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Drought Impact on the Olive-Trees in the Tunisian Jeffara

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Abstract: In spite of its high adaptation capacities and also its aptitude to grow in the arid areas, the olive-tree did not escape to the negative effects of the drought resulting usually in a fall of the production, the accentuation of the alternation production cycle and in some ultimate cases by the withering of the olive-tree. This work concerned the study of drought impact on olive-growing plantations in the Tunisian Jeffara (province of Médenine). It aim at characterizing the rainfall deficit observed in the study zone during the period 1999-2002, and to identify the meteorological drought intensity differences in the same region. The rainfall data from two gauging stations: Médenine (1903-2002) and Zarzis (1908-2002), were analyzed using several indices. It was found that drought is a recurring phenomenon in the study zone. The occurrence of successive dry years is less frequent in the costal zones than in the other localities. The year 2000-2001 is founded the most exceptional dry period which affected negatively the development and the growth of the olive trees resulting in partial or complete loss of a large number of olive-trees.

Keywords: Arid areas, Drought indices, Olive trees

1. Introduction

Historically, drought is known to affect periodically and with varying intensities the Mediterranean basin regions, Africa, Asia, Australia and America. In fact, their geographical positions make that certain areas receive more rainfall than others (Trabelsi, 1992). Tunisia, for example, due to its position between the polar and Saharan weather systems, is often threatened by climatic disturbances resulting generally in the emergence of drought conditions (Trabelsi, 1992; Benzarti *et al.*, 2001) which can prevail for one month, one season, one year and can even persist for two or three consecutive years. In this case, the water shortage and the yearly and the seasonally variability of rainfall generate hardships especially for agriculture related activities. In addition, its effect on the arboriculture plantations is variable from one site to another. Some groves resisted the water deficit but others were subject to partial or total parching though this inheritance is made mainly of olive-tree, known by its high capacity of adaptation to different bio-climate from the country and also its aptitude to be planted in arid areas (Alouini *et al.*, 1999). It is in this framework that this study was devoted to the analysis of the rainfall deficit during the last two decades and particularly the last drought (1999/2000-2001/2002) which affected the Tunisian Jeffara (province of Médenine) (**Fig. 1**) in terms of frequency, duration, intensity difference in order to explain the damages caused to the olive tree groves.

Fig. 1. Geographical location of the study area.

2. Materials and Methods

2.1. Assessment of the drought impact on the olive trees

In order to assess the drought impacts on the olive trees groves in the region, the regional department of the Ministry of Agriculture (CRDA) in Médenine, made a census of the state of the olive trees during the three consecutive dry years (1999/2000-2001/2002).

2.2. Rainfall data collected

The Rainfall data were obtained from the records available at the water resources division of the CRDA of Médenine. The selection of stations was based on the geographical position to the coast and the observation

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periods. Then, two rainfall gauging stations were chosen: Médenine sud, having 96 years of records, representing the inland zone, and Zarzis which represents the costal zone and it detains 94 years of records.

2.3. Characterization of the climatic drought

To characterize and estimate the drought intensity in the study area, several methods and indices were used.

2.3.1. Percentage departure of rainfall (PDR)

Considering the normal rainfall, as a standard of comparison the estimation of actual rainfall can be done by calculating the percentage departure of rainfall. The PDR is calculated as:

$$PDR(\%) = \left[(Pi - Pm)/Pm\right] \times 100$$

Where: Pi: actual rainfall (mm); Pm: normal rainfall (mm). The variation is positive for the wet years and negative for the dry years (Benzarti, 1992).

2.3.2. Frequency analysis

Annual rainfall records are classified in an ascending order according to their probability with not going beyond (F) whose formula is as follows:

$$F = \left[r/(N+1)\right] \times 100$$

With: r: range of the year according to an increasing classification of the rain quantities; N: number of years of observation. Then, years are classified according to their probability of occurrence into five classes (Alouini *et al.*, 2001). The humid part of the frequency value is split into "very wet" ($F \geq 85\%$) and "wet" conditions ($65\% \leq F < 85\%$. The normal conditions are indicated by $35\% \leq F < 65\%$. A drought event starts when the frequency values indicates "dry" conditions ($15\% \leq F < 35\%$) and "Very dry" conditions ($F < 15\%$).

2.3.3. Persistence of drought

The drought severity is more felt as far as the dry year follows or precedes one or several dry years. A sequence of dry years is more severe than an isolated drought (Benzarti, 1992). Drought as defined by the frequency analysis can happen on one or several years (two, three or even more consecutive years). Whereas an isolated drought, even very severe, preceded or followed by wet years has less effects.

2.3.4. Standard deviation index (SDI)

The drought severity was calculated also by using the comparison criterion to the average and to the average minus a standard deviation. This index is calculated by the comparison of the annual average rainfall (Pm) with a number of standard variations (σ) whose formula is the following (Beran and Rodier, 1987):

$$\sigma = \left[1/(N-1)\right] \sum (Pi - Pm)^{1/2}$$

When Pi is lower than Pm - σ, the drought is severe and it becomes very severe when Pi is lower than Pm - 2 σ. The moderate drought are indicated by $Pm - \sigma < Pi < Pm$.

3. Results and discussion

3.1. Assessment of the drought impact on the olive trees

It was noticed that the groves close to the coast were less affected than those in the other areas where it resulted in a significant fall of production and even by the deterioration of the olive-tree with various degrees (**Fig. 2**) leading to the pulling up for the production of wood coal (**Fig. 3**). Indeed, more than 98% of olive trees were affected in the region of Médenine while this ratio did not exceed 24% in Zarzis region.

3.2. Characterization of the climatic drought

3.2.1. Percentage departure of rainfall (PDR)

As shown by the **Figure 4**, the application of this index to the study gauging stations revealed the alternation of sequences of years with dry trends and others with humid trends. During the observation period, the percentage deficit years is higher than that of the surplus years. In fact, the percentage of deficit years ranges is 57% in Zarzis and 60% in Médenine. The PRD has detected 83% of the years, in Médenine, have a sequence of more than one dry year, whereas it is 80% in Zarzis. The longest dry sequences are 8 consecutive years from 1961-1962 to 1968-1969 in Zarzis and only 7 consecutive years from 1960-1961 to 1966-1967 in Médenine. At the level of the two stations, the overall tendency during the period 1908-1969 is marked by dry conditions interrupted with very short wet periods. However, from 1969/1970 to 1995/1996, this tendency was reversed to

Fig. 2. Partial and total drying of the olive-trees (year 2000)

Fig. 3. Pulling up and coal production from olive-tree wood (year 2001)

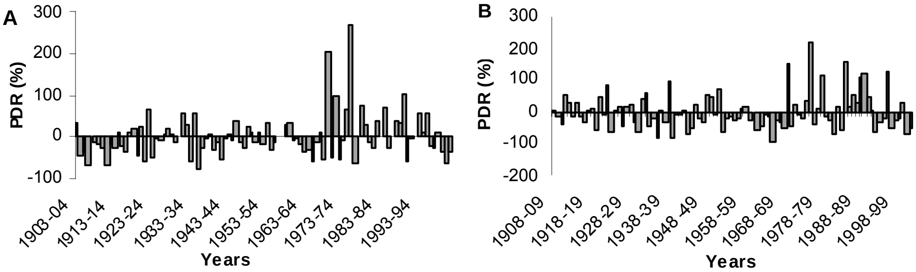

Fig. 4. Percentage of rainfall departure in Médenine (A) and Zarzis (B)

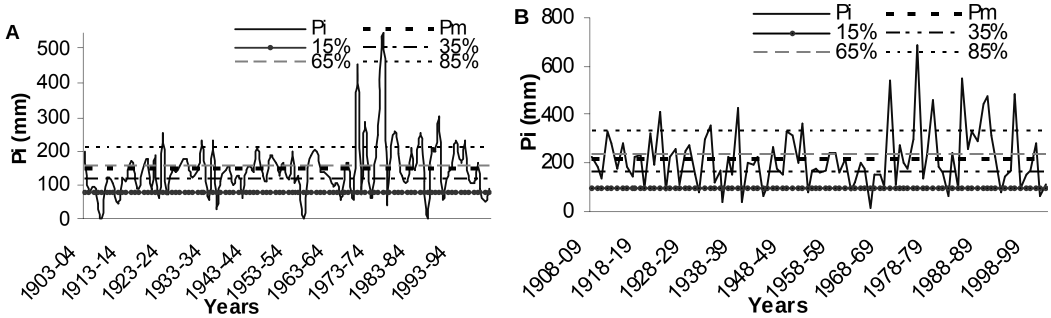

Fig. 5. Variation of the annual rains by comparison with the various classes of frequencies: 15%, 35%, 65% and 85% of the two stations: Médenine (A) and Zarzis (B)

wet but a drought period prevailed from 1996-1997 to 2001-2002.

This simple index indicates the yearly deficit and their sequences. Then, in order to better determine the drought intensity other indices could be useful such as frequency analysis, standard deviation, etc. (Benzarti, 1992).

3.2.2. Frequency analysis

The analysis of the climatic drought by this method brought more details on the normal years compared to surplus or deficit years, as indicated in **Figure 5**. This figure shows that noticed that, 14 % of the years are very dry (deficit ranges from 54.78 % to 90.77 %), 21 % are dry (deficit ranges from 25.01 to 54.41 %), 29 % are normal (24.78% of deficit and 4.28% of surplus) and 21 % o are wet (surplus from 7.51 % to 46.73 %) for Zarzis. But, it showed that only 15 % of the years are very dry (deficit ranges from 48.2 % to 75.2 %), 20 % are dry (deficit ranges from 21.7 % to 47.5 %), 30 % are normal (20.8 % of deficit and 4.6 % of surplus) and 20 % are wet (surplus from 5.54 % to 34.3 %) for Médenine. Moreover, this index detected the same percentage of very wet class for the two stations (15%). Then, in contradiction with was revealed by the percentage of rainfall departure index, only 35 % of the observation years were dry to very dry in the two stations. This index reduces sharply the occurrence of drought conditions.

3.2.3. Persistence of drought

For our case study, it was noted that the isolated droughts prevail with only 45.45 % in Zarzis for 48.5% in Médenine. Then, the two consecutive years sequences are less important for the two stations: they represent

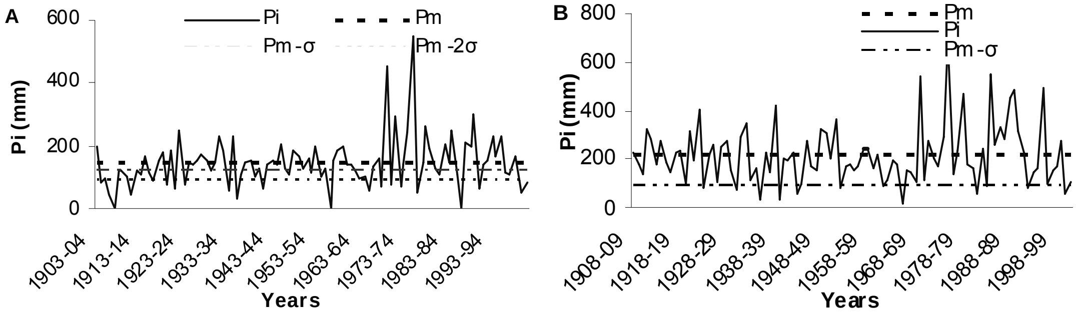

Fig. 6. Variation of the annual rainfall (Pi) by comparison with the average (Pm), the average minus one standard deviation (Pm - σ) and the average minus two standard deviation (Pm – 2σ) of the two stations Médenine (A) and Zarzis (B).

only 24%.

3.2.4. Standard deviation index (SDI)

The application of this index to the two rain gauging stations, as indicated in **Figure 6**, showed that 79.63 % of the years are represented by moderate drought years in Zarzis against 39.7 % in Médenine. Moreover, it detected only 20.37 % of severe drought years in Zarzis against 27.6 % in Médenine. For the very severe drought, 32.8 % of years are detected in Médenine whereas this type did not occur in Zarzis.

4. Conclusions

Drought is a recurring phenomenon in the Tunisian Jeffara (province of Médenine). The analyses of the rainfall records of Médenine and Zarzis, representing the study zone, allowed depicting the rainfall deficit differences at the scale of the same area. In fact, the PRDI revealed that dry years represent 60 % and 55% of the total observation records in Médenine and Zarzis, respectively. Moreover, the Standard Deviation Index revealed 32.8 % of very severe drought years in Médenine whereas this type did not occur in Zarzis. This difference of drought severity detected by the Standard Deviation Index shows better the difference of damages caused to the olive tree groves in the two study area. Therefore, the SDI seems to be the most appropriate for the characterisation of drought severity in the same region.

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