria

²Division of Bioclimatology and Agricultural Hydraulic, National Institute for Agricultural Research, Algeria

³Department of biotechnology, University of Saad Dahlab, Blida, Algeria

*Corresponding Author: M Amirouche, Department of Rural Engineering, Agricultural National High School, Algeria.

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Abstract

In Algeria, water supply through rainfall is limited. To this end, understanding crop water needs is essential to improve irrigation practices, planning and efficient water use. In this perspective, the study carried out highlights the evaluation of these parameters by calculating the reference evapotranspiration (ET₀) over a period of 22 years (1997-2018), for two distinct periods, one wet and the other dry. The various calculation steps were carried out, using the AquaCrop model, taking into account the evolution of the potato crop growth cycle in the Oued Souf region. The results showed that the average rainfall over the climate series is 69.74 mm, fluctuating between a minimum of 21 mm (dry period) and a maximum of 230.6 mm (wet period). This evolution characterizes an average reference evapotranspiration, which reaches nearly 1528.8mm, varying between 1755.8mm and 1309.0mm. The results show a close relationship with irrigation water requirement (IWR) for potato cultivation in wet (690.0mm) and dry (735.2mm) conditions. Indeed, the more severe the climatic conditions, the more crop water requirement (CWR) increases (709.0 mm to 720.0mm). These results show that the Aquacrop model can be used as a decision-making tool, allowing managers and users in the field to evaluate and optimize the use of irrigation water.

Keywords: AquaCrop; Potato; Irrigation Water Requirement; Frequency Analysis; ET₀

Introduction

In Algeria, agriculture is the sector that takes and consumes the most water, with withdrawals averaging 70% [1]. The country is classified as one of the most water-deficient regions in the world. Rainfall is irregular in space and time, ranging from 200 mm to 600 mm [2]. To this end, the rational management of irrigation water in this sector in irrigated areas is essential. Effective water management for crop production requires in-depth knowledge and effective approaches. A crop's water needs must be met to achieve potential yields. Therefore, to improve the efficiency of water use in agriculture, irrigation management must be optimized to avoid unnecessary waste of important and sometimes limited water resources. Managers therefore need a practical decision support tool to help them assess irrigation practices and resulting yields. Simulation models offer an inexpensive way to study a wide range of management options. FAO has developed AquaCrop, a water-ground-plant simulation model to be used as a decision-making tool in planning and analysis [3,4]. This study is used to assess the reference evapotranspiration (ET₀), irrigation water requirements (IWR) and potato crop water requirements (CWR) in the Oued Souf region by the AquaCrop model in a surplus, deficit and normal year based on a frequency analysis of climatic parameters including rainfall for a fairly large climatic series, ranging from 1978 to 2018.

Materials and Methods

Study site

The study area covers the wilaya of El Oued, located in south-eastern Algeria, whose physical environment is typically Saharan. The selected area, covering an area of approximately 44,586.80 km², is located between 33°21' North of Latitude, 6°51' East of longitude and at an altitude of 84 m. The El Oued region has a Saharan climate with low rainfall (< 100 mm) and average monthly temperatures over the period 1978-2018 range from 20.49°C to 33.90°C. In Algeria, potatoes are the main non-cereal crop in terms of production and consumption. Algerian potato production is estimated at 4.5 million tons cultivated over 156 thousand hectares (all productions combined), of which 25% is produced by the wilaya El Oued over an area of 33 thousand hectares. El Oued is currently the most potato-producing wilaya in Algeria with a production of 1.25 million tons cultivated on an area equal to 33.000 ha (all productions combined) with an average yield of 330 (q/ha) in 2015

Climate assessment by the AquaCrop model

AquaCrop is a model of crop water productivity developed by FAO's Land and Water Division to address food security issues and assesses the impact of environment and management on agricultural production.

AquaCrop has five important components, namely the atmosphere, with its thermal regime, rainfall, evaporation demand and carbon dioxide concentration; Culture, with its development, growth and yield constitution processes; Soil, with its water balance; Management that takes into account agronomic practices such as planting dates, fertilizer application and irrigation and initial conditions. Knowledge of the interannual variability of irrigation water needs requires a frequent study of rainfall, based on rainfall measurements taken over a fairly large climatic series, 40 years (1978-2018). This analysis will determine the dry, wet and normal year.

Results and Discussion

Rainfall measurement

Figure 1 illustrates the interannual variability of rainfall during the climate series (1978 to 2018).

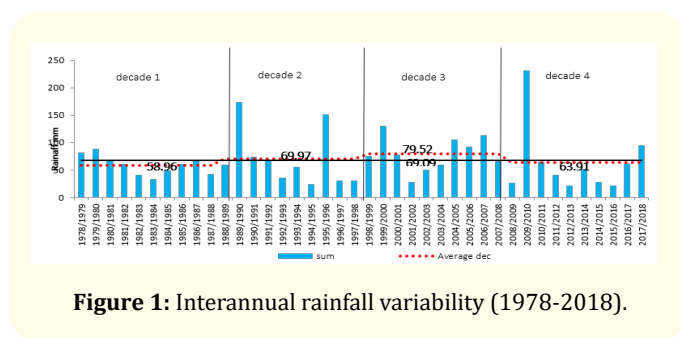


Figure 1: Interannual rainfall variability (1978-2018).

The results obtained show a heterogeneous variation in rainfall intensities over the study area. The estimated average value is about 69.09 mm, fluctuating between 230.6 mm and 21 mm. The analysis of this graph allowed us to determine the surplus year (2009/2010), the deficit year (2015/2016) and the normal year (2007/2008) in order to assess the interannual variability of the irrigation water needs of the potato crop.

Evapotranspiration ET0

The reference evapotranspiration (ET0) was calculated using the FAO Penman-Monteith method [5]. This requires as input data the temperature (minimum and maximum), humidity (minimum and maximum) as well as solar radiation and wind speed at 2 meters above the ground [6]. Figure 2 shows the interannual variation of the reference evapotranspiration (ET0), it is noted that the annual average of the ET0 is about 1528.8 mm, fluctuating between 1307.2 mm and 1755.8mm.

Figure 2: Interannual variation in reference evapotranspiration, period (1997-2018).

Irrigated water requirement

The results obtained show that the water requirements of the potato crop vary from year to year depending on climatic conditions (Figure 3).

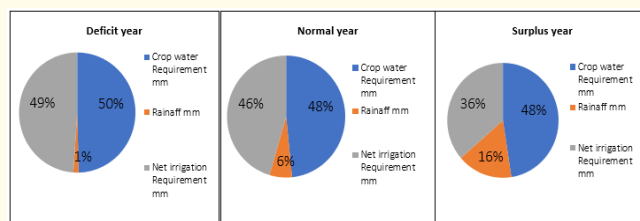


Figure 3: Estimated irrigation water requirement (EIB) and maximum water requirement (ETc) for potato cultivation.

The volume of water required for this crop to meet its needs varies from 5200 m³ for a surplus year, 6900 m³ for a normal year and 7095 m³ for a deficit year. This difference is related to the volume of effective rainwater stored in the soil.

Conclusion

The results of the study showed that for a potato area cultivated on an area of 33000 hectares, 17.2 Hm³ of water is required in wet conditions and 23.4 Hm³ of water in dry conditions. Potato cultivation consumes more water in the dry season than in the wet season. For the entire crop development cycle, irrigation water requirements reached 520 mm and 710 mm, respectively, for the wet and dry seasons. The results on CWR and IWR would make it possible to draw up a programmed irrigation schedule for potato cultivation under all climatic conditions (wet or dry) in order to optimize the water inputs allocated to the crops and thus maximize yields and explore agricultural expansion.

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