ORIGINAL PAPER

EFFECT OF WATER STRESS ON YIELD AND ITS COMPOSANTSOF SOME CEREALS IN ALGERIA

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ABSTRACT

In this study an attempt is made to study agronomic characters of adaptation to drought in yield and its composants under dry land and in irrigated conditions:25 barley varieties (16 of French origin, 7 of Syrian origin and 2 of Algerian origin), 1 variety of durum wheat (DURELLE, Fance) and 1 variety of triticale (CLERCAL, France)were compared during two successive years 2003/2004.

A net effect on most agronomic characters was noticed, with the exception of the thousand –kernel weight in the second year trial. The moderate water deficit (conditions in the Ouest Algerian zone) allowed French varieties to perform better in both conditions than Algerian and Syrian varieties because they are considered to be tolerante to drought.

KEY WORDS: Water deficit, irrigation, yield, yield components.

INTRODUCTION

Weltzien and Srivastava [16] reported that the level of sensitivity to water deficit exists at all stages of plant development , although it appears that in barley there are several critical stages of sensivity. The first stage appears at the germination (bad stand and low density), the second one coincides with the floral initiation, which reduces primordia number per surface unit and reduces tillers number, the third level is at the anthesis (reduction of grain number per spike, due to pressure on reproduction effiency). The forth critical stage is located at the beginning of the milky stage of the grain and reduces kernels weight.

The few days following flowering are a very sensitive phase for grain number component [8]. For Grignac [6], water deficit during the shooting stage affect spike number and particularly spike fertility [7]. Nutritional troubles induced by the lack of nitrogen and also by the low photosynthesis (light and temperature) [8] can be seen from the decrease in grain number per spikelet due mainly to abortion.

Jonard [10], showed an evidence of a negative effect of evatranspiration if it stays within a 2 mm per day limit. In contrast, he found a positive correlation between growth speed and grain number per spike. Varlet-Granchet and Pluchard [15], who worked on bread wheat , found that the number of grains per spike is determined early at the shooting stage. Unfavorable conditions during the shooting stage affect mainly the grain number per spikelet. For Ceccalerellis [1], water deficit during the earlystage of plant development induces a reduction in spikelets primordia, whereas water deficit late in the plant development increases flower and the entire spikelet death.

The number of grains per spike (fertility) depends on the availability of water during the early vegetative phase and during the shooting stage [14] If water deficit occurs after the flowering stage, it induces a decrease of kernel weight and thus yield.[1] The plumness of the grain depends on receiving photosynthates from green parts of the plant [5]. For Thorne [13], most of the dry matter stored in the grain comes mainly from photoassimilates produced during the post-floweringstage. In general the climatic conditions (water, temperature and evapotranspiration) play an essential role and are a larger contributor to grain filling.

The higher evapotranspiration is during the 20 days prior to flowering, the lesser the ovary weight is and thus there is a decrease in the grain weight. Chery and Berbigier [2] showed that translocation of photosynthates can be affected by high temperature (heat) in barley: The results of Geslin and Gonard [4], indicated that exposure of wheat to 30 oC during two days induced shrivelling of the grain, particularly at the milky stage.The grain weight is then the result of the speed and time(duration) of the filling process [15]- Remy and Viaux [12] and Grignac [5], believe that grain weight during maturity stage is affected by water stress and high temperatures. The effect is as important as the critical water level (stess level) is high and long. It is independent of the grain number/ m^2 and grains number/spike [6]

MATERIAL AND METHODS

Two field trials were set up at two stations of the Institute of field crops in Algeria.

The first trial is located in the East of Algeria at the station of Khroub and is characterised by a cold winter and a dry summer accompanied by high temperatures.

The second trial is located in the Ouest of Algeria at the station of Oued Smar. It is a Sub-humid region in the coastal area and characterized by a soft, rainy winter and a dry summer:

The soils of these regions are deep having a clay-loamy trxture with a low level of organic matter; high in potassium; deficient in nitrogen:and phosphorus:

Phosphyorus fertilizer with a rate of 200 kg/Ha is broadcasted and then incorporated in the soil at the time of tillage : Nitrogen is applied at the rate of 100kg /Ha at the time of seeding.

The trials were conducted in irrigated and non-irrigated treatments. Irrigation was applied by sprinkles. In the first trial, 22 varieties of barley were used together with one variety of durum wheat(DURELLE) and one variety of bread wheat (Frandoc) and one variety of triticale (CLERCAL).

In the second trial, the experiment was conducted using 16 varieties of barley. The names and some characteristics of these varieties are presented in Table 2.

Experimental Design

The trials were conducted in a split plot design using two factors: varieties and irrigation (Irrigated and non-irrigated). Each treatment was replicated 3 times. All the treatments were randomized in all the blocks.

Measurements

The observations and measurements made in all the experimental units were as follows:

- Lodging: the scale ranging from 1 to 9 (1: resistant ; 9: very sensitive)
- Mean plant height in centimeter from the base to the top of the main stand
- Heading: in number of days from first January to heading

Tableau 1: Climatic data of the trial zone for the two trials

	Oued Smar		Khrou	
	Rainfall (mm)	Temperature (oC)	Rainfall (mm)	Temperature (oC)
February	149.5	12.0	5.2	14.0
March	40.9	13.1	4.1	15.5
April	27.4	17.7	85.5	17.5
May	30.2	20.7	32.5	21.5
Jun	18.6	25.3	18.7	25.2
July	30.1	29.1	19.1	28.8

Tableau 2: Some characteristics of the varieties used in the trials

Name/Type	Origin	Spike type (2 or 6)	Earliness
ALPHA (W)	France	2	Early
PLAISANT (W)	France	6	Early
BELIVIA (W)	France	2	Early
JAIDOR (W)	France	6	Too Early
BARBEROUSSE (W)	France	6	Too Early
FAIZ (S)	Syria/Tunisia	2	Too Early
CYTRIS (S)	France	2	Early
THIBAULT W)	France	6	Early
FEDORA (alt to S)	France	2	Early
SMASH (W)	France	6	Too Early
RIHANE (S)	Syria	6	Too Early
TICHIDRETT (S)	Algeria	6	Late
SAIDA (S)	Algeria	4	Late
MATNAN (S)	Syria	6	Late
HARMAL (S)	Syria	2	Late
EXPRESS (alternarive)	France	6	Late
BARAKA (W)	France	2	Late
ALARIC (W)	France	6	Late
SELMAS (S)	Syria	2	Late
SARRAS (S)	Syria	2	Late
CF 359=CLERIX (S)	France	2	Late
FRANDOC (S)	France	Bread Wheat	Late
DURELLE (S)	France	Durum Wheat	Late
CLERCAL (S)	France	Triticale	Late

(W): Winter (S): Spring (alt): alternative

- Number of fertil spikes in 1 square meter
- Grain number harvested in 1 square meter
- Thousand kernel weight

Harvesting the plots was made with a reaping machine,the grain had a 12% humidity

Statistical Analysis

The statistical method used for the interpretation of the data is based on the analysis of variance using a statistical package "SAS"

RESULTS

The trials were conducted in two successive years. Results common to the two trials will be presented first, then the results of the variables studied only in the the second trial.

The different results are presented in Tables 3 and 4.

1- Variables common to the two trials (Field trials)

The total means (irrigated and non-irrigated) revealed a highly significant varietal effect (p=0.001) for grain yield/ha (GY), thousand kernel weight (TKW), days to heading (HD) and lodging (LD)

On one hand the analysis of variance revealed highly significant water effect (p=0.001) for GY, plant height (PH), days of heading (DH) and thousand kernel weight (TKW). For this last variable the effect is less significant during the first trial (p=0.03).On the other hand, the interaction between variety and water effect (Tables 3 and 4) is not significant for the variable GY. For this variable the varieties behave similarly in response to water.

The interaction is highly significant for the variables plant height (PH), lodging (LG) but for days of heading (DH) the effect is significant only for the first trial.

2- Variables of the second trial only

A variety effect highly significant (p=0.001) (Table 3) was observed for the variables: Grain yield (GY), thousand kernel weight (TKW), plant height (PH), days of heading (DH), lodging (LG), spike number/m2 (S/m^2), grain number/m^2 (G/m^2) and grain number/spike (G/S).

The analysis also revealed a water effect highly significant (p=0.001) for the variables: Grain yield (GY), thousand kernel weight (TKW) and spike number/m:^{2}

The effect was not significant for the variable grain number /spike (G/S).

The interaction variety by water effect (Table 3) was not significant for the variables grain yield (GY), thousand kernel weight (TKW), plant height (PH), days of heading (DH), lodging (LG), spike number /m^2 (S/ m^2)and grain number/spike (G/S).

DISCUSSION

Yield and yield components

The results showed an effect of water grain yield (GY/ha). The reduction was 32.5% in the non-irrigated treatment and could be higher if there hadn't been a rainfall during the grain filling period which generally occur in barley between March and April. The level of rainfall was almost the same in the two years (48.8 mm in the first year and 51.2 mm in the second year).

Potential Evapotranspiration (PET) during this period is relatively around the mean and; a little higher (228.1 mm) in the first year than in the second year (189mm). This positif effect on grain yield was more apparent in the first year, the rapid calculation of the difference in the evapotranspiration and the quantity of water during the grain filling show that water deficit was higher in the first trial.

PET- (Rainfall + Irrigation) == Water deficit

Fist year : 228.5-(48.4mm +125mm) =54.7mm

2nd year : 189.5-(51.2mm +115mm) =23.3mm

The comparison made using Duncun test (Tables 5 and 6) show the presence of differences among varieties inside and between treatments. Due to the fact that a high number of varieties used in the trials and since not all the varieties were used in both trials, it will be difficult to discuss the differences in yield of each variety in each treatment. We prefered to discuss about groups of varieties.

During the first trial (Table5), French varieties BARAKA (a), ALPHA (ab), BARBEROUSSE (ab),THIBAULT (ab) and ALARIC (ab), FEDORA (ab) showed a better performance in the non-irrigated treatment. Under irrigation the original French varieties also showed a better performance.

In the second trial (Table 6) French varieties ALPHA (a), PLAISANT (ab) and JAIDOR (ab) in both treatments were in the top of the classification. In the dry treatment only the two Algerian varieties (SAIDA and TICHIDRETT) tend to reach the yield of Fench varieties. This difference in favour of French varieties was not significant. In contrast, Syrian varieties showed a yield significantly lower than those of French origin. This difference is less clear in the first trial with the exception of Syrian variety HARMAL which stayed always in the bottom position of the classification.

It is not surprising that French varieties showed a better performance than Algerian and Middle East varieties when taking into account the amount of rainfall during

Tableau 3 : Analysis of variance from the second

Variables	Variety effect		Water effect		Interaction Varieties X water effect	
	F	Pr>F	F	Pr>F	F	Pr>F
GY	5.04	0.001	289.3	0.001	1.64	0.07
TKW	20.34	0.001	0.03	0.85	1.62	0.07
PH	26.68	0.001	7.93	0.001	1.75	0.06
DH	132.49	0.001	67,85	0.001	2.42	0.007
LG	7.53	0.001	255.06	0.001	5.59	0.001
S/ m^2	18.89	0.001	64.84	0.001	0.82	0.65
G/S	7.65	0.001	0.01	0.90	0.92	0.54

F= F calculated Pr> F significance probability value associated with F value

Tableau 4 :Analysis of variance from the first trial

Variables	Variety effect		Water effect		Interaction Varieties X water effect	
	F	Pr>F	F	Pr>F	F	Pr>F
GY	5.04	0.001	289.3	0.001	1.64	0.07
TKW	20.34	0.001	0.03	0.85	1.62	0.07
PH	26.68	0.001	7.93	0.001	1.75	0.06
DH	132.49	0.001	67,85	0.001	2.42	0.007
LG	7.53	0.001	255.06	0.001	5.59	0.001

F= F calculated Pr> F significance probability value associated with F value

the grain filling stage (Table1) and due to the fact that French varieties gave a better fertility (GN/spike) and grain number/m^2 (Table3).

The variety FAIZ (Syria/Tunisia) and HARMAL (Syria) showed a significantly higher number of spike/m^2 than all the varieties tested. In contrast they had the lowest GY/ha. Ear number/m^2 is an important yield component in water deficit [7]. It was found in this study that the yield component together with TKW in the conditions of our experiment play an important role in the determination of yield potential.

However, spike fertility and grain number/m^2 seem to favour French varieties in yield.

The absence of rainfall deficit and the mild temperatures (less than 25oC) (Table1) during the grain filling stage(May first half of June) , the absence of dry winds, average mean evapotranspiration during the same period (238mm and 185 mm respectively); .during the first and the second trial, all explain the results obtained in our experiment which show that the the effect of water deficit on TKW was nul during the first trial since the reduction was only by 7.2% compared to the controls.

Algerian varieties (SAIDA and TICHIDRETT which are late varieties) have longer grain filling period and have significantly higher TKW than the others.

In the Oued Smar conditions (Sub-humid regions) the varieties selected under this climate present a better agronomic expression than varieties originated from the MiddleEast and North Africa regions.

In contrast, in semi-arid conditions (Algerian high plain) and despite the low yield potential, Algerian varieties have a better performance which is due partly to their lateness and to the size of the grain.

CONCLUSION

With the exception of the TKW especially in the first trial and much less for the second trial; all agrophysiological characters (variables) were affected by water deficit. Grain yield in non-irrigated conditions decreased by 30% and 34% in the first and second trials respectively compared to control conditions.

It was noticed that French varieties performed better than the Middle East and the Algerian varieties in mild water

Tableau 5: Mean per variety for the variables: Grain yield and thousand weight in the first trial

Varieties	Yield (q.ha-1)		TKW (g)	
	Irrigated	Non irrigated	Irrigated	Non irrigated
ALPHA	52.59 bed	40.00 ab	39.70 ghij	40.30 fghi
PLAISANT	57.03 abc	31.85 cdef	38.20 hij	36.90 ijkl
BELIVIA	55.33 bed	36.30 abcde	44.00 cdefg	45.80 abcd
JAIDOR	55.55 abcde	38.15 abc	40.60 efghi	38.80 hij
BARBEROUSSE	50.37 bcde	40.74 ab	33.20 k	34.20 ki
FAIZ	52.96 bcd	34.44 bcde	40.10 fghij	47.00 abc
CYTRIS	55.33 bcd	38.15 abc	41.80 defghi	42.80 defg
THIBAULT	55.55 abcd	40.00 ab	40.80 efghi	40.60 fghi
FEDORA	62.22 a	41.11 ab	45.90 abcd	46.90 abc
SMASH	41.85 de	28.89 af	40.10 fghij	38.50 hij
RIHANE	49.63 bcde	35.92 abcde	44.70cdef	43.90 cdef
TICHIDRETT	37.78 e	29.26 def	46.70 abcd	47.40 abc
MATNAN	54.07 bed	38.15 abc	37.30 ijk	35.40 jkl
SAIDA	43.70 cde	31.11 cdef	50.10 ab	49.00 a
HARMAL	37.78 e	31.48 vdef	42.20 defghi	43.90 cdef
EXPRESS	68.14 a	36.44 abcd	42.60 defgh	41.50 efgh
BARAKA	62.22 ab	43.33 a	48.20 abc	48.20 ab
ALARIC	52.22 bed	40.37 ab	38.58 hij	39.70 ghi
SELMAS	50.37 bcde	31.11 cdef	45,40 bcde	45.90 abcd
SARRAS	9.63 bcde	34.07 bcde	38.30 hij	38.00 hij
CF 359=CLERIX	53.33 bed	35.92 abcde	43.00 defgh	44.80 bcde
FRANDOC	48.52 bcde	38.15 abc	38.70 j	34.00l
DURELLE	51.48 bcde	26.30 f	50.60 a	44.90 bcde
CLERCAL	44.81 cde	30.74 cdef	35.60 jk	40.60 fghi
Mean	51.33	35.60	41.78	41.95
CV%	11.28	8.62	4.93	3.71
F	2.95	4.09	8.77	17.45
Pr F	0.005	0.0005	0.0001	0.0001

F= F calculated **Pr>F=** Significance Probability Value asssociated to F value **CV%** =Coefficient of variation (%)

Tableau 6: Mean per variety for the variables: Grain yield components in the second trial

Varieties	GY		TKW		S/ m ^{2}		G/S		G/ m ^{2}	
	I	NI	I	NI	I	NI	I	NI	I	NI
ALPHA	53.32 a	38.27 a	42.30bcd	37.93cdef	941b	573.3bcdfg	18.59cde	23.49cd	17316abcd	12299bcd
PLAISANT	50.86ab	36.29ab	37.26de	35.65efg	660.0cdef	392.0defg	34.33a	36.66a	22530abc	1443be
JAIDORr	49.38abc	36.54ab	35.93e	34.70fgh	810.7bcd	616.0bcde	25.51abcd	27.17abc	19775abcd	16383ab
BELIVIA	49.37abc	28.89def	42.63bc	40cd	901.3bc	632bcd	15.89de	15.70de	14310bcde	9142cd
BARBEROUSSE	46.90abcd	31.60bcd	35.43e	30.50gh	784bcd	564.3bcdef	29.41abc	34.63ab	2311b	19770a
FAIZ	46.41abcd	28.14def	37.83cde	31.30gh	1184a	1148a	14.02de	11.08e	15092bcd	12720bcd
CYTRIS	46.41abcd	28.39def	39.06bcde	34.96efg	850.7bcd	593.3b	17.87cde	17.11cde	16543abcd	11828bcd
THIBAULT	46.41abcd	33.58abcd	41.83bcd	40.06cd	634.7cdef	440.0cdef	24.49abcd	26.41bed	15946abcd	11446bcd
PEDORA	45.42abcd	30.12cde	45.56bc	37.53cdef	836.0bcd	598.7bcdef	32.35ab	18.21cde	25486a	10874bcd
ACSAD176	44.93abcd	24.1ef	39.70bcde	37.70cdef	762.7bcde	538.7cdefg	22.70abcd	23.97cd	17302abcd	12425bcd
SMASH	41.97bcd	26.64def	43.70ab	39.30cde	421.3f	354.7fg	29.22abc	34.92ab	12297d	12396bcd
RIHANE	40.98bcd	29.13de	41.26bcd	41.20be	653.3cdef	386.7efg	25.48abcd	24.74bcd	16610a	9373cd
TICHIDRETT	39.50cd	32.59abcd	43.56ab	44.86ab	519.3ef	357.3fg	29.77abc	23.63cd	15528bcd	8463d
MATNAN	39.00cd	29.13de	35.60c	31.66gh	909.3be	666.7bc	20.47bcde	18.95cde	186.35cde	12633bcd
SAIDA	38.02d	35.80abc	47.53a	46.76a	465.3f	552.0g	25.34abcd	24.72bcd	11719d	8890cd
HARMAL	37.03d	2.96f	40.16bcde	36.46def	1322a	944.0a	9.51e	10.93e	12594cd	10174cd
MEAN	44.74	30.89	40.40	37.52	791.43	578.5	23.44	23.29	17197	12078.6
CV%	12.62	10.37	0.6.63	06.24	016.73	21.85	28.05	23.80	30.03	24.85
F	2.11	7.93	4.32	10.16	8.83	8.07	3.29	5.25	1.80	2.25
Pr F	0.035	0.0001	0.0002	0.0001	0.0001	0.0001	0.002	0.0001	0.07	0.01

F= F calculated **Pr>F=** Significance Probability Value asssociated to F value
CV% =Coefficient of variation (%)

deficit conditions (Zone of Oued Smar) despite the fact that these varieties are considered to be tolerant to drought. Yield components which seem to favour french varieties are: spike fertility and grain number/m^2. In addition to the late rainfall during the grain filling stage and mild temperature (>25^o C) and medium evapotranspiration.

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List of abbreviations used in the text

I: irrigated

NI: non irrigated

GY: grain yield

TKW: thousand kernel weight

PH: plant height

G/m ^{2}: grain number/m ^{2}

G/S: grain number

S/ m ^{2}: spike number/ m ^{2}2

LG: lodging

DH: days of heading

A,b,c, ab, abc......statistcal groups ranked according to Dunkan test