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Research Article

Yield Components of Barley on Different Climates Stages in the North of Tunisia

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Abstract

Barley (*Hordeum vulgare* L.) is, after wheat, the second major cereal crop in Tunisia. Limited precipitation restricts yield of wheat and barley in Tunisia. The present study is carried out in two sites of the Regional Filed Crop Research Center of Béja, in Northern Tunisia; Oued Beja which is charcterized by sub-humid climate and Oued Mliz is located in semi arid. The aim of this work is to study the effect of biocliamtic conditions and supplemental irrigation on yield and water use efficiency of two Barley cultivars. There was a significant difference ($p < 0.05$) in biological water use efficiency between the two climatic stages for all varieties; whereas in the same conditions there are no significant difference between varieties.

Keywords: Barley, Water use Efficiency between two Climatic Stages

Introduction

As one of the most arid countries in the Mediterranean, Tunisia suffers from high water scarcity. The shortage of water resources is a limiting factor to food production. Generally, water resources use is reported per economic sector, without explicitly indicating the precise purpose of water use. Irrigated land accounts to only 7% of the total cultivated land in Tunisia [4], it contributes to more than 35% to the total production of the agricultural sector and accounts for more than 80% of the total water with drawl in the country [9]. Barley (*Hordeum vulgare* L.) is one of the oldest and important crops in the world. In the world, barley is used mainly for feed (55-60%), malt (30-40%), food (2-3%) and seed (5%). The annual world harvest of barley in the late century was approximately 140 million tones cropped in an area of about 55 million hectares. Among cereals, barley (*Hordeum vulgare* L.) is one of the principal cereal crops in Tunisia since it is cultivated in different zones from northern to southern Tunisia and occupies about the 1/3 of Tunisian cereals' cultivated area, annual total need was 0.9 million tons, with 0.04 million tons produced in the country. Average barley production in the late decade (2000-2009) was 3.172 million tons, adjusted by average importation of 1.384 million tons, with annual total need of 4.56 million tons [6]. Barley productivity depends essentially on water supplies and it is threatened when the water stress is imposed at the pollination and flowering stages, rather than in the vegetative or seed filling stages [1,2,10]. Supplemental irrigation and limited or deficit irrigation have been well studied and widely practiced for improving crop yield and increasing IWUE (irrigation water use efficiency). The objective of this paper is to evaluate the relationship between climate conditions and supplemental irrigation on yield and water use efficiency of barley crop.

Materials and Methods

The experimental sites are located in Beja (36°44'05''N and 9°13'35''E) and Oued Miliz (36°26'45"E) in the north of Tunisia. Experiment was conducted from December 2015 to June 2016 at the Regional Field Crops Research Center. The climate is semi arid in the Oued Miliz region and sub humid in Beja region (Table 1). The barley, in Beja site, design was rain fed (I_b) and the experiment was randomized complete block system with three replicates per treatment, divided into three blocks each with two cultivars. The experiment in Oued Miliz was designed as completely randomize block system divided into nine blocks, with two cultivars in each block. This experiment consisted of three irrigations' level: rain fed (Io), full irrigated (Iot) and half irrigated (Iot/2). Daily weather data were recorded from meteorological station far 50 m away from experimental site. Soils of the experimental areas are mostly clay loam. Gravimetric soil water content was determined at different [0-20], [20-40] and [40-60] cm.

Experimental site	Bioclimatic stage	Soil type	pH
Beja	Sub humid	Clay loam	7.2
Oued Miliz	Semi arid	Clay loam	7.4

Table 1: Pedoclimatic condition of two sites.

Water use efficiency

For each cultivar and according to water treatment, water use efficiency (WUE) was obtained by comparing yield to relative water consumption [5, 8,11]. It was calculated by taking biological yields (straw and grain) and grain yields into account. The WUE is generally expressed in kg/ha/mm and defines the amount of production obtained by a unit of water used; thus, its unit can be converted into kg/m^3 (1 kg/m^3 = 10 kg/ha/mm) which is more easily perceived.

Statistical analysis

Statistical analyzes were carried out using the SPSS software (Version 20). For all data, analyzes of variance with the procedure (GLM), for General Linear Model have been conducted. Model-adjusted averages (LSMEANS) were calculated for each treatment. The SNK test was used for multiple comparison of means at the threshold of α = 5%.

Results and Discussion

Soil water content

Soil water content varied between 15% and 42% and decreases over time for all three depths from the maximum value in March 44.3% where there are precipitations (Figure 1). Due to the severe climatic conditions and increased crop water requirements that enhance root extraction, soil water content decreases to 14% in all soil profiles at the end of the growing season. Figure 1 b shows that for all three depths the water content is almost identical with a slight phase shift. Water content is ranging from 8.1% to 17.9%. The low values of the water content might be due to the increase of the root extraction in one hand and of low water supply by rainfall in the other hand.

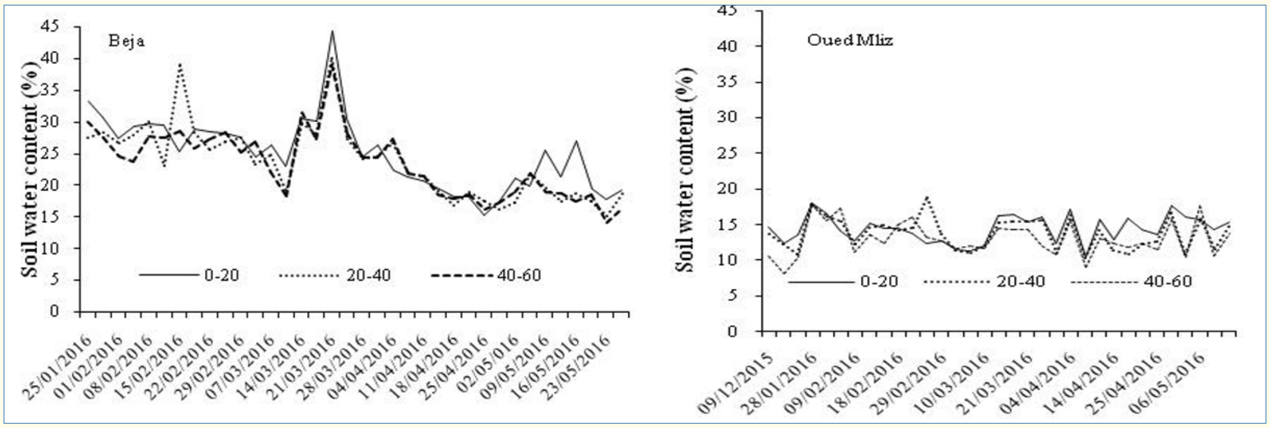

Figure 1: Soil water content for both experiment fields (a: Beja in the left and b: Oued Miliz in the right).

Barley yield components

All yield components are presented in table 2, as we can show there was no significant difference for both cultivars on biological yield, weight of thousand grains, grain yield, Number of ears/m^2, number of grain/ears; whereas there was a significant difference on harvest index, so climatic conditions don't have an effect on yield components of barley. The average grain yield was between 2.5 t/ha and 3.07 t/ha. This performance was better than the average national Tunisian production of barley over several years: 0.28, 0.19, 0.41 and 0.22 t/ha in 1994, 1995, 2000 and 2002, respectively [7].

Water use efficiency variation under two climatic conditions

Figures 2 and 3 present biological and grain water use efficiency in rain fed conditions for two barley cultivars Ssnbda and Manel. Average biological water use efficiency for Manel in both climatic conditions was higher than Ssnbda with no significant difference.

	Biological yield (Kg/m^2)	weight of a thousand grains (g)	Grain yield (g/m^2)	Number of ears/m^2	Number of grain/ears	Harvest index
Beja (Ib)						
Manel	1.026 ^{a,a}	30.83 ^{a,a}	269.4 ^{a,a}	209.7 ^{a,a}	41.95 ^{a,a}	0.26^{a,b}
Ssnbda	0.974 ^{a,a}	31.13 ^{a,a}	255 ^{a,a}	189 ^{a,a}	44.26 ^{a,a}	0.26 ^{b,a}
Wadi Miliz (I0)						
Manel	0.99 ^{a,a}	32.8 ^{a,a}	261.46 ^{a,a}	240.3 ^{a,a}	34.81 ^{a,a}	0.26 ^{a,b}
Ssnbda	0.863 ^{a,a}	32.53 ^{a,a}	307.25 ^{a,a}	232 ^{a,a}	40.65 ^{a,a}	0.35 ^{b,a}

Table 2: Yield components under two climatic conditions.

Observations affected by the same letter are not significantly different according to SNK test at 5%

Manel biological water use efficiency was about 4.18 Kg/m^3 ± 0.2 in sub humid conditions and 4.4 Kg/m^3 ± 0.81 in semi arid conditions whereas for Ssnbda were 3.96 Kg/m^3 ± 0.55 and 3.84 ± 0.44 respectively in Beja and Oued Miliz.

Figure 2: Biological water use efficiency for two varieties Ssnbda and Manel.

Observations affected by the same letter are not significantly different according to SNK test at 5%.

Figure 3: Grain water use efficiency for both varieties Ssnbda and Manel.

Observations affected by the same letter are not significantly different according to SNK test at 5%.

For Grain water use efficiency there, was no significant difference between two cultivars for both site; therefore grain water use efficiency was in semi arid conditions (Oued Miliz) was better than in sub humid conditions (Beja). Grain water use efficiency in Oued Miliz was 1.36 ± 0.27 Kg/m3 for Ssnbda variety and 1.16 ± 0.5 Kg/m3 for Manel cultivar.

Table 3 present effect of irrigation regime on yield and yield components of barely in semi arid conditions. There was a significant difference on biological yield, weight of a thousand grains, grain yield and number of ears/m^2; whereas no significant difference on number of grain/ears and on harvest index, yield of irrigated barely cultivars were more important than other treatment (Io/2) and (I0). Supplementary irrigation increase some yield component of barley Biological, yield for Manel variety was 1.55 Kg/m3 on (Iot) and 0.99 Kg/m^3 on (I0). Number of ears/m3 for Ssnbda cultivar was 303 on (Iot) and 222 on (I0).

Water use efficiency under different irrigation level

Figure 4 present biological water use efficiency in semi arid condition Oued Miliz under different irrigation regimes. There was no significant difference for both varieties at different irrigation regimes. Therefore, biological water use efficiency was higher in the full irrigated treatment for both cultivars. It was 4.88 ± 0.5 Kg/m^3 and 5.08 ± 0.7 Kg/m^3 respectively for Ssnbda and Manel.

Figure 5 presents grain water use efficiency at different irrigation level in semi arid condition as we can show there was no significant difference between the two cultivars at different irrigation levels. Grain water use efficiency was higher in the full irrigated regime (Iot) for Manel cultivar which was around 1.95 ± 0.41 Kg/m3. Therefore, for Ssnbda was higher in the half irrigated regime which was 1.52 ± 0.24 Kg/m^3.

	Biological yield (kg/m³)	weight of a thousand grain (g)	Grain yield (g/m³)	Number of ears/m²	Number of grain/ears	Harvest index
Iot						
Manel	1.55 a,a	44.25 a,a	595.27 a,a	431 a,a	31.01 a,a	0.384 a,a
Ssnbda	1.48 a,a	34.5 a,a	350.71 a,a	303 a,b	34.18 a,a	0.237 a,a
Io/2						
Manel	1.25 b,a	41.66 b,a	455.54 a,a	352 b,a	32.98 a,a	0.365 a,a
Ssnbda	0.02 b,a	45.86 b,a	430.69 a,a	222 b,b	42.17 a,a	0.451 a,a
I0						
Manel	0.99 b,a	32.8 c,a	261.46 b,a	240 b,a	34.81 a,a	0.265 a,a
Ssnbda	0.863 b,a	32.5 c,a	307.25 b,a	232 b,b	40.65 a,a	0.353 a,a

Table 3: Yield component under different irrigation level.

Observations affected by the same letter are not significantly different according to SNK test at 5%.

Conclusion

Conserving irrigation water resources is an important measure for maintaining sustainable development of barley production. For both climatic conditions sub humid and semi arid and irrigation regimes, there were no significant differences in biological and grain water use efficiency. So, it would be interesting to use less water in our conditions. Full irrigation can be recommended in semi arid conditions and results showed that water use efficiency was improved in irrigated areas.

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