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Research Note

Evaluating durum wheat performance and efficiency of senescence parameter usage in screening under Mediterranean conditions

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Abstract:
The present study was led on the experimental site of station ITGC in sétif Algeria. The objectives of this study is evaluating durum wheat performance and testing the efficiency of senescence parameter usage in screening. Grain yield (GY) and above ground vegetative biomass (BIO) were measured. Thousand-kernel weight (TKW) was determined from sub-samples taken from harvested grains of each plot. Leaf senescence (S) was evaluated by numerical image analysis (NIA) and chlorophyll content (Chl) measured by SPAD instrument. Study of correlation between grain yield and its components, revealed the absence of significant correlations between grain yield, thousand-kernel weight and biomass (r = 0.07 and 0.47 respectively) but there is a significant negative correlation between grain yield and number of days from sowing to heading (DH) (r = -0.75). A significant negative correlation between chlorophyll content and average senescence (Sa%) was noted in this study (r = -0.68). A significant positive correlation showed between Σ50s and grain yield suggests that genotypes with slow senescence showed highest yield. The absence of significant correlation between grain yield and thousand-kernel weight was noted when the water stress was seen during period of grain filling.

Key words: Durum wheat. grain yield, senescence, chlorophyll, water stress

Durum wheat is probably one of the oldest cultivated plants in the world. This species is mainly grown in the Mediterranean region under rainfed conditions without irrigation (Baldy,1986). Mediterranean climate is characterised by a progressive increase in drought (combination of water stress, high temperature and excess radiation) during late spring, coinciding with the grain filling of cereal crops (Acevedo *et al*., 1999); in addition, arid and semi-arid regions such as West Asia and North Africa (WANA), precipitation is low and erratic, and drought is frequent. Water shortage is a major constraint to agricultural production in the region (Corbeels *et al*., 1998). Drought tolerance is a complex character (independent on the yield potential) which make it difficult to find an appreciable genetic correlation between a physiological attribute and yield or plant performance under field conditions. However, drought resistance exists because there are specific mechanisms in plants which are shown under stress conditions (Blum, 1988).

As an example, these components may be used to choose parents at the beginning of a breeding program for water deficient field conditions. Alternatively at the end of a yield-based breeding program screening for drought tolerance may introduce characters that improve plant adaptability to a particular environment. Yield determination of extensive crops, such as wheat, has been frequently analysed considering its numeric components, i.e. grain number per unit area (GN) and individual grain weight (GW). Separating the effects of environmental variables on numeric components in the analysis of crop yield determination is relevant since there are differences both in the time during crop cycle when these components are defined and in their control variables. Functional and robust relationships between yield components and environmental factors have been used to assess differences in grain crops yield (Fischer, 1985). The objectives of this study were 1) Evaluating durum wheat performance through the analysis of variance and relationships between yield components 2) To test the efficiency of using senescence in screening.

A set of 10 genotypes of durum wheat (*Triticum durum* Desf.) (Table 1) were planted on 1st December 2008, in the experimental fields of ITGC, Sétif, Algeria (5°20'E, 36°8'N, 958m above mean sea level). The genotypes were grown in randomized block design with four replicates. Plots were 5 m × 6 rows with 0.20 m row spacing and sowing density was adjusted to 300 g m^{-2}. The soil of the experimental site is a rendzin, mollisol (Calcixeroll USDA) up to 0.6 m in depth, containing low organic matter. The SULFAZOT (26% N,12%S,120 Kg/ha) was applied at tillage to

all plots. Weeds were removed chemically by TOPIC (0.75L/ha) and GRANSTAR (15g/ha). Rainfall during the whole growth cycle was 338.3 mm (Figure1).

Grain yield (GY) and above ground vegetative biomass (BIO) were measured as quintal per hectare. Thousand-kernel weight (TKW) was determined from sub-samples taken from harvested grains of each plot. Leaf senescence (S) was evaluated by numerical image analysis (NIA) according to Hafsi *et al*. (2000). Leaves were photographed on black surface, between 11:00 and 12:00 solar time with a color digital camera (Canon, Power Shot A460, AiAF, CHINA). Images were stored in a JPEG (Joint Photographic Expert Group) prior to downloading onto a PC computer and analyzed using IPP (Image Pro Plus, Version 4, Media Cybernetics, Silver Spring, MA, USA) software. Senescence was expressed as the ratio of senesced area to total leaf area (in per cent). Measurements were carried out twelve times between flowering and the end of senescence on three flag leaves for each genotype. The twelve dates of assessments were expressed in sums of temperatures after flowering (Σt1 – Σt12) and the corresponding senescence values (S1 – S12). In addition to S, four parameters calculated to characterize the dynamics of senescence; average senescence (Sa%) was calculated as the mean of the S1 to S12 values. The date of mid-senescence (Σ50) was evaluated from the experimental curves S = f(Σt) as the sum of temperature corresponding to the S value of 50%. The velocity of senescence (Vs) was calculated for each date of senescence measurement as (Si+1 – Si) / (Σti+1 – Σti), the highest Vs value (Vs max) was noted for each genotype and Vsa, its mean of velocity (V1 to V12) (Table 2). The SPAD-502 measures the amount of chlorophyll (Chl) in the leaf, which is related to leaf greenness, by transmitting light from light emitting diodes (LED) through a leaf at wavelengths of 650 and 940 nm.

Data were analyzed using SAS, version 9 (SAS Institute, 1987, NC, USA). The analysis of variance was performed for senescence parameters and agronomical traits. Linear correlation analysis was used to determine the relationships between the traits measured.

In field condition, the genotype effect was significant for above-ground vegetative biomass, grain yield, thousand-kernel weight, number of grains per spike and number of grains per m²,but not significant for chlorophyll content (Table 3). For all genotypes, the senescence function with sums of temperatures after flowering was of sigmoid type. The Σ50, the sums of temperatures corresponding to the S value of 50%, differed markedly amongst genotypes, as shown in Figure 2. A highly significant genotype effects was noted for Sa% (average senescence) and Σ50s; significant genotype effects were also found for the maximal velocity of senescence (Vs_{max}) (Table 4). Study of correlation between grain yield and its components, refers to the absence of significant correlations between grain yield, thousand-kernel weight and biomass (Table 5). A significant negative correlation is noted between grain yield and number of days from sowing to heading (DH). Thousand-kernel weight is negatively correlated to number of grains per spike and number of grains per m², but positively correlated to biomass, the latter variable is positively correlated to number of grains per spike (Table 5). A significant positive correlation was found between number of grains per spike and number of grains per m². A significant correlation between chlorophyll content and average senescence (Sa%) is noted in this study (Table 6); fast declines in chlorophyll content affect the photosynthesis, which in turn adversely affect the grain yield. Degradation of chlorophyll with time (expressed in °C.day after flowering) in the ten genotypes studied was illustrated in Figure 3.

The significant negative correlation between grain yield and number of days from sowing to heading (DH) confirms that the earliness has played a very important role in stability of durum wheat yield in the dry areas, characterized by excessive temperature and hot winds during the period of grain filling (Sharma and Smith, 1986). The absence of significant correlation between grain yield and thousand-kernel weight in this study had already been registered previously by Housley *et al*.(1982). Elhani *et al*. (2007) noted the absence of significant correlation between grain yield and thousand-kernel weight in rainfall condition when the water stress had shown during period of grain filling. The significant positive correlation between Σ50s and GY (Table 6) suggests that the slow senescence leads to higher yield in wheat. There is a good agreement with these results by Rawson *et al*. (1983). Contrary to these finding many studies have demonstrated that delayed senescence delays remobilization and leads to reduced grain weight (Yang *et al*., 1997; Zhu *et al*., 1997). Slafer *et al*. (1996) argue that the lower grains weight observed with increased number of grain per m² is not only due to a lower amount of assimilates per grain but it is the result of an increased number of grains with a lower weight potential coming from more distal florets. Improved biomass and photosynthesis is a major objective for improving the yield potential of wheat (Waddington *et al*., 1987).

The significant negative correlation found between average senescence (Sa%) and chlorophyll content (Chl) suggests that the increase in rates of senescence decrease the chlorophyll content (Degradation); leaf chlorophyll content is often highly correlated with leaf N status, photosynthetic capacity, and RuBP carboxylase activity (Evans, 1983). Changes in photosynthesis most closely paralleled changes in Chlorophyll content considering results obtained with both vegetative and flag leaves. Other investigators have also reported correlations between loss of Chlorophyll and photosynthesis in both wheat and soybeans (Wittenbach, 1979). In addition, Fischer (1983) revealed that radiation use efficiency (RUE) declined during grain filling probably due to sink limitation and/or leaf senescence. Flag leaf photosynthesis in wheat contributed about 30-50% of the assimilates for grain filling (Sylvester-Bradley *et al*., 1990) and initiation of grain filling coincides with the onset of senescence, therefore, photosynthesis of flag leaf is the most important basis of the formation of grain yield, and the onset and rate of senescence are important factors for determining grain yield (Zhang *et al*., 2006).

This study confirmed suitability of using numerical image analysis (NIA) for measuring senescence in cereal leaves and a significant positive correlation between sums of temperatures corresponding to the S value of 50% (Σ50s) and grain yield suggests that genotypes with slow senescence showed highest yield. In addition, a significant negative correlation found between average senescence (Sa%) and chlorophyll content (Chl) suggests that the increase in rates of senescence decrease the chlorophyll content (Degradation). The absence of significant correlation between grain yield and thousand-kernel weight noted when the water stress is shown during the period of grain filling. The significant negative correlation between grain yield and number of days from sowing to heading (DH) confirms that the earliness has played a very important role in stability of durum wheat yield in the dry areas.

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Table 1. Origin of the teen genotypes used in the study

Cultivar	Name	Origin	Cultivar	Name	Origin
1	Bousselem	Algeria	**6**	Altar	Mexico
2	Hoggar	Algeria	**7**	Dukem	Mexico
3	Oued Zenati	Algeria	**8**	Kucuk	Mexico
4	Polonicum	Algeria	**9**	Mexicali	Mexico
5	Waha	Algeria	**10**	Sooty	Mexico

Table 2. Ranking of tested genotypes for S_a (average senescence), $\Sigma 50_S$ (sums of temperatures corresponding to an S value 50%), Vs max (maximal velocity of senescence) and Vsa (average senescence)

Sa **%**		$\Sigma 50_S$		Vs max		Vsa	
Genotype	Ranking	Genotype	Ranking	Genotype	Ranking	Genotype	Ranking
Oued Zenati	49,3(a)	Oued Zenati	290,9(d)	Oued Zenati	1,212(ab)	Oued Zenati	0,380(a)
Altar	38,96(e)	Altar	333,54(a)	Altar	0,751(c)	Altar	0,333(a)
Sooty	42,57(cd)	Sooty	305,17(c)	Sooty	1,269(a)	Sooty	0,380(a)
Polonicum	43,24(c)	Polonicum	312,82(b)	Polonicum	0,875(abc)	Polonicum	0,390(a)
Waha	48,07(a)	Waha	269,77(e)	Waha	0,802(bc)	Waha	0,325(a)
Dukem	40,31(e)	Dukem	298,59(c)	Dukem	0,916(abc)	Dukem	0,386(a)
Mexicali	35,31(f)	Mexicali	338,85(a)	Mexicali	1,065(abc)	Mexicali	0,382(a)
Kucuk	45,19(b)	Kucuk	286,63(d)	Kucuk	0,875(abc)	Kucuk	0,415(a)
Hoggar	40,95(de)	Hoggar	316,92(b)	Hoggar	1,048(abc)	Hoggar	0,502(a)
Bousselem	42,8(cd)	Bousselem	334,46(a)	Bousselem	0,849(abc)	Bousselem	0,342(a)

Means followed by the same latter are not significantly different at $p<0.05$ (NK test)

Table 3. Analysis of variance for grain yield, biomass, thousand-kernel weight, number of grains per m², number of grains per spike and Chlorophyll content

	DF	SS	MS	F
Grain Yield (Q/ha)	9	3004618,19	333846,47	5,64***
Biomass (Q/ha)	9	278310,50	30923,39	5,40***
TKW (g)	9	1326,00	147,33	15,52***
NG/m²	9	88530901,6	9836766,85	6.67***
NG/S	9	425.28	47.25	15.58***
Chl	9	57.31	6.37	0.245^{ns}

*** $p<0.001$; ns = not significant

Table 4. Analysis of variance for average senescence (Sa%), sums of temperatures corresponding to an S value 50% ($\Sigma 50_S$), maximal velocity of senescence (Vs_{max}) and average velocity (Vs_a)

Source	DF	SS	MS	F
Sa %	9	468,8	52,084	52,492***
$\Sigma 50_S$	9	14124	1569,301	82,372***
Vsmax	9	0,823	0,0915	3,465*
Vsa	9	0,069	0,00764	$1,746^{ns}$

* p<0.05, *** p<0.001; ns = not significant

Table 5. Correlations between agronomical and physiological variables

	GY	Bio	TKW	NG/S	NG/m²	Chl	DH
GY	1						
Bio	0,47	1					
TKW	0,07	0,71*	1				
NG/S	-0,04	0,66*	-0,82**	1			
NG/m²	0,24	-0,5	-0,9***	0,7*	1		
Chl	0,27	-0,28	-0,44	0,43	0,5	1	
DH	-0,75*	-0,03	0,34	-0,21	-0,51	0,39	1

* p<0.05 ; ** p<0.01 ; *** p<0.001