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Study of early growth cycle as drought factor avoidance within a group of native oasis common wheat genotypes

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Earliness is an efficient means that enables plants to avoid drought, heat and extreme solar radiation. Shortening growth cycle can, in Mediterranean settings, prevent subsequent stresses. Every temperature rise and water stress, within the period of filling of seeds, will be interpreted as a regression of that period, and will compromise yields through the reduction of carbon assimilation. Effects of water stress, in the areas affected by drought, are among the major factors reducing yields of wheat, especially just before flowering till 15 days after the emergence of anthers. This paper aims at determining the variability among a group of local genotypes pertaining to oases (Algeria) soft wheat in terms of earliness of ear emergence, duration of filling stage, seeds weight, and plants height when they attain ripeness. Gaps of ear emergence between the earliest genotype, the latest one and the two check genotypes equaled: 30, 25 and 14 days, respectively.

Keywords: Wheat, oases genotypes, Earliness, Drought, Avoidance, Water Stress

INTRODUCTION

Wheat has always been cultivated in southern Algeria oases because it is considered a major source of proteins in the diet of southern populations. In these regions, the main crops are date palms which provide the population with carbohydrates. Until recently, food resources were scarce after the autumn harvesting, and this was a subject of great concern for the local population.

Hence, earliness of certain varieties of oases wheat, represented one of the favorite agricultural choices in this region of Algeria. This option allowed not only a considerable harvest in a relatively limited time but also, to introduce a second harvest during the same time span and on the same soil.

Earliness is an excellent way to prevent drought (James et *al*., 2000), heat and extreme solar radiation (Zaharieva et *al*., 2001). The action of induced stress avoidance can lead, in Mediterranean climate, to a shortening of growth cycle (Baker, 2000). Indeed, every temperature rise causing water stress during seeds filling, will be considered as a regression of the aforementioned period, and will compromise yields through the reducing of carbon assimilation (Johnson et *al*., 1982; Borner, 2002; Yang et *al*., 2001). According to Ortiz-Monasterio et *al*., (1994)

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seed weight diminishes by 4 to 8% with every single degree of increase in a temperature range of 12 to 26°C during this period.

Temperature variations of 30-25°C (day/night) during the swelling stage until ear emergence, limit the viability of pollen grains (Dawson et Wardlaw, 1984), along with flowers abscission implying a net reduction of seed number per ear (Acevedo et *al*., 1993). A temperature rise of 15/19°C (day/night) causes a shortening of 60 to 22 days in the filling stage. However, Abbte et *al.,* (1998) showed that expanding this stage to 27 to 37 days may be associated with a rise in ears' dry weight which is equivalent to 31 till 43% rise in harvesting index.

Reducing the weight of one thousand seeds by delaying the sowing date is associated with a diminution in the filling stage duration (Ortiz et al.,1994). Genotypes with early flowering are those with a high growth rate and a quick filling at low temperatures. Moreover, these genotypes may have a high efficiency in using water (Fisher,1986).

The most sensitive period for increasing yields is the period of seed filling, connecting yields with levels of water stress (Stasna et al.,2002). At half stage of filling, the cell division and endosperm expansion cease to happen, and hence for every shortage in assimilates, an irreversible fall of storing capabilities in dry matter of wheat seeds occurs due to a lack of water (Kobata, 2000). Nevertheless, between 70 and 90% of wheat yields come mainly through post flowering photosynthesis (Austin et *al*.,1976). In the case of wheat, earliness is usually associated with a state of dwarfism induced in this species (Kobiljski *al*.,2002). A combined effect of temperature and solar radiation during the flowering period and up to 10 days after ear emergence allows for this occurrence, providing that there is no delay following the cultivating crops.

The effects of water stress, especially during the time before flowering up to 15 days after anther emergence, are among the major factors that reduce yields. Consequently, earliness enables crops to reduce their exposure to extreme heat, particularly during the seed filling stage (Acevedo et *al.,*1993). Varieties which achieve their growth cycle or attain the ripeness stage - such as short cycle varieties before critical water shortages- are the preferred farming practices of early sowing, particularly in Mediterranean climate. These allow crops to avoid, or at least to reduce drought hazards especially during the filling stage (Ortiz –Monasterio et *al.,*1994).

High productivity characteristics of semi dwarf wheat may result from its earliness as well as a high harvesting index compared to varieties of wheat with long straw (Fisher et *al.,*1986). The increase of harvesting index results mainly from the increase of seed number per square meter (Sayer et *al.,*1997), which, in fact, shows an increase in ears partition at the expense of stems during inflorescence growth . It is further associated with an extension of the period mentioned above (Abbte et *al*.,1998).

The number of seeds per square meter is determined to a large extent by factors such as temperature and sun exposure during the last weeks before flowering (Ortiz-Monasterio et *al*.,1994).

The last leaf and the two leaves below give their assimilates to the ear, whereas the older leaves feed the roots (Boyeldieu,1980). According to Lee (1996), the last leaf produces the largest part of carbohydrates for seed filling, and according to Nelson et *al*. (2001), can be up to 75%.

A prospecting work in the wide regions of southern Algeria, allowed us to gather 20 selected samples of local varieties/populations of Saharan soft wheat and to introduce them in a crossbreeding program with the cultivation of these species varieties in large zones. Earliness at ear emergence, plant height, weight of one thousand seeds and the duration of seeds filling stage, are among the characteristics studied in different genotypes.

MATERIALS AND METHODS

Twenty varieties/populations, eighteen of which originated from the Adrar region (Algeria), the common type used by oases farmers, and two varieties were used as control in the experiment. The geographical origins of these varieties were diverse. They were collected within a north-south axis of the wilaya of Adrar, on an area of about 600 km.

During the first year of this study, the experiment plot was situated at the central span of an irrigation pivot covering 40 hectares, whereas during the second year, the experiment was achieved at INRA experimental station of Adrar. The chosen experimental device was the complete random block with three repetitions. The surface of every micro plot was 5.4 m^2. The previous crop consisted of durum wheat which lasted six months, that is from December. to May, followed by a partially worked fallow. The dose of phosphorous (T.S.P) used in the experiment was 0.4q/ha, whereas potassium dose was 02 q/ha taken in a single time during soil preparation. Forty five per cent of urea was used as nitrogen supply at the rate of 05q/ha, divided up for each hectare, and as follows: raising 01q, full tillering 02q and stem elongation 02q. The main trace elements added to the soil were: iron, manganese, zinc and copper under the form of diluted chelate in irrigation water at the rate of 05kg per hectare.

Sowing was done, on November 7th on the first year and the second year on December 28th on the second year. The dose of sowing used varied between 101kg/ha and 155kg/kg according to germination property and the weight of 1000 seeds of each variety. The rate of flow of the irrigation pivot was 48l/s with a total quantity of water of 1415m^3 for the whole vegetative cycle. Illoxan B, a dual action herbicide was used to check weeds. At ripeness, every micro plot was harvested separately with a sickle. Counting and observations were made at every reference stage; Enova variance analysis was carried out and a comparison of the average values was realized according to the least of the least significant difference 'Ficher Test'.

According to the data provided by INRA in Adrar' station, the predominant climate of the region is a continental desert climate with a summer season starting at the end of March and ending in November, hence a drought extending throughout this period. Rainfall is scarce and the annual average ranges between 10 and 24 mm. Temperatures annual average varies between 23 and 26°C and monthly average between 13 and 39°C.

Annual evaporation exceeds 5000 mm/year with a daily mean extending from 6.47mm in January to 23.35 mm in July. The average annual rate of relative humidity is less than 40% and decreases to less than 25% during the summer season.

Soil samples analysis were achieved at INRA Baraki station(Algiers). Soil pH varied between 7.2 and 8.1 according to the depth with a low capacity of cation exchange, that is, from 5.16 to 7.54 meq/100g. The total rate of limestone was around 12%, while the active limestone equaled 8.4%. The soil was lacking trace elements (maganese, copper, zinc and iron) and contained slightly high amounts of potassium and magnesium. Moreover, it contained low amounts of organic matter, between 04 and 05 g/kg. The analysis of irrigation water samples was achieved at the local branch of the ANRH (*National Agency for water resources)*. This water which contains diluted salts with a dry residue of nearly 3.9g/l has a poor physicochemical quality.

RESULTS AND DISCUSSIONS

Average temperatures of the two operations (2009-2010 and 2010-2011) were particularly high during the period from March to September. This period coincides with flowering stages, seed filling and ripeness. During the first year, the following observations were:

-A disturbance in flowering and a growth of sterile spikelets, particularly those located near the base and the rachis end with different degrees of vulnerability.

- An early and rapid senescence of leaves and stems, involving an early loss of producing and storing capabilities of assimilates stored in these organs.

- A shortening in seed filling duration, which may lead to a relatively low weight of one thousand seeds .The extent of the above descriptions, differs from one variety to another. The final expression of the effects on these varieties will be reflected by a more or less important decrease in seed yield.

1. Time Period in Days of Phenological Stages Used As Makers

Table1 shows the variations between tested genotypes during sowing time, different phonological stages, and seed swelling duration in days, and their meaning.

Except for tillering stage, we noticed significant differences between the average values related to the time period of the different phenological stages. The whole set of samples contained a variability that were significant. Comparing the different successive phenological stages during the two operations (except tillering stage), we noticed that the different stages were achieved in less time for the second operation (sowing of December 8th) than the first sowing on November 7th). Consequently, this delay puts the crop under an important climatic condition stress, mainly the one exerted by the return of high diurnal temperature beginning from the end of February.

2. Earliness of Ear Emergence

Analysis of data variance relating to earliness at ear emergence, showed a highly significant difference between varieties/populations. In fact, during the experimental operation of 2010-2011, this difference was 28 days between Kot 8, the earliest variety/population, and Kot 3, the latter. However, during 2009-2010, the divergence between these two varieties was only 22 days. During the two operations, the same Kot 8 showed amazing earliness capabilities of ear emergence, flowering and ripeness. Indeed, the period 'sowing-ear emergence' equaled 71 and 78 days for the first and second year respectively (Figure.1). Similarly, regarding the period 'sowing-stem elongation' of the year 2010-2011, the varieties/populations Sabaga AEF, Sabaga Baomeur, Shouitter, Shatter and El Merakkba recorded the shortest periods equaling 71, 74, 76 and 78 days respectively. Moreover, during the years 2009-2010, we noticed that the same ranking was registered, with a single difference and that the periods were relatively shortened. As for earliness of stem elongation, the varieties Belbali, Manga Type II, Type III and Anza were the latest; this stage was achieved after 100 days for Belbali, 98 days for Mangua Type II and 97 days for Mangua Type III and Anza. The same behaviour of the latest varieties in terms of earliness of ear emergence, flowering and ripeness was noticed. ,. Regarding the varieties used as control during the first year, the number of days between spike emergence of Sabaga AEF (Kot 8) and H.D.(Kot 9) equaled 9 days, while Anza (Kot 2) equaled 20 days. However, earliness of ear emergence during the second year, showed a divergence between varieties/populations of Sabaga AEF and Anza was 25 days, while H.D equaled 14 days.

3. Period of Seeds Filling

Seed filling duration depends on the variety and medium conditions pertaining in this period. It is worth mentioning

Table 1. Achievement, in days, of main phenological stages, as from sowing.

Genotypes	Code	Tillering		Stem Elongation		Ear Emergence		Flowering		Ripeness		Swelling		Plants Height		GMP	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Belbali	Kot 3	18,3	15	84.3	99.7	90.3	107	96.0	112	121	144.3	24.67	32.7	98,8	102,4	30,69	33,65
Manga type II	Kot 20	18.7	15	86.3	97,3	93,6	102	97	103	123	140	26	36	102,7	110,4	32,22	43,68
Shouitter	Kot 11	16,7	14	73,7	78,3	74	91	77	94	109	129	32	35	98,5	98,9	33,86	39,93
El Baldi	Kot 16	17,7	14,7	79	89	82	101	85	104	115	137	30,67	33	94,26	95,3	34,98	45,98
Bent Mebarek AEM	Kot 15	17,3	14,7	77	86	78,3	96	83,6	101	115	137	31,37	36	99,1	100,6	35,37	45,11
Bel Mebrouk AEFateh	Kot 12	17,3	14,7	78,7	84	79,7	97	83	100	113	134	30,7	34	90,12	94,32	34,41	43,5
Bel Mebrouk Tamentit	Kot 6	17	14	77	81,7	78,7	92	84	97	112	134	28,03	37	90,42	91,35	34,87	49,64
Sabaga AEFateh	Kot 8	16,3	13,7	69	71,3	71,3	78	80	86	104	125	24,37	39	88,6	91,29	35,96	49,38
El Sfar	Kot 5	17,7	15	81	90,7	82,3	100	83,3	101	116	136	32,33	35	102,6	106,9	34,04	44,13
Moumna	Kot 4	17,7	14	80,7	85,3	83	97	86,7	101	116	136	28,97	35	99,7	101,4	32,6	39,19
Tazi	Kot 14	17,3	14	79,7	89,7	81,7	100	84,7	103	113	137	29	34	100,5	100,7	33,83	40,97
El Fareh	Kot 1	17,7	15	78,7	84	81,3	95	85,3	99	116	134	29,67	35	105,5	109,3	34,21	44,18
Bent Mebarek Baomeur	Kot 10	17,3	14	79	91,3	80,3	101	82,3	103	113	139	30,67	36	93,23	94,35	33,51	47,09
Sabaga Baomeur	Kot 13	16,3	13,7	71,7	74,3	72,7	85	79,1	92	107	131	28,27	39	93,84	97,1	35,66	49,39
El Merakba 7	Kot 7	16,7	14	74	77,7	75	88	80,3	93	109	132	28,03	38	93,36	94,33	33,77	48,58
Anza	Kot 2	18,7	15,7	84,3	96,7	91	103	96	110	121	143	25,33	33	80,54	81,56	32,16	36,53
H,D, 1220 (Hidab)	Kot 9	17	14	78,3	83,7	80	92	86,4	99	114	136	27,93	37	82,85	83,66	32,87	45,18
Manga type I	Kot 19	-	15	-	97.7	-	106	-	107	-	141	-	34	103,53	105,9	-	43,2
Manga Type III	Kot 21	-	15.7	-	94.3	-	105	-	112	-	145	-	33	111,62	112,9	-	38,37
Shatter	Kot 17	-	14	-	76.3	-	90	-	97	-	132	-	36	-	95,1	-	48,89
Minimum Values		16,3	13,7	69,0	71,3	71,3	78,0	77,0	86,0	104,0	125,0	24,4	33,0	80,5	81,6	30,7	33,7
Maximum Values		18,7	15,7	84,3	97,3	93,6	107	97	112	123	145	32,33	39	111,62	112,9	35,96	49,64
Means		17,31	14,43	77,45	85,06	80,31	96,30	84,61	100,70	113,94	135,68	28,96	35,53	96,30	98,39	33,82	43,83
Difference (Max-Min)		2,4	2,0	15,3	26,0	22,3	29,0	20,0	26,0	19,0	20,0	8,0	6,0	31,1	31,3	5,3	16,0
Standard Deviation		-	-	1.42	2.69	1.2	2.53	1.17	2.64	1.12	2.00	1.57	1.14		3,52	0,49	1,3
M.V.C		-	-	1.81	2.98	1.4	2.55	1.38	2.51	0.99	1.46	5.47	3.22		3,58	1,46	2,96
LSD (P<0.01)		-	-	3.14	6.04	2.5	5.68	2.58	5.92	2.472	4.49	3.47	2.51		7,9	1,17	2,92
Significations		N.S	N.S	TH.S	TH.S.	T.H.S.	T.H.S.	T.H.S	T.H.S.	T.H.S.	T.H.S.	S.	S.	H,S,	T.H.S.	S	HS

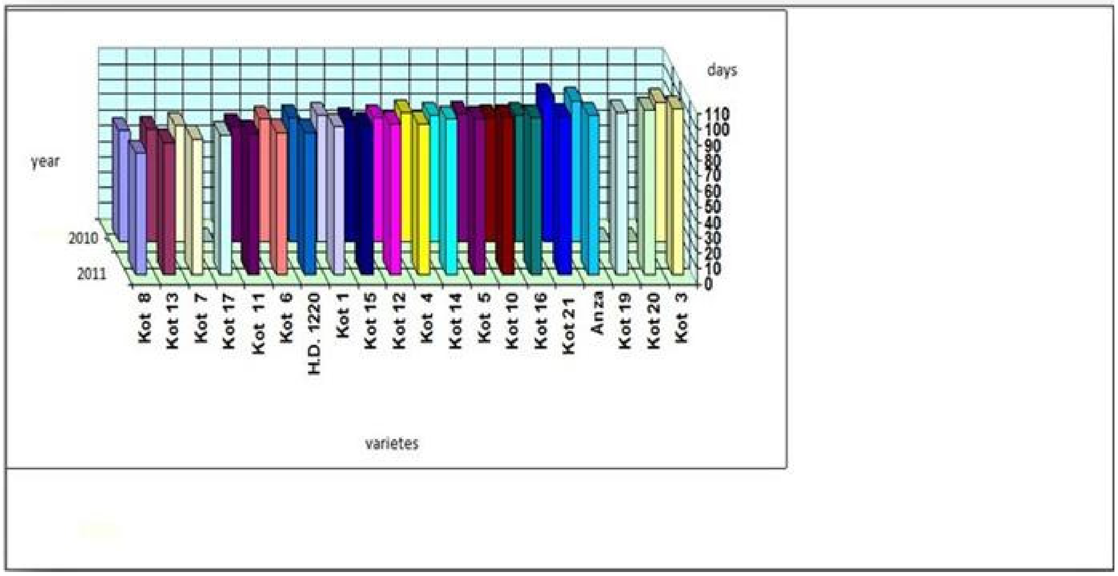

Figure1. Variations of earliness at ear emergence, in number of days, during two years

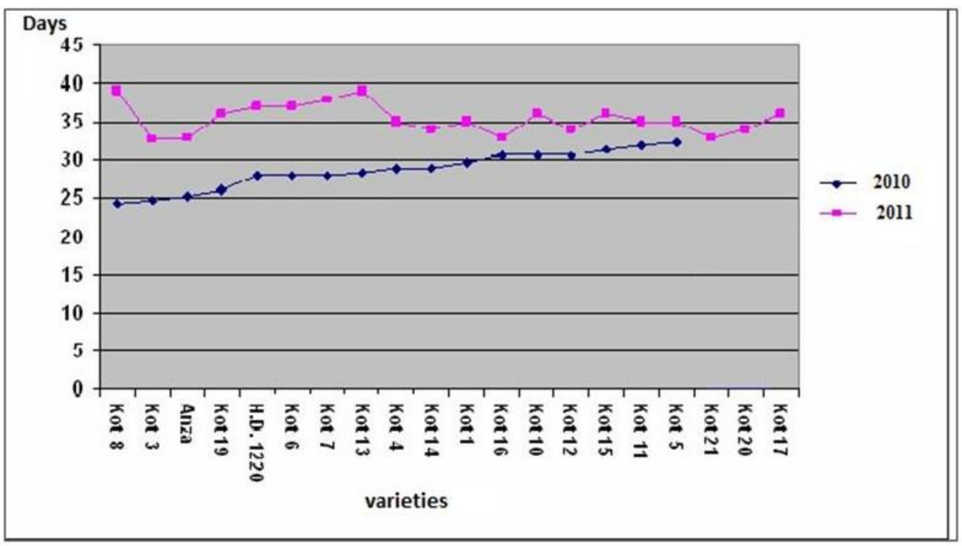

Figure2. Annual and varieties variations of seeds filling stage in days

that the weight of 1000 seeds depends, to a large extent, on the medium conditions during the transfer of assimilates, the plant synthesizes and stores in leaves and stems. Variability between genotypes for this parameter was important. In fact, during the period of 2010-2011, 7 days marked the difference between the earliest variety/population and the latest one.

During this same period, the earliest varieties of ear emergence like Sabaga AEF, Sabaga Baomeur, Shouitter, showed the longest seed filling periods, equaling 39 days for Sabagua AEF and Sabagua Baomeur, and 38 days for Shouiter (figure 2). By examining table 1, it appears that the earliest genotypes tend to extend the seed filling period in comfortable climatic conditions compared to the latest genotypes.

In fact, in the case of Sabaga AEF, the earliest variety/population, the so-called time extension could last up to 15 days, commonly associated with high values of GMP (60% more than that of hard conditions). The local set of moderately early genotypes composed by, Shouitter, El Baldi, Belmebrouk AEF and El Sfar, shows not only the shortest period, but also a more or less stable seed filling duration, fluctuating between 31 and 35 days.

The latest varieties/populations, namely Belbali, Anza and Manga Type III, recorded the shortest periods equaling 32 days for the first two varieties, and 33 days for Manga Type III. On the other hand, varieties of Hidhab (HD) and Manga Type I showed an interesting adaptability to the medium. They recorded relatively longer seed filling stage compared to that of the earliest varieties, while the first variety had an average index of earliness of ear emergence. As for the second variety, it was the last one in the ranking. Such behavior will give certain advantages: the main one being GPM increase. Regarding plant height, the local genotypes follow quite the same ranking as in the case of ear emergence. Indeed, the ultra early local genotype Sabaga AEF had the shortest stem, while the latter genotype Manga Type III had the longest. However, in terms of GMP, it appears that the more the genotype is early, the more chances we have to notice high GMPs. Though this ultra early genotype had the highest GMP, the seed filling stage was heavily affected during the first year (late sowing), it recorded the lowest average daily velocity of seed filling. During this first year, the highest GMP has been archived by the set of moderately early genotypes, namely : Shouitter, El Sfar and Bent Mebarek Baomeur, followed by the group of semi-early genotypes, and finally we find the category of earliest genotypes Sabaga AEF, Sabaga Baomeur and El Merakba with the lowest daily average rhythm of seed filling. However, during the second year of cropping (sowing date adequately respected), the latest genotypes, especially Belbali, Anza and Moumna, recorded the highest daily average rhythm, while the set of average earliness recorded low values. In terms of plant height, except the control varieties, the genotypes' aspect generally follow the type of earliness of ear emergence; and this for the two years of experimentation. In fact, the extra early genotypes, such as Sabaga AEF, reached the lowest stem heights, while the variety of Manga Type III, the latest.

CONCLUSION

This study was carried to try to understand earliness of 18 varieties/populations gathered in southern Algeria. The study revealed that differences between ultra early genotypes such as Sabaga AEF, and control genotypes, Anza and HD 1220, were respectively in the region of 20-09 days for the period 2009-2010, and 25–14 days for the period 2010-2011. Differences between the earliest variety and the latest one could reach 29 days. Consequently, within the conditions where the test was carried out, this local variety/population achieved the time period going from sowing to total ear emergence in 71 and 78 days for the two years respectively.

During the period 2010-2011, the earliest varieties of ear emergence, such as Sabaga AEF, Sabaga Baomeur, Shouitter, achieved the longest seed filling stages, reaching 39 days for Sabaga AEF and Sabaga Baomeur, and 38 days for Shouitter. The local set of medium early genotypes, comprising Shouitter, El Baldi, Belmebrouk AEF and El Sfar, has not only the shortest seed filling stage, but almost the most stable ranging between 31 and 35 days. The latest varieties/populations, namely Belbali, Anza and Manga type III, recorded the shortest periods with 32 days for the first two areas and 33 days for Manga type III. Though this experiment was carried out in irrigation conditions, the final results showed genetic capabilities that can be further exploited, including within rainy weather cultivation conditions, which predominate in wheat cultivation zones. If this peculiarity of earliness, predominant in certain local varieties/populations, is adequately exploited in climatic conditions similar to those usually prevailing in the Mediterranean regions, it will contribute to crop conservation during drought seasons and during high temperatures.

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