Study of the Effect of Salt Stress on Biometric Characteristics of Barley: Hordeum Vulgare L. (Poaceae)

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***Abstract*—The aim of our work is to study the response of the barley plant (*Hordeum vulgare L.*) to salt stress, at different NaCl concentrations (0, 50, 100, 150 and 250 mM) and follow its growth over time in the effect of salt stress . The control is based mainly on measurements of biometric parameters: length of the aerial and underground parts, fresh biomass, dry biomass and leaf area. The results clearly show the influence of salt stress on these parameters. The variety of barley, studied, showed good resistance to the phenomenon at concentrations not exceeding 150 mM salt. The study of the variance of the different parameters with ANOVA revealed no significant differences in the length of the ground aerial part and fresh biomass variations, the latter is very highly significant at a concentration greater than 150 mM of salt. Dry biomass showed no significance for concentrations less than 150 mM, while it is very highly significant for 250 mM NaCl. With regard to the leaf surface, the variations are significant for less than 100 mM and very highly significant beyond 250 mM of salt.**

***Index Terms*—*hordeum vulgare L.*, stress salt, NaCl, biometric characteristics**

I. INTRODUCTION

In arid and semi-arid regions, the plants should be irrigated to ensure crops and increase production. In these areas, the poor quality of irrigation water along with poor drainage often causes an accumulation of salts in the soil [1]-[4]. The physiology of plants growing in saline soils is thus altered, reducing their growth and yield [5]. Salinity recorded in these regions due to the strong evaporation of water from soil and irregular and insufficient rainfall, it also comes from irrigation most often poorly controlled [6]-[9].

The salinity in these ecosystems is not only related to climatic conditions but also to the man who, for economic reasons, has developed intensive agriculture often poorly controlled by practicing poor farming techniques [10]-[12]. The accumulation of salt in the profile over time without being rare liquors by rainwater gradually making land unfit for cultivation. This phenomenon is exacerbated by the excessive use of fertilizers, for plowing and irrigation method leading to a process of secondary salinization [13], [14].

II. MATERIALS AND METHOD

The experiments are conducted in a dirty ventilated room protected from bad weather, as culture substrate we used an agricultural soil mixed with the remains of animals in the proportions of 4/1. Plastic pots were filled with known amounts of prepared soil. Before potting substrate, the bottom of the pots is lined with a layer of gravel for drain. The sowing of seeds in the pots is performed for four (4) *Hordeum vulgare L.* by pot. Seeds plants are irrigated with saltwater at different concentrations of NaCl salt (Control : 0 mM, 50 mM, 100 mM, 150 mM and 250 mM) solutions following the growth of these plants for seven weeks of stress. The statistical analysis with ANOVA was carried out using MINITAB 13.31 software.

III. RESULTS AND DISCUSSION

A. Length of the Aerial Part (LAP)

The analysis of variations of length of the aerial part (LAP) reveals that it decreases with the salt concentration, it reaches a maximum of about 30 cm for the first concentration of salt, 50 mM NaCl, and a minimum of 17.5 cm for the high salt concentration (250 mM) in the 7th week of stress, which represents approximately 50% compared to the control.

The analysis of variance with ANOVA showed that there was a non-significant difference between the different average measured lengths of the aerial part (LAP) in the presence of salt stress.

B. Length of the Underground Portion (LUP)

About the variation of the underground parts of barley, we should note, that LUP peaked about 7cm for lower salt concentration (50 mM). A minimum size of 2,65 cm was recorded for the third concentration (150 mM).

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At the 7th week of stress, the length of the underground part became 35 % compared to the control. The analysis of ANOVA variance shows that there is no a significant difference between the different average measured of LUP in the presence of salt stress.

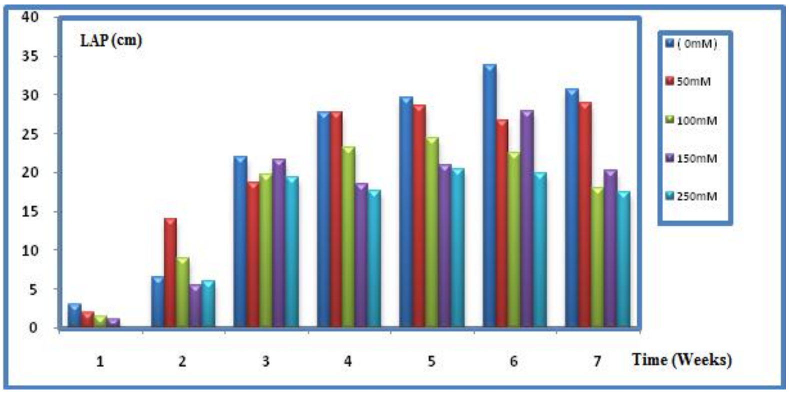

Figure. 1. Variation of length of the aerial part a function of time

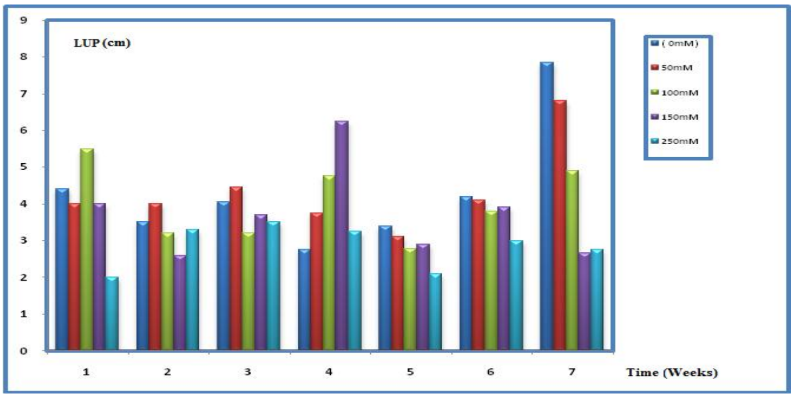

Figure. 2. Variation of length of the underground part a function of time

TABLE I: ANALYSIS OF THE LAP VARIANCE WITH ANOVA

[NaCl] (mM)	source	DL	SC	CM	F_{obs}	P	F_{the}	Signification
0 - 50	Factor	1	3	3	0 ,03	0,873	4,75	NS
	Error	12	1527	127				
	total	13	1530					
0 - 100	Factor	1	65	65	0 ,59	0,456	4,75	NS
	Error	12	1314	109				
	total	13	1379					
0 - 150	Factor	1	76	76	0 ,64	0,440	4,75	NS
	Error	12	1426	119				
	total	13	1502					
0 - 250	Factor	1	133	133	1,22	0,291	4,75	NS
	Error	12	1310	109				
	total	13	1443					

(CM: average square; DL: degree of freedom; SC: sum of squares; F_{obs}: observed factor; F_{the}: F theatrical factor; P: probability; NS: no significant; S: significant; HS: highly significant; VHS: very highly significant)

TABLE II: ANALYSIS OF THE LUP VARIANCE WITH ANOVA

[NaCl] (mM)	source	DL	SC	CM	F_{obs}	P	F_{the}	Signification
0 - 50	Factor	1	0,71	0,71	0 ,27	0,615	4,75	NS
	Error	12	31,92	2,66				
	total	13	32,63					
0 - 100	Factor	1	0,25	0,25	0 ,09	0,772	4,75	NS
	Error	12	34,60	2,88				
	total	13	34,86					
0 - 150	Factor	1	0, 00	0,00	0 ,00	0,984	4,75	NS
	Error	12	43,95	3,66				
	total	13	43,95					
0 - 250	Factor	1	5,53	5,53	3 ,1	0,101	4,75	NS
	Error	12	21,03	1,75				
	total	13	26,56					

C. Fresh Biomass (TFB)

Fresh biomass (TFB) decreases depending on the salt concentration, it reaches a maximum of about 0.43 g for a concentration of 50 mM salt and a minimum of 0,12 g for the higher concentrations of salt (250 mM) at the 7th week of stress, which represents approximately 32 % compared to control. Moreover, analysis of variance with ANOVA between different medium TFB, measured in the presence of salt stress, shows that there is no significant difference for the concentrations of 50 and 100 mM salt, highly significant for 150 mM and very highly significant beyond 250 mM of salt.

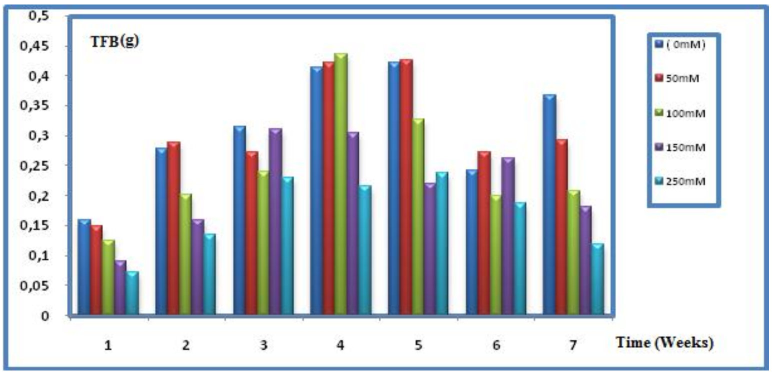

Figure. 3. Variation of the total fresh biomass a function of time

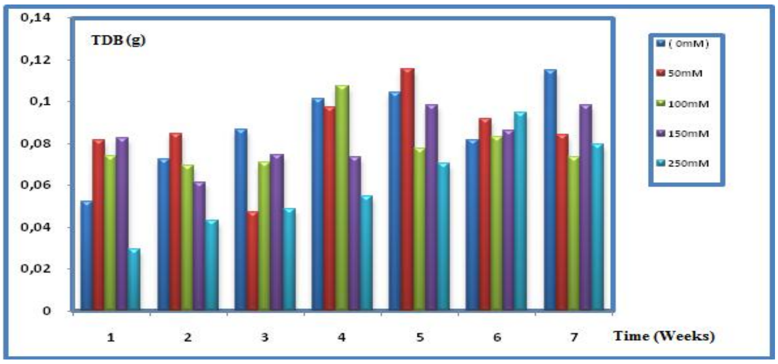

Figure. 4. Variation of the total dry biomass a function of time

TABLE III: ANALYSIS OF THE TFB VARIANCE WITH ANOVA

[NaCl] (mM)	source	DL	SC	CM	F_{obs}	P	F_{the}	Signification
0 - 50	Factor Error total	1 12 13	0,0015 0,0545 0,0560	0,0015 0,0045	0 ,33	0,577	4,75	NS
0 - 100	Factor Error total	1 12 13	0,0248 0,0739 0,0988	0,0248 0,0061	4,04	0,068	4,75	NS
0 - 150	Factor Error total	1 12 13	0,0445 0,0483 0,0928	0,0445 0,0040	11,05	0,006	9,33	HS
0 - 250	Factor Error total	1 12 13	0,0974 0,0422 0,1397	0,0974 0,0035	27,68	0,000	18,6	VHS

TABLE IV: ANALYSIS OF THE TDB VARIANCE WITH ANOVA

[NaCl] (mM)	source	DL	SC	CM	F_{obs}	P	F_{the}	Signification
0 - 50	Factor Error total	1 12 13	0,000016 0,003840 0,003856	0,000016 0,000320	0 ,05	0,826	4,75	NS
0 - 100	Factor Error total	1 12 13	0,1043 0,6026 0,7069	0,1043 0,0502	2,08	0,175	4,75	NS
0 - 150	Factor Error total	1 12 13	0,000109 0,003848 0,003957	0,000109 0,000321	0,34	0,57	4,75	NS
0 - 250	Factor Error total	1 12 13	0,002652 0,005807 0,008459	0,002652 0,000484	5,48	0,037	9, 33	HS

D. Total Dry Weight (TDB)

Analysis of the results of the variation of the total dry biomass versus stress, shows that it gradually decreases as the salt concentration increases, reaches a maximum of 0.12 g at the first concentration of 50 mM of salt, after five weeks of treatment, and a value of 0.08 g at the end of stress, to a concentration of 250 mM salt. Moreover, analysis of variance with ANOVA shows that the difference between the different measured average of the total dry biomass of barley becomes highly significant beyond a concentration of 250 mM salt .

E. Leaf Area (LA)

Results show that the leaf area LA decreases by increasing the dose of salt, it reaches the maximum per 1550 cm^2 at the first concentration of 50Mm and 570,5 cm^2 in fourth concentration of 250 mM, in the last week of stress, representing approximately 32 % of the control.

About the statistical analysis of the variance of the leaf surface by a controlled factor ANOVA, there was although a significant difference in concentrations not exceeding 150 mM NaCl, it becomes very highly significantly beyond this concentration.

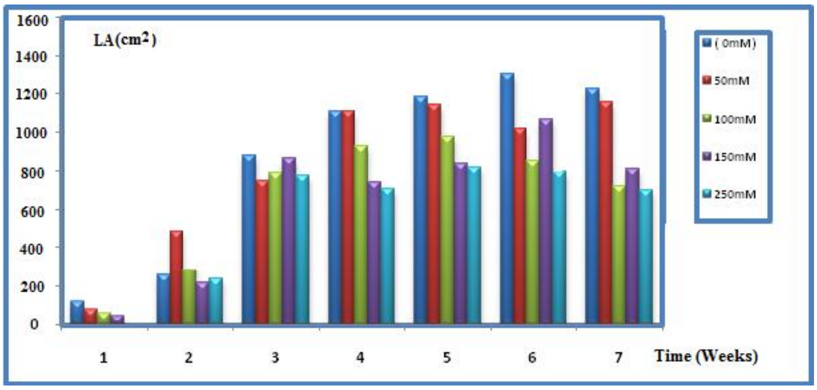

Figure. 5. Variation of leaf area a function of time

TABLE V: ANALYSIS OF THE LA VARIANCE WITH ANOVA

[NaCl] (mM)	source	DL	SC	CM	F_{obs}	P	F_{the}	Signification
0 - 50	Factor Error total	1 12 13	47198 3426 50624	47198 1713	27,55	0,034	98,5	S
0 - 100	Factor Error total	1 12 13	438741 35913 474654	438741 17957	24,43	0,039	98,5	S
0 - 150	Factor Error total	1 12 13	692224 107848 800072	692224 53924	12,84	0,070	18,5	NS
0 - 250	Factor Error total	1 12 13	1385329 2133 1387462	1385329 1066	1299,3	0,001	998	VHS

IV. CONCLUSION

Analysis of the results showed a decrease of studied parameters depending on the salt concentrations during the period of stress. Thus, the plant could not withstand the stress concentrations exceeding 150 mM salt, where we have observed a deterioration in the cells at the seventh week of stress beyond a concentration of 250 mM of salt. This result was confirmed by analysis of variance with ANOVA between the average measured biometric parameters, which showed that although the differences become significant and highly significant beyond a concentration of 150 mM salt for most parameters.

We can conclude that the barley variety, in our study, can be classified as a no halophyte and resistant plant that can adapt to irrigation with brackish and saltwater in the Saharan regions. Knowing that barley is the most resistible cereal to salinity, other grains such as wheat should be irrigated by water less salty. Barley can be considered an indicator of salt stress for other cereals.

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