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DETERMINATION OF GRAIN YIELD AND LEAF CHLOROPHYLL CONTENT OF SOME DRY BEAN (*Phaseolus vulgarıs* L.) VARIETIES

Ramazan Keles*, Hakan Bayrak and Gul Imriz

Bahri Dagdas International Agricultural Research Institute, Karatay / Konya, Turkey
***Corresponding author's e-mail: kelesramazan@tarimorman.gov.tr**

This study was conducted to determine grain yield and leaf chlorophyll content of some dry bean varieties in several growing periods in the Konya ecological conditions. The cultivars included were Akman-98, Goksun, Goynuk-98, Karacasehir-90, Noyanbey-98, Onceler-98, Yunus-90 and Zulbiye. The experiments were set up according to Randomized Block Design with 3 replicates through the dry bean growing periods (May-Oct.) of the years 2012-13 in Bahri Dağdas International Agricultural Research Institute Experimental Area. The highest values of SPAD I (early leaf chlororphyll content) were obtained from Yunus-90 with 33.78, SPAD II was shown by Onceler-98 (leaf chlororphyll content at blooming stage) with 41.55 and SPAD III (leaf chlororphyll content after blooming) was obtained from Karacasehir-90 with 42.10. The lowest values of SPAD I and SPAD II were obtained from Akman-98 with the values of 26.18 and 30.57, respectively while Noyanbey-98 showed the lowest SPAD III value with 31.77. Noyanbey-98 produced the highest grain yield with 2574.6 kg ha^{-1} while the lowest was obtained from Akman-98 with 1045.0 kg ha^{-1}.
Keywords: Dry beans, agronomic traits, crop yield, leaf chlorophyll, photosynthetic rate, SPAD value.

INTRODUCTION

One of the most important goals of plant breeders is to increase crop yield. This can be possible by developing high-yielding and disease resistant varieties as well as high-yielding varieties based on physiological properties (Tosun and Sagsoz, 2005). Plant breeders compose the variations by crossing of genetic materials and desire to select the parents and F genotypes which are superior for agronomic features among the early generations of populations (Taner, 2011). In breeding studies, it is needed for tests that are cheap, easy applicable and repeatable for selection criteria (Cekic, 2007).
Chlorophyll content is one of the physiological parameters and it is an indicator of physiological activities in plant. Chlorophyll is a mandatory pigment for the conversion reaction of light energy to chemical energy. The radiation absorption from sun is totally dependent on sum of photosynthetic rate (Curran *et al.*,1990; Santos *et al.*, 2013). The chlorophyll content of leaves is not only indicator of nitrogen nutrition also it shows photosynthetic capacity and yield potential (Kalayci, 2010). Hendry *et al.* (1987) reported that the chlorophyll content is closely related to plant stress and senescence. For the measurement of chlorophyll content can be performed indirectly by SPAD-meter which measures the leaf green coloring (Taner, 2011).
In many research articles, it is reported that the chlorophyll content of leaves shows photosynthetic capacity and a linear relationship between SPAD-unit values and chlorophyll content (Yadava, 1986; Santos *et al.*, 2013). Kariya *et al.* (1982) indicated that the chlorophyll meter (SPAD 502) is a simple, portable, diagnostic tool that measures the greenness or relative content of leaves. Compared to the traditional destructive methods, the use of this equipment saves the time, space and resources. Torres Netto *et al*. (2002) reported that relationships between SPAD readings and photosynthetic pigments concentrations was exponential (total chlorophyll and chlorophyll a) and polynomial quadratic in papaya (*Carica papaya* L.) leaves. Similarly, Torres Netto *et al*. (2005) determined the relationships between total chlorophyll and SPAD readings as quadratic and at high level (R^2=0.96) in coffee (*Coffea canephora*) leaves.
In contrast, Gurler and Ozcelik (2007) stated that there was no statistical significance (r=-132) for relation between leaf chlorophyll content (33.53-36.10 SPAD-unit) and crop yield. Abou El-Yazied (2011) determined the effects of leaf chlorophyll content on growth, biochemical components, physiological parameter and yield of bean and reported the average leaf chlorophyll content was varied between 35.4-46.4 SPAD-units. Similarly, El-Bassiony *et al*. (2010) reported the leaf chlorophyll content of dry bean as 30.02-39.87 SPAD-units.
Despite the lack of advantages, Turkey is an important diversity area for many vegetable species. Dry bean is one of the most important plant species for Turkey in terms of direct use in human nutrition and nutrients it contains (Sozen and Bozoglu, 2013; Kan, 2018). Because of that, yield is very important parameter on breeding stage and also desired criteria both farmers to produce it and breeders for selection. Yield estimation in by using different techniques and parameters in different growing periods is important for

Table 1. Some physical properties with micro and macro nutrition element compositions of soils in field trial*

Deep (cm)	Texture Sand (%)	Clay (%)	Silt (%)	Class	pH	Organic matter (%)	Ca^{+2} (%)	Salt (µS cm^{-1})	P_2O_5 (mg kg^{-1})	K_2O (mg kg^{-1})	Zn^{+2} (mg kg^{-1})
0-30	30.83	41.62	27.55	Clayey	7.8	2.28	29.26	272	4.64	92.31	0.262

* Laboratory analyzes were made in Konya Commodity Exchange.

plannning and creating database for crop production. It was aimed with ***this*** study to determine grain yield and leaf chlorophyll content of some dry bean varieties in several growing periods in the Konya ecological conditions.

MATERIALS AND METHODS

***Description of the experimental area*:** The research was conducted in experimental field of Bahri Dagdaş International Research Institute, in the years of 2012-13. For the long years (1975-2013), and the experimental years through the vegetation periods the avarage rainfalls were recorded as 90.5 mm, 62.2 mm, 78.0 mm, and the avarage temperatures were 22.3°C, 22.0°C, 22.1°C, respectively.

The first 30 cm depth of soil of experimental field was clay textured. The soil was medium in organic matter content (2.28%), high in lime content (29.26%), slightly alkaline (pH 7.82), rich for phosphor (4.64 mg $kg^{-1}$of P_2O_5) and Potassium (92.31 mg $kg^{-1}$of K_2O), very poor for Zinc (0.262 mg kg^{-1}), at normal level for salinity (272 µS cm^{-1}) (Table 1).

***Field experiment and chlorophyll content analyses*:** In total eight local dry bean varieties (Akman-98, Goksun, Goynuk-98, Karacasehir-90, Noyanbey-98, Onceler-98, Yunus-90 and Zulbiye) were involved in this experiment. The experimental design *was* randomized complete block with three replications. Parcel size was set up as 9 m^2 (=0.45m X 5m X 4 rows), planting was done with 45 cm intervals, and to depth of 3-4 cm. The planting dates were 9th of May in 2012, and 17th of May in 2013. Fertilization was made as 30 kg ha^{-1} of N and 7 kg ha^{-1} of P_2O_5. When the plants were at 3-4 leaf stage, weed management, hoeing and reducing the plant density (as 10 cm intervals between plant rows) was done. Hoeing irrigation and earthing up were applied as per need. Crop was harvested by hand for first year on 5th of Oct, 27th of Sep for second year.

For analyses of leaf chlorophyll content, 3 measurements were taken at different phenological stage of plant, respectively; early leaf stage=SPAD I: (20th of June), flowering stage=SPAD II: (22nd of July), and beginning of pod formation=SPAD III (22nd of Aug). The measurements were taken in SPAD-unit by using the instrument of *SPAD 502, MINOLTA™ Camera Ltd. Japan*. For each parcel, 20 measurements (taken from 2 leaf edges of 10 different plants) were recorded. The leaf chlorophyll content of each parcel was calculated by taking the arithmetic average of the data.

Statistical analysis: Variance analysis of randomized complete blocks was applied for data obtained from results. The difference between averages of the data was determined by "F" test and grouped according to "LSD" significance test. Linkage between chlorophyll content and crop yield was determined by correlation and regression analysis. JMP 11.2.1 (Anonymous, 2011) statistical program was used for analysis.

RESULTS AND DISCUSSION

Averages leaf chlorophyll contents and yield values of varieties are given in Table 2. The difference between genotypes for SPAD I values was found as significant (P<0.01) and was calculated as 30.18 SPAD-unit. Yunus-90 showed the highest value with 33.78 SPAD-unit and the lowest value was obtained from Akman-98 with 26.18 SPAD-unit (Table 2).

Table 2. Genotypes leaf chlorophyll content and yield.

GENOTYPES	SPAD I	SPAD II	SPAD III	Yield (kg ha^{-1})
AKMAN-98	26.18c	30.57c	35.47bc	1045.0d
GOKSUN	26.92c	33.90bc	37.20ab	2095.8b
GOYNUK-98	28.62bc	37.52ab	38.10ab	2035.6b
KARACASEHİR-90	33.45a	37.48ab	42.10a	1465.4c
NOYANBEY-98	29.83abc	33.98bc	31.77c	2574.6a
ONCELER-98	28.38bc	41.55a	38.42ab	1993.0b
YUNUS-90	33.78a	40.30a	41.67a	1949.2b
ZULBIYE	31.25ab	40.10a	34.33bc	2061.4b
General Average	30.18	36.93	37.38	1902.50
F	4.12**	4.69**	3.80**	17.98**
$CV_{(\%)}$	11.46	11.68	11.83	13.90
$LSD_{(0.05)}$	4.04	5.10	5.23	312.86

For SPAD II (***flowering stage***) measurement values, the difference among genotypes was found significance at P<0.01 and the average chlorophyll content values was determined as 36.93 SPAD-unit. The highest SPAD value was recorded in variety Onceler-98 while no statistical difference was found among Onceler-98, Yunus-90 and Zulbiye, which were statistically at par. For these three varieties, SPAD values were 41.55, 40.30, 40.10 SPAD-unit, respectively. The lowest SPAD value was recorded in variety Akman-98 with 30.57 SPAD-unit (Table 2).

A strong positive correlation (r=0.61**) was determined between SPAD I and yield capacity of varieties (P<0.01) (Table 3).

Table 3. Correlation coefficients between the features which examined in the study.

	SPAD II	SPAD III	Yield
SPAD I	0.78**	0.42**	0.61**
SPAD II		0.48**	0.66**
SPAD III			0.27*

A positive relationship (r=0.66**) was obtained between SPAD II and yield capacity of varieties, which was significant at $P<0.01$ level (Table 3).

For SPAD III (***beginning of pod formation***) measurement values, the difference among genotypes was found significant at $P<0.01$ and the average chlorophyll content was determined as 37.38 SPAD-unit. The highest SPAD value was noted in variety Karacasehir-90; however, no statistical difference was found between Yunus-90 and Karacasehir-90. For these two varieties, SPAD values were 41.67 and 42.10 SPAD-unit, respectively (Table 2). The lowest SPAD value was recorded for variety of Noyanbey-98 with 31.77 SPAD-unit.

The correlation (r=0.27*) between SPAD III and yield capacities of varieties was found significance at $P<0.05$ (Table 3).

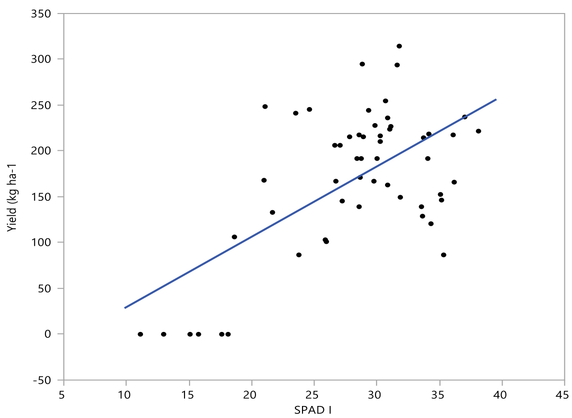
Leaf chlorophyll content at different phenological stages (SPAD I, II, III) varied from 26.18 to 42.10 SPAD-unit, but the early leaf stage measurements showed very low level for SPAD values. However, chlorophyll content of dry bean was reported as 30.02-46.40 SPAD-units by many researchers (Abou El-Yazied, 2011; El-Bassiony *et al*., 2010; Gurler and Ozcelik, 2007). In our experiment, average SPAD I (early leaf chlorophyll content measurement) value was determined as 30.18 SPAD-unit which is low than previously reported values. The reason of low SPAD value is associated with intolerance of varieties for Zinc deficiency in experimental area and low air temperature in early season.

Lindsay and Norwell (1978) classified the receivable Zn^{+2} content level in soil as too high (>8.0), high (2.4-8.0), sufficient (0.7-2.4 ppm), low (0.2-0.7 ppm) and too low (< 0.2 ppm). Zinc content of our experimental area soil (0.262 ppm) can be classified in group of low Zn^{+2} level (Table 1); however, it can be almost included in the last group (too low group) since its Zn^{+2} value was very close to the lowest limit. In addition, high levels of clay and phosphorus content of the experimental area soil were considered as possible aggravating factors (Kenbaey and Sade, 1997). In experimental area, presence of both possibilities is very probable (Table 1). In Konya Basin, most part of agricultural land is subject to high level of Zn^{+2} deficiency (Chaudry and Kacar, 1980; Gunes *et al*., 1996). In this regard, as typical symptoms of Zn^{+2} deficiency, reduction in quantity and quality of crop yield, short statured plant, scald symptoms by merging the grey-pale brown necrosis, especially on middle aged and old leaves (Cakmak, 1998), badges on growth cone, shortening internodes and shrinkage of leaves (Oktay *et al.*,1997) were observed in different severities based on dry bean varieties in our experiment. Eker *et al*. (1997) reported that there could be a different reaction among not only plant varieties but also genotypes of a plant variety for Zn^{+2} deficiency tolerance. The difference among dry bean genotypes for zinc deficiency tolerance was reported by many researchers (Judy *et al.*, 1965; Moraghan and Grafton, 1999; Hacısalihoglu *et al.*, 2004). Graham and Rengel (1993) pointed out different Zn^{+2} tolerance reaction of genotypes related to mechanism of usage and uptake Zn^{+2}. Loue (1986) reported that bean varieties are susceptible to Zn^{+2} deficiency and zinc deficiency symptoms could be observed on young leaves in early seasons (Hacısalihoglu, 2002). This was related to soil temperature and explained by highly increasing of Zn^{+2} deficiency symptoms in early spring, disappearing of the symptoms while increasing of the soil temperature through the growing season (Schwartz *et al.*, 1987). Likely, Sinclair *et al*. (1990) reported that Zn^{+2} content of soil was four times more in summer than spring time and they associated it to increasing microbial mineralization of Zn^{+2} from organic substances and promoting plant root growth by rising soil temperature through the growing season. Likely, the chlorophyll content values of SPAD II, SPAD III increased and Zn^{+2} deficiency symptoms disappeared by rising soil temperature in our study.

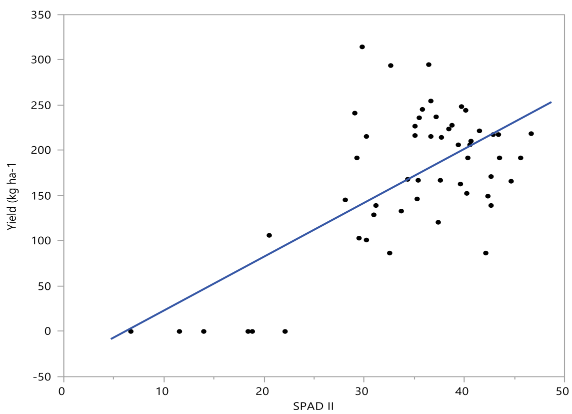
In regression analysis for determination of linear relationship between yield and SPAD values, the statistical significance between yield and SPAD I was at $P<0.05$, SPAD II was at $P<0.01$, and analysis of yield and SPAD III values was found as insignificant. The highest linear relationships between yield and SPAD were obtained from SPAD I (R^2=0.37*) and SPAD II (R^2=0.43**) measurements (Fig. 1).

Regarding seed yield, difference among the varieties was found at $P<0.01$significance level. The average yield of genotypes was recorded as 1691.2 kg ha^{-1} and the highest yield was obtained from Noyanbey-98 with 2574.6 kg ha^{-1}, while the lowest was given by Akman-98 with 1045.5 kg ha^{-1} (Table 2).

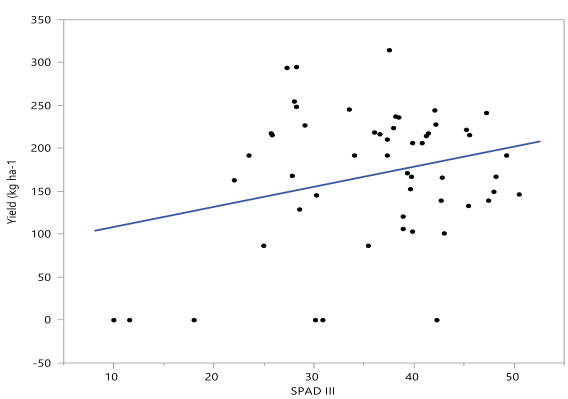
The amount of absorbed solar radiation by a leaf is a function for photosynthetic pigment content, thus, chlorophyll content, photosynthesis potential and yield can be directly determined amount of absorbed solar radiation (Curran *et al.*, 1990; Filella *et al.*, 1995; Gitelson *et al.*, 2003). Zinc is an important micronutrient which increases chlorophyll synthesis in photosynthetic mechanism (Aravind and Parasad, 2004), and its deficiency can cause severe chloroplast damage and reduction of chlorophyll content (Chen *et al.*, 2007), and cause yield loss by inhibiting the photosynthesis in many plant varieties (Kosesakal and Unal, 2009). Torun *et al.* (1997) indicated that dry matter amount of plant was affected parallel to zinc deficiency symptoms that changed depending on plant varieties and genotypes. Linkage between SPAD measurements is an indicator of photosynthetic capacity, and genotype potentials, morphological features and physiological functions, quantitative features controlled by genotype, and seed yield capacities controlled by environmentally (Poehlman and Sleper, 1995) was analyzed in detail and a parallel relationship was determined between low SPAD values and yield capacity with very low product. In this study, according to stepwise regression results, SPAD I and II were determined as independent (free) variation which effect the yield as dependent variation and estimation model was calculated as Yield= -64.32+3.21*(SPAD I)+4.15*(SPAD II). According to regression analysis of SPAD II values, R^2 was determined as 0.46 and statistical significance at P<0.01 level.



Yield= -47.1+7.67*SPAD I; R^2= 0.37*



Yield = -36.4+5.95*SPAD II; R^2= 0.43**



Yield= 85.18+2.34*SPAD III; R^2= 0.07^{ns}

Figure 1. Linear relationship between yield and SPAD values.

***Conclusıon*: ** The leaf chloropghyll content in dry bean varieties indicated that atearly stage, the lower leaf chloropghyll content was associated with micro nutritient defficiency and the soil temperature in relevance with the planting time. For tolerance to zinc deficiency, there were great differences among the plant varieties; the similarities can be seen for plants in plant variety as well. The source of this variation is difference of Zinc fixation and utilization. The level of zinc deficiency indry bean could be determined by measuring early chlorophyll content using a SPAD-meter. Zinc deficiency is a limiting factor of biological yield capacity.

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