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Correlations in Leaf Chlorophyll and Yield Related Traits of Dry Bean (*Phaseolus vulgaris* L.)

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The aim of the present study was to investigate correlations between leaf chlorophyll, yield and yield contributing characters in dry bean. Six dry bean lines and 4 cultivars were evaluated in terms of leaf chlorophyll, seed yield, 100 seed weight (100 seed weight), pod number per plant, seed number per plant, seed number per pod, harvest index and plant height. Except for leaf chlorophyll and harvest index, there were significant differences among cultivars in relation to investigated traits. There were significant correlations between seed yield and pod number per plant ($r = 0.727$, $p < 0.05$), seed yield and seed number per plant ($r = 0.831$, $p < 0.01$), seed yield and harvest index ($r = 0.718$, $p < 0.05$), pod number per plant and seed number per plant ($r = 0.925$, $p < 0.01$) and seed number per plant and seed number per pod ($r = 0.702$, $p < 0.05$). Path coefficient analysis revealed that pod number per plant (0.9873), 100 seed weight (0.7209) and seed number per pod (0.4762) had significant direct effect on seed yield. Although leaf chlorophyll had a small direct effect on seed yield, it had substantial indirect effect *via* 100 seed weight. The study revealed that the dry bean lines and cultivars having the lowest leaf chlorophyll reading value taken at 38 d after emergence is not a sign for poor yield. The highest chlorophyll reading value taken at that stage does not warrant for higher yield.

Key Words: Correlation and Path analysis, Dry bean (*Phaseolus vulgaris* L), Leaf chlorophyll.

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 developing countries. Therefore improving high yielding varieties with high nutritional value is of vital importance for communities. 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[1]. There have been many studies with different crops in relation to identification of these characters[2,3]. But most of these studies concentrated on more or less the same characters. Recently

researchers concentrated on relationship between leaf chlorophyll and plant morphology. Working with peanut, some authors found that there were close relationships between SPAD (Soil-Plant Analyses Development) chlorophyll meter reading, water use efficiency, transpiration efficiency, specific leaf area and specific leaf nitrogen[4-6]. Kabanova and Chaika[7] 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.*[8] working with maize found that chlorophyll concentration had a small direct effect on grain yield, but it had a great indirect effect on grain yield *via* kernel number per year 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 chlorophyll, yield and yield contributing traits and also to determine significant traits having great contribution to seed yield through correlation and path coefficient analysis.

EXPERIMENTAL

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, N 0.068 %, $CaCO_3$ 2.89 %, 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 3 replications. Six dry bean lines (KFBVD-1, KFBVD-2, KFBVD-3, KFBVD-4, KFBVD-5 and KFBVD-6) and 4 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 4 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.

Plants were harvested on 15 September 2006. 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 10 plants in each plot. Harvest index was calculated as the ratio of seed yield to total plant weight. Leaf chlorophyll was measured by SPAD 502 chlorophyll meter (Minolta) on 20 plants in each plot at 38 d after emergence.

Data were evaluated by using ANOVA and Path Coefficient analyses. Means were compared by using LSD test. The path coefficient analysis was performed to calculate the direct effects of the traits on seed yield. In path analysis seed yield per plant was dependent variable and the other traits were considered as independent variables[9].

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 harvest index except for KFBVD-5.

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}

CHL = SPAD reading value measured 38 d 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).
In a column, means followed by the same letter are not significantly different at the 5 % level.

Leaf chlorophyll reading value ranged from 33.53 (KFBVD-5) to 36.10 (KFBVD-1). The KFBVD-5 and cv Noyanbey which had the lowest chlorophyll 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 supplied plants due to slow metabolic activity resulting in accumulation of nutrient (concentration effect) in plant tissue[10]. Leaf chlorophyll reading values found in this study were lower than those of the values reported by Marquard and Tipton[11] and Shaaban and El-Bendary[12] 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 chlorophyll reading was taken 38 d 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.*[13] working with two dry bean cultivars found that chlorophyll reading value at 35 d 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 ($r = 0.925$, $p < 0.01$) and SY and SNPP ($r = 0.831$, $p < 0.01$). There were also significant correlation between SY and PNPP ($r = 0.727$, $p < 0.05$), SNPP and SNPPod ($r = 0.702$, $p<0.05$) and SY and HI ($r = 0.718$, $p < 0.05$). Although they were not significant, there were negative correlations between leaf chlorophyll 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 chlorophyll and yield for different crops[14-17]. This result might be attributed to the measurement date of chlorophyll. Leaf nitrogen changes day to day depending on the growing stages[13].

TABLE-2
CORRELATION MATRIX BETWEEN INVESTIGATED CHARACTERS OF DRY BEAN

	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
100SW			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

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[3]. 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 chlorophyll reading value had a small direct effect on SY, it had greater indirect effect through 100 SW which was the second most important trait having substantial direct influence on SY. In most of studies it was found that leaf chlorophyll value measured by SPAD chlorophyll meter was closely related with yield[14,15,18]. In this study small direct effect of chlorophyll on SY might be explained with the measurement date of chlorophyll (38 d after emergence). Smeal and Zhang[19] and Blackmer and Schepers[18] found higher correlation between chlorophyll reading and grain yield in maize during later stage of development. Ramesh *et al.*[14] measured leaf chlorophyll of rice in 5 times at 7 d intervals beginning 72 d after sowing and found that leaf chlorophyll content at 79 d 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 chlorophyll reading

TABLE-3
DIRECT, INDIRECT AND % CONTRIBUTION OF VARIOUS TRAITS TO SEED YIELD PER PLANT IN DRY BEAN

Variables	Direct effect	Indirect effects						
		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%)

value taken at 38 d after emergence is not a sign for poor yield. Or the highest chlorophyll 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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