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A STUDY ON COEFFICIENT ANALYSIS AND ASSOCIATION BETWEEN AGRONOMICAL CHARACTERS IN DRY BEAN (*PHASEOLUS VULGARIS* L.)

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Abstract

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This study was carried out to determine simple correlations between seed yield and certain important agronomical characters and direct and indirect effects of these characters on seed yield in field bean. The research was conducted with 30 bean cultivars or lines under Isparta ecological conditions in 1996 and 1997. Seed yield, number of branches per plant, number of pods per plant, number of seeds per pod, number of seeds per plant, number of immature pods per plant, biomass yield, seed yield per plant, 1000 seed weight, pod lenght, pod width, plant height and first pod height were observed in the study.

According to the results, simple correlation coefficients were positively significant in all pairs of the characters except correlations between seed yield per hectare and pod lenght, pod width and first pod height. The highest positive correlations were observed between seed yield per plant with biomass yield (r= +0.974**), number of pods per plant (r =0.860**) and number of branches per plant (r =+790**).

Path coefficient analysis indicated that seed yield per plant had the greatest direct effect (+0.668) on seed yield per hectare, followed by 1000 seed weight (+0.185) and plant height (+0.301). Percentages of direct effects on seed yield per hectare were 63.1%, 51.7% and 48.9%, respectively, for seed yield per plant, 1000 seed weight and plant height. In the study, characters such as number of pods per plant, biomass yield, number of branches per plant, number of seeds per plant, number of immature pods per plant, number of seeds per pod and plant height gave the highest indirect effects on seed yield per hectare through seed yield per plant (with contributions 63.6%, 63.0%, 62.8%, 58.1%, 47.8%, 42.3%, and 33.6% respectively).

Key words: *Phaseolus vulgaris*, agronomical characters, correlation coefficient, path analysis

Introduction

Plant proteins provide 65% of the world protein supply for humans, with 45-50% coming from legumes and cereals, mainly for the populations of developing countries (Mahe et al., 1994). The vegetable proteins have a significant function and responsibility in covering the protein need of more than half of the population (Rutkowski, 1988). The prices of animal pruducts are rather high and that they contain saturated fats and cholesterol. The values of dry legumes have increased in the fullfillment of protein requirements. Dry legumes are the food crops that have the highest protein content. On the other hand, they are also rich in

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calcium required for bone structure and general health, in iron required for blood making, in different types of vitamin B which are effective on the nervous system (Baysal and Basoglu, 1988). Dry bean (*Phaseolus vulgaris* L.), also called field bean, French bean, common bean, kidney bean etc. is one of the most important legume crops in the world. It has special role rich and poor countries.

Dry bean or common bean is important food legumes gown in Turkey for human nutrition over thousands of years. However production and yield is not sufficiently enough yet. Yield is lower than the word mean, possibly because of a lower yield due to climatic and soil requirements and various fungal diseases, which from year to year, may result in dramatic yield losses requiring new breeding attends to increase yield and quality (Onder and Babaoglu, 2001)

Seed yield is affected by genotype and environmental factors because it is a quantative characters. Therefore, generally, seed yield has a low heritability. Using as selection criteria of characters direct relationship with seed yield increase the success of selection in plant breeding.

Correlation analysis describes marely the mutual relationship between different pairs of characters without providing the nature of cause and effect relationship of each character. Hence, the path analysis was also performed to determine the direct and indirect contribution of each character to seed yield (Berhe et al., 1998). Any component of yield may affect yield directly and/or it may act indirectly by influencing components which will be produced later in the developmental sequence (Doust et al., 1983).

Success in crop breeding is also depending on the isolation of genetically superior genotypes based on the amount of variability present in the material. Therefore, information on genetic variability existed in a group of populations of dry bean are essential. (Raffi and Nath, 2004). Previous some studies were carried out by Shete and Kale (1988); Mebrahtu et al. (1991); Ribeiro et al. (2000); Onder and Babaoglu (2001); Rai et al. (2001); Raffi and Nath (2004); Peksen and Gulumser (2005) etc.on variability and interrelationship of characters in dry bean.

Many previous researches reported that seed yield was positively associated with number of pods per plant, number of seeds per pod and seed yield per plant and number of pods per plant had directly effect on seed yield per hectare (Duarte and Adams, 1972; Westerman and Crothers, 1977; Prakash and Ram, 1981; Onder, 1994; Onder and Ozkaynak, 1994; Bozoglu and Gulumser, 1999; Helvacioglu and Sehirali, 2001; Kurek et al., 2001; Yorgancilar et al., 2003; Peksen and Gulumser, 2005).

This study was carried out to determine direct and indirect effects of certain yield components on seed yield and to estimate correlations between seed yield and its components in dry bean lines and varieties.

Materials and Methods

The research was carried out in the fields of Research and Application Centre of Faculty of Agriculture, Suleyman Demirel University, in the years 1996 and 1997. The experimental area is located in one of the transitional zones of Turkey (The Lakes Region). The soil is classified as silt clay loam texture according to Prescott et al. (1934); pH is neutral (7.5), lightly alkali, lime, middle phosphate, middle organic matter (Anonymous, 1997 a).

Average temperatures, total rainfall, average relative humidity were 12.5°C and 13.4°C, 541.6 mm and 494.4 mm, 61.1% and 64.9% in 1996 and 1997, respectively (Anonymous, 1997b).

Thirty bean cultivars or lines were grown in the fields of Researh Atabey Campus. Field experiments were conducted in a randomized complete block design with three replications. Each plot consisted of four rows that 5 m. long with 50 cm between rows. The seeding rate 20 plant m^2 (50 plant every row). Plot size was 8 m^2 at harvest. 45 kg of nitrogen, phosphorus and potassium per hectare as compose fertilizer (15-15-15) were applied prior to sowing. The Rhizobium bacterium inoculation wasn't done. The sowing was conducted 9 May 1996 and 21 May 1997 by hand. Hand hoeing was done three times. Plants were irrigated four times in 1996 and three times in 1997 at different growth periods. Plots were harvested by

hand.

Twelve agronomical characters such as number of branches, number of pods per plant, number of seeds per plant, number of seeds per pod, number of immature pods, biomass yield per plant (g), seed yield per plant (g), 1000 seed weight (g), pod lenght (cm), pod width (cm), plant height (cm) and first pod height (cm) were measured on ten plants selected randomly from all plots at each year. The seed yield was measured as mature seed harvested and threshed from 4 m lengths of four rows and added 10 plant seed yield selected for measure. An analysis of variance was made for each trait combined over years. Simple correlation coefficients were obtained between all possible combinations of characters related to seed yield per hectare. Significance of correlation coefficients were tested in the probably levels of 0.05 and 0.01. These correlations were further analyzed using path coefficients as illustrated by Li (1968).

Coefficients of correlation and path coefficients analysis of the results were done using a computerized statistical program called "TARPOPGEN" obtained from the Faculty of Agriculture, Ege University, Izmir, Turkey.

Results

Positive and significant correlations ($p<0.01$) were found among number of branches per plant ($r=+0.531^{**}$), number of pods per plant ($r=+0.531^{**}$), number of seeds per plant ($r=+0.515^{**}$), number of seeds per pod ($r=+0.234^{**}$), biomass yield ($r=+0.644^{**}$), seed yield per plant ($r=+0.673^{**}$), 1000 seed weight ($r=+0.228^{**}$) and plant height ($r=+0.490^{**}$) with seed yield per hectare according to the two-years results of the research, as seen in Table 1. However, a negative and significant correlation was determined between seed yield per hectare and number of immature pods per plant. On the other hand, correlations between seed yield per hectare and pod length, pod width and first pod height were not statistically significant.

The correlations were significantly found among number of branches per plant with number of pods per plant ($r=+0.781^{**}$) number of seeds per plant ($r=+0.710^{**}$) number of seeds per pod ($r=+0.213^{**}$) biomass yield ($r=+0.788^{**}$) and seed yield per plant ($r=+0.790^{**}$).

Positive correlations were observed among number of pods per plant with number of seeds per plant ($r=+0.866^{**}$) number of seeds per pod ($r=+0.306^{**}$) biomass yield ($r=+0.848^{**}$), seed yield per plant ($r=+0.860^{**}$) and plant height ($r=+0.188^{**}$) over two-year combined results.

Number of seeds per plant were given positive and significant associates with number of seeds per pod ($r=+0.658^{**}$), biomass yield ($r=+0.849^{**}$) and seed yield per plant ($r=+0.854^{**}$). However, significant negative correlations were found between numbers of seeds per plant with 1000 seed weight (-0.241). While number of seeds per pod had positively and significantly correlations with biomass yield and seed yield per plant, it was negative and significant correlations with number of immature pods per plant and 1000 seed weight (respectively, $r=+0.400^{**}$, $r=+0.398^{**}$, $r=-0.142^{**}$ and $r=-0.443^{**}$).

In present study, number of immature pods per plant was negative and significant correlated with biomass yield and seed yield per plant ($r=-0.216^{*}$ and $r=-0.229^{**}$, respectively). However, biomass yield had positive and significant correlations with between seed yield per plant ($r=+0.974^{**}$) and plant height ($r=+0.290^{**}$) (Table 1).

The highest correlation coefficient in the research were given relationship between biomass yield and seed yield per plant ($r=+0.974^{**}$) followed by correlations between seed yield per plant and number of pods per plant ($r=+0.860^{**}$), number of seeds per plant ($r=+0.854^{**}$) and number of branches per plant ($r=+0.790^{**}$). The highest correlation among seed yield per hectare and other characteristics were achieved by association between seed yield per hectare and seed yield per plant ($r=+0.673^{**}$).

In the study, seed yield per hectare was taken as a dependent variable and plant height, number of branches per plant, number of pods per plant, number of seeds per plant, number of seeds per pod, number of immature pods per plant, biomass yield, seed

Table 1

Correlation coefficients among some agronomical characters in dry bean*

Characters	2	3	4	5	6	7	8	9	10	11	12	13
1. Seed yield per hectare	0.531**	0.531**	0.515**	0.234**	-0.175*	0.644**	0.673**	0.228**	0.057 ns	0.013 ns	-0.101 ns	0.490**
2. Number of branches per plant	-	0.781**	0.710**	0.213**	-0.011 ns	0.788**	0.790**	0.097 ns	-0.001 ns	0.094 ns	-0.050 ns	0.237**
3. Number of pods per plants		-	0.866**	0.306**	-0.091 ns	0.848**	0.860**	-0.057 ns	0.025 ns	0.039 ns	-0.052 ns	0.188**
4. Number of seeds per plant			-	0.658**	-0,130 ns	0.849**	0.854**	-0.241**	0.025 ns	0.010 ns	0.005 ns	0.204**
5.Number of seeds per pod				-	-0.142*	0.400**	0.398**	-0.443**	0.014 ns	-0.043 ns	0.078 ns	0.115ns
6. Number of immature pods					-	-0.216**	-0.229**	-0.064 ns	-0.084 ns	-0.039 ns	0.100 ns	-0.177*
7. Biomass yield						-	0.974**	0.054 ns	0.014 ns	0.044 ns	-0.050 ns	0.290**
8. Seed yield per plant							-	0.067 ns	0.036 ns	0.044 ns	-0.058 ns	0.309**
9. 1000 seed weight								-	0.035 ns	0.092 ns	-0.051 ns	0.115 ns
10. Pod length									-	0.007 ns	0.048 ns	0.063 ns
11. Pod width											-0.037 ns	0.045 ns
12. First pod height											-	0.051 ns
13. Plant height												-

* ** Significant at P= 0.05 and P=0.01, respectively

* Correlation coefficients are values over means of two-years

yield per plant, 1000 seed weight, pod length, pod width and first pod height as independent variables. All the data were subjected to path analysis to determine the direct and indirect effects of the independent variables on the seed yield (Dewey and Lu, 1959).

Seed yield per plant had the highest positive direct effect on seed yield per hectare (+0.6684). This direct effect made up 63.1 % of the positive significant correlation (r=+0.673**) between seed yield and seed yield per plant. Also, seed yield per plant having the highest direct effect on seed yield per hectare was followed by 1000 seed weight (+0.185). It was determined that 1000 seed weight had a positive direct effect of 51.7 % on seed yield per hectare. On the other hand, plant height provided high and positive direct effect on seed yield (+0.301). This high and significant direct effect had a participation of 48.9 % to correlation between seed yield and plant height (r= + 0.490**). The first pod height showed high and negative direct effect (-0.085) on seed yield per hectare. The participation to this correlation of negative direct effect was determined as 49.4%. But an insignificant correlation was examined between seed yield and first pod height.

Association among biomass yield and seed yield per hectare gave the highest positive correlation coefficient (r=+0.644**), although seed yield was negatively and directly affected by biomass yield (-0.1064). So, biomass yield had a reducing effect the correlation between seed yield and biomass yield. This negative direct effect on seed yield contributed of 10.3 % to correlation between biomass yield and seed yield.

In our study, number of pods per plant, biomass yield, number of branches per plant, number of seeds per plant, number of seeds per pod and plant height showed the highest indirect effect on seed yield per hectare through seed yield per plant. The participation to the correlations of indirect effects were 63.6%, 63.0%, 62.8%, 58.1%, 42.3% and 33.6%, respectively (Table 2).

Seed yield per plant which formed highest and positive correlation with seed yield per hectare had hightly direct effect to this correlation (63.1%). On the other hand, the biomass yield which had a high and positive relation with seed yield per hectare showed negative and low direct effect on seed yield per hectare (-0.106). However, biomass yield displayed a high and positive indirect effect on seed yield per hectare through seed yield per plant (63.0%). Also, number of pods per plant had the highest positive indirect effect on seed yield per hectare through seed yield per plant (63.6%).

Number of branches per plant which formed positive and significant correlation with seed yield per plant, number of pods per plant and number of seeds per plant had low direct effect on seed yield per hectare whereas number of branches per plant had a high indirect effect on seed yield through seed yield per plant (62.8%).

A 1000 seed weight gave low and insignificant indirect effects on seed yield per hectare, while it formed a positive and high direct effect to the positive correlation between seed yield and 1000 seed weight.

Discussion

Knowledge of relationship among yield and the other agronomic characters is important in plant breeding, especially for the individual plant selection. If the aim of a planned breeding programme is to increase seed yield to determine associations between certain agonomical characters and seed yield provides direction correctly of plant breeding progammes. Therefore, the objective of this research was to estimate the simple correlations and to determine direct and indirect contributions of certain characters to seed yield in dry bean.

Results revealed that seed yield per hectare was positively and highly associated with number of branches per plant, number of pods per plant, number of seeds per plant, number of seeds per pod, biomass yield, seed yield per plant, 1000 seed weight and plant height. Many previous studies indicated that seed yield per hectare in the bean was positively correlated with number of pods per plant, number of seeds per pod and seed yield per plant (Duarte and Adams, 1972; Westerman and Crothers, 1977; Prakash and Ram, 1981; Onder, 1994; Onder and

Table 2

Path coefficients*—Direct effects (in first column) and indirect effects

Characters	Direct effects		Number of branches per plant		Number of pods per plant		Number of seeds per plant		Number of seeds per pod		Number of immature pods		Biomass yield		Seed yield per plant		1000 seed weight		Pod lenght		Pod width		First pod height		Plant height	
	Path	%	Path	%	Path	%	Path	%	Path	%	Path	%	Path	%	Path	%	Path	%	Path	%	Path	%	Path	%	Path	%
Number of branches per plant	0.011	1.3	-	-	0.029	3.5	-0.066	7.9	0.025	2.9	-0.001	0.04	-0.084	10.0	0.528	62.8	0.018	2.1	0.000	0.0	-0.004	0.5	0.004	0.5	0.071	8.5
Number of pods per plant	0.037	4.1	0.009	0.9	-	-	-0.081	8.9	0.035	3.9	-0.003	0.4	-0.090	10.0	0.575	63.6	-0.011	1.2	0.0004	0.04	-0.002	0.2	0.004	0.5	0.057	6.3
Number of seeds per plant	-0.093	9.1	0.008	0.8	0.032	3.3	-	-	0.076	7.7	-0.005	0.5	-0.090	9.2	0.571	58.1	-0.045	4.5	0.0004	0.04	-0.0004	0.04	-0.004	0.04	0.061	6.2
Number of seeds per pod	0.116	18.4	0.002	0.4	0.011	1.8	-0.061	9.7	-	-	-0.005	0.8	-0.043	6.8	0.266	42.3	-0.082	13.0	0.0002	0.03	0.002	0.3	-0.007	1.1	0.035	5.5
Number of immature pods	0.036	11.1	-0.001	0.04	-0.003	1.1	0.012	3.8	-0.016	5.1	-	-	0.023	7.2	-0.153	47.8	-0.012	3.7	-0.001	0.4	0.002	0.5	-0.009	2.6	-0.053	16.6
Biomass yield	-0.106	10.3	0.009	0.8	0.032	3.0	-0.079	7.7	0.046	4.5	-0.008	0.7	-	-	0.651	63.0	0.010	0.95	0.0002	0.02	-0.002	0.2	0.004	0.4	0.087	8.4
Seed yield per plant	0.668	63.1	0.009	0.8	0.032	3.0	-0.08	7.5	0.046	4.3	-0.008	0.8	-0.066	9.8	-	-	0.012	1.2	0.001	0.05	-0.002	0.2	0.005	0.5	0.093	8.8
1000 seed weight	0.185	51.7	0.001	0.3	-0,002	0.6	0.022	6.3	-0.051	14.3	-0.003	0.6	-0.066	1.6	0.045	12.8	-	-	0.001	0.15	-0.004	1.05	0.004	1.2	0.035	9.7
Pod lenght	0.016	20.5	0.000	0.01	0.001	1.2	-0.002	2.9	0.002	2.0	-0.002	3.8	-0.066	1.9	0.024	30.2	0.006	8.1	-	-	-0.003	0.4	-0.004	5.1	0.019	23.9
Pod width	-0.041	34.5	0.001	0.9	0.001	1.2	-0.001	0.8	-0.005	4.2	-0.001	1.2	-0.066	4.0	0.029	24.8	0.017	14.3	0.0001	0.1	-	-	0.003	2.6	0.013	11.4
First pod height	-0.085	49.4	-0.001	0.3	-0.002	1.1	-0.001	0.3	0.009	5.3	0.004	2.1		3.1	-0.039	22.7	-0.01	5.5	0.001	0.5	0.002	0.9	-	-	0.016	9.0
Plant height	0.301	48.9	0.003	0.4	0.007	1.1	-0.019	3.1	0.013	2.2	-0.006	1.0	-0.066	5.0	0.207	33.6	0.021	3.5	0.001	0.2	-0.002	0.3	-0.004	0.7	-	-

P: Path coefficient, %: Percentage of direct and indirect effects, *: Path coefficients are values mean of over two-years.

Ozkaymak, 1994; Bozoglu and Gulumser, 1999; Helvacɔoglu and Sehirali, 2001; Yorgancilar et al., 2003.

There were positive correlations between number of seeds per plant and number of seeds per pod, biomass yield and seed yield per plant but number of seeds per plant was negatively and highly associated with 1000 seed weight. In our study, the highest correlation coefficient was found between biomass yield and seed yield per plant followed by number of pods per plant and number of seeds per plant, while relationships between many other characters were positive and significant. Our findings on relationships between number of seeds per plant and number of seeds per pod, biomass yield and seed yield per plant were in agreement with the results reported by Peksen and Gulumser (2005). In addition, our results on correlations between number of seeds per pod and the other characters investigated are in agreement with those of Bozoglu and Gulumser (1999) and Yorgancilar et al. (2001) who reported that number of seeds per pod was positively and significantly correlations with biomass yield and seed yield but negatively and significantly associations with number of immature pods per plant and 1000 seed weight.

In present study, seed yield per plant had the geatest direct effect on seed yield, followed by 1000 seed weight and plant height. Percantages of direct effects on seed yield were 63.1%, 51.7% and 48.9%, respectively, for seed yield per plant, 1000 seed weigt and plant height. In previous studies, it was reported that pod weight and seed number per pod had highest and positive direct effect on seed yield (Amini et al., 2002; Dursun, 2007). In addition, earlier researchers revealed that direct effect of number of pods per plant on seed yield was positive and highly significant (Rodrigo et al., 1972; Sehirali, 1980; Dhiman, 1996; Pooran-Chand, 1999; Amini et al., 2002). On the other hand, Shinde and Dumbre (2001) found that 100 seed weight and number of seeds per pod showed strong positive direct effects while number of pods per plant and number of branches per plant showed moderate direct effects.

According to the results of present study, number of pods per plant, biomass yield, number of branches per plant, number of seeds per plant number of seed per pod and plant height gave the highest indirect effects on seed yield per hectare over seed yield per plant. A proportion of 63.6% of positive and significant correlation (r=+0.531) between number of pods per plant and seed yield per hectare was achieved by indirect effect (+0.575) over seed yield per plant of number of pods per plant. In a similar research, Peksen and Gulumser (2005) reported that seed weight had highest indirect effect on seed yield through number of seeds per pod. Dursun (2007) found that number of seeds per pod showed the highest indirect effect on yield via wet pod weight.

Conclusions

Correlation and path analysis were made between plant height, 1000 seed weight, seed yield per plant, seed number per pod, biomass yield, seed number per plant, pod number per plant, number of branches per plant, number of immature pods, pod lenght pod width, first pod height with seed yield per hectare in the research, including dry bean lines and varieties. In the breeding of dry bean, generally highly positive correlations between seed yield and seed number per pod, seed number per plant, pod number per plant and branch number are expected and desired. In this study, positive and significant associations were observed between seed yield per hectare and branch number, pod number per plant, seed number per plant, seed number per pod, seed yield per plant, biomass yield, 1000 seed weight, and plant height according to the two years results.

Path analysis indicated that direct effect of seed yield per plant on seed yield per hectare was positive and the highest in the study. This trait was followed by plant height and 1000 seed weight. However, number of pod per plant had the highest positive indirect effects on seed yield per hectare via seed yield per plant.

As results, the path coefficient analysis showed that seed yield per plant, 1000 seed weight and plant height were the most important characteristics in determin-

ing seed yield per hectare. The results relived that seed yield per plant, 1000 seed yield and plant height could be used as a selection criterion in dry bean breeding for high yield.

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