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Relationships between Some Spectral Traits and Grain Yield in Bread Wheat under Rainfed Conditions

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ABSTRACT

Developing varieties adapted to dry conditions is one of the biggest targets for breeders. It is important to use inexpensive spectral sensing methods saving time in variety development. The aim of this study was to select bread wheat genotypes having high grain yield by using spectral sensing methods. Twenty-five bread wheat (*Triticum aestivum* L.) genotypes were evaluated under rainfed condition at three locations in Central Anatolia Region. The experiment was arranged in randomized complete block design with three replications. Grain yield (GY), Canopy Temperature (CT), Soil Plant Analysis Development (SPAD) and Normalized Difference Vegetation Index (NDVI) values were recorded. GY, CT, SPAD and NDVI were found to be statistically significant in terms of both genotype and environment. The relationship between grain yield and NDVI (R^2*=0.321***) values was linear. The positive correlation of GY (0.5671**) and SPAD (0.1729*) with NDVI suggest that NDVI can be used as efficient and precise selection criteria for identifying high effiency wheat varieties under rainfed conditions.

1. Introduction

Wheat is one of the most cultivated crops in the world. Drought is one of the biggest factors limiting wheat yield. On the other hand, as in the province of Konya, the World's population is increasing and production areas are decreasing. For this reason, it is necessary to increase the yield per unit area in order to meet the increasing food demand. Therefore, breeders, physiologists and agronomists are trying to register variety and develop new agronomic techniques. For success of any breeding program, it is essential for the breeders to have a material with a wide array of diversity to be tested for desired characteristics in a variety of environments. The objectives including selection of suitable cross combinations, experimental design, location, nursery screening are essential elements for breeding programs. Existence of highly variable starting material and proper use of them are other key elements of breeding programs for positive achievement. Breeders want to select genotypes having desirable traits from early generation. Physiological characteristics of plants offer useful tools to breeders as indications of several desired characteristics. For this purpose, various indirect measurement methods such as Soil Plant Analysis Development (SPAD), Normalized Difference Vegetation Index (NDVI) and Canopy Temperature (CT), which can be applied easily, are used. Remote sensing technique has the advantage of being a cost-effective technique (Araus et al 2001).

SPAD meter which measures leaf chlorophyll content as indirect can be used in breeding programs (Giunta et al 2002; Shapiro et al 2013). Several studies suggest a positive correlation between SPAD value and chlorophyll content (Yadava 1986; Fischer 2001; Uddling et al 2007; Nemeskéri et al 2018).

NDVI is calculated by reflection of light in near infrared and red wavelengths. NDVI ranges from 0.1 to 1 and as it approaches to 1, it means the healthier plant (Usman et al 2013). It was reported that NDVI are used in many areas such as the indirect determination of plant biomass (Laidler et al 2008; Magney et al 2016), nitrogen level in the plant (Magney et al 2016), and leaf area index (Steltzer and Welker 2006; Fan et al 2009).

The relationship of leaf temperature with soil water content and transpiration is negatively linear (Pallas et al 1967). That is, as soil water content and transpiration

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increase, the CT decreases. Many researchers (Babar et al 2006; Mason and Singh 2014; Tahmasebi et al 2014; Thapa et al 2018; Sohail et al 2020) reported that CT can be used as a selection criterion.

The objective of the present study was to find out relationship between grain yield and some spectral traits in 25 bread wheat genotypes under rainfed conditions.

2. Materials and Methods

The experiment was carried out with 25 bread wheat (*Triticum aestivum* L.) variety, landraces and pure lines (Table 1) during 2009-2010 growing season at Center of Konya, İçeri Çumra and Gözlü locations of Central Anatolia under rainfed condition.

Table 1
Genotypes of the experiment

G.No	Genotypes
1	BAYRAKTAR 2000 (variety)
2	GEREK 79 (variety)
3	KARAHAN 99 (variety)
4	TOSUNBEY (variety)
5	BEZOSTAYA 1 (variety)
6	SYD/3/NAI60/HN//BUC/4/KEA/TOW/5/YAN7875.128 (breeding line)
7	ERAYBEY (variety)
8	AK 702/BDME 4 (breeding line)
9	EGL//BUC/PVN/3/KIRAÇ (breeding line)
10	ARG/R16//BEZ*2/3/AGRI/KSK/5/TRK13/6/494J6.1111/MNCH (breeding line)
11	IG42644/6/ZCL/3/PGFN//CNO67/SON64(ES86-8)/4/SERI/5/UA-2837/7/BJN 837/GRK//ES84.24 (breeding line)
12	LOV26//LFN/SDY(ES84-24)/3/SERI/4/SERI/5/SUL-TAN/6/TAST/SPRW//ZAR (breeding line)
13	90-1004a112/3/AU/CO652337//2*CA8055/6/PI/MZ//CNO67/3/LFN/4/ANT/5/AT-TILA (breeding line)
14	YEREL GENOTİP (landrace)
15	GV/4/D6301/NAİ//WRM/3/CNO*3/CHR/5/ BL2973/6/ LOVRİN6/SAMSUN (breeding line)
16	DAGDAS/KAROUS3//ALTAY (breeding line)
17	NAI60/3/1453/ODIN//CI1344/4/GRK/5/ATAY85/6/BAYRAKTAR (breeding line)
18	İKİZCE96/ EDECH28 (breeding line)
19	K340//FN/TH/3/NP"S"/4/093-44/4/ BAYRAKTAR (breeding line)
20	İKİZCE/TÜRKMEN (breeding line)
21	BEZOSTAYA-1/BAYRAKTAR (breeding line)
22	ABN/JUN//ATAY/3/ATAY (breeding line)
23	GUN/DRUM1//HKAYA (breeding line)
24	TAST/ANZA/3/F1.SU185/LTTO//BUG/BJY/4/KTK/5/SZN (breeding line)
25	TX69A330-1/3/NAD63/361-2-2//BEZ/4/KK/ITD//DAC/5/ID800994.W/VEE (breeding line)

The experiments were arranged in randomized complete block design with three replications. The plot dimensions are 1.2 by 5 m long (6 rows consist of 0.2 m space). Sowings were done at second week of October with 550 seeds m^{-2}. Harvesting was at second week of July. 70 kg N and 70 kg P ha^{-1} were applied. All of the phosphorus fertilizer was applied in DAP (Diammoniumphosphate) form with sowing. 27 kg ha^{-1} N (coming from DAP) was applied with sowing and 43 kg ha^{-1} N (ammonium nitrate) was applied in spring time.

SPAD was taken from flag leaf of main tiller by using SPAD-502 meter (Minolta Co.). Green-seeker (NTec Industries, Inc.) for NDVI and infrared thermometer (Testo 826-T2) for canopy temperature were used at Zadoks growth stage 50.

Data were analyzed with the "JMP" software. The significance of differences of means was checked by LSD test. A regression analysis was calculated using Microsoft Excel software. The regression graph between grain yield and NDVI was created using all locations and their replications.

3. Results and Discussion

Result of the analysis of variance show that there were significant differences ($p<0.01$) between all traits and locations. There also were significant differences among genotypes ($p<0.01$) with grain yield, canopy temperature and SPAD; between genotypes and NDVI values ($p<0.05$). Interaction between GY x L was significant $p<0.01$); between GY x SPAD & NDVI ($p<0.05$). There was no interaction between CT x L (Table 2).

Table 2
Analysis of variance for GY, CT, SPAD and NDVI

Source	Df	GY (kg ha^{-1})	CT (ºC)	SPAD value	NDVI value
Genotype (G)	24	**	**	**	*
Location (L)	2	**	**	**	**
G x L	48	**	NS	*	*
CV %	16	5	6	9	

NS, Non significant; P< 0.05 (* %5 significant level); P< 0.01(**%1 significant level)

Mean GY, CT, SPAD and NDVI values of the genotypes were given in Table 3; mean values for the same traits were given in Table 4.

Table 3
Mean values of traits measured at locations

Source	GY	CT	SPAD	NDVI
Center of Konya	4063 a	26.15 a	48.28 a	0.749 a
Gözlü	3656 b	17.35 c	44.13 b	0.697 a
İçeri Çumra	2759 c	23.03 b	47.36 a	0.608 b
LSD (%5)	320	1.83	1.42	0.05

3.1 Grain yield

Grain yield was elevated in terms of location and genotypes. While the highest grain yield (4063 kg ha^{-1}) was in Centre of Konya location, the least grain yield (2759 kg ha^{-1}) was İçeri Çumra location (Table 3). As for genotypes, while genotype 11 (2735 kg ha^{-1}) was the lowest, Karahan 99 variety (4352 kg ha^{-1}) was the highest (Table 4).

Table 4
Averages for GY, CT, SPAD and NDVI values

G.No	GY	CT	SPAD	NDVI
1	3258 e-j	23.25 ab	42.62 ıj	0.647 cd
2	3491 d-h	23.69 a	44.88 g-ı	0.667 b-d
3	4352 a	22.11 c-e	51.64 a	0.688 a-d
4	3567 c-h	23.61 a	45.40 f-h	0.661 cd
5	3677 b-e	21.86 de	49.93 a-c	0.727 ab
6	4043 a-c	22.72 a-d	49.56 a-c	0.744 a
7	4122 ab	22.05 c-e	50.20 ab	0.706 a-c
8	3593 b-g	21.80 de	45.74 e-g	0.692 a-d
9	3466 d-h	22.22 b-e	46.56 d-g	0.693 a-d
10	3657 b-f	22.00 c-e	45.72 e-g	0.675 b-d
11	2735 j	21.11 c-e	47.34 c-g	0.639 d
12	3869 a-d	21.52 e	42.95 h-j	0.661 cd
13	3062 h-j	21.36 e	45.84 e-g	0.689 a-d
14	2934 ıj	22.13 b-e	44.73 g-ı	0.670 b-d
15	3553 c-h	22.30 b-e	47.52 c-f	0.660 cd
16	3184 e-j	21.94 de	48.04 b-e	0.657 cd
17	3539 c-h	21.58 e	42.96 h-j	0.650 cd
18	3476 d-h	21.77 de	48.80 b-d	0.674 b-d
19	3137 f-j	21.97 c-e	41.91 j	0.748 a
20	3516 c-h	21.77 de	45.85 e-g	0.696 a-d
21	3856 a-d	21.91 de	44.87 g-ı	0.687 a-d
22	3086 g-j	22.16 b-e	49.28 a-c	0.678 b-d
23	3185 e-j	21.66 de	49.61 a-c	0.745 a
24	3673 b-e	23.08 a-c	47.57 b-f	0.672 b-d
25	3287 e-ı	21.83 de	45.16 f-ı	0.689 a-d
LSD(%5)	530.9	1.12	2.62	0.06

Grain yield is affected by genetic structure of genotype, soil characteristics, climate factors such as precipitation, temperature. Therefore, different results are obtained from different experiments. While Yağmur et al (2021) found the grain yield between 2395-3317 kg ha^{-1}, Aydoğan and Soylu (2017) obtained between 4474-7091 that they carried out their studies with different genotypes. Our results were similar to the results of Yağmur et al (2021). Keser et al (2017) reported that Karahan 99 had the highest grain yield with mean 3650 kg ha^{-1} obtained from 21 locations located in Central Anatolia. Similarly, Karahan 99 became prominent in our studies, too.

3.2. Canopy temperature

The highest canopy temperature was 26.15 ºC at centre of Konya location followed by İçeri Çumra (23.03 ºC) and Gözlü (17.35 ºC). In the present study, there were significant differences in terms of canopy temperature between locations (Table 3). It was determined that the canopy temperature was statistically significant according to the environment (Lopes et al 2012; Ohnishi et al 2021). While variety 2 (Gerek 79) gave the highest canopy temperature (23.69 ºC), genotype 11 had the lowest canopy temperature (21.11 ºC) (Table 4). As stated in the previous study (Sohail et al 2020), differences between genotypes may be resulted from genetic characteristic of genotypes. Although some researchers like Babar et al (2006), Mason and Singh (2014), Sohail et al (2020) stated that there was a significant relationship between CT and grain yield, the result of Araus et al (2001) was on the contrary. We also didn't determine any correlation between grain yield and CT, but canopy temperature was positively correlated with SPAD (0.4017**) (Table 5).

Table 5
Correlation matrix among grain yield, SPAD, NDVI and canopy temperature

	GY	SPAD	CT
NDVI	0.5671**	0.1729*	0.0478
CT	0.0164	0.4017**	-
SPAD	0.0966	-	-

3.3. Soil Plant Analysis Development

The highest SPAD values was obtained from centre of Konya followed by İçeri Çumra and Gözlü locations respectively with 48.28, 47.36 and 44.13 (Table 3). As reported by some researchers like Roy et al (2021), there were differences in SPAD values among genotypes. The highest SPAD (51.64) was recorded on Genotype 3 (Karahan 99) (Table 4). While positive relationship was detected between SPAD and grain yield in some studies (Spaner et al 2005; Yıldırım et al 2013; Islam et al 2014; Faisal and Al-Tahir 2014; Fotovat et al 2007; Ramya et al 2016), we didn't any relationship between them (Table 5).

3.4. Normalized Difference Vegetation Index

NDVI measured among locations were ranged between 0.608 (İçeri Çumra) and 0.749 (Konya) (Table 3). As for genotypes, it ranged between 0.639 (genotype 11) and 0.748 (genotype 19). Genotype 3 (Karahan 99), genotype 6, genotype 7 (Eraybey) and genotype 21 having high NDVI had high grain yield at the same time (Table 4). The NDVI were positively correlated with SPAD (0.1729*) and grain yield (0.5671**) (Table 5). These results show that NDVI can use to estimate the grain yield. Similar results were reported by Roy et al (2021), Marti et al (2007), Sultana et al (2014), Morgounov et al (2014), Mekliche et al (2015).

By considering the positive correlation between grain yield and NDVI, regression analysis was carried out (Fig. 1). This regression was positively linear (r^2=0.321**) formulated Y=5229X-87.45. Since the NDVI is an indirect measurement of biomass, this positive regression can be associated with plant density per unit area which is one of the yield components. Mekliche et al (2015) suggested that the grain yield could be predicted using a single regression with NDVI. In addition to grain yield, Hazratkulova et al (2012) also stated that NDVI can be used for identifying physiological superior.

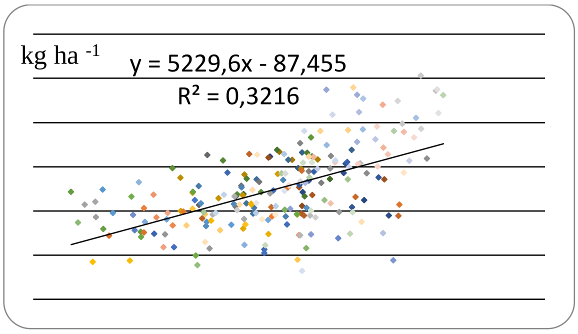

Figure 1
The regression between grain yield (kg ha^{-1}) and NDVI value

4. Conclusion

As a result, the significant and positive relationship between grain yield and NDVI show that NDVI can use to estimate the grain yield. This method is inexpensive, easy and useful. Many genotypes obtained from breeding program can be screened speedily in short time by using NDVI. NDVI also provides a useful tool to the breeders with utilization of physiological indirect selection criteria in drought conditions.

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