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Which Genotype of Barley (*Hordeum Vulgare* L.) Can Be Selected in the Algerian Semi Arid Region ?

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Abstract: Drought is the first abiotic stress affecting the production of barley in the semi-arid regions. It's induced a reduction in the yield and the potential yield and also creates variability between years. In another side, drought is heterogeneous in the time because of the difference in the seasons and the years and unpredictable. This situation increases the difficulty to simulate the action of stress condition on the plant. Our study is to compare between six genotypes of barley (*Hordeum vulgare* L.) selected in the Algerian semi arid region. These genotypes are considered the most adapted to the instability of this environment. The results obtained express the relationship between varieties and the environment. The drought occurred usually at anthesis stage disturbing the natural comportment of the plants. The adapted genotypes are those who respond to this stress by regulating their physiological and biochemical mechanisms and give good yields. We have found that under droughty year barley produce biomass. increasing the rate of total sugars whereas in under a less droughty year the best yield obtained is regulated by a high RWC and rate of proline, a good production of biomass and high weight of the grain.

Key words: drought, Barley, RWC, sugars, proline, yield and components.

INTRODUCTION

The drought is the first abiotic stress causing not only differences between the average output and the potential production but also causes variability between years with another (instability of the production). In addition, the drought is also heterogeneous in time (through the seasons and the years) and is unpredictable what makes difficult the simulation of the conditions stressing of drought [1].

The selection of earliness in cereal is the more used way to escape the dryness which occurs in end of the cycle. It is characterized by a high speed of growth in the spring of the genotypes and by a capacity of growth at low temperatures and its insensitivity to the photoperiod [2].

On the basis of its character several genotypes were selected in arid semi zone but it seems difficult to explain the fluctuations observed during the development of the plant. Every genotype develops specificity for the mechanisms of resistances to the drought. Indeed, the selection for the morpho physiological characters are very much used in the programs of selection [3] which are a parental criteria very indicated in the crossings of resistance to water deficiency.

The adaptation mechanisms changes with the genotype, the age of plant, the environment, also with the type of tissue and the organs [4]. In this approach, it is better to study various conditions to which the plant is subjected; to observe the type of answer that is physiological, biochemical or morphological. The contribution of osmotic adjustment in the mechanisms of tolerance or adaptation to the drought is very studied by the osmotic potential which is conditioned by accumulation of osmoticums essentially composed by of sugars and amino-acids [5].The relative water content in the plant allows to evaluate the statute of water in the cells and thus its level of resistance with respect to the unfavorable conditions of the environment [6]. The rate of chlorophyll is very affected by the water deficiency with the inhibition of the electron transport between quinones A and B who leads to the fading of plant [7]. The loss of membrane integrity according to a water stress involves metabolic trouble which induces generally a very important escape of solutes between the different cellular compartments or extra cellular space [8]. The morphological characters are also good criteria of selection and, for a long time, the base of the varietals selection.

This study makes it possible to compare the genotypes which were selected in the Algerian semi

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arid region in order to emphasize the characters which would seem to be implied in the tolerance to the environment variation particularly the drought taking place every year at the end of the cycle of the cereals.

MATERIALS AND METHODS

Six genotypes of barley (*Hordeum vulgare* L.) were studied. they are selected in Algerian semi arid region by the technical institute of the field crops of Setif (ITGC) (table I).

Table I: Genotypes of barley studied in the experimentations

Genotype	*row*	*Origin*
Tichedrett	6r	Algerian landrace
Soufara	2r	Syria
Rahma	2r	Introduced from Syria
Tissa	2r	Introduced from Syria
Elfouara	6r	Syria
Elbahia	6r	landracex French cultivar

The experimental site is at an altitude exceeding the 1080 m, this site represent the central region of the high plateau situated in the semi arid region in a city na;ed Setif. The experimentation was led on two trials one in 2004 - 2005 and the second in 2005-2006.

The site is characterized by cold winters with one long dry season (4 to 5 months from March to September). The region is very exposed to early risks of sirocco and to the late frost. The precipitations are irregular especially at the end of the cycle coinciding, generally, with the end of tillering and the anthesis stage. The rains in 2004/2005 were higher (375.20 mm) than 2005/2006 (386 mm). The Temperatures were in identical averages for the two trials, their distinction starts about March with 2004/2005 colder than 2005/2006 (figure 01).

The experiment is a block completely randomized design with three replicates. The width the elementary parcel consisted 6 spaced rows of 20 Cm, the length is 6 m, and therefore the surface of each micro parcel is 6 m^2. The sowing date of is the 29/11/2004 for the first trial and in 21/11/2005 for the second. Nitrate fertilizers (urea 33%) is practiced with an amount of 1q/ha. The weeding is carried out in spring with the emergence of weeds using Granstar and Zoom.

Physiological and biochemical characters were measured according to three times starting from the anthesis: **P1**: at the anthesis, **P2**: 10 days after the anthesis and **P3**: 20 days after the anthesis every variable measured is repeated 4 times.

The physiological characters measured are the relative water content (RWC) the method used is that described by (9). From fresh and weighed (PF) leaves are cut into small pieces (1cm) and put in distilled water and placed into an incubator with 4^0C during 24 hours then the samples are weighed to have the turgid weight leaves (PT). The dry weight (PS) is obtained after drying samples at 80^0C during 24 hours. The relative water content is calculated starting from the following equation: RWC=PF-PS/PT-PS.

Total Chlorophyll (CHT) content was extracted as described by (10) in an 80% acetone on 100 mg from fresh leaves. The membrane stability index (ISM) is measured according to the method of [11] modified by [12]. Samples of 0.1g of sheets are cut. Each sample is washed with tap water then with bidistilled water and put into a tube with 10 ml of bidistilled water. The tubes are put in bain Marie at 40^0C during 30 minutes; after cooling the electric conductivities (C1) is measured. The samples passed thereafter to the bain Marie with 85^0C during 10 minutes. After cooling new electric conductivity (C2) is measured. The membrane stability index is calculated according to the following formula: ISM= (1-C1/C2) X 100.

The osmotic potential is measured with an osmometer. Total sugars are measured according to the method of [13]. The proline is measured according to the method of [14], 100 mg (for each test) taken from the median part of leaves, are immediately weighed then placed into a tube. A volume of 2 ml of methanol with 40% is added to the sample and the whole is heated, during 1hour in a bain Marie at 85°C. After cooling, 1 ml of the solution of extraction is added to 1 ml of acetic acid, 25 mg of ninhydrine and 1 ml of distilled water mixture - acid acetic - acid ortho phosphoric (120, 300, 80: v/v/v). The unit is carried to boiling during 30 minutes in the bain Marie, then cooled and added with 5 ml of toluene. After agitation with the vortex, Na_2SO_4 is added in each tube.

The total dry weight is the addition of the number of tiller and ears. The morphological characters are the height of the plant, the length of the ears and the length of the awns at maturity.

At maturity the following parameters are measured either the number of ears per unit of area (NE), number of grains per ear (NGE), the weight of 1000 grains (PMG), the yield (RDT), the weight of the straws (MSP), the total biomass at maturity (MSTM) and the harvest index (HI) determined by the ratio (RDT/MSTM x 100). Statistical study was realized with the software *stat box pro*, it related to an analysis of the variance and analysis of principal components (ACP).

RESULTS AND DISCUSSIONS

The RWC decreases regularly starting from anthesis, it seems to be identical for all the genotypes. In addition it changes according to the year and according to the period of sampling (Table II). During the first trial (2004/2005) a low RWC from 54 to 35% is noted. During the second trial (2005/2006), the RWC

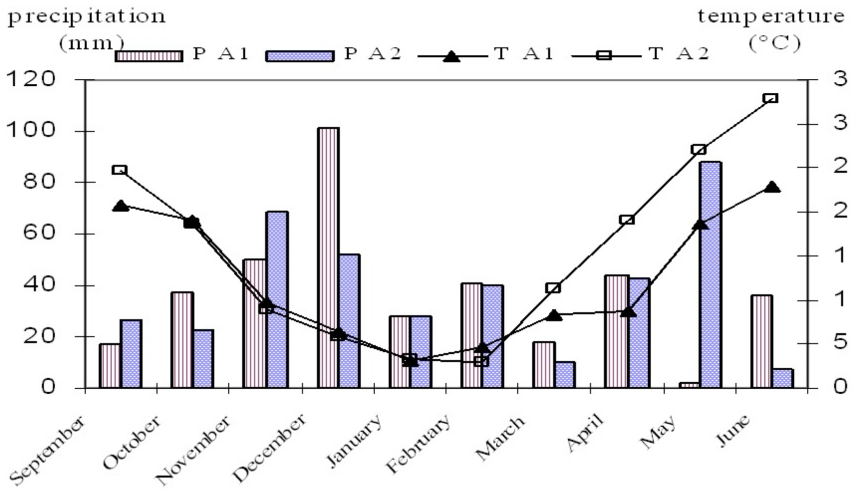

Fig. 1: representation of climatic condition of the two trials. PA1: rains of 2004/2005, PA2: Rains of 2005/2006, TA1: Temperatures of 2004/2005, TA2: Temperatures of 2005/2006.

was between 88.52% and every genotype have maintain an average near to this mean.

Total chlorophyll (CHT) presents identical concentrations during this two studied years. Genotypes present significant differences and decrease as the maturity approaches. The osmotic potential (PO) present a variation due to the conditions of the environment and its interaction with the period of sampling. During 2004/2005, each genotype has presented low osmotic potential with Soufara followed by Tichedrett whereas highest is noted for Rahma. At 10 days after anthesis osmotic potential augment slightly for all the varieties with an almost identical average. 20 days after anthesis this values decrease with a low pressure. Elbahia presented the high value. During the following trial 2005/2006, the osmotic potential was more fairly higher for all the genotypes who seems presented the same PO the difference is noted for Tissa with the lowest value at anthesis. PO increases linearly progressively; this coincides with the falls of rain which characterized this period.

Soluble sugars are very different between genotypes and vary according to the conditions of the environment (table II). The highest concentrations are noted during 2004/2005 with Tichdrett, Tissa, Elbahia and Soufara with maintenance of this concentration whereas Elfouara and Rahma presented lower concentrations but they were variable starting from anthesis. During 2005/2006 a low soluble sugar concentration is accumulated in the leaves and it does not vary throughout the periods of sampling and in comparison to the genotypes. The accumulation of the proline in the leaves reveals differences very highly significant that is between genotypes or years or different periods of sampling or their interactions.

During 2004/2005 the rate of proline was very high for all the genotypes, this rate increases from the anthesis then decrease slowly, exception is for Elfouara which is distinguished by increase in its synthesis of proline towards the end of the cycle with 13.09 µg/g MF. During 2005/2006, the synthesis of proline was reduced of half for all the genotypes with stability throughout the controlled period.

During 2004/2005, ISM is very low for all the genotypes, the membrane seems to be very porous and loses solutions but the rains improve its integrity. For 2005/2006, the membrane seems to lose its integrity as maturity approaches.

Statistical analysis shows that differences between genotypes is highly significant with a high height noted with Elbahia and Tichedrett this during 2004/2005. Whereas, during 2005/2006, Elbahia maintained its height rose compared to all the other varieties (table III).

In the Algerian semi arid zone, the height is regarded as criterion of selection in the improvement programs[15,16]. In droughty periods the plant develops a high height which is sign of tolerance[17]. The length of the ears (LE) is very variable between genotypes; Rahma was highest with 6.74 cm and the weakest were Elfouara and Tichedrett respectively 5.31 and 4.27 cm. According to[18], the length of ears is variable between the various types of genotype and can be different within the same plant as it is prone to the great influence of environment.

Under the effect of the environment, the awns length is different. Elfouara and Tichedrett present the longest awns whereas during 2004/2005 and Soufara in the second trial. The length of awns is often regarded as selection criteria for resistance to the drought in

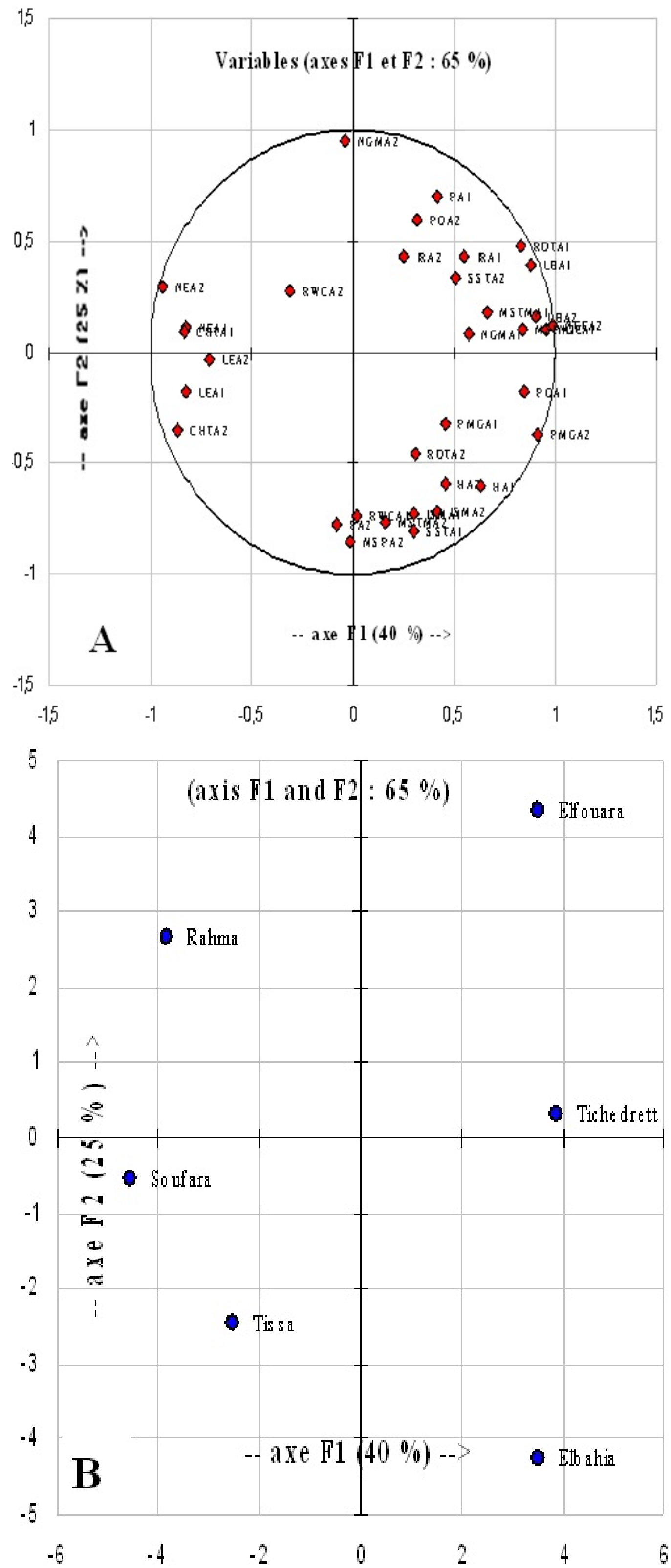

Fig. 2: ACP representation of variables (A) and genotypes (B).

Tableau II: Mean value and significance of the physiological and biochemical parameter of the genotypes, trial, sampling and their interaction.

	RWC		SUGARS		PROLINE		PO		ISM		CHT	
	A1	*A2*	*A1*	*A2*	*A1*	*A2*	*A1*	*A2*	*A1*	*A2*	*A1*	*A2*
Tichedrett	51,13	90,09	137,74	20,26	7,67	3,32	-3,15	-1,01	49,13	46,38	1,04	1,41
Soufara	56,73	88,04	132,90	20,29	7,34	3,33	-3,65	-1,07	48,53	41,64	1,09	1,60
Rahma	49,46	92,44	122,54	19,91	7,25	3,18	-3,33	-1,02	45,52	38,02	1,19	1,55
Tissa	56,67	86,90	137,14	18,96	7,55	3,79	-3,33	-1,52	54,81	43,12	1,11	1,70
Elfouara	53,64	86,29	126,34	20,56	8,96	3,23	-3,20	-0,98	49,84	38,51	0,93	1,35
Elbahia	58,48	87,39	136,90	20,38	7,06	3,51	-3,00	-1,14	53,71	44,69	0,94	1,42
Genotype effect(G)	ns		***		***		ns		ns		***	
Trial 1 (A1)	54,35		132,26		7,64		-3,28		50,26		1,05	
Trial 2 (A2)	88,52		20,06		3,393		-1,12		42,06		1,50	
Trial effect (A)	***		***		***		***		***		NS	
Sampling (P1)	80,76		79,99		5,057		-2,32		36,36		1,47	
Sampling (P2)	74,09		73,29		5,652		-2,05		55,94		1,42	
Sampling (P2)	59,46		75,21		5,84		-2,23		46,18		0,93	
Sampling effect (P)	***		NS		***		NS		***		***	
General mean	71,44		76,16		5,52		-2,20		46,16		1.276	
interaction GxP	0		***		***		ns		ns		***	
interactions PxA	0		***		***		***		***		***	
interactionsGxPxA	ns		***		***		0		ns		***	

*, **, ***: Significant at $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively; ns, not significant.

Table III: Mean value and significance of the morphological parameters of the genotypes, trial, and their interaction.

	Height		Awns Length		Ears Length	
	A1	*A2*	*A1*	*A2*	*A1*	*A2*
Tichedrett	85,00	56,52	15,24	13,25	4,81	3,73
Soufara	64,33	55,14	11,18	8,12	7,09	5,30
Rahma	64,67	56,90	10,67	8,98	6,91	6,58
Tissa	66,67	54,20	10,97	11,43	6,33	6,10
Elfouara	61,67	56,10	16,43	15,15	5,63	5,00
Elbahia	88,33	77,33	13,06	12,63	6,32	5,32
Genotypes effect (G)	***		***		***	
Trial effect (T)	***		***		***	
Trial 1 (A1)	71,78		12,93		6,18	
Trial 2 (A2)	59,37		11,60		5,34	
Interaction GxT	0		ns		ns	
General mean	65,57		12,26		5,76	

*, **, ***: Significant at $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively; ns, not significant.

Table IV: Means value and significance of the yield components and yield of the genotypes, trial, and their interaction

	NE		NGE		PMG (g)		RDT(g/m^2)		MSTM(g/m^2)		MSP (g/m^2)		IR	
	A1	*A2*	*A1*	*A2*	*A1*	*A2*	*A1*	*A2*	*A1*	*A2*	*A1*	*A2*	*A1*	*A2*
Tichedrett	413,33	400,00	35,93	35,23	33,00	57,79	338,00	590,77	798,00	1533,33	396,00	726,67	0,43	0,39
Soufara	523,33	776,67	20,27	18,37	26,03	46,83	193,67	467,03	624,33	1600,00	234,33	900,00	0,31	0,30
Rahma	710,00	866,67	19,67	20,93	28,81	48,34	285,00	548,07	758,33	1570,00	354,67	763,33	0,39	0,35
Tissa	653,33	623,33	24,73	22,03	27,55	52,45	202,00	455,70	867,67	1473,33	365,33	790,00	0,27	0,34
Elfouara	443,33	503,33	44,87	37,60	25,55	53,93	358,33	408,03	977,00	1223,33	457,00	526,67	0,37	0,34
Elbahia	423,33	403,33	39,40	34,90	30,26	59,41	301,67	613,53	857,33	2230,00	440,00	1216,67	0,36	0,30
genotypes	**		***		***		ns		ns		ns		ns	
Trial 1 (A1)	527,78		30,81		28,53		279,78		813,78		374,56		0,35	
Trial 2 (A2)	595,56		28,18		53,12		513,86		1605,00		820,56		0,34	
Trial effect	ns		ns		***		***		***		***		ns	
InteractionGxT	ns		ns		ns		ns		ns		ns		ns	
General mean	561,67		29,49		40,83		396,82		1209,39		597,56		0,35	

*, **, ***: Significant at $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively; ns, not significant

cereals[19]. The development of long barbs helps photosynthetic activity to continue and to tolerate the drought after senescence of the leaves [20].

Variations of NE, NGE, the weight of 1000 grains, the yield, the biomass at maturity and the production of straw are in favor of 2005/2006 (table IV). The yield during this trial was supported by the NE and the weight of 1000 grains. The decrease of PMG during 2004/2005 explains the low yield obtained.

Harvest index was relatively identical for the two trials because of the high biomass realized during the second year. The total biomass at maturity and the yield of straws are conditioned by the environment conditions.

The first four axes of the ACP explain 92% of the variation available. With the first axis which explains 40% of the total variation is positively correlated the following variables: Variables of 2004/2005 with the NGEA1, RDTA1, MSTMA1, MSPA1, HA1, LBA1, and POA1. In 2005/2006, the variables are the NGEA2, the PMGA2, and LBA2. The variables which are correlated negatively with this axis are the NE, LE and CHT of the two trials.

The axis 2, which explains 25% of the variation, explains in the positive side POA2 and PA1. In the negative one, we have: MSTMA2, MSPA2 and HA2. For the physiological and biochemical parameters we have RWCA1, SSTA1, PA2, ISMA1 and ISMA2. At the axis 3 (17%) we have correlated on it the following variables: RWCA2, IRA1, PMGA1 and RDTA2 which are positively correlated to him. the axis 4 (10%) are represented positively by IRA2 and negatively by SSTA2.

The projection of the average points of our genotypes on our axis 1 presents in positive side only the local genotype Tichedrett is represented which is characterized by its elevate fertility, PMG and high production of biomass under unfavorable condition and its raised HI when the environment is more favorable. The negative side represents the correlation between the two genotypes Soufara and Rahma which are characterized by their high number and length of ears, as well as the high concentration of total chlorophyll they are not very fertile, produce less biomass in unfavorable conditions. Their stems and barbs are not very long. They are the genotypes who offered the lowest yield under effect of drought.

According the second axis we have two genotypes which are opposite. On the positive side, we have Elfouara which gives, in favorable (A2) condition, high osmotic potential. In unfavorable conditions (A1), it seems to accumulate more proline that the other genotypes. On negative one, Elbahia is characterized by its development of the biomass and the height during the second trial this by developing a high osmotic pressure with a high accumulation of proline and with a high membrane integrity. Tissa is negatively correlated to axis 3 which is characterized by less production in total biomass in droughty trial, contrary, when the environment is more favorable its potential is lower, produces little biomass and presents the low yield and its low RWC.

The physiological and biochemical changes are a consequence of the ability of the plant to survive at severe water deficits depends on its ability to restrict water loss through the leaf epidermis after the stomata have attained minimum aperture [21].

Conclusion: The existing variability between the most adapted genotypes to the conditions of semi-arid region of Setif is the result of the variation of environment: i) rain of May and April ii) the late days of freezing in April iii) the high temperatures associated to the end of the vegetative cycle and iv) other factors such as the sirocco. It should be noted that the late frosts which coincide with the anthesis and the early drought which affects the filling of the grains affect the instability of the yield. According to [22], the selection multi character was largely adopted in Algerian semi arid region, and is in favor of the genotype which has the capacity to produce a high biomass before the anthesis and makes a good use of this biomass.

They operate on the physiological and biochemical adaptive mechanisms of these genotypes. Dry years being characterized by: a good production of biomass and an accumulation of total sugars. Whereas, the good years present: high yields controlled by: the RWC, accumulation of proline, a high biomass and PMG

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