Cultivation of Barley Under Harsh Environmental Conditions in Kuwait

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Cultivation of barley under harsh environmental conditions in Kuwait

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Abstract

The State of Kuwait is at the north-western corner of the Arabian Gulf. During the summer, the desert is extremely harsh with temperatures that can reach 44.7°C, with dust storms, during a period where most annual plants become dormant. During the winter the air temperature is cool and pleasant and can drop to 8°C [1]. Due to the harsh environment, Kuwait is facing many obstacles for barley production including aridity (water shortage, high temperature, high evaporation rate, low soil fertility), in addition to climate change. To overcome this situation Kuwait Institute for Scientific Research (KISR) has undergone various studies for the adaptation of barley under stressful conditions, and those studies that were performed in KISR showed that barley can be produced under harsh environment. This crop has showed positive adaptation strategies to a warmer and drier environment that is being noticed to occur during the past years. Three studies were performed that included a study that was done by taking 332 lines of barley and were tested under Kuwait's environment resulting in 10 promising lines, another study was done by taking 141 lines of barley and were tested under similar condition resulting in 5 promising lines, On another hand a study with the collaboration with The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) was performed, by studying 40 promising lines of barley focusing on planting time and stressful conditions resulting with a breed that tolerates drought and adapt to climatic change which indicated that the planting time of barley with the combination of stressful conditions of barley greatly effected. the yield production. This paper focus on five promising lines from the previous studies under two different irrigation regimes.

Keywords: Kuwait; Barley; stressful conditions; high temperatures; yield production; climate change

1. 1. Introduction

Deserts are having very minimal water availability due to shortage of rainfall, and because of that there is a great risk on the survival of both wildlife and humans. This resulted in an evolution which had a great change in climate from extremely harsh cold environment to long periods of heat. Human beings had an impact on that change with industrial revolution [2]. Crop production and performance is greatly effected during the growing season which also indicates that plant growth is greatly affected by climatic change [3].In an environment like Kuwait which is considered as a desert, there are many serious problems and challenges. Lack of water due to the change in the environment makes the survival very difficult for both wildlife and people. The desert has a very different, ancient civilization that should be protected from the fragile creatures that crawl in the desert to the humans that occupy these lands. Ecologically, it has a different ecosystem with two large components: the physical environment and the biological environment. The physical environment includes: atmospheric factors and soil; and the biotic component include the plants, wildlife, and microorganisms [2]. Desertification is occurring which is a process where the desert area overcomes the grassy areas. Therefore, all these changes in the environment will have a major effect on

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human welfare at a time when a big demand of food is needed. One has to put an effort in concentrating on ways to fix these issues so that the world does not get affected dramatically and will be balanced [2].Degradation is a huge problem in terms of area affected with as much as 80% of arid, semi-arid and dry climatic zones suffering from some degree of soil degradation, and human beings have also contributed in the change of degradation of the vegetative areas by removing naturally grown plants in the area and replacing them with artificial ones causing a change in the habitat of the area and new types of vegetation resulting in the area [2]. Kuwait is considered as a dry desert area, with cool short winters. Low and uncertain rainfall are the major environmental problems that Kuwait is facing and therefore, has to be thoroughly looked upon. Cloudbursts are common from October to April and bring heavy rain, which can damage roads and houses; sandstorms and dust storms occur throughout the year but occur mainly in March and August [4]. Due to the limitation of climate, Kuwait's agricultural development is majorly effected, and because of that Kuwait Institute for Scientific Research (KISR) has undergone many projects to study this behavior and study different forages that can withstand such temperature or climate. This paper portrays the cultivation of barley in Kuwait, and the efforts done by KISR to produce promising lines of barley suitable for the arid environmental conditions of Kuwait.

1. 2. Kuwait's Yearly Barley Production

In Kuwait, barley is mainly grown as an animal feed which needs plenty of water for optimal growth, and because of that many efforts were under taken by KISR to produce barley under drought conditions.

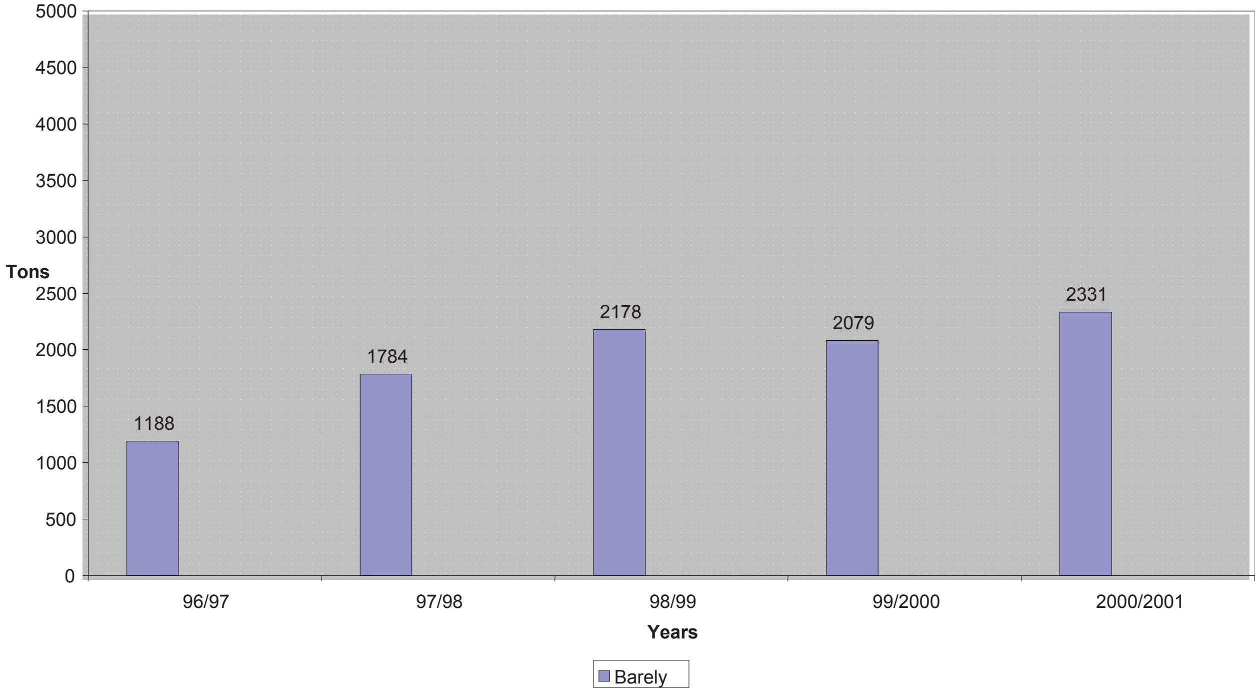

Fig 1: Yearly Crop production (Tons) [5]

Fig 1. shows that during 96-97 barley production was very low (1188 tons) and this production reached 2331 in the years from 2000-2001. This proves that more rainfall in the years 2000/2001 and the usage of more adapted lines resulted in elevation in barley production.

1. 3. Materials and Method

KISR has undergone different studies for forage production and its adaptation to climate change. 141 barley lines were selected and tested under Kuwait's climate that can adapt to drought and climatic change [6]. A study was also done by selecting 332 lines of barley and they were tested under Kuwait's harsh environment by identifying and selecting the salt tolerant crop using rapid screening techniques between fresh and highly brackish water, and also that study evaluated the impact of irrigation water salinity on various growth, yield and quality parameters under environmentally controlled greenhouse and field conditions [7]. Another study was done with the collaboration with ACSAD in which 40 different varieties of barley were chosen to obtain a breed that tolerates drought and adapt to the climatic change, and all these varieties were collected from different institutes to establish efficient data [8]. Since harsh weather is a restraint in the growth of forage crop, KISR has formulated a production program to adapt these varieties for high temperatures.

From the above mentioned studies a wide range of exotic materials were planted under Kuwait's environment. Five promising lines were selected as the most adapted lines. This research focused on the response of these promising lines to two irrigation regimes (normal and stress treatment). Two experiments were conducted in the Agricultural Research Station at Sulaibya during 2009/2010 and 2010/2011.

A split plot design with three replicates was used, and two irrigation regimes (Normal 5550m^3 and stress 3550m^3) were assigned to the main plots. The five promising lines were randomly allocated to the sub-plots. The total water applied (TWA) was 5550m^3 and 3550m^3/hectare. TWA was given by using sprinkler irrigations through out the barley growing season Table (1). The sub plot area was 3m^2. It consists of six rows, 2.5 m long and border of 20 cm width. Plant density was 400 plants /m^2. The fertilization rate was 60 kg ha $^{-1}$ N plus 50 kg ha^{-1} P_2O_5. All other recommended cultural practices were implemented in the experiment.

The yield and yield components for different lines under two irrigation regimes were determined taking into account the number of days observed from sowing to heading (50% heading on plants basis) (DHE). Right before harvest, five plants were selected randomly from each sub- plot and the plant height was measured from ground level to the end of main spike excluding awns. Moreover, number of spikes/m^2 was counted from each plot. Five main spikes were selected randomly, cut and threshed to obtain the number of grains / spike. At harvest, two external rows from each plot were eliminated to avoid border effect. Hence, four rows were harvested, weighed and threshed; and their grain yields were weighed and adjusted to tons per hectare (t ha^{-1}) to indicate the biological and grain yield. The thousand-grain weight was obtained by counting 1000 grains in each plot three times with grain counter and weighing them. Then the average of these weights were calculated.

Statistical Analysis

Combined analyses of variance for grain yield and its related characters were performed over trails after verifying the homogeneity of trial variance errors using Bartlett's test. Least Significant Difference (L.S.D) values were calculated at the 5% probability level. The microcomputer statistical program Statistical Package for the Social Sciences (SPSS) was used.

Table 1. Total applied water (TWA) m^3/hectare

Month	Normal	Stress
December	1300	850
January	1100	710
February	1100	710
March	1300	820
Total	5550	3550

1.4. Results and Discussion

a. Days to Heading: Days to heading were significantly decreased (8%) under stress conditions as compared with control (Fig 2). It varied from 87days (Line 3) to 80 days (Line 4) under control conditions. While, it ranged from 80 days (Line 2) to 72 days (Lines 5). Results obtained showed that water stress has low effect on earlier lines as compared with the latest lines.

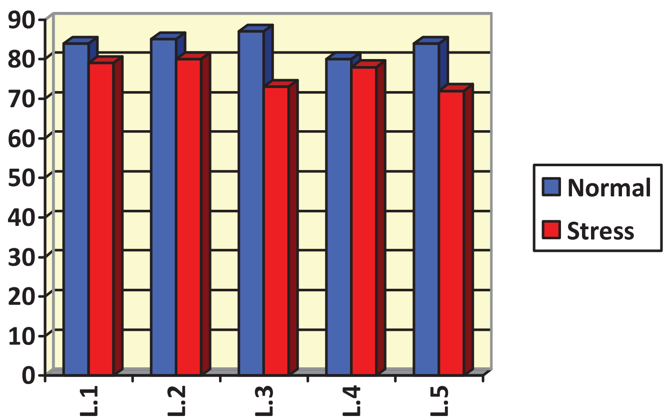

Fig 2. Means of days to heading under normal and stress condition

b. Plant height: New barley lines under normal conditions were taller than those grown under stress condition. The average plant height under normal condition was only 69cm and it ranged from 64 to 71 cm. Stress condition has significant effect on reducing plant height (Fig 3). This reduction was about 14% in Line 3 and only 5% for Line 2. The result showed that the combined effect of harsh environmental conditions and water stress had strong effect on reduction in plant height. This effect was more pronounced in taller lines than in shorter lines.

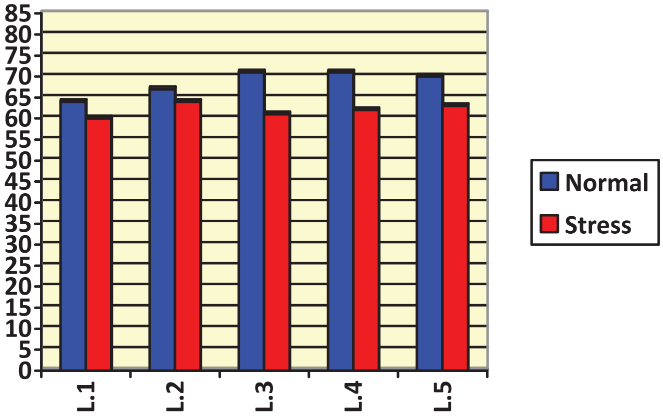

Fig 3. Means of plant height under normal and stress condition

c. Number of Spikes per Square Meter: The highest number of spikes was observed in Line 1 under control conditions. The water stress decreased the number of spikes to about 28%. This decrease ranged from 10% (Line 5) to 44% (Line 3). These differences may be related to the genotypic variability under drought conditions (Fig 4).

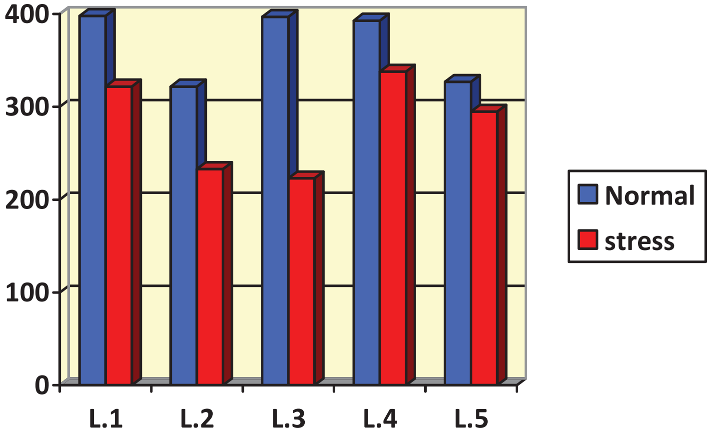

Fig 4. Means of Number of spikes per m^2 under normal and stress condition

d. Thousand Grain Weight: Results obtained showed higher kernel weight under normal conditions. It was reduced by 23% when barley was grown under stress conditions. This reduction ranged from 5% (Line 2) to 49% (Line 4) (Fig 5). This may be due to the difference in performances of the genotypes to drought tolerance during filling period to obtain complete filled grains.

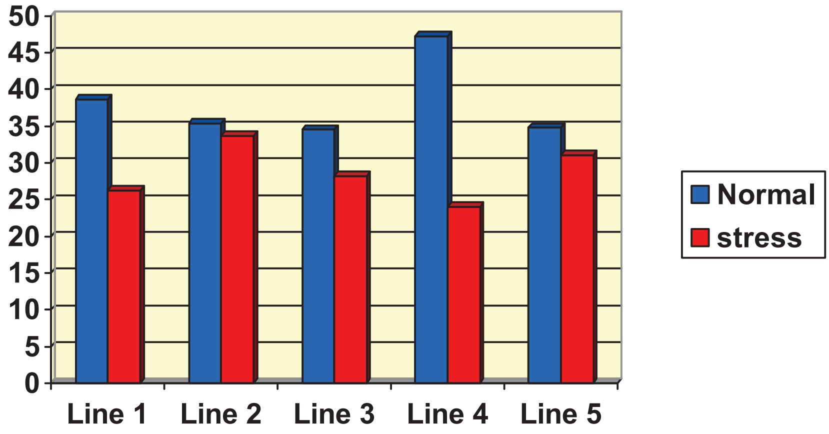

Fig 5. Means of thousand grain weight under normal and stress condition

e. Grain Yield: The results showed that the grain yield was greater under normal irrigation regime than under stress conditions. The average yields under controlled irrigation varied from 2.85 to 1.37t ha^{-1} and under stress conditions varied from 1.21-0.62 t ha^{-1}. Grain yield showed a reduction under drought stress from 78.15% (Line 4) to 11.65% (Line 3) as compared to control. Results from this study revealed that the differences in yield between barley genotypes grown under normal and water stress conditions were least in earlier genotypes (Line 4) which showed a longer grain-filling period under high temperature (Fig 6)

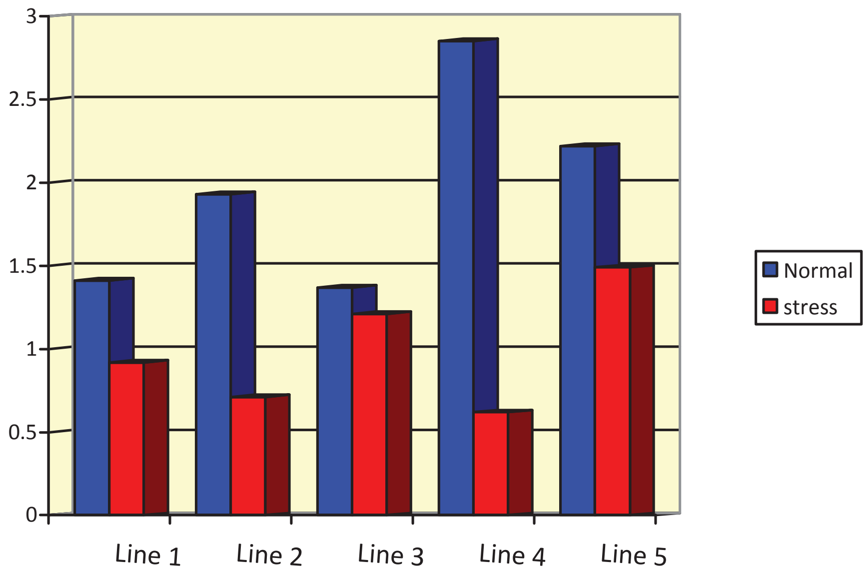

Fig 6. Means of grain yield t ha^{-1} as under normal and stress condition

5. Conclusion

The studies conducted have proved that barley can be successfully grown under drought conditions. The reduction in yield components were measured using different criteria like days to heading, plant height, number of spikes/m^2, 1000 grain weight and grain yield. Even though there was a reduction in grain yield under stress as compared to normal conditions, Line 3 and Line 5 were found to be promising lines under drought conditions in Kuwait.

Acknowledgements

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