Response of Bread Wheat to Sowing Dates and the Genotypes in Morocco

ABSTRACT

A field study was conducted to determine the effects of sowing date on the growth and yield of different bread wheat genotypes in two locations of Morocco (the plain of Saïs; Douyet and the Atlas Montaigne; Annoceur). The trial was conducted using a randomized complete block design with three replications in 2011/2012 and 2012/2013. The chosen dates were: 1st and 15th November in Douyet; 1st and 15th December in Annoceur and three bread wheat varieties (Achtar, Mehdia and Arrehane). Results revealed that seedlings in 1st November in the Saïs region and 1st December in the Atlas Montaigne increased grain yield for 11.15% compared to seasonal sowing, and any delay in bread wheat sowing might reduce wheat yield. The variety Arrehane surpassed the two other varieties Mehdia and Achtar in both growing seasons and at both locations with an average of 10.95% and 21.05% for grain yield, and for all components measured; number of spike m^{-2}, 1000-grain weight, number of grains per spike, plant height and harvest index.

Key Words: *Sowing date; bread wheat; grain yield; yield components; Morocco.*

1. INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is one of the most important cereals cultivated in rainfed area in Morocco. The Mediterranean climate typical of semiarid regions of morocco produces rainfall and temperature patterns that significantly impact cereal crop production. Crop growth is usually restricted by lack of rainfall and extreme temperatures at the beginning and end of growing season [1]. Also, the climate projections for Morocco show gradually increasing aridity because of reduced rainfall and higher temperatures [2]. This will cause reductions in the wheat production. Wheat yield is a result of many contributing factors and among these the time of planting is an important one and can only be achieved by sowing of wheat crop at its optimum time. Heat stress at the end of the crop cycle due to late sowing beyond certain limits lowers grain yield significantly [3].

In Egypt, the late sowing of wheat after harvesting cotton, maize and vegetables is one of the most limiting factors reducing yield [4]. Higher grain yields in wheat had been obtained by early sowing [5]. The fluctuation in climatic conditions such as day length, temperature, humidity and precipitation may alter plant functions and productivity [3]. In Upper Egypt the grain yield was reduced under heat stress in late sowing, in the range of 30-46% in comparison with optimal sowing [6]. One among the strategies that farmers can use to stabilize and increase crop yields in the face of a changing climate is to adjust sowing dates [7]. The early sowing allows taking advantage of maximum of precipitation.

In addition, certain wheat genotypes may respond better to earlier or later sowing dates [8]. Selecting appropriate crops can help increase water productivity in water limited regions such as the Mediterranean [9]. For producers of cereals, the goal is to select a sowing date that gives an opportunity to develop as many fall tillers as possible while avoiding potentially severe damage associated with hot temperatures at the end of the crop cycle.

A field trial was set up in two locations at the Experimental Stations of Douyet and Annoceur in both growing seasons, with the objectives to stabilize and increase the production of bread wheat in Moroccan rainfed areas of the Saïs region and the Atlas Montaigne, through better management of sowing dates and genotypes.

2. MATERIAL AND METHODS

2.1 Experimental Site and Treatments

The experiment was conducted during the 2 successive seasons 2011/2012 and 2012/2013 at two Experimental Stations (National Agricultural Research Institute, Morocco). The first experiment was sowing in 1st November and 15th November in Douyet (plain of Saïs) (34°2'N, 4°50'E, altitude: 416 m a.s.l.). The second experiment was sowing in 1st December and 15th December in Annoceur (Middle Atlas Montaigne) (33°41'N, 4°50'E, altitude: 1345 m a.s.l.). The Green Morocco Plan provides for the reduction of the area under cereals 1 million hectare and concentrate this culture in favorable areas including Meknès-Tafilalet region which contains the plain of Sais and the Middle Atlas is the reason for the choice of its two sites. Three bread wheat genotypes (*Triticum aestivum* L.) were used in this study (Table 1). These varieties are chosen because they are among the ones that are largely grown and used by farmers in Morocco. A randomized complete block design was used in the experiment. Each treatment was replicated tree times and the basic plot was 15 m^2 (3 x 5 m). The seeding rate was 300 grains m^{-2} and the amounts of fertilizers applied were 60 kg ha^{-1} of N, 60 kg ha^{-1} of P and 40 kg ha^{-1} of K. In the rainy year (2012/2013), 100 kg ha^{-1} of N was applied for Douyet.

Table 1. Characteristics of genotypes (Achtar, Mehdia and Arrehane)

Variety	Achtar	Mehdia	Arrehane
Origin	INRA-Morocco	INRA-Morocco	INRA-Morocco
Year of Registration	1988	1993	1996
Maturity to heading	Medium-early	Early	Early

(Moroccan Official Catalogue: SONACOS, 2013)

The characteristics of the soil layer of Annoceur and Douyet stations for the 0-30 cm horizon are presented in Table 2. For Douyet, the soil is generally more than 0.75 m deep with fine textured; this soil has a good structure for plant growth. in contrary for Annoceur, the soil is generally less than 0.50 m deep (young soil; Montaigne), with presence of pebbles; which makes the soil very infiltrating. In addition, this site is characterized by cold temperatures because of its location in a mountainous region (Table 2). These reasons do not allow producing high grain yields in this site compared to Douyet, especially in rainy years.

Table 2. Soil characteristics of the experimental fields in both seasons

	Annoceur	Douyet
Clay (%)	17.51	39.90
Silt (%)	21.97	48.50
Fine sand <2 mm (%)	10.66	11.60
Coarse sand >2 mm (%)	49.86	0
Organic matter (%)	2.8	1.6
Available phosphorus (P) ppm	36.6	13.6
Available potassium (K) ppm	515	388
Limestone total (%)	7	32.8
Active lime (%)	-	16.2
pH	7.7	7.7
Electric conductivity (1/5)	0.10	0.10

Ferti-council Laboratory analyzes of soil and water irrigation (DSSMA ENA. Meknès, Morocco)

2.2 Weather Conditions

Rainfalls of the both growing season and for different sowing dates are grouped in Table 3. Although the rainfall was low in 2011/2012, it was well distributed during the growing season. While, the crop year 2012/2013 was very rainy and rainfalls were not well distributed with torrential rains.

Table 3. Rainfall and temperatures in the experimental station of Annoceur and Douyet for 2011/2012 and 2012/2013

Site	Climatic parameters	Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Total
Annoceur	Rain fall (mm)	2011-2012	10.0	42.0	142.0	20.0	23.0	15.0	27.0	95.0	11.0	0.0	0.0	385
		2012-2013	41.0	99.5	152.0	66.6	138.7	59.5	150.1	57.0	21.6	2.0	0.0	788
	Mean Max Temp (°C)	5 years	23.5	23.1	17.2	11.6	11.0	11.2	13.7	15.2	18.7	23.4	30.3	
	Mean Min Temp (°C)	5 years	13.9	9.7	5.9	2.4	2.7	3.6	6.7	9.6	11.5	15.1	19.1	
Douyet	Rain fall (mm)	2011-2012	0.0	46.5	106.5	11.0	32.0	8.0	9.0	75.5	7.5	3.0	0.0	299
		2012-2013	33.4	83.2	121.0	35.4	100.8	68.0	194.0	32.2	34.0	0.0	0.0	702
	Mean Max Temp (°C)	5 years	30.9	28.3	22.5	16.6	17.1	16.6	19.6	21.6	27.2	31.5	33.7	
	Mean Min Temp (°C)	5 years	14.4	12.4	8.2	2.5	3.6	4.5	6.7	8.5	11.5	14.9	16.8	

The 2011-2012 growing season was dry which pushed us to opt for supplementary irrigation. 60 mm of irrigation water was applied at stem elongation stage for all plots in Douyet and in Annoceur.

2.3 Sampling and Analysis

At harvest, plants in 0.5 m^2 (2 rows x 1 linear meter) on the middle plot were harvested to determine number of tillers and spikes per unit area. Then, ten from each sub-plot were chosen randomly to estimate 1000 grain

weight, number of grains per spike, plant height and to calculate the grain yield. Grain yield was expressed at 14% moisture.

2.4 Statistical Analysis

Data were analyzed by analysis of variance (ANOVA) and coefficient of variation using the SPSS software (version 17.0). The SNK (Student-Newman-Keuls) was used for means comparison.

3. RESULTS AND DISCUSSION

3.1 Grain Yield

Early sowing date (D1) improved the grain yield, in both growing seasons at the both locations than the seasonal sowing date (D2). The average gain in the dry year was 2.22 q ha^{-1} for the both locations. While, in the wet year the gain in Annoceur was much superior (3.83 q ha^{-1}) than that recorded in Douyet (2.56 q ha^{-1}) (Tables 4 and 5). The temperature, rainfall in 2011-2012 crop year and the nature of the soil of Douyet is probably the cause of these differences. Indeed, the virtisols in Douyet retain more water than the soil of Annoceur. These results are in agreement with the findings of [8, 10, 11]. Mohammadi [12] reported that early sowing date showed the highest potential yield in stress conditions.

Statistical analyses revealed in both experimental seasons and in both locations a highly significant effect of the varieties on grain yield. The variety Achtar (registered in Moroccan Official Catalogue in 1988) gave the lowest grain yield with an average of 20.42 q ha^{-1} in Annoceur and 26.25 q ha^{-1} in Douyet, followed respectively by Mehdia (registered in Moroccan Official Catalogue in 1993) with an average of 22.84 q ha^{-1} in Annoceur and 27.92 q ha^{-1} in Douyet and the Arrehane (registered in Moroccan Official Catalogue in 1996) with an average of 25.32 q ha^{-1} in Annoceur and 31.0 q ha^{-1} in Douyet (Tables 4 and 5). This may be due to the differences in the response of bread wheat genotypes studied to the climatic factors in both seedlings dates. While, Bendidi [13] reported no differences between the Achtar and Arrehane varieties in 2007-2009 in Douyet. These results show that there is a genetic progress for Moroccan varieties of bread wheat.

Results in Table 4 and 5, shows that the interaction between sowing date and variety was not significant for this component. These results show that regardless of the year and the planting date, the variety Arrehane allowed grain yields superior than the varieties Mehdia and Achtar.

3.2. 1000- grain weight (TGW)

The variety had a significant effect on the 1000-GW. Indeed, the same trends recorded for grain yield were observed for this component with higher results for Arrehane variety (27.5 g at Annoceur and 30.83 g at

Douyet) followed respectively by Mehdia (25.92 g at Annoceur and 29.34 g at Douyet) and Achtar (24.67 g at Annoceur and 28.0 g at Douyet) (Tables 4 and 5). Similar findings were also reported by several authors [14, 15, 16].

While, sowing date did not influence this yield component in both growing seasons of the trial and in the both sites (Tables 4 and 5). This may be due to the negative effect of hot and dry wind coming from the Sahara (Chergui) that prevalent in the region at the end of the crop cycle. Even sowing 15 days before the seasonal sowing date has not managed to avoid negative effect of hot winds in the end of the cycle of the culture. However, supplemental irrigation at heading stage (60 mm) helped to overcome this problem of Chergui [13]. These results do not corroborate with those found by [17], who concluded that date of sowing had considerable influence on the mass of 1000-grain weight.

The interaction sowing date x variety was significant in observations of 1000-GW. This indicates that varieties responded differently to the planting dates (Table 4 and 5).

3.3 Number of spikes m^{-2}

Analysis of variance for number of spikes per unit area revealed significant (p = .05) differences among date sowing in Annoceur in the both years. Unlike, in Douyet where it has no significant effect (Tables 4 and 5). In Annoceur the tillering coincide with low temperatures; early planted wheat had more time for vegetative growth period to give a higher number of tillers per unit area, a higher number of grains per spike and thereafter a higher number of grains per unit area. Similar results were observed by [18], who have found that the number of tillers and spikes m^{-2} was remarkably and highly significant affected by sowing dates.

The number of spikes per unit area was significantly influenced by the genotypes (Tables 4 and 5). in the both sites and in both growing seasons, Arrehane variety recorded the highest the average for number of spikes per m^{-2} (310) followed by Mehdia and Achtar (285). Similar results were obtained in Pakistan. Wheat varieties Abadgar and Anmol as well as advance line MPT-6 had better tillering in comparison with 4 other genotypes [19].

The interaction between sowing date and variety was significant except in the dry year at Annoceur and the rainy year at Douyet.

3.4 Grain per spike

The number of grains per spike was influenced by sowing date, for the case of Annoceur in 2011/2012 and for Douyet in 2012/2013 (Tables 4 and 5). Even for the case where there is no significant difference, we observed an increase in the number of grains per spike for the early sowing. These increases added to increases in the

number of spikes per unit area explain the difference in grain yields. Similar results were founded by other authors [20, 21, 22].

This component was not significantly affected by the genotype except at Annoceur in the dry year (Tables 4 and 5). While, Darby [23] had found that grain per spike was higher with genotype MPT-6 followed by V-7002.

The interaction sowing date x variety was not significant in both growing seasons at the both locations except for 2011-2012 in Annoceur.

3.5 Plant height

During the two growing seasons and at the both sites, early sowing (D1) registered an average plant height of 57 cm. while, seasonal sowing (D2) allowed only an average plant height of 53.4 cm (Tables 4 and 5). These results are in accordance with those of [24] who had observed that the last sowing date of 25th October had the lowest plant height. Similar results were also observed by [9, 14, 20].

For its part, the genotype influenced the plant height. Indeed, the variety Arrehane was the longest (58.2 cm) followed respectively by Achtar (54.8 cm) and Mehdia (52.8 cm), except the dry year at Annoceur where all three genotypes did not differ statistically.

The interaction sowing date x variety was not significant in both growing seasons at the both locations. The variety Arrehane was the tallest for every planting date and the two sites (Tables 4 and 5).

3.6 Harvest Index

Sowing date has influenced the harvest index (HI) in both locations and in the two years of experimentation, except Annoceur in the 2011-2012 crop year. The early seedling allowed gains as regards this parameter compared to planting seasons (Tables 4 and 5).

The genotype has also an effect on harvest index. The Achtar variety gave the lowest index regardless of the year and site (30.71%) in comparison with the two other varieties; Mahdia (31.71%) and Arrehane (33.23%) (Tables 4 and 5).

Table 4. Main effects of planting date and varieties on grain yield, 1000-grain weight, plant height, number of grains per spike number of spikes per m^2 and Harvest Index in 2011/2012 and 2012/2013 at Annoceur

	Grain yield (q ha^{-1})		1000-GW (g)		Plant height (cm)		Grains per spike		Spikes m^{-2}		HI (%)	
	2011-2012	2012-2013	2011-2012	2012-2013	2011-2012	2011-2012	2012-2013	2012-2013	2011-2012	2012-2013	2011-2012	2012-2013
D1	21.44	27.50	25.22	26.88	52.89	48.44	24.44	27.75	346.89	367.33	34.78	35.38
D2	18.89	23.67	25.11	26.78	44.89	39.00	23.22	25.89	317.78	340.00	33.11	32.78
Planting	*	**	NS	NS	*	*	NS	NS	*	*	NS	**
Achtar	16.50	24.33	23.33	26.00	45.17	45.83	22.00	26.67	316.00	351.00	31.50	31.83
Mehdia	20,17	25.50	25.17	26.67	48.00	38.50	25.50	28.00	316.67	339.00	34.67	34.17
Arrehane	23.83	26.80	27.00	28.00	53.50	46.83	24.00	25.40	364.33	371.00	35.67	36.40
CV%	18.07	9.63	8.76	5.63	16.94	18.06	11.18	11.85	10.55	8.48	8.72	7.25
Variety	**	**	**	*	NS	*	*	NS	*	*	*	**
Planting x Variety	NS	NS	NS	**	NS	NS	*	*	NS	**	NS	*

*, ** Significantly different at $p = 0.05$ and $p = 0.01$ probability levels, respectively NS: not significant.

Table 5. Main effects of planting date and varieties on grain yield, 1000-grain weight, plant height, number of grains per spike number of spikes per m^2 and Harvest Index in 2011/2012 and 2012/2013 at Douyet

	Grain yield (q ha^{-1})		1000-GW (g)		Plant height (cm)		Grains per spike		Spikes m^{-2}		HI (%)	
	2011-2012	2012-2013	2011-2012	2012-2013	2011-2012	2011-2012	2011-2012	2012-2013	2011-2012	2012-2013	2011-2012	2012-2013
D1	20.22	38.78	25.33	33.33	57.00	69.67	34.56	45.67	238.00	250.67	27.78	34.22
D2	18.33	36.22	25.00	33.89	54.78	62.78	32.67	41.44	226.00	255.33	26.56	30.33
Planting	*	**	NS	NS	*	**	NS	*	NS	NS	*	**
Achtar	17.33	35.17	24.00	32.00	54.83	63.67	32.00	44.17	230.00	244.00	27.50	32.00
Mehdia	19.17	36.67	24.67	34.00	54.83	65.17	34.00	43.50	230.00	248.00	26.83	31.17
Arrehane	21.33	40.67	26.83	34.83	58.00	69.83	34.83	43.00	236.00	267.00	27.17	33.67
CV%	11.08	7.67	7.61	5.51	4.29	7.15	15.21	7.8	16.78	5.65	6.34	10.21
Variety	**	**	*	*	*	**	NS	NS	NS	*	NS	*
Planting x Variety	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	**	NS

*, ** Significantly different at $p = 0.05$ and $p = 0.01$ probability levels, respectively NS: not significant.

4. CONCLUSIONS

Early sowing date of bread wheat in Douyet at 1st November and at 1st December in Annoceur recorded the highest grain yield compared to the seasonal sowing dates (15th November and 15th December). This result was achieved through two yield components; the number of spikes per unit area and the number of grain per spike. Our results indicate that the Arrehane variety (registered in Moroccan Official Catalogue in 1996) surpassed the two other varieties Mehdia (registered in Moroccan Official Catalogue in 1993) and Achtar (registered in Moroccan Official Catalogue in 1988) in both growing seasons and at both locations regardless of sowing dates for grain yield and for all components measured. These results show that there is a genetic progress for Moroccan varieties of bread wheat.

REFERENCES

1. El Hafid R. Morphological and physiological traits associated with early-season drought resistance in durum wheat. PhD. Colorado State University; 1996.
2. Gommes R, El Hairech T, Rosillon D, Balaghi R, Kanamaru H. Impact of climate change on agricultural yields in Morocco. World Bank Morocco study on the impact of climate change on the agricultural sector; 2008.
3. Muhammad I, Mohammad F, Khalil IH, Arif M, Khan W, Saifullah, Azam SM. Yield Potential of F4:7 Bread Wheat (*Triticum aestivum* L) Lines under Normal and Late Plantings. International Journal of Basic & Applied Sciences IJBAS-IJENS. 2013; 7-11.
4. Abd-Allah, Soheir MH, Amin IA. Genotypic Differences for Heat Tolerance Traits in Bread Wheat Using Five Parameters Genetic Model. Alex. J. Agric. Res. 2013; 83-96.
5. Arain MA, Sial MA, Javed MA. Stability analysis of wheat genotypes tested in multi- environmental trials (METs) in Sindh Province. Pak. J. Bot. 2001; 33: 761-765.
6. Abd EL-Shafi AM, Ageb OAA. Breeding strategy for developing heat tolerant varieties adapted to Upper Egypt and Sudan. In: D.A. Saunders and G.P. Hetted (eds). Wheat in Heat Stressed Environment, Irrigated, Dry Areas, and Rice-Wheat Farming Systems. Proc. Int. Conf. on Wheat in Hot, Dry, Irrigated Environments. CIMMYT. Mexico. 1994; 33-39.
7. Lauer JG, Carter PR, Wood TM, Diezel G, Wiersma DW, Rand RE, Mlynarek MJ. Corn hybrid response to planting date in the northern Corn Belt. Agronomy Journal, 1999; 91, 834–839.

8. Darby H, Madden L, Burke C, Cummings E, Harwood H, Monahan S. 2013 Organic Spring Wheat Planting Date Trial. University of Vermont Extension. 2014a; March 2014.
9. Karrou M, Oweis T. Water and land productivities of wheat and food legumes with deficit supplemental irrigation in a Mediterranean environment. Agricultural Water Management. 2012; 107:94-103.
10. Refay YA. Yield and yield component parameters of bread wheat genotypes as affected by sowing dates. Middle-East journal of science Research. 2011; 7 (4): 484-489, 2011.
11. Witt M D. Delayed planting opportunities with winter wheat in the central Great Plains. J. Prod. Agric. 1996; 9: 74-78.
12. Mohammadi S, Janmohammadi M, Javanmard A. Assessment of drought tolerance indices in bread wheat genotypes under different sowing dates. Cercetări Agronomice în Moldova. 1998; 151: 25-39.
13. Bendidi A, Daoui K, Kajji A, Dahan R, Ibriz M. Effects of Supplemental Irrigation and Nitrogen Applied on Yield and Yield Components of Bread Wheat at the Saïs Region of Morocco. American Journal of Experimental Agriculture Sciencedomain international. 2013; 3(4): 904-913.
14. Ahmad J, Chaudhry MH, Din S, Ali MA. Stability for grain yield in wheat. Pakistan J. Bot. 1996; 28: 61-66.
15. Iqbal MS, Yar A, Ali A, Anser MR, Iqbal J, Akram MH. Effect of sowing dates and seed rate on grain yield of wheat (CV. 93-BT-022). J. Agric. Res. 2001; 39: 217-238.
16. Nyamudeza P, Mutema Z. Wheat sowing date trials. Lowveld Research Station Review and Planning Workshop. Chiredzi Research Station, P.O. Box 97, Chiredzi, Zimbabwe; 2002.
17. Protic R, Jovin P, Protic N, Jankovic S, Jovanovic Ž. Mass of 1000 grains in several winter wheat genotypes, at different dates of sowing and rates of nitrogen fertilizer. Romanian Agricultural Research. 2007; 39-42.
18. Seleiman M, Ibrahim M, Abdel-Aal S, Zahran G. Effect of Sowing Dates on Productivity, Technological and Rheological Characteristics of Bread Wheat. Journal of Agro Crop Sciences. 2011; 2 (1): 1-6.
19. Khokhar Z, Hussain I, Khokhar B, Sohail M. Effect of planting date on yield of wheat genotypes in Sindh. Pakistan J. Agric. Res. 2010; 103-107.
20. Mahmoud MA. Effect of sowing date and time of nitrogen application on some wheat and barley varieties. Ph. D. Thesis, Faculty of Agriculture, Minia University, Egypt. 1992.

239 21. Salem M. Effect of sowing dates and seeding rates on productivity of three newly wheat cultivars
240 (*Triticum aestivum* L.). Journal of Agricultural Sciences. 1999; 24: 4379-4395.
241 22. El-Shami MM, Sharshar MS, Abdel Latif AH. Effect of late planting date and nitrogen fertilization on
242 wheat. Egyptian Journal of Applied Sciences 1995; 10: 177-188.
243 23. Darby H, Cummings E, Burke C, Harwood H, Monahan S. 2013 Organic Winter Wheat Planting Date
244 Trial. University of Vermont Extension. 2014b; January 2014.
245 24. Khan NA, Qayyum SM, Ansari AH, Kalwar MA, Kalwar MN. Effect of different planting dates on the
246 growth and yield of wheat (*Triticum aestivum* L.) Pakistan J. Agric. Engg. Vet. Sci. 1989; 4(102): 7-13.