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Effect of Sowing Date on Grain Yield, its Components and Some Morpho-Phenological Traits of Durum Wheat (*Triticum durum* Desf.) In Semi-Arid Zone in Algeria

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ABSTRACT

This study was conducted at Setif Agricultural Experimental Station in 2017–2018 crop season, the experimental material used in this study consisted of 5 cultivars (*Triticum durum* Desf.) based on their difference between early and late cultivation. The genotypes tested were sowing in in a random block design with three replications, each plot consisted of 2 rows of 2.5 m long spaced of 20 cm. The aim of this study is to assess the impact of the choice of sowing date on grain yield, these components as well as some morpho-phenological traits in order to have an idea on the best sowing date. Two-way analysis of variance showed that the effect of sowing date was significant (p<0.001–0.05) with the variables above ground biomass (BIO), spike weight (SW), Thousand kernels weight (TKW), Flag leaf area (LA), plant height (PH), number of days to heading (DH) and canopy temperature (CT), this effect caused the decrease of major parameters studied and mainly grain yield (GY), accompanied by decrease of BIO, SW, TKW, relative Water contents RWC, LA, PH and DH. Ofanto is shown to be the most suitable genotype for the late sowing date (January). The correlation analysis show that GY was significantly, strongly and positively correlated (p<0.001) under both sowing date with BIO and SW. CT was negatively correlated with GY, BIO, SW and HI (p<0.05) who suggest that our plants underwent water stress during the second sowing date.

KEYWORDS: Algeria, durum wheat, grain yield, semi-arid, sows date

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1. INTRODUCTION

Durum wheat [*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.] is grown on 10% of the world wheat area. It occupies approximately 11 mha in the Mediterranean basin. The world's durum wheat acreage is concentrated in the Middle East, North Africa, Russia, the North American Great Plains, India, and Mediterranean Europe (Golabadi et al., 2006). Durum wheat is the 10th most important crop worldwide with an annual production of over 40 million tons (Sall et al., 2019). The largest producer is the European Union, with 9 mt in 2018, followed by Canada, Turkey, United States, Algeria, Mexico, Kazakhstan, Syria, and India (Tedone et al., 2018).An estimate by the UN-FAO indicates that, by 2050, the global demand for agricultural products will rise by 50%. Meeting this demand will require traditional development of improved cultivars coupled with modern best management practices as well as innovations that are transformational (Beres et al., 2020). Among cereal crops, durum wheat is widely cultivated in the Mediterranean region and others semi-arid areas of the World (Ahmed et al., 2019). In Algeria, the actual production of cereals during the period 2010–2017 is estimated at 4.54 mt on average, an increase of 26% compared to the decade 2000–2009 when production is estimated on average at 3.59 mkg. In Algeria, with these topographical and bioclimatic characteristics, which show a diversity of landscapes and cropping systems, cereal growing is the predominant speculation of agriculture. It covers an annual area of approximately 3.6 mha of the useful agricultural areas (UAA), production consists mainly of durum wheat and barley, which respectively represents 51% and 29% of all cereal production on average 2010–2017 (Anonymous, 2018). Climate changes are recorded in the composition and geographic redistribution of ecosystems in Algeria. This situation has resulted in a shift towards the north of the arid zones, until then confined between the Sahara and the high cereal plains (Frih et al., 2021). Sowing date is one of the most important agronomic factors which need great emphasis for maximum yield of crops. Durum wheat grain yield are dependent on the environment, genetic factors and the interaction between them (Coventry et al., 2011). Optimum sowing date positively affect grain yield of wheat, resulting in better adjustment to the physiology, phenology and environmental conditions (Ribeiro et al., 2009, Silva et al., 2011). The appropriate sowing date also affects the water, temperature and solar radiation available for the crop. The highest values of some vegetative characters, yield attributes and grain-yields as well as enhancement in biological and economical yield occurred when wheat was planted earlier (Qasim et al., 2008). The choice of the ideal sowing date, poses a big problem for farmers because of the changes in the climate which weighs on this choice. Khan and Salim (1986) observed that early seeding resulted in higher yields as compared with late seeding. Shahzad et al. (2012) and Shah et al. (2006) recorded maximum grain yield when crop was being sowed on November 01. Hameed et al. (2003) reported that wheat varieties performed better when sown in last week of October or 1st week of November. Subhan et al. (2003) and Qasim et al. (2008) concluded that the crop planted on November 15, produced higher grain yield as compared to late and early planting. Our study aims to assess the impact of the choice of sowing date on grain yield. We analyze these components as well as certain morphological and phonological traits in order to have an idea on the best sowing date.

2. MATERIALS AND METHODS

2.1. Study area

This study consists of 5 cultivars (*Triticum durum* Desf.) (Table 1) based on the difference between early and late cultivation. Early crops are sown in November 15, 2017, while late crops are sown in January 08, 2018 during the 2017–2018 crop season in Setif Agricultural Experimental Station (ITGC-AES, 36° 12'N and 05° 24'E and 1.081 m asl, Algeria), in a random block design with three replications. Each plot consisted of 2 rows of 2.5 m long spaced of 20 cm. No specific treatment was given to the two types of crops.

Table 1: Origin of the five genotypes studied

Cultivar	Name	Abbreviation	Origine
1	Boussellem	Bouss	ICARDA
2	Mohamed Ben Bachir	MBB	Algeria
3	OumRabie	Mrb5	ICARDA
4	Ofanto	Ofa	Italia
5	Waha	Waha	ICARDA

2.2. Method of data collection

The following measurements were applied for early and late plots: Grain yield (GY kg ha^{-1}), Above ground biomass (BIO kg ha^{-1}), number of spikes per meter square (NS m^{-2} spike^{-2}), spike weight (SW g), thousand kernel weight (TKW g), harvest index (HI%), relative water contents (RWC%), flag leaf area (LA cm^2), Plant height (PH cm), number of days to heading (DH day) (from 1/1/2018), canopy temperature (TC °C),

3.3. Statistical analysis

All statistical analyses will be performed by Costat 6.400 (Anonymous, 1998).

For analysis of variance, Fisher's LSD multiple ranges test was employed for the mean comparisons.

3. RESULTS AND DISCUSSION

3.1. Analyze of variance (ANOVA)

The results of the 2-way ANOVA (Table 2) show that the genotype effect was significant (p<0.05; 0.01 and 0.001) with the variables: NS m^{-2}, TKW, HI, PH, DH and TC while the sowing date effect was significant (p<0.05; 0.01 and 0.001) with the variables: BIO, SW, TKW, LA, PH, DH and TC. The Interaction (genotype×precocity) was not significant for all variables.

The ranking of the different variables of both crops were presented in Table 2.

3.1.1. Grain yield (GY)

In early sowing date, GY takes the values of 6.64 t $ha^{-1}$for Waha genotype to 8.67 t $ha^{-1}$of the Mrb5 genotype with an average of 7.59 t $ha^{-1}$for all the genotypes studied, in late cropping GY takes the values from 8.38 t ha^{-1} for MBB-11.06 t ha^{-1} for Ofa with a genotypic mean of 7.3 t ha^{-1}. The difference between the both cropping is 3.82% (table 3) in favor of early sowing date (Figure 1). Arduini et al. (2009) reported that yield loss caused by the delay of sowing from November to March was essentially due to a lower number of kernels per spike, that, in turn, was mainly consequence of the drastic decrease (30–40%) of the number of spikelets $spike^{-1}$. Spikelet number is an important yield determinant in Mediterranean conditions, where sowing date is often delayed to the end of winter (Mahdi et al., 1998, Elhani et al., 2007).

3.1.2. Aboveground biomass (BIO)

In early sowing date, BIO takes the values of 14.55 t ha^{-1} for Ofa genotype to 19.98 t ha^{-1} for Bous genotype with an average of 17.46 t ha^{-1} for all the genotypes studied, in late cropping BIO takes the values from 12.82 t ha^{-1} for Waha to 18.25 t ha^{-1} for Ofa with a genotypic mean of 125.32 t ha^{-1}. The difference between the both cropping is 13.59% (table 3) in favor of early sowing date (Figure 1). These results are very consistent with the work of Khan (2000) who reported that early (Nov.) sowing and higher plant density increased biomass by increasing leaf area index (LAI), especially early in the season.

3.1.3. Number of spikes m^{-2} (NS m^{-2})

In early crop , NS m^{-2} take the value of 330 spikes.m^{-2} for Ofa genotype to 733.33 spikes m^{-2} for Waha genotype with an average of 572.67 spikes m^{-2} for all the genotypes studied, in late cropping NS m^{-2} takes the values from 500 spikes m^{-2} for Ofa to 720 spikes m^{-2} for Waha with a genotypic mean of 600 67 spikes m^{-2}. The difference between the both cropping is 4.66% (table 3) in favor of late sowing date (Figure 1). This result is very consistent with the work of Arduini et al. (2009) who report that the number of spikes per meter square increases with the delay in sowing. Spiertz et al. (1971) and Stapper and Fischer (1990) reported that

Table 2: 2-way ANOVA of the different variables measured

	DF	Mean of squares										
		GY	BIO	NS m^{-2}	SW	TKW	HI	RWC	LA	PH	DH	CT
Geno-type	4	Ns	ns	94183.33***	ns	78.64**	192.32*	ns	ns	856.40***	80.55***	3.49**
Sowing date	1	Ns	3477.63*	ns	9284.35*	440.53***	ns	ns	19.22*	940.8***	258.13***	17.74***
G×S date	4	Ns	ns	ns	ns		ns	ns	ns	ns	ns	ns
CV%	-	27.96	17.35	16.30	20.03	7.74	16.48	4.64	14.85	5.42	1.58	3.80

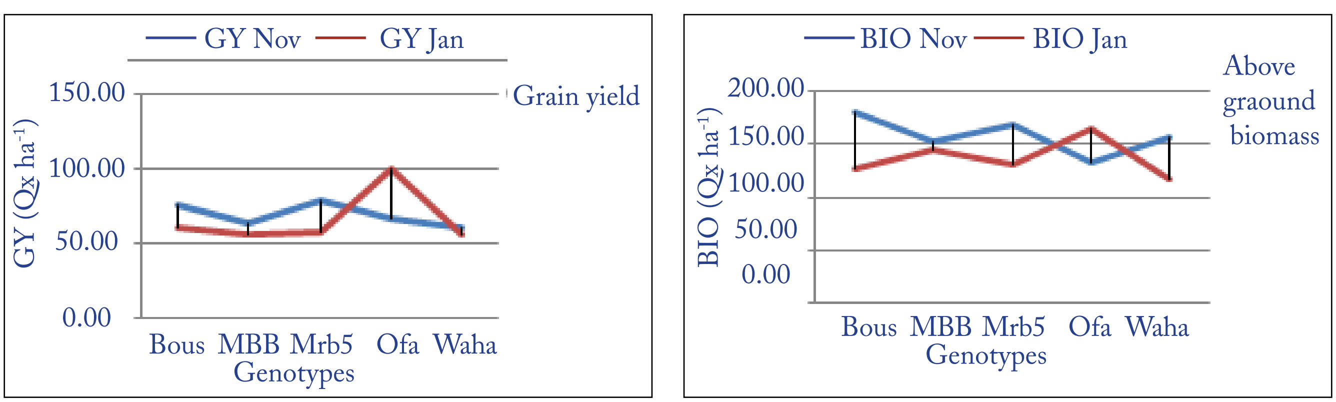

Figure 1: Continue...

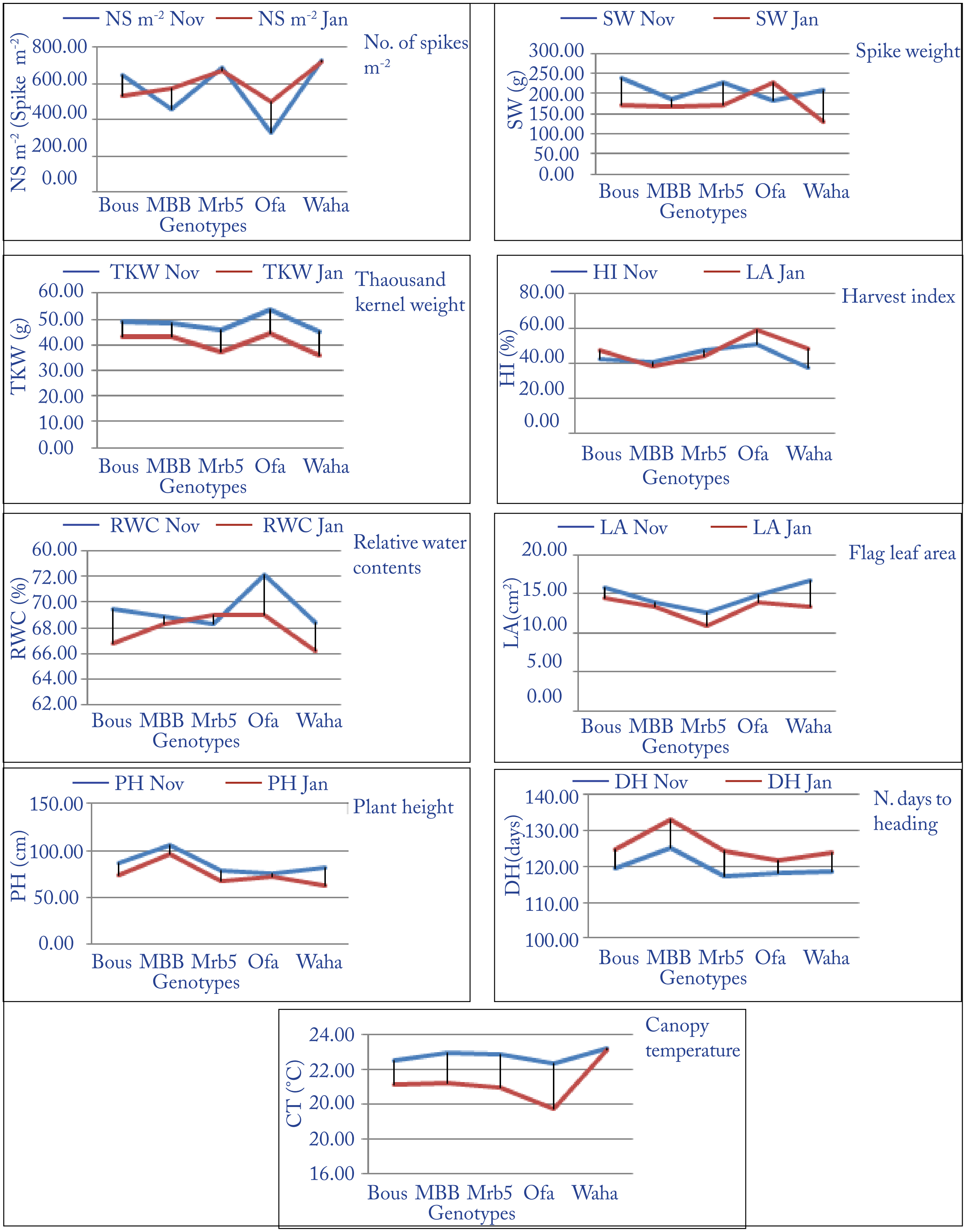

Figure 1: Interaction of genotype×sowing date on different variables measured

Table 3: Ranking of tested genotypes for the different variables measured

Variables	GY t ha^{-1}		BIO t ha^{-1}		NS m^{-2} spike m^{-2}		SW_g		TKW_g		HI%	
Sown date	Nov.	Jan.	Nov.	Jan.	Nov.	Jan.	Nov.	Jan.	Nov.	Jan.	Nov.	Jan.
Bous	8.33	6.68	19.99	13.96	650.00	533.33	241.03	172.42	48.88	42.87	42.02	47.67
MBB	6.96	6.16	16.9	16.06	463.33	573.33	184.87	168.13	48.67	43.41	41.08	38.18
Mrb5	8.67	6.36	18.52	14.33	686.67	676.67	227.73	171.40	46.08	37.01	47.08	44.39
Ofa	7.34	10040	14.55	18.26	330	500	183.73	229.04	53.96	44.68	50.85	58.78
Waha	6.64	11.07	17.34	12.82	733.33	720	210.63	131.07	44.81	36.11	37.77	48.14
Mean	7.59	7.3	17.46	15.09	572.67	600.67	209.60	174.41	48.48	40.82	44.76	47.43
Min	6.64	6.16	14.55	12.83	330	500	183.73	131.07	44.81	36.11	37.77	38.18
Max	8.67	11.07	19.99	18.26	733.33	720	241.03	229.04	53.96	44.68	50.85	58.78
CV%	1.67	3.8	1.78	2.14	20.53	13.67	16.57	25.83	9.47	5.44	8.38	19.67
G eff	ns		Ns		***		ns		**		*	
P eff	ns		*		ns		*		***		ns	
G*Peff	ns		ns		ns		ns		ns		ns	
% of dif	3.82↓		13.59↓		4.66↑		16.79↓		15.81↓		7.74↑	

Table 3: Continue...

Variables	RWC%		LA cm^2		PH cm		DH day		CT°C	
Sown date	Nov.	Jan.	Nov.	Jan.	Nov.	Jan.	Nov.	Jan.	Nov.	Jan.
Bous	69.52	66.72	15.88	14.51	86.17	73.33	119.33	124.67	21.55	21.13
MBB	68.88	68.35	13.94	13.36	105.50	95.83	125.00	133.00	21.64	21.22
Mrb5	68.35	68.98	12.66	10.83	78.17	67.50	117.33	124.33	21.64	20.91
Ofa	72.15	69.04	14.95	14.00	75.33	71.67	118	121.67	21.64	19.73
Waha	68.37	66.18	16.69	13.42	82.50	63.33	118.67	124.00	22.25	23.13
Mean	69.45	67.86	14.82	13.22	85.53	74.33	119.67	125.53	21.75	21.23
Min	68.35	66.18	12.66	10.83	75.33	63.33	117.33	121.67	21.55	19.73
Max	72.15	69.04	16.69	14.51	105.50	95.83	125.00	133.00	22.25	23.13
CV%	4.90	4.65	9.76	20.38	3.68	6.57	1.41	0.85	4.16	3.84
G eff	ns		ns		***		***		**	
P eff	ns		*		ns		***		***	
G×Peff	ns		ns		ns		ns		ns	
% of dif	2.30↓		10.80↓		13.09↓		4.67↑		2.39↓	

late sowings were generally accompanied by a reduction in the number of spikes $plant^{-1}$.

3.1.4. Spike weight (SW)

In early crop, SW takes the values of 183.73 g for Ofa genotype to 241.03 g for Bous genotype with an average of 209.60 g for all the genotypes studied, in late cropping SW takes the values from 131.07 g for Waha-229.04 for Ofa with a genotypic mean of 174.41 g. The difference between the both cropping is 16.79% (table 3) in favor of early sown date (Figure 1). It is normal because reducing of thousand kernel weight who suggest a reduce of the weight of kernels. The delay of sowing is generally associated with a reduced kernel weight (Jessop and Ivins, 1970, Radmehr et al., 2003).

3.1.5. Thousand kernel weight (TKW)

In early crop, TKW takes the values of 44.81 g for Waha genotype to 53.96 g for Ofa genotype with an average of 48.48g for all the genotypes studied, in late cropping TKW takes the values from 36.11 g for Waha to 44.68 for Ofa with a genotypic mean of 40.82 g. The difference between the both cropping is 15.81% (Table 3) in favor of early sown date (Figure 1). In the same sowing interval, the mean kernel weight was not affected or only slightly decreased (Arduini et al., 2009).

3.1.6. Harvest index (HI)

In early sowing date, HI takes the values of 37.77% for Waha genotype to 50.85% for Ofa genotype with an average of 44.76% for all the genotypes studied, in late cropping HI takes the values from 38.18% for MBB to 58.78% for Ofa with a genotypic mean of 47.43%. The difference between the both cropping is 15.81% (Table 3) in favor of late sowing date (Figure 1). This result is not compatible with that of Jessop and Ivins (1970) reported that delay of sowing reduces harvest index, grain number spike^{-1}, and leaf area index.

3.1.7. Relative water contents (RWC)

In early crop, RWC takes the values of 68.35% for Mrb5 genotype to 72.15% for Ofa genotype with an average of 69.45% for all the genotypes studied, in late cropping RWC takes the values from 66.18% for Waha to 69.04% for Ofa with a genotypic mean of 67.86%. The difference between the both cropping is 2.30% (Table 3) in favor of early cropping (Figure 1). Bassu et al. (2009) reported that under such conditions, sowing as early as October to avoid terminal water shortage and heat stress will minimize the negative impact from climate change.

3.1.8. Flag leaf area (LA)

In early crop, LA takes the values of 12.66 cm^2 for Mrb5 genotype to 16.69 cm^2 for Waha genotype with an average of 14.82 cm^2 for all the genotypes studied, in late cropping LA takes the values from 10.83 cm^2 for Mrb5 to 14.51 for Bous with a genotypic mean of 13.22 cm^2. The difference between the both cropping is 10.80% (table 3) in favor of early sown date (Figure 1). This result is compatible with the work of Araus et al. (1989) who report that the flag leaf area decreases with delay; this change is due to a change in the structure of the flag leaf for reasons of gas exchanges.

3.1.9. Plant height (PH)

In early sowing date, PH takes the values of 75.33 cm for Ofa genotype to 105.50 cm for MBB genotype with an average of 85.53 cm for all the genotypes studied, in late cropping PH takes the values from 63.33 cm for Waha–95.83 cm for MBB with a genotypic mean of 74.33 cm. The difference between the both cropping is 13.09% (table 3) in favor of early sowing date (Figure 1). In general, late June to mid-July sowing increased plant height of durum wheat. This increment in plant height might be due to the fact that at early sowing crop may have enjoyed better environmental conditions especially soil moisture, temperature and solar radiation which resulted to tallest plants (Bizuwork, 2020). In conformity with this result, Tahir et al. (2009) reported that increasing of plant height of wheat in early sowing.

3.1.10. Number of days to heading (DH) (from 01/01/2018)

In early crop, DH takes the values of 117.33 days for Mrb5 genotype to 125 days for MBB genotype with an average of 119.67 days for all the genotypes studied, in late cropping DH takes the values from 121.67 days for Ofa to 133 days for MBB with a genotypic mean of 125.53 days. The difference between the both cropping is 4.67% (table 3) in favor of late sown date (Figure 1). This result is contradictory with that of Wajid et al. (2006) who claim that number of days to heading decreases with delay. The difference may be due to the difference on their genetic makeup and also due to their differential response to different sowing season (Nayeem and Delvi, 1992).

3.1.11. Canopy temperature (CT)

In early crop, CT takes the values of 21.55°C for Bous genotype to 21.64°C for MBB, Mrb5 and Ofa genotypes with an average of 21.75°C for all the genotypes studied, in late cropping CT takes the values from 19.73°C for Ofa to 23.13°C for Bous and Waha genotypes with a genotypic mean of 21.23°C. The difference between the both cropping is 2.39% (table 3) in favor of early sown date (Figure 1). CT is one of the important criteria for the selection of stable genotypes under late heat and very late heat stress conditions and can help in improving production and productivity of durum wheat under terminal heat stress conditions (Amit et al., 2015) .

3.2. Correlation analysis

Table 4 present the correlations of different variables studied under both sowing dates (early and late cropping), GY was strongly and positively correlated under both cropping with BIO ($p<0.001$) (r=0.79***, 0.84***) and SW (r=0.88***, 0.72**). Several authors on the highly significant and positive correlation between GY and BIO (Hannachiet al., 2013, Fellahiet al., 2013), GY is also strongly and positively correlated with HI ($p<0.001$) under second sown date (r= 0.84***). A high significant and positive correlation was observed between BIO and SW under both sown dates ($p<0.001$) (r=0.94***,0.88***). CA was negatively correlated with GY ($p<0.05$) under second sown date (r=-0.60*), Guendouz et al. (2012) reported that canopy temperature was negatively correlated with grain yield under stressed conditions,accordingto same author CA was a good indicator for drought stress. Similar results were reported by Talebi (2011), where CA is also negatively correlated under the same cropping date with BIO, SW and HI ($p<0.05$) (r=-0.54*, -0.57* and -0.51* respectively) who suggest that our plants underwent water stress during the second sowing date. Highly and positive correlation between DH and PH ($p<0.001$) (r= 0.81*** under both sown dates) this high correlation was observed by Mohammadi et al. (2011).

Table 4: Simple linear correlation of the different variables measured in the tow (Nov./Jan.) sowing dates

	GY (Nov) GY (Jan)	BIO (Nov) BIO (Jan)	NS m^{-2} (N) NS m^{-2} (Jan)	SW (N) SW (Jan)	TKW (Nov) TKW (Jan)	HI (Nov) HI (Jan)	RWC (Nov) RWC (Jan)	LA (Nov) LA (Jan)	PH (Nov) PH (Jan)	DH (Nov) DH (Jan)	CT (Nov) CT (Jan)
GY (Nov)	1										
GY (Jan)	1										
BIO (Nov)	0.79***	1									
BIO (Jan)	0.84**	1									
NS m^{-2} (Nov)	ns	0.67**	1								
NS m^{-2} (Jan)	ns	ns	1								
SW (Nov)	0.88***	0.94***	0.65**	1							
SW (Jan)	0.72**	0.88***	ns	1							
TKW (Nov)	ns	ns	ns	ns	1						
TKW (Jan)	ns	ns	-0.59*	ns	1						
HI (Nov)	ns	ns	-0.54*	ns	ns	1					
HI (Jan)	0.84***	ns	ns	ns	ns	1					
RWC (Nov)	ns	ns	ns	ns	ns	ns	1				
RWC (Jan)	ns	ns	ns	ns	ns	ns	1				
LA (Nov)	ns	ns	ns	ns	ns	ns	ns	1			
LA (Jan)	ns	ns	ns	ns	ns	ns	ns	1			
PH (Nov)	ns	ns	ns	ns	ns	ns	ns	ns	1		
PH (Jan)	ns	ns	ns	ns	ns	ns	ns	ns	1		
DH (Nov)	ns	ns	ns	ns	ns	ns	ns	ns	0.81***	1	
DH (Jan)	ns	ns	ns	ns	ns	ns	ns	ns	0.81***	1	
CT (Nov)	ns	ns	ns	ns	-0.65**	-0.60*	ns	ns	ns	ns	1
CT (Jan)	-0.60*	-0.54*	ns	-0.57*	ns	-0.51*	ns	ns	ns	ns	1

ns: No significant, *: Significant at 0.05, **: Significant 0.01, ***: Significant at 0.001

4. CONCLUSION

Analysis of variance showed that effect of sowing date was significant (p<0.001–0.05) with BIO, SW, TKW, LA, PH, DH and CT, Ofanto is shown to be the most suitable genotype for the late sowing date. Correlation analysis show that GY was strongly and positively correlated (p<0.001) under both sowing date with BIO and SW. CT was negatively correlated with GY, BIO, SW and HI (p<0.05) which suggests that our plants underwent water stress during the second sowing date.

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