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Effect of Reflectance Index (RGB) and Chlorophyll Contents on Yielding of Some Durum Wheat [*Triticum turgidum* L. ssp. *Durum* (Desf.) Husn.] Genotypes Growing under Semi-arid Conditions in Algeria

B. Frih[1], A. Guendouz[2], A. Oulmi[1], S. Benkadja[3], H. Bendada[4], S. Selloum[4]

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ABSTRACT

Background: We aim to determine the effects of RGB reflectance index and chlorophyll contents on yielding of 15 durum wheat genotypes growing under semi-arid conditions.

Methods: The genotypes tested were sown in a random block design with three replications.The following traits were measured from the head, number of days to heading, RGB reflectance index by numerical images analysis of flag leaves and using Mesurim Pro (version 2.8) software and Chlorophyll contents. Grain yield, thousand kernels weight, number of spikes per meter square, and plant height were measured at maturity.

Result: ANOVA showed that genotype effect significant for all traits. The local landrace Boutaleb witch was the best yielding genotype registered a low red reflectance index and an average green reflectance index, blue reflectance index and chlorophyll contents. The study of the correlations reveled that chlorophyll contents was significantly and negatively correlated with reflectance index at red and blue bands and very significantly and positively correlated with reflectance index at green band. PCA showed thatgrain yield was affected by number of spike per mete square, a negative relation was observed between chlorophyll contents and RGB reflectance index.

Key words: Chlorophyll, Grain yield, Reflectance, RGB, Semi-arid.

INTRODUCTION

Durum wheat [*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.] is one of the most essential cereal species and is cultivated worldwide over almost 17 million ha, with a global production of 38.1 million tonnes in 2019 (Ioannis *et al*. 2020). Canada is the largest cultivator in the world, followed by Italy and Turkey (Pastaria International, 2015). However, the largest consumers are the Mediterranean countries, where most of the production process takes place. The main environmental constraints limiting the cultivation of durum wheat in the Mediterranean Basin are drought and extreme temperatures (Nachit *et al*., 2004). 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 million hectares of the useful agricultural areas (UAA) (MADR, 2012). Solar radiation impinging on the leaf surface is either reflected, absorbed or transmitted. The nature and amounts of reflection, absorption and transmission depend on the wavelength of radiation, angle of incidence, surface roughness and the differences in the optical properties and biochemical contents of the leaves. (Guendouz *et al*. 2013). Pigments are integrally related to the physiological function of leaves. Chlorophylls absorb light energy and transfer it into the photosynthetic apparatus. Carotenoids (yellow pigments) can also contribute energy to the photosynthetic system. (Demmig-Adams and Adams, 1996). When light strikes a leaf, part of the light is reflected towards the observer. The amount energy reflected at each light frequency is named reflectance spectrum, sometimes abbreviated by spectra or by reflectance. Reflectance depends on leaf surface properties and internal structure, as well as by the concentration and distribution of biochemical components. In the visible spectrum, (VIS, between 400 and 700 nm)

[1]Department of Biology and Plant Ecology, VRBN Laboratory, Farhat Abbas Sétif University, Algeria.
[2]National Institute of Agronomic Research of Algeria (INRAA), Sétif Unit, Algeria.
[3]Department of Agronomy, VRBN Laboratory, Farhat Abbas Sétif University, Algeria.
[4]Technical Institute of Field Crops, Setif, Algeria.

Corresponding Author: B. Frih, Department of Biology and Plant Ecology, VRBN Laboratory, Farhat Abbas Sétif University, Algeria.
Email: benaliafrih@gmail.com

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reflectance depends mainly on the presence of photosynthetic pigments such as chlorophyll. In the near infrared domain (NIR, between 700 and 13000 nm), where there are no strong absorption features, the magnitude of reflectance is governed by structural discontinuities encountered in the leaf. The shortwave infrared region (SWIR, between 1300 nm and 3000 nm), (Peñuelas *et al*. 1998). This study aim to determine the effects of red, green, blue reflectance index (RGB) and chlorophyll contents on yielding of 15 [*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.] genotypes growing under semi-arid conditions in the eastern of Algeria.

MATERIEL AND METHODS

The Study site

This study was conducted during the 2020/2021 cropping season at Setif Agricultural Experimental Station (ITGC-AES, 36°12′N and 05°24′E and 1.081 m asl, Algeria).

Plant material

The genetic material used in this study consists of 11 advanced lines and 4 genotypes which 3 were local landrace used as control to evaluate their performance (Table 1).

Experimental device

The genotypes tested were sown at November 19, 2020 with sowing density adjusted to 300 grains.m^{-2} in a random block design with three replications, each plot consisted of 6 lines of 10 m long spaced of 0.2 m witch make 12 m^{2} as plot area. R.G.B reflectance index (Red, Green and Blue) was evaluated by numerical image analysis (NIA) according to Guendouz and Maamri (2011), Bendada *et al* (2021) and Frih *et al* (2022); 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 Mesurim Pro (version 2.8) software (Fig 1).

Chlorophyll contents (CC) of the flag leaf was measured using digital chlorophyll meter (CCM) with (cci) units, this device allows measuring the absorbance of light in the leaf.Agronomic traits 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 kernels weight (TKW) (g). Number of spikes per meter square (NSm^{-2}). Number of days to heading (DH) (days) calculated from sown date November 19, 2020 and plant height (PH) (cm).

All statistical analyses will be performed by Costat 6.400 (1998) and R core Team (2020)Softwares.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA)

Analysis of variance (ANOVA) is a statistical tool used to detect differences between experimental group means. (Sawyer, 2009).

Agronomic traits

ANOVA (Table 2) showed that genotypic effect was significant ($p < 0.05$; 0.001) with TKW, NSm^{-2}, DH and PH.GY ranged from 2.87 Qs.ha^{-1} for G11 advanced line to 13.59 Qs.ha^{-1} for the local landrace Boutaleb with 6.34 Qs.ha^{-1}as genotypic mean. TKW ranged from 30.91 g for the advanced line G8 to 46.69 g for G9 with genotypic mean of 39.40 g, the high value of TKW was observed with the local landrace Boutaleb with 44.96 g. NSm^{-2} ranged from 178.33 s.m^{-2} for G4 advanced line to 320 s.m^{-2} for the local landrace Boutaleb with a genotypic mean of 255.77s.m^{-2}. DH ranged from 136 days for advanced lines G1, G2, G8, G10 and Jupare C 2001 foreign race to 147 days for Boutaleb local landrace with 140.6 days as genotypic mean. Plant height ranged from 56.11 cm for G4 to 67.38 cm for G10 with a mean of 62.76 cm local landrace Boutaleb registered a high plant height (66.16 cm).

Table 1: Varieties and their pedigrees.

Genotype	Pedigrees
G1	RASCON_37/GREEN_2/9/USDA595/3/D67.3/RABI//CRA/4/ALO/5/…
G2	MINIMUS_6/PLATA_16//IMMER/3/SOOTY_9/RASCON_37/9/…
G3	CMH77.774/CORM//SOOTY-9/RASCON-37/3/SOMAT-4
G4	CNDO/PRIMADUR//HAI-OU-17/3/SNITAN/4/SOMAT-3/
G5	RASCON_37/GREEN_2/9/USDA595/3/D67.3/RABI//CRA/4/ALO/5/…
G6	SILVER 14/MOEWE//BISU_l/PATKA_3/3/PORRON_4/YUAN_l/9/...
G7	GUANAY /HU ALITA / 10/PLATA _10/6/MQUE/4/USDA573/...
G8	BCRIS/BICUM//LLARETA INIA/3/DUKEM_ 12/2*RASCON 21/5/R
G9	Simeto/3/Sora/2*Plata_12//SRN_3/Nigris_4/5/Toska_26/...
G10	Ossl1/StjS5/5/Bicrcderaal/4/BEZAIZSHF//SD19539/Waha/3/St
G11	Stj3//Bcr/Lks4/3/Ter-3/4/Mgnl3/Aghrass2
G12	Jupare C 2001
G13	Boussellem
G14	Boutaleb
G15	Oued Bared

Physiologic traits

ANOVA showed that genotype effect was high significant (P<0.001) for reflectance index at all bands (Red-R, Green-G, Blue-B) and chlorophyll contents (CC) (Table 3). Reflectance index at red (R) ranged from 41.86% for advanced line G6 to 48.76% for local landrace Oued El bared with 44.67 % as genotypic mean. Reflectance index at green band (G) ranged from 38.23% for G7 advanced line to 44.13% for Oued El bared local landrace with genotypic mean of 40.65. Reflectance index at Blue (B) ranged from 28.77% for G10 advanced line to 33.04 % for the same local landrace (Oued El Bared) with 30.72 % as mean for all genotypes studied. This results were very consistent with the study of Guendouz *et al* (2012a) how found that the lowest reflectance was observed at the Blue band of the spectrum from 400 to 500 nm . Chlorophyll contents ranged from 20.42 for Oued El Bared to 31.01 cci for G4 advanced line with genotypic mean of 26.58 cci. Chlorophyll tends to decline more rapidly than carotenoids when plants are under stress or during leaf senescence (Gitelson and Merzlyak, 1994). Variations in leaf chlorophyll content detectable by spectral reflectance have also been shown to be related to leaf development and senescence (Carter and Knapp, 2001). The local landrace Boutaleb witch was

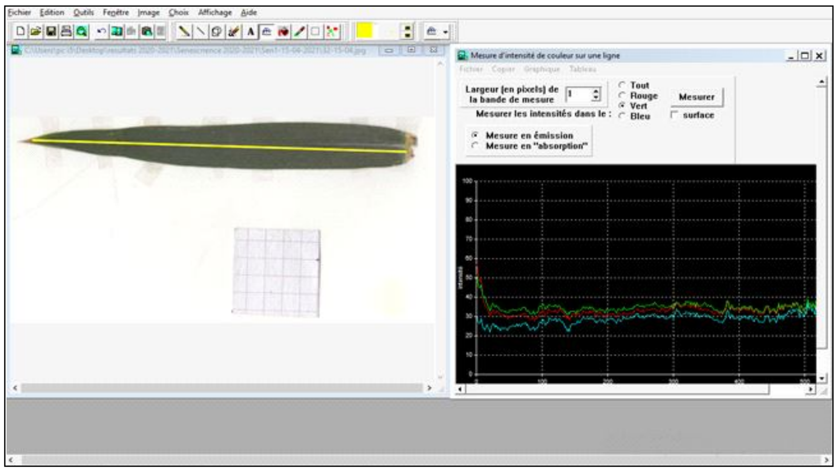

Fig 1: Reflectance calculating in R.G.B bands using Mesurim pro (version 2.8) software.

Table 2: Analysis of variance of agronomic traits.

Genotypes	Agronomic traits				
	GY (Qs.ha^{-1})	TKW (g)	NSm^{-2}	DH (days)	PH (cm)
G1	7.00 (bc)	41.98 (bc)	236.66 (bcde)	136 (d)	62.72 (cd)
G2	3.96 (bc)	35.62 (ef)	213.33 (de)	136 (d)	61.50 (d)
G3	7.05 (bc)	40.83 (bcd)	220.00 (cde)	142 (c)	61.88 (d)
G4	2.88 (c)	36.80 (de)	178.33 (e)	142 (c)	56.11 (e)
G5	4.70 (bc)	36.10 (e)	220.00 (cde)	142 (c)	61.27 (d)
G6	6.16 (bc)	31.88 (fg)	240.00 (bcde)	142 (c)	61.27 (d)
G7	6.89 (bc)	34.36 (efg)	253.33 (abcde)	142 (c)	57.66 (e)
G8	4.45 (bc)	30.91 (g)	268.33 (abcd)	136 (d)	61.16 (d)
G9	6.61 (bc)	46.69 (a)	310.00 (ab)	142 (c)	65.55 (abc)
G10	8.69 (ab)	41.98 (bc)	268.33 (abcd)	136 (d)	67.38 (a)
G11	2.95 (c)	44.47 (abc)	285.00 (abcd)	142 (c)	67.22 (a)
Jupare C 2001	7.89 (bc)	41.98 (bc)	255.00 (abcd)	136 (d)	63.61 (bcd)
Boussellem	4.75 (bc)	40.39 (cd)	291.66 (abc)	142 (c)	63.94 (bcd)
Boutaleb	13.59 (a)	44.96 (ab)	320.00 (a)	147 (a)	66.16 (ab)
Oued El Bared	7.59 (bc)	43.27 (abc)	276.66 (abcd)	146 (b)	63.88 (bcd)
Mean	6.34	39.40	255.77	140.6	62.76
Min	2.87	30.91	178.33	136	56.11
Max	13.59	46.69	320	147	67.38
Génotype effect	*	***	*	***	***
LSD$_{(5\%)}$	5.672	4.162	76.53	1.526	3.167

*Significant (P<0.05); **Significant(0.01); ***Very highly significant (P<0.001).

the best yielding genotype (GY=13.59 $Qs.ha^{-1}$) registered the low reflectance index at Red (42.59%), a Green reflectance index , blue reflectance index and chlorophyll contents close to the average (30.09 30.25 % and 24.18cci respectively) comparing to genotypic means.

Simple Linear Correlation (SLC)

A simple linear correlation was used when there is only one predictor variable, matrix of simple between grain yield and its components was computed according to the formula given by Snedecor and Cochran (1981).

$$r(x,y) = \frac{[\sum xy-(\sum x)(\sum y)/n]}{\sqrt{[\sum x^2-(\sum x)^2/n]\,[\sum y^2-(\sum y)^2/n]}}$$

r: correlation coefficient , x: first character , y: second character , n: total of number of observations.

Correlations among agronomic traits

The simple linear correlation (Table 4) showed that GY was highly, significantly (P< 0.01; 0.001) and positively correlated with TKW and NSm^{-2} (r = 0.38**; 0.61***). A high, significant (P <0.01; 0.001) and positive correlation was observed between TKW on the one hand and NSm-2, PH on the other hand (r = 0.39**; 0.61***). NSm^{-2} was significantly (P<0.05) and positively correlated with PH (r = 0.34*).Several works have proven the high correlation between Grain Yield and some agronomic traits (Frih *et al.*, 2021; Guendouz *et al.*, 2012b; Aissaoui and Fenni, 2021 and Mansouri *et al.*, 2018).

Correlations among physiologic traits

The simple linear correlation (Table 4) showed that reflectance index at Red band (R) was very highly, significantly (P<0.001) and positively correlated with reflectance index at Green (G) and Blue (B) bands (0.94***; 0.70*** respectively), it is also highly, significantly (P<0.01) and negatively correlated with chlorophyll contents (-0.41**). A very high significant (P<0.001) and positive correlation was observed between reflectance index at Green band (G) and reflectance index at Blue band (B) and chlorophyll contents (0.72***; 0.49*** respectively).Chlorophyll contents was highly, significantly (P<0.01) and negatively correlated to reflectance index at Blue band (B) (-0.46**).The negative and significant correlation between reflectance at Red and Blue and chlorophyll content suggest that the decrease in the photosynthetic capacity of the canopy increase leaf reflectance at Red and Blue due to the degradation of chlorophyll content (guendouz *et al*. 2012a). In the Blue region, both chlorophylls and carotenoids have high absorbances (Penuelas and Filella, 1998). Red reflectance, especially when standardized by reflectance in a non-absorbing waveband is highly correlated with chlorophyll content (Everitt *et al*. 1985).

Pricinpal components analysis (PCA)

The principal component analysis PCA reflects the importance of the largest contributor to total variation at each axis of differentiation (Sharma, 1998). The data presented in the Table 5 showed that the first 3 components of the

Table 3: Analysis of variance of physiologic traits

Genotypes	Physiologic traits			
	R (%)	G (%)	B (%)	CC(cci)
G1	47.20 (b)	42.07 (b)	32.31 (b)	24.59 (f)
G2	46.75 (bc)	41.75 (c)	30.91 (e)	25.48 (ef)
G3	46.48 (c)	41.86 (bc)	31.57 (cd)	26.02 (def)
G4	43.86 (f)	40.63 (e)	30.33 (fg)	31.01 (a)
G5	43.17 (g)	40.43 (ef)	30.12 (gh)	24.13 (f)
G6	41.86 (i)	39.26 (gh)	31.30 (d)	27.39(cde)
G7	41.93 (i)	38.23 (i)	28.88 (i)	29.98 (ab)
G8	44.65 (e)	40.17 (f)	30.75 (e)	28.29 (bcd)
G9	44.23 (ef)	40.40 (ef)	30.62 (ef)	29.08 (abc)
G10	43.92 (f)	40.49 (e)	28.77 (i)	25.08 (ef)
G11	43.11 (g)	39.54 (g)	29.88 (h)	28.65 (abc)
Jupare C 2001	46.31 (c)	41.10 (d)	30.27 (fg)	29.55 (abc)
Boussellem	45.32 (d)	40.56 (e)	31.80 (c)	24.87 (f)
Boutaleb	42.59 (h)	39.09 (h)	30.25 (g)	24.18 (f)
Oued El Bared	48.76 (a)	44.13 (a)	33.04 (a)	20.42 (g)
Mean	44.67	40.65	30.72	26.58
Min	41.86	38.23	28.77	20.42
Max	48.76	44.13	33.04	31.01
Génotype effect	***	***	***	***
$LSD_{(5\%)}$	0.645	0.312	0.358	2.495

*** Very highly significant (P<0.001)

PCA were the most important, they accumulates alone nearly than 80% of the information on variability. Table 5 and 6 show that PC1 was positively correlated with reflectance index at R.G.B bands (r = 0.69; 0.71; 0.64 respectively), TKW (r = 0.69) and PH (r = 0.63), Boussellem and Oued El Bared local landraces were the best genotypes related to this component (cor = 1.05; 4.23). PC1 is also negatively correlated to CC (r = -0.78) with the advanced lines G4, G5, G6, G7, G8 as best related genotypes (cor = -2.71;-0.93;-1.71;-3.18;-1.52).PC2 was positively correlated with GY and NSm^{-2} (r = 0.57;0.75) with G9, G11 advanced lines and Boutaleb as best related genotypes (cor = 1.77;1.72;3.80),

Table 4: Correlations among physiologic and agronomic traits.

	R	G	B	CC	GY	TKW	NSm^{-2}	DH	PH
R	1								
G	0.94***	1							
B	0.70***	0.72***	1						
CC	- 0.41**	0.49***	- 0.46**	1					
GY	0.01	-0.01	- 0.04	- 0.08	1				
TKW	0.24	0.25	0.09	-0.11	0.38**	1			
NSm^{-2}	-0.06	-0.11	-0.02	-0.04	0.61***	0.39**	1		
DH	-0.25	-0.11	0.17	-0.22	0.18	0.28	0.20	1	
PH	0.09	0.08	0.01	-0.17	0.27	0.61***	0.35*	0.03	1

*Significant (P<0.05); **Highly significant (P<0.01); ***Very highly significant (P<0.001).

Table 5: Correlations of the traits measured with the first 3 components of the PCA.

Components	% de var	Measured traits								
		R	G	B	CC	GY	TKW	NSm^{-2}	PH	DH
PC1	37.03	0.69	0.71	0.64	-0.78	0.45	0.69	0.46	0.63	0.24
PC2	30.22	-0.64	-0.66	-0.55	0.11	0.57	0.45	0.75	0.56	0.39
PC3	12.65	0.23	0.08	-0.31	0.25	-0.13	0.20	0.09	0.42	-0.83

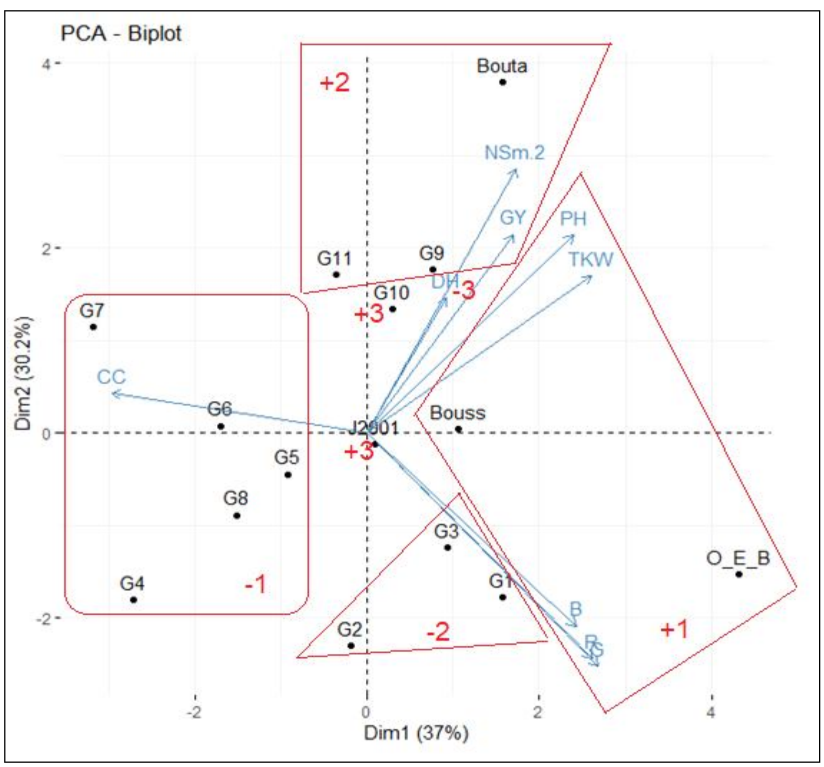

Fig 2: Biplot of the relation of the 15 genotypes studied and the measured traits with the first 3 components of the PCA.

Table 6: Coordinates of the 15 genotypes on the first 3 components of PCA.

Components	Genotypes														
	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	J2001	Bous	Bout	O_E_B
PC1	1.56	-0.19	0.93	-2.71	-0.93	-1.71	-3.18	-1.52	0.76	0.30	-0.36	0.09	1.05	1.58	4.32
PC2	-1.78	-2.30	-1.24	-1.81	-0.44	-0.08	1.15	-0.88	1.77	1.56	1.72	-0.12	0.04	3.80	-1.53
PC3	0.75	0.84	-0.48	-0.86	-0.85	-1.28	-0.84	0.68	0.63	1.88	0.86	1.69	-0.32	-1.32	-1.39

G1,G2,G3 advanced lines were negatively related to this component.PC3 was negatively correlated with DH (r = -0.83), G10 advanced line and jupare C2001 foreign race were positively related to this component.The relations of measured traits and the 15 genotypes tested with the first 3components are graphically summarized in Fig 2.

CONCLUSION

This study aim to determine the effects of RGB reflectance index and chlorophyll contents on yielding of 15 durum wheat genotypes growing under semi-arid conditions.ANOVA showed that genotype effect was significant ($P<0.001$; 0.01; 0.05) for all traits studied. The local landrace Boutaleb witch was the best yielding genotype registered a low Red reflectance index and an average Green reflectance index, blue reflectance index and chlorophyll contents. The study of the correlations reveled that chlorophyll contents was significantly ($P<0.01$) and negatively correlated with reflectance index at Red and Blue bands and very significantly ($P<0.001$) and positively correlated with reflectance index at Green band. The negative and significant correlation between reflectance at Red and Blue and chlorophyll content suggest that the decrease in the photosynthetic capacity of the canopy increase leaf reflectance at Red and Blue due to the degradation of chlorophyll content. PCA showed that grain yield was affected by number of spike per mete square, the high values of RGB reflectance index contribute at the elevation of the weight of 1000 kernels and plant height, a negative relation was observed between chlorophyll contents and RGB reflectance index.

Conflict of interest

The authors have declared no conflict of interests exists.

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