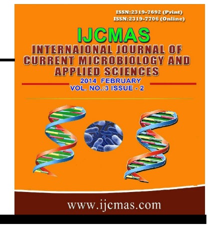


International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 3 Number 2 (2014) pp. 711-721**
http://www.ijcmas.com

Original Research Article

Comparing the interactive effects of NPK fertilization and saline water on tow genotypes of barley (*Hordeum vulgare* L.) grown in southern of Tunisia

Abdennaceur Ben khaled*, Taoufik Hayek, Elhem Mansour and Ali Ferchichi

Institut Des Regions Arides De Medenine, Laboratoire D'Aridoculture Et Des Cultures Oasiennes, 4119, Tunisia

Corresponding author

A B S T R A C T

Barley (*Hordeum vulgare* L.) is the major cereal in many dry areas of the world. "Ardhaoui" is a local landraces cropped in southern Tunisia which is characterized by its resistance to drought and salinity. In order to study its response to different fertilization doses, an experimental design was used in a split-split plot arrangement: 96 elementary parcels were cultivated with two varieties of barley, 6 doses of fertilizer (NPK; kg), 0-0-0, 200-0-0; 200-250-0; 200-0-150; 0-250-150; 200-250-150) and tow levels of salinity. The total biomass at final harvest, straw yield and yield compound associated with different fertilizer doses were determined. The results showed negative effects of salinity on the growth and the development of the barley in comparison with control treatment. Moreover, significant effects of the treatments, variety and their interactions were identified in yield compounds. The twice comparison between the different fertilization treatments show that Nitrogen (N) affect positively the number of spikes/m^2, the grain number/m^2 and the grain yield/ m^2. In the same way, Phosphorus (P) increase the total biomass/m^2 and the grain yield /m^2. The Potasuim (K) doesn't affect the different yield parameter. The local barley "Ardhaoui" response to N fertilization consisted in a higher number of grains per unit land area and thus in a higher tillering rate. In addition, grain yield was strongly affected by spikes and grain number per unit surface, which in turn was related to P and N fertilization. Moreover, the locale genotype " Ardhoui" present a high capacity of tolerance to salinity in comparison with Bakistani and respond positively with the nutritional elements applied by increasing straw and grain yield;

K e y w o r d s

Barley; "Ardhaoui"; salinity; fertilization, Nitrogen; Phosphorus; Potassium.

Introduction

Barley (*Hordeum vulgare* L.) is one of the most salt tolerant crop species and it is the fourth largest cereal crop in the world (Jiang et al., 2006). However, salinity limits barley production and it is one of the major abiotic stresses, especially in arid and semi-arid regions where salt concentration can be close to that in the seawater (Shannon, 1998). Several accessions of barley exist in Tunisia and the most known are "Souihlis", "Ardhaoui", "Frigui", "Beldi", "Djebali", "Sfira" and "Djerbi" (El Faleh and Mdimagh, 2005). Salinity is one of the important limiting factor for agriculture overall in the Mediterranean region. It affects about 7% of the world's total land area (Flowers et al., 1997). Approximately 930 million ha of cultivated land affected are currently threatened by salinity (Munns, 2002; Kefu et al., 2002). Tunisia is concerned by the salinity problem. Based on FAO (2005), about 1.8 million hectares representing 11.6% of the total surface of the country, are affected by salinity.

Nutrition and fertilization belong among the most significant intensification and rationalization measures at barley growing. Fertilizer management can strongly affect crop productivity under conditions of drought or salinity. Thus, the addition of nutrients can either enhance or decrease plants' resistance to drought or salinity or have no effect at all, depending on the level of water availability and salt stress. Salinity- or drought-to-fertility relationships have been reviewed during the last decades (Oertli, 1991; Alam, 1999; Grattan and Grieve, 1999). However, since most dry areas also suffer from salinity, a comparison of mineral-nutrient management for salinity and drought stresses will help to develop strategies that improve plant resistance to either and/or both of these stresses.

Under semi arid Mediterranean conditions, nitrogen fertilization (N fertilization) may also increase WUE by stimulating dry matter production (Latiri- Souki et al., 1998), through a more rapid growth and improved transpiration efficiency. However, yields and WUE may be reduced when excessive N fertilizer is applied (Bladenopoulos and Koutroubas, 2003; Cantero-Martınez et al., 1995). Moreover, N fertilization has to be adjusted because excessive N fertilization is an economical loss and leads to negative environmental consequences (Shepherd et al., 1993). In the Mediterranean basin, N fertilizer rates for barley production has been usually applied between 200 and 250 kg of N ha^{-1} without agronomical control in many cases (Cantero-Martınez et al., 2003). These rates must be reduced to reach equilibrium among cost, environment and productivity. The objectif of this work are (i) to study the effects of salinity stress and NPK fertilization on the yield parameters (ii) To compare the capacity of tolerance to salinity and the response to NPK fertilization of local (Ardhaoui) and introduced (Bakistani) varieties under salt conditions.

Materials and Methods

General conditions

The experiment was carried out during 2010-2011 growing season in the experimental field of the Institute of dry lands of Medenine (IRA). The experiment focused on variability among tow genotypes of barley under saline water and different mineral fertilization combination. The climate is arid of Mediterranean type with a mild winter, characterized by 20 years average annual of 150 mm mostly concentrated in autumn and winter months, with maximum air temperature of 35-42°C in summer. The main weather parameters, including air temperature, precipitation, were from a standard agro-metrological station located at 100m from the experimental filed. The soil, 0.7-0.8m deep, is a sandy soil with the following texture: clay 5.38%, loam 6.72%, thin sands 4.15%, very thin sands 6.72% and coarse sands 40.88%,C/N 26.8, Hcc:23.75%, PFP: 14.1%, Da:0.9 g/cm3; Na^+(ppm):9.83, K^+(ppm):57.5 and electrical conductivity of saturation extract (ECe) equal to 2.78dS/m before sowing .the experiment was always hand-sown carefully in objective to maximize the uniformity of the plot. In all experiment, plots were managed to minimize interferences from biotic stresses. Weeds were removed by hand, to avoid any negative effect of hormonal herbicides.

Treatments and agronomic management

The experimental design was split-split-plot design with four replicate. Salinity levels were assigned to main plots, fertilization treatments assigned as sub plot and barley genotypes as sub-sub-plot. The salinity of irrigation incorporated tow levels 2.6 ds/m and 10.5 ds/m. the mineral fertilization treatments induced by six combination of NPK as showing in table 1 and finally the barley genotypes induced tow genotypes: “Ardhoui” selected from southern Tunisia as tolerant to drought and salinity stresses and “Bakistani” introduced variety by the ministry of agriculture as very tolerant variety to abiotic stress. Water was applied through the crop cycle by drip irrigation system in objective to keep the plots close to filed capacity and to avoid any forms of drought. The experiment was hand sown at 250 seeds/m^2 on 8 December 2010 in sub-sub-plot of 8 rows, 0.15 m apart (1.2m of width) and 1.5m long (with a separation between sub-plots of 2m). The mineral fertilization was applied in the beginning of the experience as 100%, 100% and 25% of the total quantity respectively for, P_2O_5, K_2O and N. While the other quantity of Nitrogen (75% of the total quantity) was applied at the beginning of tillering.

Yield analysis

Harvest date was determined at grain moisture of 15%. Yield was determined in sampling areas of 1 m^2 from the central rows of each sub-plot, where the number of grains, 1000-grain weight, grain yield and aboveground biomass were measured. Mean 1000 grains weight was calculated from the weight of 1000 grains each from the sampling area.

Statistical analysis

All data were statistically analyzed by ANOVA using SPSS software 18.0. Three factors (salinity levels, Minerals fertilization treatments and Barely genotypes) were analyzed together, according to a spli-strip experimental design. Mean separation was performed only when the F-test indicated significant ($P<0.05$) differences among the factors. The different interactions were also reported and significant differences were analyzed at $P<0.05$.

Results and Discussion

The weather regime, in terms of maximum (Tmax) and minimum air temperature (Tmin) and rainfall, during the experimental year 2010-11 is shown in Fig.1. The averages of air temperature during the season was very similar to the 20-year average values. In the season 2010-2011 and before sowing we recorded an amount of 35.8 mm (43% of the total precipitation).In fact during the crop cycle we recorded 47.3 mm.

Table.1 Agronomic and management practices carried out during the experiment.

Observation	**2010-2011**
Sowing date	8 December 2010
Genotypes	Ardhaoui and Bakistani
Seeding depth (cm)	4-5
Row space (cm)	15
Seeding rate (plants/m^{-2})	250
Cultivated area (m^{2})	120
Plot superficie (m^{2})	1.8
Irrigation salinity (dS/m)	2.6 and 10.5
Fertilisation treatments (kg/ha)	**T1**: 0 kg/ha N -0 kg/ha P2O5- 0 kg/ha K2O **T2**: 200 kg/ha N -0 kg/ha P2O5- 0 kg/ha K2O **T3**: 200kg/ha N -250 kg/ha P_2O_5- 0 kg/ha K_2O. **T4**: 200 kg/ha N -0 kg/ha P_2O_5- 150 kg/ha K_2O. **T5**: 0kg/ha N -250 kg/ha P_2O_5- 150 kg/ha K_2O. **T6**: 200kg/ha N -250 kg/ha P_2O_5- 150 kg/ha K_2O.
Harvest	25 May 2011
Growin period (days)	167 days

Table.2 Analysis of variance for spike number, grain number/m2, Total Biomass, straw yield and Grain yield under the effect of the salinity levels, genotypes, Fertilization treatment and their interaction

Source of variation	**d.f**	**Spikes number**	**Grain/m^{2}**	**Total Biomass**	**Straw yield**	**Grain yield**
E_A Salinity (S)	1	***	***	***	***	***
E_B Genotypes (G)	1				*	
S*G	1					
E_c Fertilization (F)	5	***	***	***	***	***
F*S	5			**	**	
G*F	5					
S*G*F	5					

*** significant at 1‰** significant at 1%, * significant at 5%.

Yield and yield components

The analysis of variance presented by table 2 shows the effect of Salinity, Genotypes and the fertilization treatments on the different parameters studied.

Salinity and fertilization treatments present highly significant effect on the different parameters (i.e, spikes number and the yield components). while, the genotypes show significant effect only for grain number per spike and the straw yield, in the same way the different interactions between the factors show significant effect in Total dry matter and straw yield only for the interaction Fertilization*salinity.

The results show that the salinity affects negatively the spike number/m^2 (figure 2). Therefore, without fertilization (treatment 1) Bakistani don't show any significant difference between spike number in the tow salinity levels. The spike number decrease from 169 spikes/m^2 to 146 spikes/m^2 for Ardhaoui.

The different fertilization treatments show significant difference in the spike number/m^2 for the tow genotypes. The Nitrogen increase the spike number /m^2 (comparison of the tow treatments 1 and 2) for the tow genotypes and under the tow levels of salinity. Therefore, this average increase by 60%, 20% in 2.6 dS/m and 25%, 28% in 10.5 dS/m respectively for Bakistani and Ardhaoui. The highest spike number/m^2 for the tow genotypes were recorded in the treatment 6 (200kg/ha N - 250 kg/ha P2O5- 150 kg/ha K2O) by 276 and 235 spike/m^2 in 2.6 dS/m and by 223 and 225 spike/m^2 in 10.5 dS/m, respectively for Bakistani and Ardhaoui.

The ANOVA results show that the two factors salinity and fertilization treatments have significant effects on the variation of the grains number/m^2 but their interaction is not significant (table 2). The salinity decreases the grain number/m^2. Therefore, the averages decrease from 3581 grains/m^2 to 2558 grains/m^2 for Bakistani and from 3364 grains/m^2 to 2138 grains/m^2 for Ardhaoui, respectively in 2.6 dS/m and 10.5 dS/m. in the same way, the response of Bakistani variety to the different fertilization combination (NPK) are clearer than Ardhaoui in the tow salinity levels (2.6 dS/m and 10.5 dS/m). The highest grains number/m^2 were recorded in the treatment 6 (200kg/ha N -250 kg/ha P2O5- 150 kg/ha K2O) by 8698 and 6588 grains/m^2 in 2.6 dS/m and by 7788 and 6119 spike/m^2 in 10.5 dS/m respectively for Bakistani and Ardhaoui.

The statistic results show that the two factors salinity levels and fertilization treatments have significant effects on the variation of the grains yield but their interaction is not significant (table 2).

The figure 3 illustrate the variation of the grain yield for the tow genotypes under tow salinity levels and six fertilization treatments. The averages of grain yield varies between 95g/m^2 to 266 g/m2 for Bakistani, between 89g/m^2 to 235 g/m^2 for Ardhaoui in 2.6 dS/m. In the same way (figure 3) Ardhaoui present significant decrease of 10% in the treatment 1at 10.5 dS/m in comparison with the same treatment in 2.6 dS/m. For the higher of salinity, we observe a significant decrease in grain yield (figure 3).

Figure.1 Rainfall, air temperature (T_{min} and T_{max}) during the tow experimental years (2010-2011.

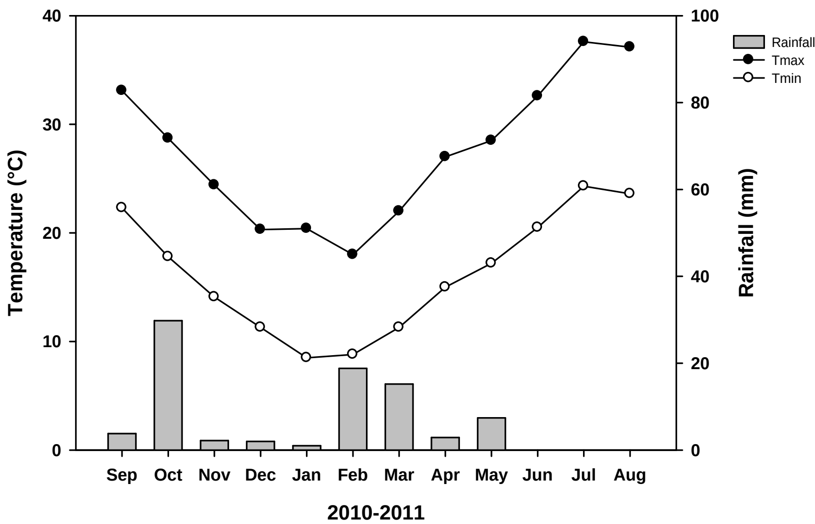
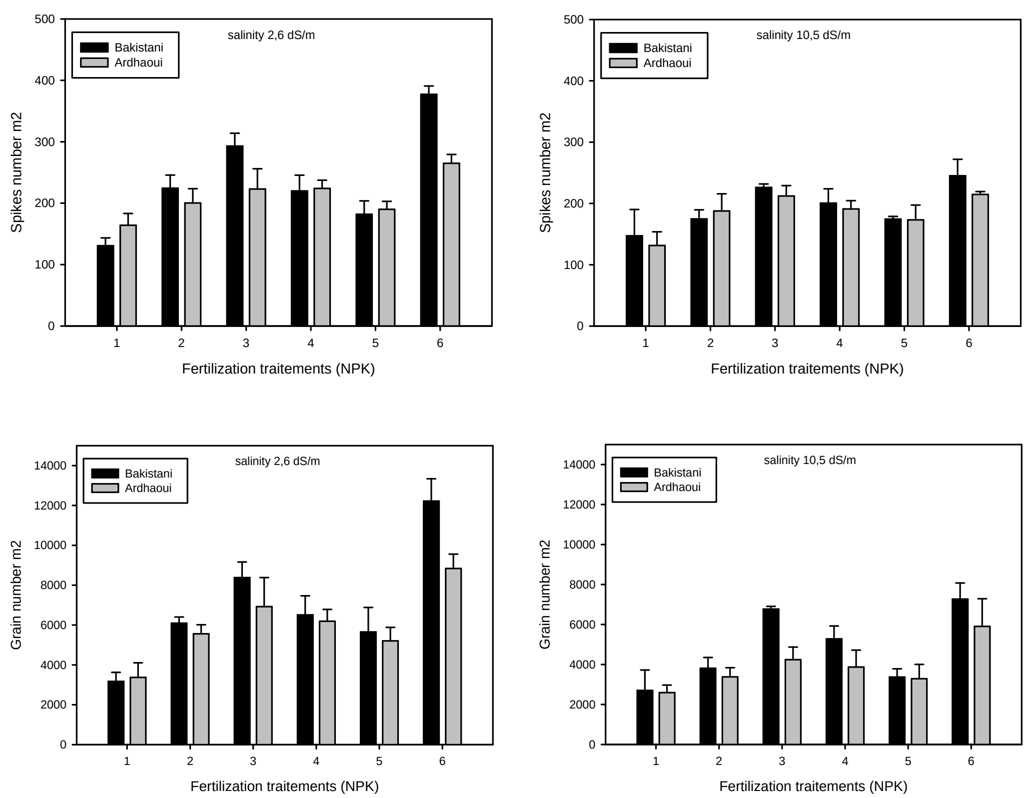


Figure.2 Variation of the mean spike number/m^2 and Grain number/m^2 between genotypes and between fertilization treatments (T1-T6) under two levels of salinity (2.6 dS/m and 10.5 dS/m). Vertical bars indicate standard errors of means.



Nitrogen fertilization (comparison between treatment 1 and 2) increase the grain yield for the tow genotypes in the tow salinity levels. Therefore, the averages increase by 60 g/m^2 in 2.6 ds/m and by 30 g/m^2 in 10.5 dS/m for the tow genotypes.
The salinity 10.5 dS/m affect the grain yield and the tow genotypes don't show significant difference under the fertilization treatment. The highest grain yield for the tow genotypes were recorded in the treatment 6 (200kg/ha N -250 kg/ha P2O5- 150 kg/ha K2O) by 266 and 235 g/m^2 in 2.6 dS/m and by 165 and 149 g/m^2 in 10.5 dS/m respectively for Bakistani and Ardhaoui.

The total biomass can be divided in 2 components: the grain and the straw yield. Indeed, these two components reflect the different aspects of plant development. Thus, the major part of the straw production takes place during the early stage of growth cycle and it is essentially related to the vigor and the vegetative growth as the tiller number, the leaves number, the height of the plants and the accumulation of the reserves during the vegetative stage. Whereas the grains yield takes place mainly during the productive phase and it is essentially influenced by spike number, spike fertility, grain-filling period and by the efficiency of the reserve mobilization.

Salinity levels, genotypes and fertilization treatment affect significantly the straw yield. The total biomass was affected by the salinity levels and the fertilization treatment and only the interaction salinity*fertilization affects both straw yield and total biomass.

The figure 4 point up the variation of the total biomass and the straw yield for the tow genotypes under tow salinity levels and six fertilization treatments. The averages of the total biomass varies between 182g/m^2 to 448 g/m^2 for Bakistani, between 209g/m^2 to 446 g/m^2 for Ardhaoui in 2.6 dS/m. At 10.5 dS/m, we observe a significant decrease in total biomass for all the fertilization treatment.
Nitrogen fertilization (comparison between treatment 1 and 2) increase the total biomass for the tow genotypes in the tow salinity levels. Therefore, the averages increase by 120g/m^2 in 2.6 ds/m and by 50 g/m^2 in 10.5 dS/m for the tow genotypes.

Results of this trial shows that the total biomass and the grain yield are negatively affected by salinity. Thus, in 2.6 dS/m we recorded a grain yield varies between 95g/m2 to 266 g/m2 for Bakistani and between 89g/m2 to 235 g/m2 for Ardhaoui .whereas in the conditions of moderate stress (10.5 dS/m) the grain yield decreases by 10%. Similar results showing a reduction of the barley yield under salt stress were founded by Sohrabi (2008), Taffouo (2009) and Gill (1979). The depressive effects of the salinity on the growth and the productivity of the plants are the results of the difficulties in water uptake, mineral nutrition and the toxicity of the ions accumulated within plant tissue (L.Xiong et al., 2002).

The twice comparison between the different fertilization treatments show that Nitrogen (N) affect positively the number of spikes/m^2, the grain number /m^2 and the grain yield / m^2. In the same way, the Phosphorus (P) increases the total biomass/m^2 and the grain yield /m^2. The Potasuim (K) doesn't affect the different yield parameter. Grain yield was strongly affected by the number of grains per unit surface, which in turn was related to N fertilization across all the fertilization treatments. The strict relationship between

Figure.3 Variation of the mean grain yield /m^2 between genotypes and between fertilization treatments (T1-T6) under two levels of salinity (2.6 dS/m and 10.5 dS/m). Vertical bars indicate standard errors of means

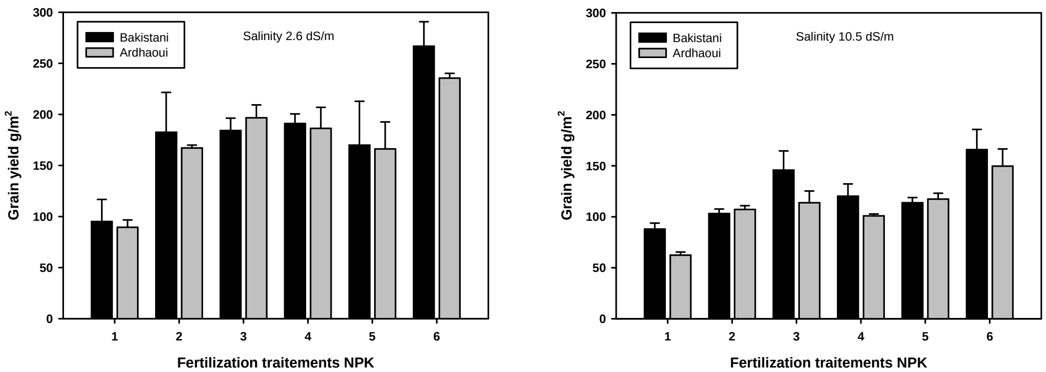


Figure.4 Variation of the mean total biomass/m^2 and straw yield/m^2 between genotypes and between fertilization treatments (T1-T6) under two levels of salinity (2.6 dS/m and 10.5 dS/m). Vertical bars indicate standard errors of means

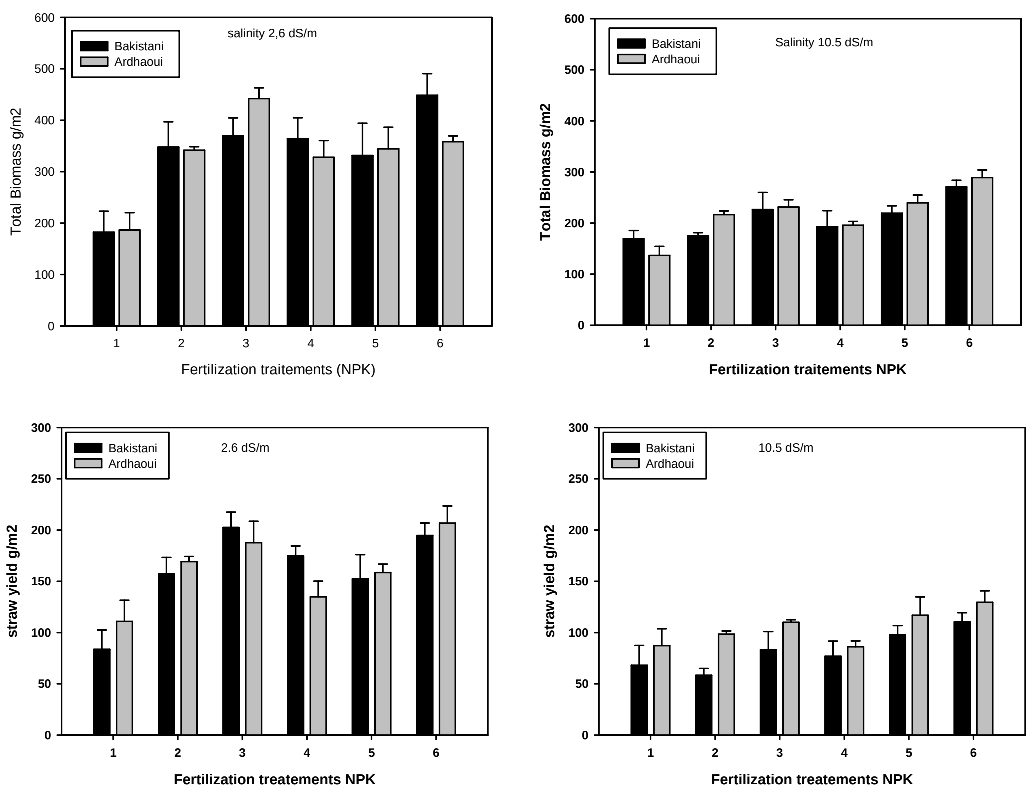
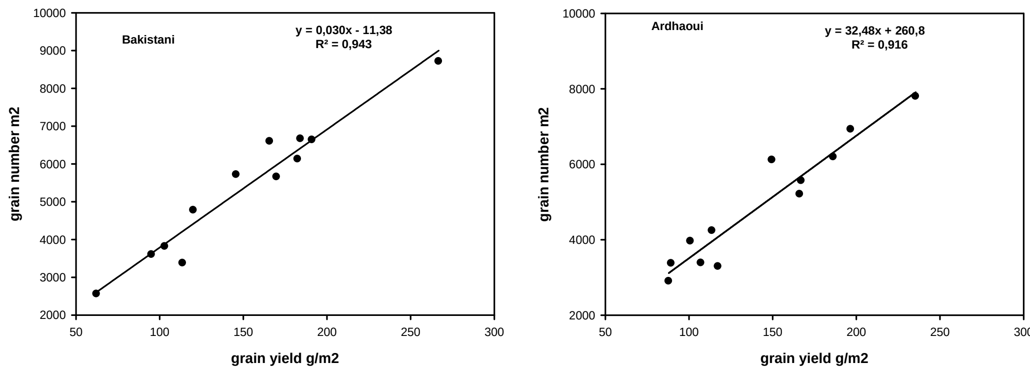


Figure.5 Relationship between grain yield/m^2 and grain number/m^2 for the tow genotypes Bakistani and Ardhaoui



the number of grains and yield has been observed by several authors in many species (Fischer, 1985; Demotes-Mainard et al., 1999; Cossani et al., 2007, 2009) and it is common in winter cereals (Jamieson et al., 1995). The effect of N fertilization mainly on the number of grains/m^2 has been observed also in other studies (Karam et al., 2009). Because only mild water stress did occur during the experimental period, different crop traits mainly emerged in response to nitrogen fertilization.

Barley response to N fertilization consisted in a higher number of grains per unit land area and thus in a higher tillering rate compared to wheat; hence differences between the crops occurred mainly during the early growth stages. This behaviour can be explained with the greater availability of N deriving from fertilizer during the initial growth period, as demonstrated by Garabet et al. (1998). As concerns the higher yield potentiality of wheat at higher N rates, Karam et al. (2009) observed that the supply of 150 and 200 kg N ha^{-1}, compared to 100 kg ha^{-1}, increased the number of grains per unit land area by 11 and 17% and 24 and 39%, as average of 3 years in two durum wheat cultivars.

The local barley “Ardhaoui” response to N fertilization consisted in a higher number of grains per unit land area and thus in a higher tillering rate. In addition, grain yield was strongly affected by spikes and grain number per unit surface, which in turn was related to P and N fertilization. Moreover, the locale genotype “ Ardhaoui” present a high capacity of tolerance to salinity in comparison with Bakistani and respond positively with the nutritional elements applied by increasing straw and grain yield.

Acknowledgements

We thank Jamel Zaroug and Bachir Chwikhi (works, Institute of Dry Area Medenine, Tunisia), Belgacem Lachiheb and Leila Ben Yahia (lab technicians, Arid and Oases Cropping Laboratory) for their collaboration in field and in lab works. This work was supported by PRF project “amelioration of barley yield in southern Tunisia” from Tunisian ministry of agriculture.

References

Alam, S. M. 1999: Nutrient uptake by plants under stress conditions, in

Pessarakli, M.: Handbook of Plant and Crop Stress. Marcel Dekker, New York, pp. 285–314

Bladenopoulos, K.B., Koutroubas, S.D., 2003. Influence of autumn nitrogen fertilisation and climate on winter barley in Greece. Agricoltura Mediterranea 133: 202-210.

Cantero-Martínez, C., Angás, P., Lampurlanés, J., 2003. Growth, yield and water productivity of barley Hordeum vulgare, L. affected by tillage and N fertilization in Mediterranean semiarid, rainfed conditions of Spain. Field Crops Res., 84: 342-357.

Cantero-Martínez, C., J.M. Villar, I. Romagosa and E. Fereres. 1995a. Growth and yield responses of two contrasting barley cultivars in a Mediterranean Environment. Eur. J. Agron., 4:317-326

Cossani, C.M., Savin, R., Slafer, G.A., 2007. Contrasting performance of barley and wheat in a wide range of conditions in Mediterranean Catatonia Spain. Ann. Appl. Biol. 151, 167–173.

Cossani, C.M., Slafer, G.A., Savin, R., 2009. Yield and biomass in wheat and barley under a range of conditions in a Mediterranean site. Field Crops Res. 112, 205– 213

Demotes-Mainard, S., Jeuffroy, M.H., Robin, S., 1999. Spike dry matter and nitrogen accumulation before anthesis in wheat as affected by nitrogen fertilizer: relationship to kernels per spike. Field Crops Res. 64, 249–259.

El Faleh, M., Mdimagh, S.: Food barley in Tunisia. In Food Barley: Importance, uses and local Knowled e pp. 29-35, ICARDA, 2005.

Fischer, R.A., 1985. Number of kernels in wheat crops and the influence of solar radiation and temperature. J. Agric. Sci. 105, 447–461.

Flowers, T.J., Garcia, A., Koyama, M., Yeo, A.R.: Breeding for salt tolerance in crop plants: the role of molecular biology. Acta Physio. Plantarum. 19: 427-433, 1997. http://dx.doi.org/10.1007/s11738-997-0039-0

Garabet, S., Wood, M., Ryan, J., 1998. Nitrogen and water effects on wheat yield in a Mediterranean-type climate. 1. Growth, water-use and nitrogen accumulation. Field Crops Res. 57, 309–318.

Grattan, S. R., Grieve, C. M. 1999: Mineral nutrient acquisition and response by plants grown in saline environments, in Pessarakli M.: Handbook of Plant and Crop Stress. Marcel Dekker, New York, pp. 203–229.

Jamieson, P.D., Martin, R.J., Francis, G.S., 1995. Drought influences on grain yield of barley, wheat, and maize. N. Z. J. Crop Hortic. Sci. 23, 55–66.

Jiang, Q., Roche, D., Monaco, T.A., Durham, S.: Gas exchange, chlorophyll fluorescence parameters and carbon isotope discrimination of fourteen barley genetic lines in response to salinity. Field Crops Research. 96: 269-278, 2006.

Karam, F., Kabalan, R., Breidi, J., Rouphael, Y., Oweis, T., 2009. Yield and waterproduction functions of two durum wheat cultivars grown under different irrigation and nitrogen regimes. Agric. Water Manage. 96, 603–615.

Kumar, A., Singh, D.P., Singh, P.: Influence of water stress on photosynthesis, transpiration, water-use efficiency and yield of Brassica juncea L. Field Crops Res. 37: 95-101, 1994.

Latiri-Souki, K., Nortcliff, S., Lawlor, D.W., 1998 Nitrogen fertilizer can increase dry matter, grain production and radiation and water use efficiencies for durum wheat under semi-arid conditions. Eur. J. A., 9: 21–34.

Munns, R.: Comparative physiology of salt and water stress. Plant Cell and Environment. 25: 239-250, 2002. http://dx.doi.org/10.1046/j.0016-8025.2001.00808.x

Oertli, J. J. 1991: Nutrient management under water and salinity stress, in: Proceeding of the symposium on nutrient management for sustained productivity. Depart. Soils Punjab Agric. Unver. Ludhiana, India, pp. 138–165

Shannon, M.C.: Adaptation of plants to salinity. Adv. Agron. 60: 75–119, 1998.

Shepherd, M.A., Davies, D.B., Johnson, P.A., 1993. Minimizing nitrate losses from arable soils. Soil Use Manag., 9: 94-98.

Sohrabi, Y., Heidari, G., Esmailpoor, B.: Effect of salinity on growth and yield of desi and kabuli chickpea cultivars. Pak. J. Biol. Sci. 11: 664-667, 2008.

Sohrabi, Y., Heidari, G., Esmailpoor, B.: Effect of salinity on growth and yield of desi and kabuli chickpea cultivars. Pak. J. Biol. Sci. 11: 664-667, 2008.

Taffouo, V.D., Kouamou, J.K., Ngalangue, L.M.T., Ndjeudji, B.A.N., Akoa, A.: Effects of salinity stress on growth, ions partitioning and yield of some cowpea Vigna unguiculata L. Walp. cultivars. Int. J. Bot. 5: 135-143, 2009.

Xiong, L., Zhu, J.K.: Salt tolerance. In The Arabidopsis Book, American Society of Plant Biologists pp: 1–22, 2002.