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Correlation and Path Analysis for Yield and Yield Components in Common Bean Genotypes (*Phaseolus vulgaris* L.)

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Summary: Determination of breeding criteria is quite important for plant breeders. The present study was carried out to determine yield and its components which are affecting seed yield and to study the relationships between yield components and other characteristics. A total of 42 common bean genotypes that are widely grown in Turkey were used as material. Direct and indirect effects of the yield components on seed yield were analyzed using path coefficient analysis. Seed yield (kg ha^{-1}) was most affected by biologic yield (84.56%), harvest index (65.47%) as positive and negatively affected by number of main branches per plant (28.45%) and flowering day (13.27%) respectively. Correlation analysis showed that seed yield (kg ha^{-1}) was effected by biologic yield (0.8224**), harvest index (0.2913**) as positive and negatively affected by flowering day (-0.3256**), first pod height (-0.2473**), plant height (-0.2406**) and pod number per plant (-0.2272*) respectively. According to the path analysis, the biologic yield, harvest index, number of main branch per plant and days to flowering are important due to direct effect on the increase of seed yield on selection studies.
Key words: beans, path coefficient, seed yield, yield components

Introduction

Dry bean has superior adaptation ability. It has a wide range of genetic diversity in Turkey especially in Konya which has the most production quantity. A previous research showed that a total of 38 common dry bean genotypes were ranged as the values from 0.48 to 0.97 genetic similarity degrees which welded the ISSR method. Several researches related to the yield of dry bean (kg ha^{-1}) in different regions of Turkey was summarized as following: 840-1320 in Ankara (Şehirali 1971), 2341 in Erzurum (Akçin 1974), 1150-2260 in Samsun (Özçelik & Gülümser 1988), 1130-1150 in Van (Yılmaz & Çiftçi 1994), 574-1196 in Çukurova (Anlarsal et al. 2000), 692.9-1550.7 in Konya (Kahraman & Önder 2009).

Seed yield is one of the main purposes in breeding programs. It is recommended to develop the useful plant genotypes which are adaptive to the region. In this respect, breeders who need to specify the basics of selection should determine the impact factors and the degree of relationships through yield components (Torun & Köycü 1999). Understanding of the interactions between the plant characteristics which are effective in the region, component of yield and quality in plants is the main principle of the variety improving programs (Poehlman 1979). Yield is a quantitative characteristic which is under the effects of many factors by means of genetic structure. Some of the characters affect the yield as directly while the others effect indirectly (Önder & Şentürk 1996). Therefore, path analysis is used as a supplement component of correlation coefficients. This calculation allows separation of components as their direct and indirect effects and it uses a standard partial regression coefficient (Ghoss & Chatterjee 1988, Shabana et al. 1990). Path analysis method gives the exact idea about the effects of every single characteristic on yield or quality (Önder

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1995, Önder 1996, Önder & Akçin 1996, İşler & Çalışkan 1998, Önder & Babaoğlu 2001).

This research was made to estimation of the correlations and path analysis among some important characteristics in dry bean genotypes to determine selection criteria for high yield. Using correlation alone is not enough to understand the importance of the direct and indirect influence from individual components on seed yield. Therefore, path analysis was made to figure out the section criteria which based on seed yield.

Materials and Methods

In this research, a total of 42 common bean genotypes (Table 2) that are widely grown in Turkey were used as material. All of the used common bean genotypes were collected depending on the following criteria: situation of preference, stability status over years, harvested in the last year, high market and cooking quality. The growth type of the used genotypes is dwarf. Field observations which were performed according to the randomized complete block design with three replications during the year of 2008 were as follows: days to flowering, number of main branches per plant, number of leafs per plant (during flowering time), plant height (cm), number of pod per plant, number of seed per pod, first pod height (cm), biologic yield (kg ha^{-1}), yield (kg ha^{-1}), harvest index (%) and 1000 seed weight (g). The means of investigated characteristics of the used genotypes were used in a different study which is entitled as "Determination of Yield and some Yield Components of Common Bean (*Phaseolus vulgaris* L.) Genotypes that Grown in Konya Province" as an oral presentation in Hatay/Turkey (Kahraman & Önder 2009).

The relationships between the investigated characteristics and seed yield per plant, correlation coefficients, direct and indirect effects were performed using "TARIST" computerized statistical program.

Results and Discussion

Summary of the analysis of variance and the investigated values is shown in Table 1. Most of the investigated characteristics showed statistically importance at the level of 1%.

Analysis to determine the correlation coefficients (Table 2) revealed that seed yield was affected by biologic yield (0.8224**), harvest index (0.2913**) as positive and negatively affected by flowering day (-0.3256**), first pod height (-0.2473**), plant height (-0.2406**) and pod per plant (-0.2272*) respectively (Table 3).

Path analysis showed that the most important characteristics were the biologic yield, harvest index, number of main branch per plant and days to flowering, due to their direct effect on seed yield of the investigated common bean genotypes (Table 4).

According to the results of the present study, seed yield was mostly affected by biologic yield (84.56%), harvest index (65.47%) as positive and negatively affected by main branch per plant (28.45%) and flowering day (13.27%) respectively.

A previous research reported that the yield affecting factors in dry bean were number of pod per plant, number of seed per pod, weight of seed

Table 1. Variance analysis and values of the investigated characteristics

Characteristics	Variance analysis summary	Genotype					
		Minimum			Maximum		
		No	Name	Value	No	Name	Value
Seed yield (kg da^{-1})	XX	22	Şeker	69.29	12	Amerikan Çalısı	155.07
Days to flowering	ns	29	Üveynk	40.67	34	Ayşe Kadın	58.00
Number of leaf per plant	XX	44	Horoz	19	15	Dermason	42.50
Number of pod per plant	XX	17	Weihing	10.05	6	Horoz	42.84
Number of seed per pod	XX	19	Akman 98	3.42	15	Dermason	7.67
Number of main branch per plant	ns	15	Dermason	6.67	16	Horoz	10.33
Plant height (cm)	XX	20	Amerikan	31.23	22	Şeker	112.23
First pod height (cm)	XX	9	Kanada	4.60	19	Akman 98	20.25
Harvest index (%)	XX	38	Dermason	33	8	Bombay	58
1000 seed weight (g)	XX	2	Sarıkız	239.78	31	Kırgız Yuvarlak	416.15

XX: p<1%, ns: not significant

Table 2. Collection number (no), place (source) of collection and local names of the investigated dry bean genotypes (*: Certified lines)

No	Place	Local name
1	Başarakavak Town 1	Horoz
2	Başarakavak Town 2	Sarıkız
3	Başarakavak Town 3	Kanada
4	Çumra 1	Şeker (Bıyıklı)
5	Çumra 2	Kırgız Çalısı
6	Çumra 3	Horoz
7	Çumra 4	Beyşehir Çalısı
8	Çumra 5	Bombay (Bomba)
9	Çumra 6	Kanada
10	Altınekin 1	Amerikan Kollu
11	Altınekin 2	Sarnıç
12	Altınekin 3 (Mantar Village)	Amerikan Çalısı
14	Konya (Center)	Gina
15	Ereğli 1 (Center)	Dermason
16	Ereğli 2 (Center)	Horoz
17	Kadınhanı 1	Weihing
18	Kadınhanı 2	Kanada
19	Kadınhanı 3	Akman 98*
20	Derbent 1	Amerikan (Beretta)
22	Derbent 5	Şeker
23	Beyşehir 1 (Göçü Village)	Horoz
24	Seydişehir 1	Sıra (originated from Çumra)
25	Ilgın 1 (Beykonak Village)	Beyaz Horoz
27	Sarayönü 1	Kanada
28	Sarayönü 2 (Bayramlı Village)	Amerikan Çalısı
29	Yunak 2	Üveynk (Veynk)
30	Yunak 4	Kanada
31	Çumra 7	Kırgız Yuvarlak (Kollu Barbunya)
32	Derbent 2	Yuvarlak Barbunya
33	Akşehir 4	Dermason
34	Akşehir 5 (Sorkun Village)	Ayşe Kadın
35	Akşehir 6	Horoz (Oturak)
36	Akşehir 7	Dermason (Oturak)
37	Kazım Karabekir 1	Kanada (Kara Yaprak)
38	Kazım Karabekir 2	Dermason (Kırgız)
39	Eskişehir- Anadolu Agr. Res. Ins.	Akman 98*
40	Eskişehir- Anadolu Agr. Res. Ins.	Eskişehir-855*
41	Erzurum- Atatürk University	Elkoca-2005*
42	Erzurum- Atatürk University	Kantar-2005*
43	Çumra 8	Amerikan Çalısı
44	Derbent 3	Horoz
45	Akşehir 2	Ayşekadın

Table 3. Correlations among the investigated characteristics in the investigated common bean genotypes.

Investigated characteristics	1000 seed weight (g)	Flowering day	Main branch/Plant	Leaf/Plant	Plant height (cm)	Pod/Plant	Seed/Pod	First pod height (cm)	Biologic yield (kg da^{-1})	Yield per da (kg da^{-1})	Harvest index (%)
1000 seed weight (g)	1,0000	-	-	-	-	-	-	-	-	-	-
Flowering day	0,1516	1,0000	-	-	-	-	-	-	-	-	-
Main branch/Plant	-0,0011	-0,0376	1,0000	-	-	-	-	-	-	-	-
Leaf/Plant	-0,0839	0,1408	-0,0355	1,0000	-	-	-	-	-	-	-
Plant height (cm)	0,0197	0,2353**	-0,0460	0,1639	1,0000	-	-	-	-	-	-
Pod/Plant	-0,0280	0,1451	0,2300**	0,1221	0,3041**	1,0000	-	-	-	-	-
Seed/Pod	-0,2377**	-0,0687	-0,1443	0,0933	-0,1256	-0,1707	1,0000	-	-	-	-
First pod height (cm)	0,2277*	0,1762*	0,0226	0,2601**	0,1335	0,2832**	-0,1871*	1,0000	-	-	-
Biologic yield (kg da^{-1})	0,2438**	-0,2067*	-0,0071	-0,0796	-0,1566	-0,1726	0,0754	-0,0384	1,0000	-	-
Seed Yield (kg da^{-1})	0,0844	-0,3256**	-0,0050	-0,1445	-0,2406**	-0,2272*	0,1547	-0,2473**	0,8224**	1,0000	-
Harvest index (%)	-0,2456**	-0,1543	0,0283	-0,1089	-0,1732	-0,0853	0,1244	-0,3600**	-0,2742**	0,2913**	1,0000

Table 4. Direct – indirect effects, and contribution (%) of various characteristics to seed yield in the investigated common bean genotypes.

Investigated characteristics	Correlation	Direct Effects		Indirect Effects																			
				1		2		3		4		5		6		7		8		9		10	
		P	%	P	%	P	%	P	%	P	%	P	%	P	%	P	%	P	%	P	%	P	%
1.1000 seed weight (g)	0,0844	-0.0135	3.3547	-	-	-0.0070	1.7427	0.0000	0.0113	0.0007	0.1830	0.0058	1.4398	0.0002	0.0417	-0.0031	0.7617	0.0008	0.1930	0.2341	57.9774	-0.1385	34.2948
2.Flowering day	-0,3256**	-0.0469	13.2781	-0.0020	0.5749	-	-	0.0004	0.1189	-0.0013	0.3571	0.0129	3.6449	-0.0013	0.3629	-0.0009	0.2441	0.0006	0.1641	-0.2011	56.9155	-0.0860	24.3395
3.Main branch/Plant	-0,0050	-0.0119	28.4541	-0.0001	0.1251	0.0017	3.9802	-	-	0.0004	1.0571	-0.0012	2.9483	-0.0020	4.8940	-0.0018	4.3345	0.0001	0.1863	-0.0058	13.8921	0.0167	40.1283
4.Leaf/Plant	-0,1445	-0.0088	5.4392	0.0011	0.6970	-0.0067	4.1238	0.0006	0.3647	-	-	0.0057	3.4994	-0.0010	0.6433	0.0012	0.7417	0.0009	0.5590	-0.0728	44.8084	-0.0636	39.1235
5.Plant height (cm)	-0,2406**	0.0356	7.5131	-0.0022	0.4680	-0.0170	3.5916	0.0004	0.0868	-0.0014	0.2986	-	-	-0.0022	0.4601	-0.0029	0.6052	0.0007	0.1505	-0.2360	49.8707	-0.1749	36.9553
6.Pod/Plant	-0,2272*	-0.0089	3.5829	0.0003	0.1042	-0.0068	2.7502	-0.0027	1.1080	-0.0010	0.4222	0.0087	3.5380	-	-	-0.0021	0.8683	0.0009	0.3793	-0.1679	67.9310	-0.0477	19.3160
7.Seed/Pod	0,1547	0.0126	7.2293	0.0033	1.9084	0.0032	1.8537	0.0017	0.9835	-0.0008	0.4878	-0.0081	4.6648	0.0015	0.8702	-	-	-0.0006	0.3560	0.0726	41.7486	0.0693	39.8978
8.First pod height	-0,2473**	0.0033	1.1981	-0.0032	1.1817	-0.0083	3.0456	-0.0003	0.1033	-0.0025	0.8986	0.0077	2.8360	-0.0025	0.9291	-0.0024	0.8702	-	-	-0.0423	15.5006	-0.2005	73.4368
9.Biologic yield (kg/da)	0,8224**	0.9744	84.5666	-0.0033	0.2825	0.0097	0.8407	0.0001	0.0061	0.0007	0.0573	-0.0086	0.7476	0.0015	0.1324	0.0009	0.0812	-0.0001	0.0123	-	-	-0.1529	13.2732
10.Harvest index (%)	0,2913**	0.5574	65.4729	0.0034	0.3953	0.0072	0.8505	-0.0004	0.0419	0.0010	0.1184	-0.0112	1.3105	0.0008	0.0891	0.0016	0.1836	-0.0012	0.1382	-0.2673	31.3996	-	-

and number of plant in unit area. In this research, the results of path analyze were differed depending on varieties (Westermann & Crothers 1977). Similarly, the most effective factors in common bean were determined as plant height, number of pod, number of seed per pod and 1000 seed weight (Önder & Özkaynak 1994). Another research revealed that the bean characteristics such as number of seed per pod, number of leaf per plant, plant height and 1000 seed weight had direct effects on the yield (Yorgancılar et al. 2003).

Seed yield in bean showed positive and high level of relation with number of pod per plant, biologic yield, 1000 seed weight, plant height, harvest index, seed size index and flowering period (Bozoğlu & Gülümser 1999).

Research in some common bean genotypes presented that seed yield had an important and positive relationship with plant height, and it had positive and high level of relationships with number of pod, number of seed per plant, length of pod, stem yield and height of first pod (Pekşen & Gülümser 2005). Path analysis revealed that the main contributors of seed yield were number of seed (0.8605), average seed weight (0.4314) and number of pod per plant (0.3408) respectively due to their high, direct and positive effects. This valued research proved that the mentioned characteristics could be used as selection criteria to achieve high seed yield in breeding trials of common bean genotypes.

Conclusions

Data of the present research showed that the biologic yield and harvest index had positive effects on seed yield, while number of main branch per plant and days to flowering had negative effects on seed yield. Evaluation of the investigated common bean genotypes in terms of seed yield was also made by path analysis. This method put forth that the biologic yield, harvest index, number of main branch per plant and days to flowering had positive effects on seed yield.

Results of this study recommend that the mentioned characteristics could be used in common bean selection programs which are based on seed yield.

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Korelaciona i path analiza prinosa i komponenti prinosa u genotipovima pasulja (*Phaseolus vulgaris* L.)

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Sažetak: Određivanje oplemenjivačkih kriterijuma je veoma važno za oplemenjivače. Ovo istraživanje je sprovedeno da bi se utvrdio prinos i njegove komponente koje imaju uticaj na prinos semena, kao i da bi se izučili odnosi između komponenti prinosa i drugih karakteristika. Ukupno 42 genotipa pasulja koji su gajeni širom Turske su korišćeni kao materijal. Direktni i indirektni efekti komponenti prinosa na prinos semena su analizirani koristeći path analizu. Na prinos semena (kg ha-1) najveći pozitivni uticaj su ispoljili biološki prinos (84,56%) i žetveni indeks (65,47%), a negativni broj glavnih stabljika po biljci (28,45%) i dana do cvetanja (13,27%). Korelaciona analiza je pokazala da su na prinos semena (kg ha-1) pozitivni uticaj ispoljili biološki prinos (0,8224**), žetveni indeks (0,2913**), a negativni dani do cvetanja (-0,3256**), visina prve mahune (-0,2473**), visina biljke (-0,2406**) i broj mahuna po biljci (-0,2272*). Prema path analizi, biološki prinos, žetveni indeks, broj glavnih stabljika po biljci i dani do cvetanja su značajni zbog direkton efekta na povećanje prinosa semena u selekcionim ispitivanjima.

Ključne reči: komponente prinosa, pasulj, path analiza, prinos semena