Article

Effect of Flag Leaf Reflectance Index (RGB) on Grain Filling in Some Durum Wheat [*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.] Cultivars Sowed under Semi-arid Condition

Abdelmalek Oulmi [1], Ali Guendouz [2], Benalia Frih[3*] and Sarah Benkadja[4]

[1]VRBN Laboratory, Farhat Abbas University Sétif 1, Algeria, oulmi@yahoo.fr .
[2] National Institute of Agronomic Research of Algeria (INRAA), Sétif Unit, guendouz.ali@gmail.com
[3]VRBN Laboratory, Farhat Abbas University Sétif 1, Algeria, benaliafrih@gmail.com .
[4]VRBN Laboratory, Farhat Abbas Sétif University 1, Algeria , sarahbenkadja8@gmail.com
* Correspondence: benaliafrih@gmail.com ; Tel.: 213559953066.

Abstract: Our study aim to test the influence of RGB reflectance and chlorophyll content on grain fill and grain yield of 15 durum wheat cultivars sown under semi-arid conditions. the evolution of chlorophyll content during three stages showed a stability during the heading stage, the chlorophyll content begins at this degradation during grain filling. Boutaleb genotype which was the best yielding genotype was characterized by low values of RGB reflectance and high values of majority of grain filling parameters and thousand kernels weight. Grain filling follows a sigmoid curve. Chlorophyll content was positively correlated with reflectance under the green band and negatively with both Red and Blue bands. A positive correlation was recorded between thousand kernel weight and grain yield, maximum grain dry weight and grain filling duration. The duration of the grain filling was positively influenced by the maximum dry weight of the grain and negatively by the grain filling ratio, the grain filling ratio was positively affected by reflectance at blue band. The principal component analysis separated the cultivars considered into 3 principal components, the absorption/reflectance component, the profitability component and the component of grain filling rate to which the local landrace Boutaleb belongs in terms of grain yield.

Keywords: Grain yield; reflectance; chlorophyll; semi-arid; grain filling; Algeria

1. Introduction

Algeria, with these topographical and bioclimatic characteristics which testify to a diversity of landscapes and cropping systems, cereal growing is the predominant speculation of agriculture. It covers an annual area of about 3.6 million hectares of useful agricultural land (UAA) [1].Solar radiation striking the leaf surface is either reflected, absorbed or transmitted. The nature and amounts of reflection, absorption and transmission depend on the wavelength of the radiation, the angle of incidence, the roughness of the surface and the differences in the optical properties and biochemical content of the leaves [2]. The pigments are integrally linked to the physiological function of the leaves. Chlorophylls absorb light energy and transfer it to the photosynthetic apparatus. Carotenoids (yellow pigments) can also provide energy to the photosynthetic system [3].When light hits a leaf, some of the light is reflected back to the viewer. The amount of energy reflected at each light frequency is called the reflectance spectrum, sometimes abbreviated as spectra or reflectance. Reflectance depends on the properties of the leaf surface and internal structure, as well as the concentration and distribution of biochemical components. In the visible spectrum (VIS, between 400 and 700 nm) the reflectance mainly depends on the presence of photosynthetic pigments such as chlorophyll. In the near infrared region (NIR, between 700 and 13000 nm), where there are no strong absorption characteristics, the amplitude of the reflectance is governed by the structural discontinuities encountered in the sheet. The short wave infrared region (SWIR, between 1300 nm and 3000 nm) [4].Grain

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 July 2022 doi:10.20944/preprints202207.0301.v1

filling, a final process associated with yield performance, is a crucial determinant of grain yield in cereal crops (Al-Ajlouni, 2016). The main effect of high temperatures during grain filling is to cause a reduction in the mass of individual grains [5]. Grain development in field crops is initially slow, but eventually enters a linear phase where the rate of growth is rapid and then slows towards maturity [6].This study aims to determine the influence of leaf reflectance (RGB) and chlorophyll content on grain filling and possibly on grain yield of 15 seeded cultivars under semi-arid conditions.

2. Materials and Methods

2.1. Study site

This study was carried out during the 2020/2021 agricultural campaign at the Agricultural Experiment Station of the Technical Institute of Field Crops ITGC of Sétif (ITGC-AES, 36°12'N and 05°24'E and 1,081 m altitude , Algeria).

2.2. Plant material

The genetic material used in this study consists of 11 advanced lines, 03 local varieties of 01 genotype introduced to evaluate their performance. (Table 1).

2.3. Experimental device

The genotypes tested were sown on November 19 with a seed rate adjusted to 300 seeds. m^{-2} in a random block design (RBD) with three repetitions, each plot was composed of 6 lines of 10 m long spaced 0.2 m wide, which makes 12 m2 of plot area.

Table 1. List of the 15 cultivars evaluated, their pedigrees and their origins.

Names	Pedigrees	Origins
G1	RASCON_37/GREEN_2/9/USDA595/3/D67.3/RABI//CRA/4/ALO/5/ …	CIMMYT
G2	MINIMUS_6/PLATA_16//IMMER/3/SOOTY_9/RASCON_37/9/…	CIMMYT
G3	CMH77.774/CORM//SOOTY-9/RASCON-37/3/SOMAT-4	CIMMYT
G4	CNDO/PRIMADUR//HAI-OU-17/3/SNITAN/4/SOMAT-3/	CIMMYT
G5	RASCON_37/GREEN_2/9/USDA595/3/D67.3/RABI//CRA/4/ALO/5/ …	CIMMYT
G6	SILVER 14/MOEWE//BISU_1/PATKA_3/3/PORRON_4/YUAN_1/9/...	CIMMYT
G7	GUANAY /HU ALITA / 10/PLATA _10/6/MQUE/4/USDA573/...	CIMMYT
G8	BCRIS/BICUM//LLARETA INIA/3/DUKEM_ 12/2*RASCON 21/5/R	CIMMYT
G9	Simeto/3/Sora/2*Plata_12//SRN_3/Nigris_4/5/Toska_26/...	CIMMYT
G10	Ossl1/StjS5/5/Bicrcderaal/4/BEZAIZSHF//SD19539/Waha/3/St	CIMMYT
G11	Stj3//Bcr/Lks4/3/Ter-3/4/Mgnl3/Aghrass2	CIMMYT
Jupare C2001	STINKPOT//ALTAR-84/ALONDRA	CIMMYT
Boussellem	Heider/Martes//Huevos de Oro.	CIMMYT-ICARDA
Boutaleb	GTA dur /Ofanto	ITGC-Setif
Oued El Bard	Hedba3/Ofanto	ITGC-Setif

2.4. Measured parameters

2.4.1. Chlorophyll content

We followed the evolution of the chlorophyll content of the flag leaf for all the elementary plots during 09 dates from the beginning of the heading phase until the end of physiological maturity using a digital counter of chlorophyll (CCM), this device measures the absorbance of light in the leaf, 04 dates of taking the chlorophyll content affected the grain filling period.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 July 2022 doi:10.20944/preprints202207.0301.v1

2.4.2. The RGB reflectance index (Red-Green-Blue)

The R.G.B (Red, Green and Blue) reflectance index was evaluated by digital image analysis (NIA) used by Guendouz and Maamri [7]; the leaves were photographed on a black surface, between 11:00 a.m. and 12:00 p.m., solar time, with a color digital camera (Canon, Power Shot A460, AiAF, CHINA). The images were stored in a JPEG (Joint Photographic Expert Group) before being downloaded to a PC computer and analyzed using the Mesurim Pro software (version 2.8) (Figure 1), this software allowed us to calculate the refelctance of the flag leaf under the three Red-Green and Blue bands.

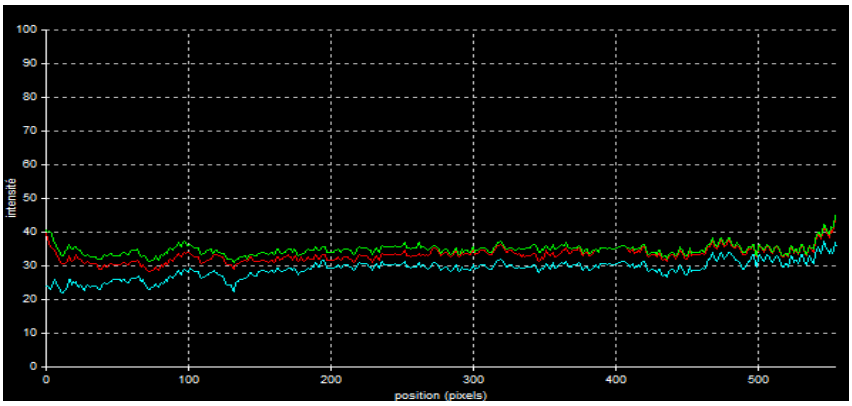

Figure 1. Graph of the reflectance under the Red-Green-Blue bands produced using the Mesurim pro software (version 2.8).

2.4.3. Grain filling

Grain filling was monitored from anthesis to physiological maturity, 5 ears from each elementary plot were harvested at random, dried at 80°C for 24 hours and then threshed, to perform filling measurements grains of the grain filling.

2.4.4. Grain Fill Parameters

Four grain filling parameters (Table 2) are used to characterize the grain filling of 15 cultivars of which 03 are local varieties, 01 introduced genotype and 11 advanced lines.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 July 2022 doi:10.20944/preprints202207.0301.v1

Table 2. Grain Filling Parameters Calculations.

Grain filling parameters	Symbols	Units	Calculating methods	References
Maximum of Grain Weight	MGW	mg	Estimated from the weight of a single grain at different samples	[8]
Grain Filling Rate	GFR	mg.100 GDD.jour^{-1}	GFR= Grain final weight / GFD	[8]
Grain Filling Duration	GFD	°C	GDD accumulated from anthesis	[8]
Maximum of Filling Rate	MFR	mg.100 GDD.jour^{-1}	Estimated from AFI of eatch cultuvar	[9]
Absolute Filling Intensity	AFI	mg.jour^{-1}	AFI = (P2-P1) / (T2-T1)	[10]
Growing Degrees Day (cumulated temperatures)	GDD	°C	Tn = ((Tmax+Tmin)/2) –Tb Tn : daily averages	[8]

2.4.4. Agronomic characters

Agronomic characteristics were measured at maturity:

- *Grain yield (GY)*

The cereal yield performances of the different cultivars were measured at maturity in quintals per hectare (Qs. ha-1) by measuring the grain yield in one linear meter and converting it into quintals per hectare.

- Thousand grain weight (TKW) (g)

The weight of 1000 grains of all cultivars

2.5. Statistical analysis

All statistical analyzes will be performed by Costat 6.400 [11] and R core Team [12] softwares.

3. Results

3.1. Chlorophyll content

The results of the monitoring of the evolution of the chlorophyll content according to the phenological stages (Table 3) based on the observations of 9 dates spread over three early heading stages – full heading and the grain filling phase showed a stabilization of the chlorophyll content during the heading stage. The chlorophyll content begins to degrade after anthesis and the onset of grain filling (Figure 2).The analysis of variance (Table 5) showed that the average chlorophyll contents varied from 20.42 for Oued El Bared to 31.01 cci for the advanced line G4 with a genotypic average of 26.58 cci.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 July 2022 doi:10.20944/preprints202207.0301.v1

Table 3. Estimated chlorophyll content (cci) for all cultivars studied from heading to physiological maturity.

	Beginning of heading			Full Heading			Grain Filling			Averages
G1	33,70	33,23	30,43	28,69	29,00	27,84	26,67	7,19	4,54	24,59
G2	32,54	36,79	33,99	28,81	30,19	30,57	28,80	6,28	1,32	25,48
G3	31,63	42,23	31,26	30,39	30,22	30,49	24,99	8,18	4,83	26,02
G4	40,82	43,04	38,60	34,48	40,82	35,66	24,48	11,19	10,04	31,01
G5	29,13	34,09	28,24	28,79	29,71	29,07	24,61	9,44	4,11	24,13
G6	30,28	32,16	31,36	32,94	31,40	32,29	35,39	12,09	8,61	27,39
G7	31,93	41,44	34,21	33,26	37,73	37,02	32,02	13,19	9,02	29,98
G8	39,59	40,81	40,08	33,84	32,16	33,02	28,16	5,53	1,38	28,29
G9	29,94	37,38	37,33	33,33	36,12	36,68	36,09	8,56	6,29	29,08
G10	31,67	35,19	33,83	31,66	33,84	32,12	22,13	3,59	1,67	25,08
G11	32,78	36,70	36,78	33,01	35,90	36,98	28,80	10,10	6,78	28,65
Jupare C 2001	33,03	36,39	34,50	36,39	38,17	37,72	38,36	8,97	2,40	29,55
Boussellem	29,37	33,78	31,40	28,65	34,16	30,99	26,96	5,03	3,49	24,87
Boutaleb	26,36	31,54	26,99	25,00	29,67	30,88	24,23	14,41	8,54	24,18
Oued el Bared	25,33	28,05	25,09	23,24	26,65	26,93	21,51	4,32	2,69	20,42

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 July 2022 doi:10.20944/preprints202207.0301.v1

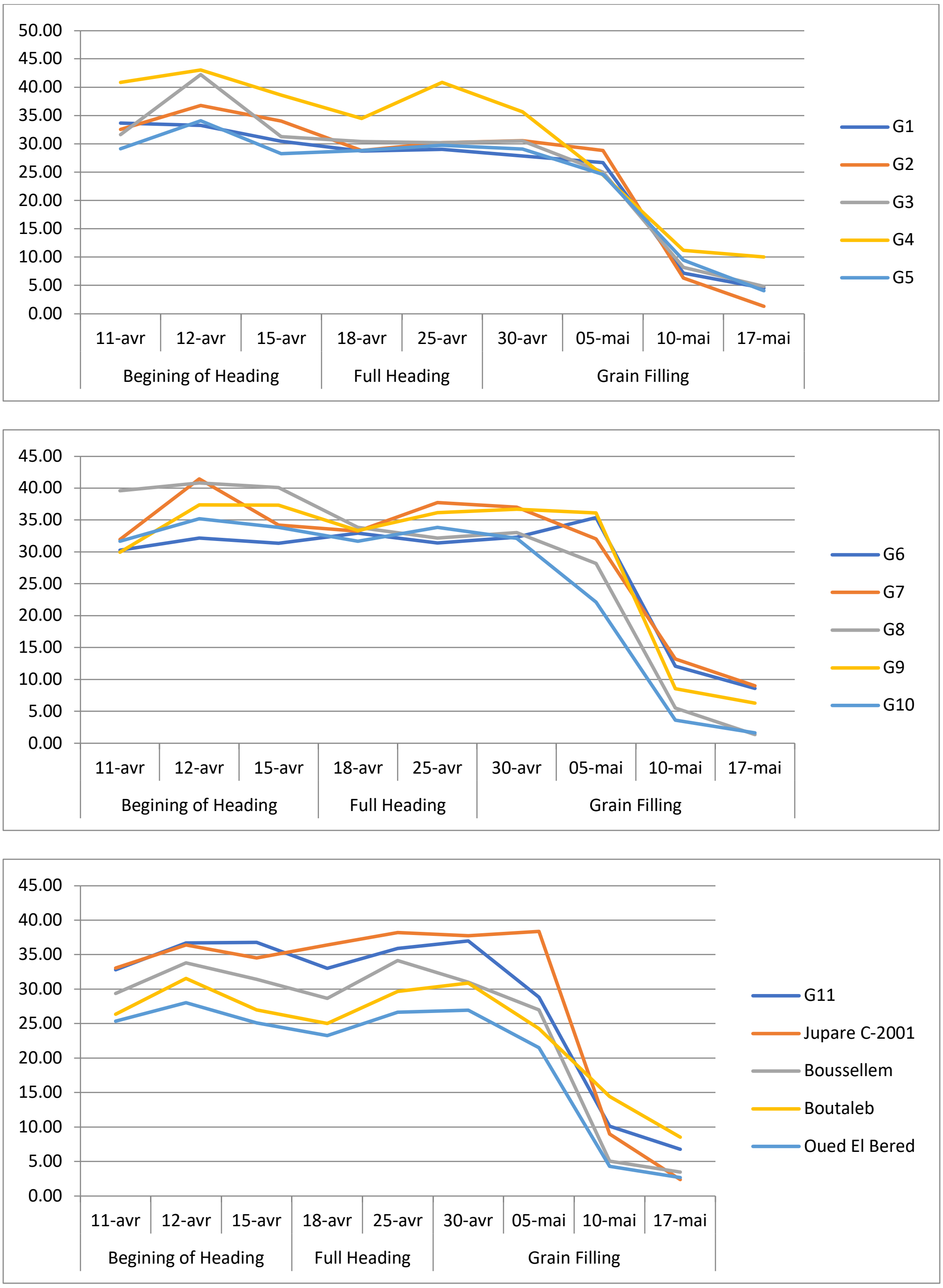

Figure 2. Evolution of chlorophyll content according to phenological stages for all cultivars studied.

3.2. flag leaf reflectance

Analysis of variance (Table 4) showed that the effect of genotype was highly significant for leaf reflectance in all its bands (Red, Green and Blue) and for chlorophyll content. The red reflectance index ranged from 41.86% for the advanced line G6 to 48.76% for the local variety Oued El bared with 44.67% as the genotypic average. The green band reflectance index varied from 38.23% for the advanced line G7 to 44.13% for Oued El bared with a genotypic average of 40.65%. The reflectance index for the Blue band was between 28.77% for the advanced line G10 and 33.04% for the local variety Oued El Bared with an average of 30.72% for all the cultivars studied.The local variety Boutaleb which was the most profitable cultivar in terms of grain yield (GY=13.59 Qs.ha-1), recorded the lowest

 doi:10.20944/preprints202207.0301.v1

Red reflectance (42.59%), an average Green and blue reflectance and (30.09 and 30.25%) and an average chlorophyll content close to the average (24.18 cci) this in relation to the genotypic averages recorded.

3.3. The grain filling

Table 4 represents the evolution of the average weights of the grains of the various cultivars studied from anthesis until physiological maturity where the grain of wheat reaches its maximum weight (MGW), the advanced lines G9, G10, G11 as well that the local variety Boutaleb had won the best maximum average weights. The Analysis of Variance (Table 5) showed that the genotype effect was significant for all grain filling parameters, the maximum grain dry weight ranged from 32.91 mg for the advanced line G10 to 49.27 mg for the advanced line G10 with an average of 42.13 mg for all the cultivars studied. The grain fill rate was 0.17 mg.100 GDD. Day-1 for advanced line G5 has 0.23 mg .100 GDD. Day-1 for the local variety Oued El bared with a genotypic average of 0.20 mg .100 GDD. Day 1. The maximum rate of grain filling varied from 0.28 mg .100 GDD for the advanced line G9 to 0.55 mg .100 GDD for the advanced line G3 with 0.39 mg .100 GDD as the genotypic mean while the duration of grain filling varied from 619 .6°C for the advanced line G8 to 764.9°C for the advanced line G1 taking an average of 707.85°C for all the cultivars studied.

Table 4. Average grain dry weight (mg) of all cultivars throughout from anthesis to physiological maturity.

	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	MGW
G1	3,07	9,16	17,76	37,37	37,98	38,82	40,14	41,32	41,40
G2	4,44	16,63	16,54	31,54	34,92	36,22	36,92	36,86	37,13
G3	3,56	11,26	16,89	36,71	38,99	39,61	41,28	42,45	44,40
G4	3,33	8,10	13,65	31,73	34,67	39,01	40,24	40,46	42,93
G5	2,54	14,36	14,29	31,39	36,03	36,30	35,43	38,24	38,92
G6	2,14	6,29	9,98	26,30	32,41	32,62	34,16	36,18	38,57
G7	3,42	6,35	14,58	32,19	34,36	36,75	37,19	39,04	41,28
G8	3,68	8,52	14,58	31,35	31,75	32,63	33,43	35,85	38,48
G9	4,72	15,15	17,63	39,77	42,43	45,91	46,27	47,35	48,46
G10	3,34	18,96	20,27	38,26	41,46	42,39	43,68	47,33	47,34
G11	5,81	15,68	18,52	36,98	42,27	44,85	44,97	47,81	49,85
Jupare C 2001	3,80	11,42	18,18	31,87	40,04	40,23	41,49	41,64	43,27
Boussellem	2,09	12,58	18,06	24,70	40,23	41,88	42,06	43,04	45,12
Boutaleb	2,72	8,85	13,37	38,74	41,57	44,60	45,92	47,36	49,82
Oued El Bared	3,86	13,34	15,30	36,47	39,13	42,14	43,13	43,74	43,93

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 July 2022 doi:10.20944/preprints202207.0301.v1

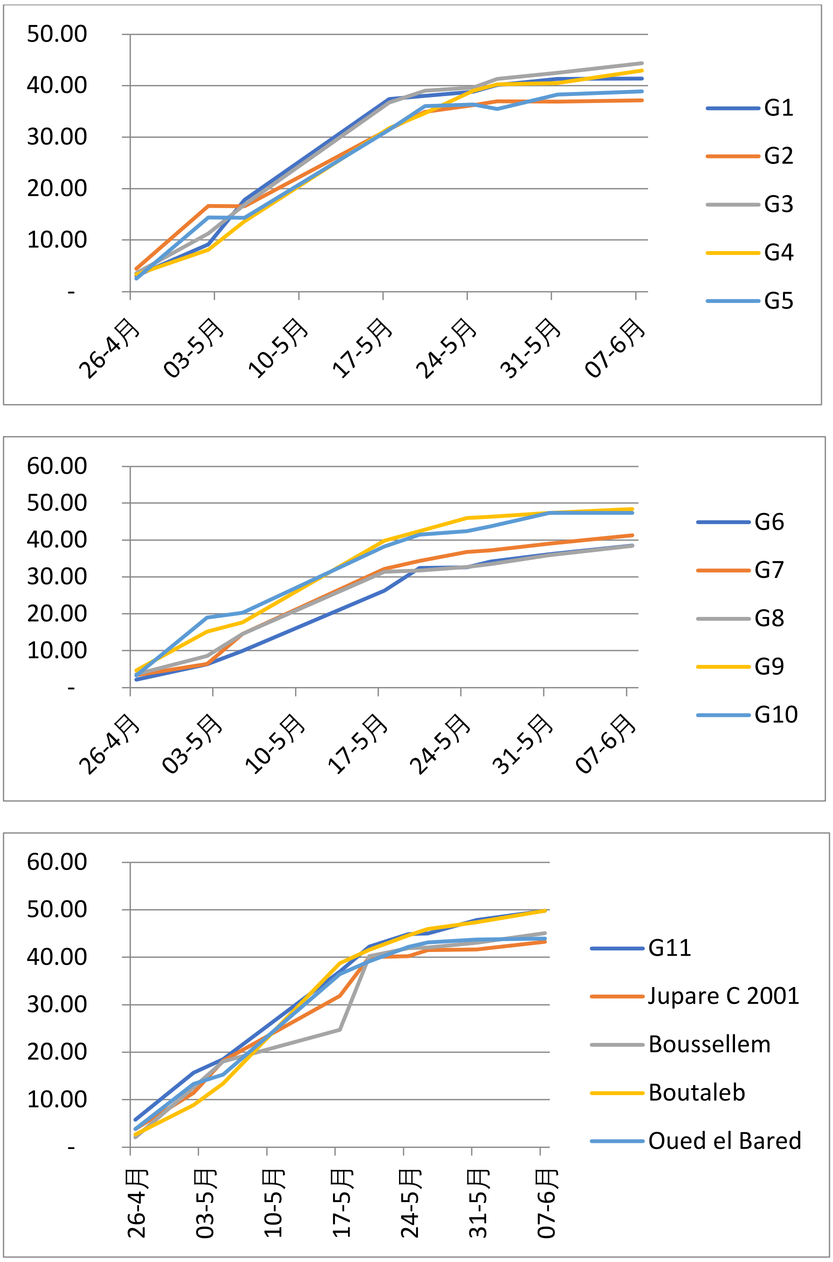

Figure 3. Curves of grain filling as a function of time of the 15 cultivars studied.

3.4. *grain yield and thousand grain weight*

The analysis of variance showed significance for the parameters grain yield, weight of a thousand grains. The grain yield ranged from 2.87 Q.ha-1 for the advanced line G11 to 13.59 Q.ha-1 for the local variety Boutaleb with 6.34 Q.ha-1 as the genotypic average. The TKW ranged from 30.91 g for the advanced line G8 to 46.69 g for the G9 line with a genotypic mean of 39.40 g, the highest thousand grain weight value was observed with the local variety Boutaleb with 44.96g.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 20 July 2022 doi:10.20944/preprints202207.0301.v1

Table 5. Results of the analysis of variance on the various parameters studied.

	R(%)	G(%)	B(%)	CC(cci)	MGW(mg)	GFR(mg.100GDD.J-1)	MFR(mg.100GDD.J-1)	GFD(°C)	GY(Q.ha-1)	TKW(g)
G1	47.20 (b)	42.07 (b)	32.31 (b)	24.59 (f)	42,46 (bcdef)	0,19 (f)	0,38 (abc)	764,90 (a)	07,00 (bc)	41,98 (bc)
G2	46.75 (bc)	41.75 (c)	30.91 (e)	25.48 (ef)	37,87 (fg)	0,21 (abcd)	0,42 (abc)	677,60 (e)	03,96 (bc)	35,62 (ef)
G3	46.48 (c)	41.86 (bc)	31.57 (cd)	26.02 (def)	45,96 (abcd)	0,20 (def)	0,55 (a)	717,20 (c)	07,05 (bc)	40,83 (bcd)
G4	43.86 (f)	40.63 (e)	30.33 (fg)	31.01 (a)	41,13 (cdef)	0,19 (ef)	0,43 (abc)	717,20 (c)	02,88 (c)	36,80 (de)
G5	43.17 (g)	40.43 (ef)	30.12 (gh)	24.13 (f)	39,25 (def)	0,17 (g)	0,37 (abc)	756,30 (b)	04,70 (bc)	36,10 (e)
G6	41.86 (i)	39.26 (gh)	31.30 (d)	27.39 (cde)	32,91 (h)	0,21 (bcde)	0,33 (bc)	629,90 (g)	06,16 (bc)	31,88 (fg)
G7	41.93 (i)	38.23 (i)	28.88 (i)	29.98 (ab)	38,10 (ef)	0,17 (g)	0,38 (abc)	717,20 (c)	06,89 (bc)	34,36 (efg)
G8	44.65 (e)	40.17 (f)	30.75 (e)	28.29 (bcd)	33,04 (gh)	0,23 (a)	0,37 (abc)	619,60 (h)	04,45 (bc)	30,91 (g)
G9	44.23 (ef)	40.40 (ef)	30.62 (ef)	29.08 (abc)	47,18 (ab)	0,22 (ab)	0,28 (c)	717,20 (c)	06,61 (bc)	46,69 (a)
G10	43.92 (f)	40.49 (e)	28.77 (i)	25.08 (ef)	49,27 (a)	0,20 (cdef)	0,39 (abc)	756,30 (b)	08,69 (ab)	41,98 (bc)
G11	43.11 (g)	39.54 (g)	29.88 (h)	28.65 (abc)	47,19 (ab)	0,22 (bcd)	0,35 (bc)	717,20 (c)	02,95 (c)	44,47 (abc)
Jupare C 2001	46.31 (c)	41.10 (d)	30.27 (fg)	29.55 (abc)	43,27 (bcd)	0,19 (f)	0,50 (ab)	764,90 (a)	07,89 (bc)	41,98 (bc)
Boussellem	45.32 (d)	40.56 (e)	31.80 (c)	24.87 (f)	42,94 (bcde)	0,20 (cdef)	0,38 (abc)	717,20 (c)	04,75 (bc)	40,39 (cd)
Boutaleb	42.59 (h)	39.09 (h)	30.25 (g)	24.18 (f)	47,36 (ab)	0,21 (bcde)	0,40 (abc)	685,90 (d)	13,59 (a)	44,96 (ab)
Oued El Bared	48.76 (a)	44.13 (a)	33.04 (a)	20.42 (g)	44,05 (bcd)	0,23 (a)	0,29 (c)	659,20 (f)	07,59 (bc)	43,27 (abc)
Mean	**44.67**	**40.65**	**30.72**	**26.58**	**42,13**	**0,20**	**0,39**	**707,85**	**06,34**	**39,40**
Min	**41.86**	**38.23**	**28.77**	**20.42**	**32,91**	**0,17**	**0,28**	**619,60**	**02,87**	**30,10**
Max	**48.76**	**44.13**	**33.04**	**31.01**	**49,27**	**0,23**	**0,55**	**764,90**	**13,59**	**46,69**
LSD (5%)	**0.64**	**0.31**	**0.35**	**2.49**	**4,92**	**0,01**	**0,20**	**2,02**	**05,67**	**04,16**

3.5. The study of correlations

3.5.1. Leaf reflectance and chlorophyll content

The study of the correlations (table 6) showed that the reflectance indices under all the bands (R-G-B) were all very highly, significantly and positively correlated with each other ($P<0.001$; R/G = 0.94***; R/B=0.70***; G/B=0.72***). Chlorophyll content was significantly and positively correlated with reflectance under the green band (P<0.001; 0.49***) and negatively correlated with leaf reflectance under the Red and Blue bands (P<0.01; -0.41** ;-0.46** respectively).

3.5.2. Grain fill, grain yield and thousand kernels weight

A highly significant correlation (P<0.01-0.001) was recorded between thousand kernel weight and grain yield, maximum grain dry weight and grain filling duration (0.38**; 0.82 ** * and 0.41** respectively). Grain filling duration was very strongly, significantly and positively correlated with maximum grain dry weight (P<0.001; 0.49***) and very significantly and negatively correlated with grain filling rate of grain filling (P<0.001;-0.58***) (Table 6).

3.5.3. Correlations between physiological, agronomic and grain filling parameters

Only leaf reflectance under the blue band was significantly (P<0.05) and positively correlated with grain filling rate (0.34*) (table 6).

Table 6. Results of the correlations of the different parameters studied.

	R	V	B	CC	MGW	GFR	MFR	GFD	GY	TKW
R	1									
G	**,94*****	1								
B	**,70*****	**,72*****	1							
CC	**- ,41****	**,49*****	**-,46****	1						
MGW	,14	,16	-,09	-,08	1					
GFR	,24	,26	**,34***	-,06	0,22	1				
MFR	,10	,03	-,06	0,21	0,19	-,10	1			
GFD	,08	,05	-,30*	,06	**,49*****	**-,58*****	0,19	1		
GY	,01	-,01	- ,04	- ,08	,24	-0,05	,04	,05	1	
TKW	,24	,25	,09	-,11	**,82*****	,25	,01	**,41****	**0,38****	1

3.6. Principal component analysis (pca)

3.6.1. For parameters measured

The PCA of principal component analysis reflects the importance of the largest contributor to the total variation on each axis of differentiation [13]. The data presented in table 19 showed that the first 3 components of the PCA were the most important, they alone accumulate almost 83% of the information on the variability. Figure 27 shows that PC1 was positively correlated with the three bands of leaf reflectance (RGB) (0.86; 0.89 and 0.76 respectively) and negatively correlated with chlorophyll content which implies that leaf reflectance decreases with the increase in chlorophyll content due to the increase in light absorbance caused by the increase in green chlorophyll pigments, it can be said that PC1 set a reflectance-light absorbance axis PC2 was positively correlated with weight maximum grain dryness, filling time, grain yield and thousand grain weight (0.80; 0.85; 0.45 and 0.68 respectively) this axis can be an axis of profitability.

The grain filling rate and the maximum grain filling rate are negatively and positively correlated with PC3 (-0.56; 0.65 respectively), PC3 is a grain filling rate axis.

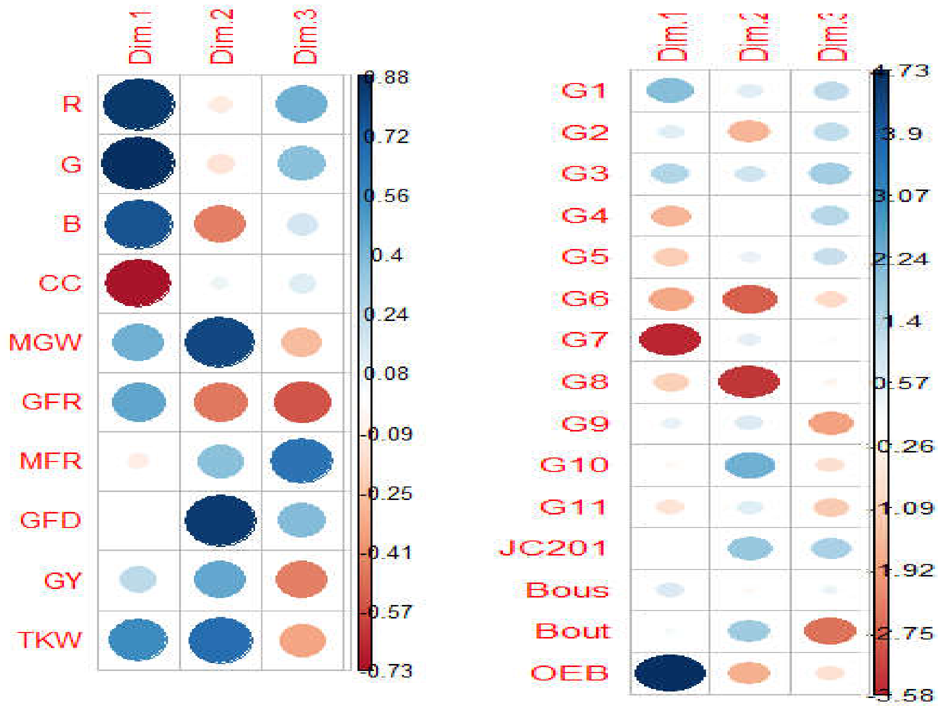

Figure 4. visualisation of variables and cultivars studied with the first's 3 components of PCA .

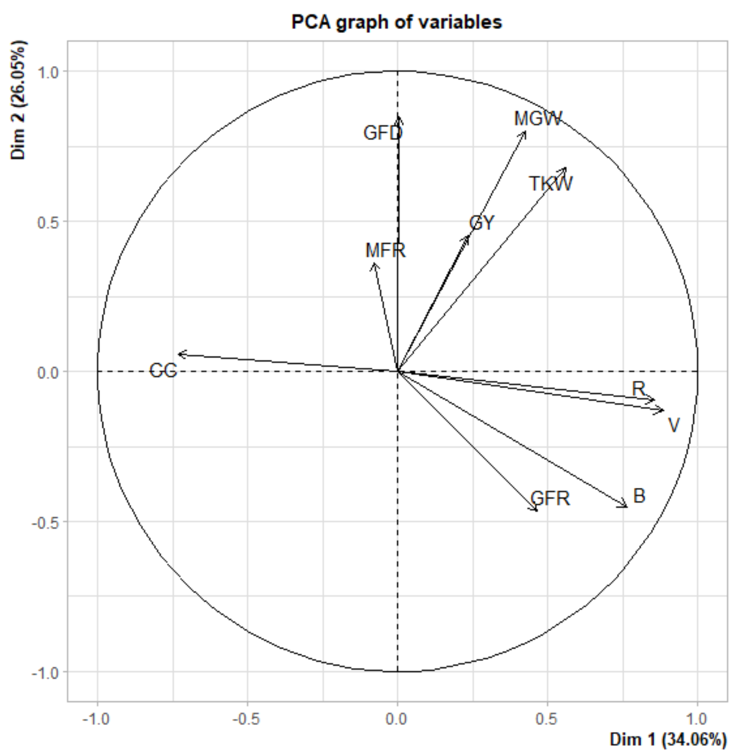

Figure 5. Circle of correlations of the different parameters studied with the first's 3 components of PCA.

3.6.2. For cultivars studied

Table 8 shows that the advanced line G1, Boussellem and Oued El Bared are positively linked to the PC1 reflectance / absorbance axis, these cultivars are known for their high reflectance on the three R-G-B bands as well as low values of average content in chlorophyll, the advanced lines G5 and G7 are negatively linked to this axis, they presented a low reflectance. The advanced line G10 and the introduced genotype Jupare

C2001 are positively related to the PC2 profitability axis, they recorded better grain filling times, their maximum dry weights and their thousand-grain weights exceed the genotypic averages, the advanced lines G2, G6 and G8 are negatively related to this axis because of their low values in grain filling time, maximum dry weight and thousand grain weight. The advanced lines G3 and G4 are positively related to the axis of the rate of filling thanks to their high values in maximum rate of filling of grains on the other hand the advanced lines G9, G11 and Boutaleb recorded better values in rate of filling of grains it is for this reason that they were negatively linked to this axis. Figure 5 summarizes the association of the different cultivars with the first components of the ACP.

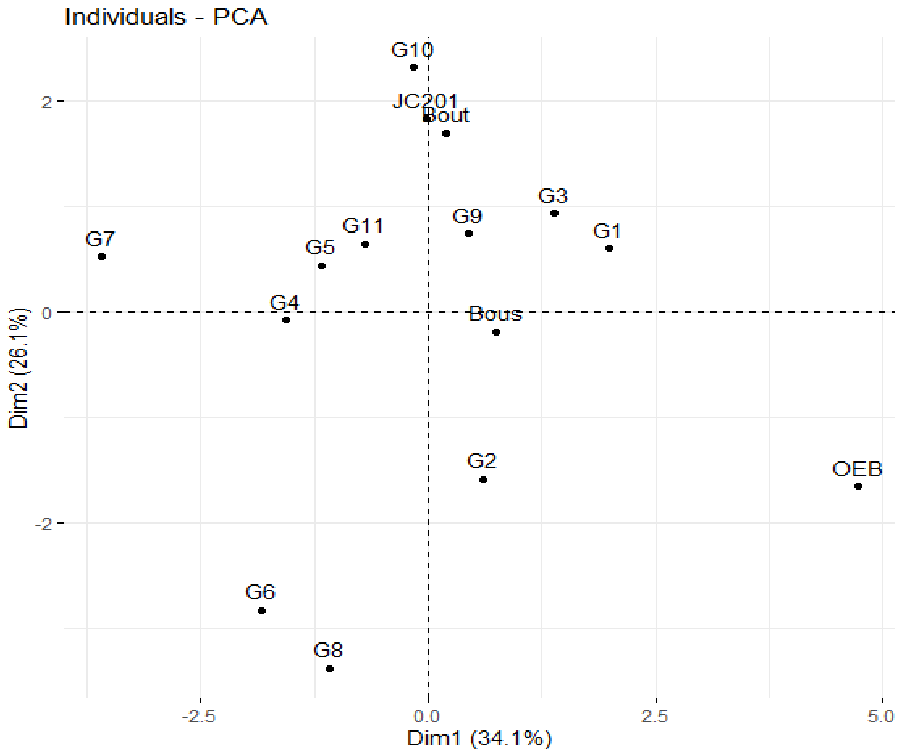

Figure 5. Biplot of the relationship of the 15 cultivars studied with the first 3 components of PCA.

4. Discussion

The Chlorophyll degradation may be due to the intensity of photosynthesis in grain filling phase, this phase was responsible for the production of the assimilas necessary for the filling of grains that exhausting the pigments chlorophyllian responsible for the capture of light energy.

Chlorophyll tends to decline faster than carotenoids when plants are stressed or during leaf senescence [14]. The results for RGB reflectance index was very consistent with the study of Guendouz et al [15] which found that the lowest reflectance was observed in the blue band of the spectrum from 400 to 500 nm. The grain growth of the cultivars studied follows a sigmoid curve similar to that described by Triboi [16] and Guendouz and Maamri [17] (Figure 26).

As described by Yoshida [6], grain filling is the final process associated with yield performance, is a crucial determinant of grain yield in cereal crops; Field crop grain growth is initially slow, enters a linear phase where the rate of growth is rapid and then slows towards maturity.The negative and significant correlation between the reflectance to Red and Blue and the chlorophyll content suggests that the decrease in the photosynthetic capacity of the canopy increases the reflectance of the leaves to Red and Blue due to the degradation of the chlorophyll content [18].

In the blue region, chlorophylls and carotenoids have high absorbances [4]. Red reflectance, especially when normalized by reflectance in a non-absorbing waveband, is strongly correlated with chlorophyll content [18].

5. Conclusions

This study aims to determine the influence of the reflectance of the flag leaf under these three bands Red, Green and Blue (RGB) and of the chlorophyll content on the grain filling and grain yield of 15 durum wheat cultivars seeded in semi-arid conditions.

The results of the monitoring of the evolution of the chlorophyll content according to three stages of development beginning of heading - full heading and the grain filling phase showed a stabilization of the chlorophyll content during the heading stage, the in chlorophyll begins at this degradation after anthesis and the onset of grain filling.

The analysis of variance showed that the genotype effect was significant for all the parameters studied, the local variety Boutaleb which was the most profitable genotype was characterized by low values of RGB reflectance and high values of majority of grain fill parameters and thousand grain weight. Grain growth follows a sigmoid curve, grain filling, is the final process associated with yield performance.

The study of the correlations revealed that the reflectance under these three (R-G-B) were all positively correlated, the chlorophyll content was positively correlated with the reflectance under the green band and negatively with two Red and Blue bands. Highly significant correlation was recorded between thousand kernel weight and grain yield, maximum grain dry weight and grain filling duration. The duration of the grain filling was positively influenced by the maximum dry weight of the grain and negatively by the rate of grain filling of the grain filling, the rate of grain filling was positively affected by the reflectance in the Blue band.

The principal component analysis separated the cultivars studied into 3 components, an absorption / reflectance component, a second profitability component and the third component of the grain filling rate to which the local variety Boutaleb belongs, the most common genotype. Profitable in terms of grain yield.

6. Patents

Author Contributions: A.O. and A.G.; methodology, B.F.; software, S.B.; validation, B.F., A.O. and A.G.; formal analysis, B.S.; investigation, S.B.; resources, B.F.; data curation, B.F.; writing—original draft preparation, O.A.; writing—review and editing, A.G.; visualization, S.B.; supervision .All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors have declared no conflict of interests exist.

References

1. MADR. 2012. Ministère de l'Agriculture et du Développement Rural, Statistiques agricoles, superficies et productions, Direction des Statistiques Agricoles et des Enquêtes Economiques, Série B.
2. Guendouz,A.,Guessoum,S.,Maamri,K.,Benidir,M., Hafsi,M.2013. Flag leaf Reflectance Efficiency as Indicator for Drought Tolerance in Durum Wheat (*Triticum durum* Desf.) Under Semi Arid Conditions. International journal of Agronomy and Plant Production, 4 (6), 1204-1215.
3. Demmig-Adams, B. and Adams, W.W. 1996. The role of xanthophyll cycle carotenoids in the protection of photosynthesis. Trends in Plant Science, 1, 21-27.
4. Peñuelas J, Filella I.1998. Visible and near-infrared reflectance techniques for diagnosing plant physiological status, 3(4), 151–6.
5. Wardlaw, I.F., Sofield, I. and Cartwright, P.M. 1980.Factors limiting the rate of dry matteraccumulation in the grain of wheat grown athigh temperature. Australian Journal of PlantPhysiology 7: 87- 400.
6. Yoshida, S. (1981). Fundamentals of Rice Crop Science. International Rice Research Institute, Los Banos, Philippines. pp. 59- 60.
7. Guendouz, A. and Maamri, K. 2011. Research Note Evaluating durum wheat performance and efficiency of senescence parameter usage in screening under Mediterranean conditions.Electronic Journal of Plant Breeding, 2(3), 400-404.
8. Vesna, K., Dejan, D., Miroslav, Z., Ana, N., Gordana, Š. M., Željko, K., Goran, A., Nenad, Đ. 2018. Grain filling parameters of two- and six-rowed barley genotypes in terminal drought conditions. Italian Journal of Agrometeorology - 2/2018.

 doi:10.20944/preprints202207.0301.v1

9. Badr, A., Müller, K., Schäfer-Pregl, R., El Rabey, H., Effgen, S., Ibrahim, H. H., … Salamini, F. 2000. On the origin and domestication history of Barley (Hordeum vulgare). Molecular Biology and Evolution., 17(4): 499–510.
10. Radford, P. K., 1967. Growth analysis formulae. The uses and abuses. Crop Science., 7: 171- 175.
11. Costat 6.400, 1998. Copyright©1998-2008, CoHort Software798 Lighthouse Ave BMP 320, Montery,CA 93940 , USA , Email: info@cohort.com,URL http://www.cohort.com .
12. R Core team.2020. R: A language and environment for statistical computing. R foundation for statistical computing, Vienna, Austria. Available at: http://www.R-project.org. Accessed on Saturday, December 05, 2020.
13. Sharma, J.R.1998. Stastical and Biometrical Techniques in Plant Breeding. New Age International (P) Limited Publishers, New Delhi Pp. 432.
14. Gitelson, A. and Merzlyak, M.N. 1994. Spectral reflectance changes associated with autumn senescence of Aesculus hippocastanum L and Acer platanoides L leaves - spectral features and relation to chlorophyll estimation. Journal of Plant Physiology, 143: 286-292.
15. Guendouz, A., Guessoum, S., Maamari, K., Hafsi,M. 2012. Predicting the efficiency of using the RGB (Red, Green and Blue) reflectance for estimating leaf chlorophyll content of Durum wheat (Triticum durum Desf.) genotypes under semi arid conditions. American-Eurasian Journal of Sustainable Agriculture, 6(2),102-106.
16. Triboi, E. (1990). Modelé d'élaboration du poids du grain chez le blé tendre (Triticum aestivum) en thell. Agronomie. 1: 191- 200.
17. Guendouz, A., and Maamari, k. 2012. Grain-filling, chlorophyll content in relation with grain yield component of durum wheat in a Mediterranean environment. African Crop Science Journal., 20 (1): 31 – 37.
18. Guendouz, A., Guessoum, S., Maamri, k. and Hafsi, M. 2012. The effect of supplementary irrigation on grain yield, yield components and some morphological traits of durum wheat (*Triticum durum* Desf.) cultivars. Advance in Environmental Biology 6(2), 564-572.
19. Everitt, J.H., Richardson A.J. and Gaussman, H.W. 1985. Leaf reflectance-nitrogen-chlorophyll relations in buffelgrass. Photogrammetric Engineering and Remote Sensing, 51, 463-466.