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Relationships Between Leaf Chlorophyll and Yield Related Characters of Dry Bean (*Phaseolus vulgaris* L.)

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Abstract: SPAD leaf Chlorophyll (CHL) reading is closely related with leaf nitrogen and yield. The aim of the present study was to investigate relationships between leaf CHL, yield and yield contributing characters in dry bean. Six dry bean lines and four cultivars were evaluated in terms of leaf CHL, Seed Yield (SY), 100 seed weight (100 SW), Pod Number Per Plant (PNPP), Seed Number Per Plant (SNPP), Seed Number Per Pod (SNPPod), Harvest Index (HI) and Plant Height (PH). Except for leaf CHL and HI, there were significant differences among cultivars in relation to investigated traits. There were significant correlations between SY and PNPP (r = 0.727*), SY and SNPP (r = 0.831**), SY and HI (r = 0.718*), PNPP and SNPP (r = 0.925**) and SNPP and SNPPod (r = 0.702*). Path coefficient analysed revealed that PNPP (0.9873), 100 SW (0.7209) and SNPPod (0.4762) had significant direct effect on SY. Although leaf CHL had a small direct effect on SY, it had substantial indirect effect via 100 SW. The study revealed that the dry bean lines and cultivars having the lowest leaf CHL reading value taken at 38 days after emergence is not a sign for poor yield. Or the highest CHL reading value taken at that stage does not warrant for higher yield.

Key words: Dry bean (*Phaseolus vulgaris* L.), leaf chlorophyll, correlation and path analysis

INTRODUCTION

Dry bean has high importance for human nutrition and constitutes great proportion of protein source of human diet especially in developing and the least developed countries. Therefore improving high yielding varieties with high nutritional value is of vital importance for communities. As in the other crops, yield is a result of complex soil-plant-environment interactions. Determination of yield contributing characters facilitates selection of high yielding varieties from breeding materials (Singh, 2001). There have been many studies with different crops in relation to identification of these characters (Noor *et al*., 2003; Sürek and Beser, 2003; Raffi and Nath, 2004; Yücel *et al*., 2006). But most of these studies concentrated on more or less the same characters. Recently researchers concentrated on relationship between leaf CHL and plant morphology. Working with peanut, some authors found that there were close relationships between SPAD chlorophyll meter reading, water use efficiency, transpiration efficiency, specific leaf area and specific leaf nitrogen (Nageswara *et al*., 2001; Lal *et al*., 2006; Sheshshayee *et al*., 2006). Kabanova and Chaika (2001) reported that there were significant relationships among leaf anatomy, plant morphology and chlorophyll content in Triticale. They suggested that these traits might be useful in practical triticale breeding. Wang *et al*. (1999) working with maize found that CHL concentration had a small direct effect on grain yield, but it had a great indirect effect on grain yield via kernel number per ear and grain filling duration. There is limited information between leaf chlorophyll and yield contributing characters of dry bean. Therefore the aim of the present study was to evaluate dry bean cultivars in relation to their leaf CHL, yield and yield contributing traits and also to determine significant traits having great contribution to seed yield through correlation and path coefficient analysis.

MATERIALS AND METHODS

This study was conducted on a loam soil in the research field of Black Sea Agricultural Research Institute in Samsun, Turkey in 2006 (41° 21' N Latitude, 36° 15' E Longitude, elevation 4 m). Experimental soil had a pH of 6.85, $CaCO_3$ 7.24%, organic matter 1.36%, available P 5.24 kg ha^{-1} and exchangeable K 200 kg ha^{-1}. Meteorological data for experimental site were as follows: Total precipitation during growing period (from May to September) was 262.5 mm, mean relative humidity 76.8% and mean temperature 20.4°C.

Experimental design was completely randomized block with three replications. Six dry bean lines (KFBVD-1, KFBVD-2, KFBVD-3, KFBVD-4, KFBVD-5, KFBVD-6) and

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four cultivars (Sahin 90, Yunus 90, Göynük, Noyanbey) were tested. Dry bean lines and cultivars were planted on a 5 m long and 2.80 m wide plot consisting of four rows on 13 May 2006. Inter planting and inter row spacing were 0.45 and 0.70 m, respectively. Before planting, each plot received 50 kg ha^{-1} N as Calcium ammonium nitrate (26% N) and 60 kg ha^{-1} P as Triple super phosphate (42% P_2O_5) as basal dressing.

Seed yield (g $plant^{-1}$), 100 seed weight (g), pod number per plant, seed number per plant, seed number per pod, harvest index and plant height (cm) were taken from randomly selected ten plants in each plot. Leaf CHL was measured by SPAD 502 chlorophyll meter (Minolta) on 20 plants in each plot at 38 days after emergence.

Data were evaluated by using ANOVA and Path Coefficient analyses. Means were compared by using LSD test.

RESULTS AND DISCUSSION

Leaf chlorophyll, yield and yield related characters: Except for SPAD chlorophyll reading and harvest index there were significant differences among cultivars in terms of investigated characters (Table 1). KFBVD-3, cv Noyanbey and KFBVD-5 had the highest SY. These cultivars also had the highest PNPP, SNPP and SNPPod. Although there was no significant difference among cultivars in HI, these cultivars also had the highest HI except for KFBVD-5.

Leaf CHL reading value ranged from 33.53 (KFBVD-5) to 36.10 (KFBVD-1). The KFBVD-5 and cv Noyanbey which had the lowest CHL reading value gave the highest seed yield. This might be attributed to dilution effect of the nutrients. Most of the nitrogen might be used for organic compound synthesis. In most of the plant nutrition studies, it was found that control plants (no nutrient supply) had higher nutrients than those of nutrient supply plants due to slow metabolic activity resulting in accumulation of nutrient (concentration effect) in plant tissue (Jarrel and Beverly, 1981). Leaf CHL reading values found in this study were lower than those of the values reported by Marquard and Tipton (1979) and Shaaban and El-Bendary (1999) for snap bean (4-43, 39.7-41.6, respectively). This difference might be resulted from cultivar difference, date of measurement and fertilizer management. In present study CHL reading was taken 38 days after emergence which corresponds to the most active stage of the plant (flowering). This also supports dilution or concentration effect of nutrients in plant. Silveira *et al.* (2003) working with two dry bean cultivars found that CHL reading value at 35 days after emergence ranged from 29 to 32.7 for cv Jalo precoce and from 37.0 to 40.8 for Perola.

Correlation between investigated characters: Correlation matrix between traits of dry bean is presented in Table 2. There were highly significant correlations between PNPP and SNPP (r = 0.925**) and SY and SNPP (r = 0.831**).

Table 1: Chlorophyll reading value, seed yield per plant, 100 seed weight, pod number per plant, seed number per plant, seed number per pod, harvest index and plant height of dry bean cultivars

Cultivar	CHL	SY	100 SW	PNPP	SNPP	SNPPod	HI	PH
KFBVD-1	36.10	19.13^{bcd}	42.90^{bc}	13.90^{cd}	46.10^{c}	3.33^{bcd}	0.42	60.70^{bc}
KFBVD-2	35.83	14.83^{d}	56.91^{a}	9.26^{e}	26.40^{e}	2.85^{ef}	0.40	50.40^{de}
KFBVD-3	35.96	31.85^{a}	49.11^{ab}	20.30^{a}	73.51^{a}	3.63^{ab}	0.51	51.76^{de}
KFBVD-4	35.96	20.80^{bc}	56.86^{a}	12.16^{d}	36.60^{d}	3.02^{de}	0.39	48.90^{e}
KFBVD-5	33.53	22.92^{b}	33.10^{d}	17.79^{ab}	65.66^{ab}	3.69^{a}	0.42	54.27^{cde}
KFBVD-6	35.33	20.00^{bc}	36.74^{cd}	17.50^{b}	54.13^{c}	3.09^{de}	0.47	55.43^{cde}
Sahin 90	34.20	17.54^{cd}	35.84^{cd}	14.54^{cd}	48.71^{c}	3.51^{ab}	0.44	57.13^{bcd}
Yunus 90	35.77	18.36^{bcd}	38.75^{cd}	18.33^{ab}	48.63^{c}	2.63^{f}	0.38	73.96^{a}
Göynük	35.10	21.46^{bc}	41.23^{bcd}	16.16^{bc}	51.53^{c}	3.19^{cd}	0.39	63.36^{b}
Noyanbey	34.10	28.06^{a}	48.75^{ab}	18.56^{ab}	63.20^{b}	3.40^{abc}	0.61	56.56^{bcd}
F-test	ns	**	**	**	**	**	ns	**
LSD	ns	4.404	8.399	2.602	8.713	0.3069	ns	7.413
CV (%)	3.31	11.80	11.08	9.43	9.73	5.54	21.92	7.55

CHL = SPAD reading value measured 38 days after emergence; SY = Seed yield (g $plant^{-1}$); 100 SW = 100 Seed Weight (g); PNPP: Pod Number Per Plant; SNPP = Seed Number Per Plant; SNPPod = Seed Number Per Pod; HI = Harvest Index; PH = Plant Height (cm); ** Indicate significance at 1%; ns = not significant; In a row, means followed by the same letter are not significantly different at the 5% level; CV = Coefficient Variation (%)

Table 2: Correlation matrix between investigated characters of dry bean

Variables	SY	CHL	100 SW	PNPP	SNPP	SNPPod	HI	PH
SY	1.000	-0.132	0.110	0.727*	0.831**	0.581	0.718*	-0.209
CHL		1.000	0.539	-0.309	-0.436	-0.556	-0.347	0.044
100 SW			1.000	-0.506	-0.449	-0.299	0.088	-0.511
PNPP				1.000	0.925**	0.396	0.512	0.347
SNPP					1.000	0.702*	0.603	0.059
SNPPod						1.000	0.478	-0.398
HI							1.000	-0.251
PH								1.000

*, ** Indicate significant at 5% and 1% level

Table 3: The direct, indirect and % contribution of various traits to seed yield per plant in dry bean

		Indirect Effects						
Variables	Direct effect	CHL	100 SW	PNPP	SNPP	SNPPod	HI	PH
CHL	0.0069		0.3885	-0.3050	0.0306	-0.2647	0.0116	0.0001
	(0.68%)		(38.56%)	(30.27%)	(3.03%)	(26.28%)	(1.14%)	(0.01%)
100 SW	0.7209	0.0037		-0.4995	0.0315	-0.1426	-0.0029	0.0007
	(51.42%)	(0.26%)		(35.63%)	(2.24%)	(10.17%)	(0.21%)	(0.05%)
PNPP	0.9873	-0.0021	-0.3648		-0.0648	0.1884	-0.0171	0.0005
	(60.76%)	(0.13%)	(22.44%)		(3.98%)	(11.59%)	(1.04%)	(0.02%)
SNPP	-0.0701	-0.0030	-0.3237	0.9131		0.3344	-0.0201	0.0001
	(4.20%)	(0.18%)	(19.44%)	(54.85%)		(20.08%)	(1.20%)	(0.005%)
SNPPod	0.4762	-0.0038	-0.2159	0.3905	-0.0492		-0.0159	-0.0005
	(41.33%)	(0.33%)	(18.73%)	(33.89%)	(4.26%)		(1.38%)	(0.05%)
HI	-0.0333	-0.0024	0.0634	0.5050	-0.0423	0.2277		-0.0003
	(3.81%)	(0.27%)	(7.25%)	(57.74%)	(4.83%)	(26.04%)		(0.04%)
PH	0.0014	0.0003	-0.3682	0.3427	-0.0041	- 0.1893	0.0084	
	(0.15%)	(0.03%)	(40.26%)	(37.47%)	(0.45%)	(20.70%)	(0.91%)	

There were also significant correlation between SY and PNPP (r = 0.727*), SNPP and SNPPod (r = 0.702*) and SY and HI (r = 0.718*). Although they were not significant, there were negative correlations between leaf CHL reading, yield and yield contributing traits of dry bean except for 100 SW and PH. These results are disagreement with the results of other studies which found significant correlations between leaf CHL and yield for different crops (Ramesh *et al*., 2002; Boggs *et al*., 2003; Güler *et al*., 2006a, b). This result might be attributed to the measurement date of CHL. Leaf nitrogen changes day to day depending on the growing stages (Silveira *et al*., 2003).

Path coefficient analysis: The direct, indirect effects of investigated traits on seed yield and their percent of contribution to seed yield per plant is presented in Table 3. According to path coefficient analysis, PNPP (0.9873, 60.76%), 100 SW (0.7209, 51.42%) and SNPPod (0.4762, 41.33%) had the highest direct effect on SY. These results are in agreement with the result of Raffi and Nath (2004). SNPP had a small negative direct effect on SY, but it had great positive indirect effect via PNPP (0.9131, 54.85%) and SNPPod (0.3344, 20.08%). Although leaf CHL reading value had a small direct effect on SY, it had greater indirect effect through 100 SW which the second most important trait having substantial direct influence on SY. In most of studies it was found that leaf CHL value measured by SPAD chlorophyll meter was closely related with yield (Blackmer and Schepers, 1995; Ramesh *et al*., 2002; Boggs *et al*., 2003). In this study small direct effect of CHL on SY might be explained with the measurement date of CHL (38 days after emergence). Smeal and Zhang (1994) and Blackmer and Schepers (1995) found higher correlation between CHL reading and grain yield in maize during later stage of development. Ramesh *et al*. (2002) measured leaf CHL of rice in 5 times at seven days intervals beginning 72 days after sowing and found that leaf CHL content at 79 days after sowing correlated well with the grain yield of rice.

In conclusion, according to correlation and path coefficient analysis, PNPP, 100 SW, SNPPod and SNPP were the traits having higher contribution to seed yield of dry bean. Also, the lines and cultivars having the lowest leaf CHL reading value taken at 38 days after emergence is not a sign for poor yield. Or the highest CHL reading value at that stage does not warrant for higher yield. Dry bean is different from other crops due to being a leguminous crop. It converts air nitrogen into organic compounds through biological nitrogen fixation. Therefore this issue should be investigated elaborately.

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