EVALUATION OF DIVERSITY FOR YIELD TRAITS IN DRY BEAN GENOTYPES FROM ROMANIA

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Abstract: *Common bean (Phaseolus vulgaris L.) is the most important edible food legume in the world, representing 50 % of grain legumes for direct human consumption, normally complementing cereals. Common bean is an interesting crop from the point of view of the consumer, farmer and processor. In plant breeding, grain yield of a cultivar is usually the most important attribute for crop production. Globalisation of trade in agricultural products will increase the pressure to improve bean yields. Seed yield in P. vulgaris is generally expressed as the product of three components: pods/plant, seeds/pod and seed weight. The objective of the current study was to evaluate the phenotypic diversity between 15 dry bean genotypes from Romania in terms of some yield traits, in order to identify the genotypes which could be considered of interest in breeding programs. Following the study, genotypes that exhibit high values of yield traits were identified, which can be used as genes source for breeding of dry bean. Therefore, at F 822/95 line the high level of yield per plant is strongly associated with high number of pods/plant and number of grains/plant, and a medium value of TGW, respectively. Ami variety and F 835/95, F 1247/92, F 962/97 lines, recorded higher yield and values of the other traits above the experience mean. Crossing the phenotypically differentiated genotypes like: Avans - F 822/95; Vera - F 822/95; Diva - Avans; F 1235/91 - F 822/95 ; F 835/95 - F 822/95, allows obtaining hybrids that possess useful gene combinations and show high levels of heterosis for different yield traits.*

Key words: dry bean, phenotypic diversity, yield traits

INTRODUCTION

Globalisation of trade in agricultural products will increase the pressure to improve bean yields. Yet, in a crop as diverse as beans, yield potential must be taken in a very relative sense. Thus goals for yield potential must be seen in the context of a given region, production system and grain type. Breeding for high yield in dry bean must be conducted within the major constraints of growth habit, maturity (adaptation), and seed size (quality) preferences as well as disease resistance factors (Kelly et al 1998).

Seed yield in *P. vulgaris* is generally expressed as the product of three components: pods/plant, seeds/pod and seed weight. Generally, the highest seed yields are obtained when all these components are maximized (Dawo and Sanders, 2007). The seed size for bush determinate Type I and indeterminate Type II and III cultivars is often negatively correlated with yield and its components, pods/plant and seeds/pod (Nienhuis and Singh 1986; White and Gonzalez 1990).

Selection for greater seed yield tends to increase harvest index to the point where biomass accumulation during the growing season becomes a limiting factor (Beaver and Osorno, 2009). Beebe et al. (2008) reported that bean lines selected for abiotic stress tolerance also had greater harvest indices and increased seed yield in favorable environments. Wallace et al. (1993) recommended that breeding for increased seed yield potential should include simultaneous selection for increased biomass accumulation and a greater rate of seed yield accumulation.

The objective of the current study was to evaluate the phenotypic diversity between 15 dry bean genotypes from Romania in terms of some yield traits, in order to identify the genotypes which could be considered of interest in breeding programs.

MATERIAL AND METHODS

The studied material was composed by six varieties and nine lines of dry bean with determinate growth. The experimental design was a randomized complete block (RCB) with three replications, during 2010-2011. From each plot 20 plants were evaluated for the following yield traits: pods number/plant; grains number/plant; grains weight/plant; 1000 grains weight.

The data were analyzed by Jaccard similarity coefficients, UPGMA cluster analysis (Fielding, 2007), principal components, ANOVA (Ciulca 2006). The distance matrix was used for cluster analysis using the unweighted pair-group method with arithmetic averages (UPGMA), with the Neighbor program of the Phylip package, version 3.5c.

To make possible the display in a single graph of the performance of each genotype for each of the five traits, the basic principle of the biplot technique developed by Gabriel (1971) and GGE biplot method developed by Yan et. al. (2000) was used.

RESULTS AND DISCUSSIONS

The pods number/plant for varieties and lines included in the study (Table 1) ranged between 5,50 in Avans variety and 10,20 in F822/95 line, with a variation amplitude of 4.70, on the background of a high variability within genotypes respectively a medium one between genotypes. The highest share submits the varieties and lines with 6-7, respectively 7-8 pods per plant.

Table 1

The significance of differences between dry bean genotypes in terms of pods number/plant

No	Genotype	Pods number/plant	Compared to exper.mean		Compared to control	
		$\bar{x} \pm s_{\bar{x}}$	Relative value (%)	Difference Significance	Relative value (%)	Difference Significance
1	Star	6.82±0.62 cde	92.41	-0.56	100.00	Control
2	Diva	8.78±0.84 b	118.97	1.40*	128.74	1.96**
3	Vera	6.73±0.82 cde	91.19	-0.65	98.68	-0.09
4	Avans	5.50±0.34 e	74.53	-1.88^{00}	80.65	-1.32
5	Ami	7.88±0.84 bc	106.78	0.50	115.54	1.06
6	Ardeleana	7.75±0.55 bc	105.01	0.37	113.64	0.93
7	F 1235/91	6.01±0.68 de	81.44	-1.37^{0}	88.12	-0.81
8	F 23C/93	6.13±1.23 de	83.06	-1.25	89.88	-0.69
9	F 835/95	6.86±0.80 cd	92.95	-0.52	100.59	0.04
10	F 962/97	7.85±0.84 bc	106.37	0.47	115.10	1.03
11	F 831/95	7.25±1.80 bcd	98.24	-0.13	106.30	0.43
12	F 957/96	6.93±0.68 cd	93.90	-0.45	101.61	0.11
13	F 822/95	10.20±1.45 a	138.21	2.82***	149.56	3.38***
14	F 1247/92	7.50±1.77 bc	101.63	0.12	109.97	0.68
15	F 504/96	8.50±0.65 b	115.18	1.12	124.63	1.68*
	Exper. mean	7.38±0.31	100.00	Control	108.21	0.56

$LSD_{5\%}$	$LSD_{1\%}$	$LSD_{0.1\%}$
1.33	1.79	2.37

In comparison with the experience mean, about 47% of the genotypes recorded a higher number of pods, but positive and statistically assured differences were presented by F

822/95 (2,82***) line and Diva (1,40*) variety, while Avans and 1235/91 achieved a significantly lower number of pods to experience mean.

Against Star as a control variety, most of the studied genotypes with four exceptions (Vera and Avans varieties, F 1235/91 and F 23C/93 lines respectively) have achieved higher values of this trait. The largest statistically assured increases were recorded at: F 822/95 (3,38***) and Diva 1,96**), as such the listed genotypes are worthy of being considered and used in the selection process or as a genes source for improving the number of pods/plant.

In terms of the number of grains/plant (Table 2) the studied collection ranged between 23,25 in F 23C/93 and 40,22 for Diva, with a variation amplitude of 16.97 and a medium variability between genotypes, and a high one within them, respectively. The majority of genotypes achieved between 30 and 40 grains/plant

Table 2

The significance of differences between dry bean genotypes in terms of grains number/plant

No	Genotype	Grains number/plant $\bar{x} \pm s_{\bar{x}}$	Compared to exper.mean		Compared to control	
			Relative value (%)	Difference Significance	Relative value (%)	Difference Significance
1	Star	30.91±2.92 bcd	101.38	0.42	100.00	Control
2	Diva	40.22±5.50 a	131.91	9.73*	130.12	9.31*
3	Vera	29.64±5.15 cde	97.21	-0.85	95.89	-1.27
4	Avans	20.10±1.65 f	65.92	-10.39^{00}	65.03	-10.81^{00}
5	Ami	35.13±3.72 abc	115.22	4.64	113.65	4.22
6	Ardeleana	28.25±3.52 cde	92.65	-2.24	91.39	-2.66
7	F 1235/91	28.70±3.47 cde	94.13	-1.79	92.85	-2.21
8	F 23C/93	23.25±5.45 ef	76.25	-7.24	75.22	-7.66^{0}
9	F 835/95	30.71±3.08 bcd	100.72	0.22	99.35	-0.20
10	F 962/97	33.77±4.22 abcd	110.76	3.28	109.25	2.86
11	F 831/95	23.04±5.76 ef	75.57	-7.45^{0}	74.54	-7.87^{0}
12	F 957/96	26.86±2.96 def	88.09	-3.63	86.90	-4.05
13	F 822/95	38.80±8.56 a	127.25	8.31*	125.53	7.89*
14	F 1247/92	30.83±7.10 bcd	101.12	0.34	99.74	-0.08
15	F 504/96	37.17±3.82 ab	121.91	6.68	120.25	6.26
	Exper. mean	30.49±1.51	100.00	Control	98.64	-0.42

$LSD_{5\%}$	$LSD_{1\%}$	$LSD_{0.1\%}$
7.36	9.93	13.18

In comparison with the experience mean, about 54 % of the genotypes achieved a higher grains number/plant, without these differences to be significant, except F 822/95 line (8,31*) and Diva (9,73*) variety. Therefore, increases of 15-16% were observed for F 504/96 and Ami. In case of Avans variety and F 831/95 line it has recorded a number of grains / plant significantly below the experience mean.

Compared to Star variety higher values of this trait were observed for five genotypes, but only F 822/95 line submitted significant differences. Also, this character showed significantly lower values in Avans variety ($-10,81^{00}$) and F 23C/93 ($-7,66^{0}$), F 831/95 ($-7,87^{0}$) lines.

For studied varieties and lines (Table 3), TGW recorded values between 309 g for Vera and 574 g for F831/95, with a variation amplitude of 265 g, on the background of a high variability within genotypes and a medium one between genotypes, respectively. The highest share (53%) is represented by the varieties and lines with a TGW over 500 g, while at four genotypes this trait range between 400 and 500 g, and at three genotypes values below 400 g have been registered, respectively.

Reported to the experience mean, about 60% of the genotypes showed higher values of this trait, but significant increases were presented only by F 831/95 (21.56 %) line, while at Ardeleana and Vera varieties a significant reduction of TGW with 20-35% has been found.

Compared to Star contro variety, most of the studied genotypes with five exceptions (Diva, Vera and Ardeleana varieties, F 1235/91 and F 504/96 lines) have achieved higher values of TGW. The largest significant increases were recorded at: F 831/95 (134 g), F 23C/93 (98 g) şi F 835/95 (95 g), as such the listed genotypes are worthy of being considered and used in the selection process or as a genes source for grains size. Across the experience F831/95 showed a significant and superior grain size to 50% of the remaining genotypes, with increases ranging between 96 and 309 g.

Table 3

The significance of differences between dry bean genotypes in terms of 1000 grains weight

No	Genotype	TGW (g)	Compared to exper.mean		Compared to control	
		$\bar{x} \pm s_{\bar{x}}$	Relative value (%)	Difference Significance	Relative value (%)	Difference Significance
1	Star	439±28 cdef	93.08	-33	100	Control
2	Diva	422±39 def	89.50	-50	96.15	-17
3	Vera	309±34 g	65.55	-163^{000}	70.42	-130^{00}
4	Avans	523±33 abc	110.89	51	119.13	84
5	Ami	502±43 abcd	106.44	30	114.36	63
6	Ardeleana	380±21 fg	80.47	-92^{0}	86.45	-60
7	F 1235/91	396±26 efg	83.86	-76	90.09	-44
8	F 23C/93	538±72 ab	113.91	66	122.37	98*
9	F 835/95	534±25 ab	113.14	62	121.55	95*
10	F 962/97	530±44 ab	112.24	58	120.58	90*
11	F 831/95	574±49 a	121.56	102*	130.60	134**
12	F 957/96	478±41 bcde	101.36	6	108.89	39
13	F 822/95	502±58 abcd	106.31	30	114.22	62
14	F 1247/92	550±54 ab	116.48	78	125.14	110*
15	F 504/96	406±28 ef	86.01	-66	92.41	-33
	Exper. mean	472±20	100	Control	107.43	33

$LSD_{5\%}$	$LSD_{1\%}$	$LSD_{0.1\%}$
90 g	121 g	161 g

Regarding the grain weight/plant the experimented genotypes showed values (Table 4) between 9,17 g for Vera and 19,47 g for F 822/95, with a high variatiobn amplitude (10.30 g), due to a high interindividual variability in most of the lines and varieties. Approximately 60% of genotypes recorded a grain yield / plant up to 16 g.

Against the experience mean, around 47 % of the studied genotypes showed a higher grain yield / plant, without registering significant differences, except for F 822/95 (5,18*). High values of yield and also increases of 18-25% have been observed in: Ami, F 1247/92 and F 962/97. For Vera variety the value of this trait was significantly below experience mean.

Table 4

The significance of differences between dry bean genotypes in terms of grains weight/plant

No	Genotype	Grains weight/plant $\overline{x} \pm s_{\overline{x}}$	Compared to exper.mean		Compared to control	
			Relative value (%)	Difference Significance	Relative value (%)	Difference Significance
1	Star	13.58±1.53 cdef	95.03	-0.71	100.00	Martor
2	Diva	16.99±2.49 abc	118.89	2.70	125.11	3.41
3	Vera	9.17±1.60 g	64.17	-5.12^0	67.53	-4.41^0
4	Avans	10.52±1.34 fg	73.62	-3.77	77.47	-3.06
5	Ami	17.65±2.41 ab	123.51	3.36	129.97	4.07*
6	Ardeleana	10.73±0.69 fg	75.09	-3.56	79.01	-2.85
7	F 1235/91	11.36±1.15 efg	79.50	-2.93	83.65	-2.22
8	F 23C/93	12.50±3.39 defg	87.47	-1.79	92.05	-1.08
9	F 835/95	16.40±1.46 abcd	114.77	2.11	120.77	2.82
10	F 962/97	17.89±2.10 ab	125.19	3.60	131.74	4.31*
11	F 831/95	13.22±2.70 cdef	92.51	-1.07	97.35	-0.36
12	F 957/96	12.85±1.67 defg	89.92	-1.44	94.62	-0.73
13	F 822/95	19.47±3.31 a	136.25	5.18*	143.37	5.89**
14	F 1247/92	16.95±3.35 abc	118.61	2.66	124.82	3.37
15	F 504/96	15.09±1.52 bcde	105.60	0.80	111.12	1.51
	Exper. mean	14.29±0.81	100.00	Martor	105.23	0.71

$LSD_{5\%}$	$LSD_{1\%}$	$LSD_{0.1\%}$
3.98 g	5.36 g	7.12 g

In comparison with Star variety, significant increases in grains weight/plant were observed for: Ami (4,07*), F 962/97 (4,31*) and F 822/95 (5,89**). Also in the case of Vera variety, the values of grains yield / plant were significantly lower than this control.

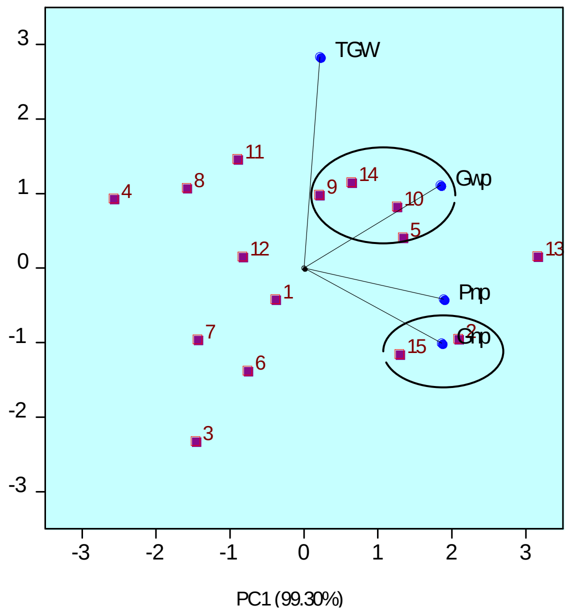

Fig. 1. Biplot for the studied genotypes and yield traits

For these genotypes the multivariate analysis (Fig.1) based on the first two principal components fully expresses the variability of the four traits included in the study. The biggest differences between genotypes were recorded for TGW, while in terms of pods number/plant the intergenotipic variability was the lowest.

Depending on the projection of each genotype on the vectors of different traits, it is found that for F 822/95 the high level of yield per plant is strongly associated with high number of pods / plant and number of grains / plant, and a medium value of TGW, respectively. In the case of Diva variety and F 504/96 line, the high number of pods and grains per plant provide a yield higher than mean, associated with a reduced grain size. Ami variety and F 835/95, F 1247/92, F 962/97 lines, recorded higher yield and values of the other traits above the experience mean. The upper grains size for Avans, F 23C/93, F 831/95, was associated with low values, below average for the other traits.

According to the vectors position on biplot, it is noted that at the studied genotypes the high values of yield are strongly correlated with high numbers of pods and grains on plant, and a small size of the grains respectively.

The highest similarity in terms of analyzed traits at these genotypes was recorded between: F 835/95 - F 1247/92 (99.38 %); F 962/97 – F 1247/92 (98.98 %); Diva – F 504/96 (98.39 %); Star – F 957/96 (98.30 %); F 23C/93 – F 831/95 (97.99 %). As such, it is unlikely that the hybrids obtained by combining these genotypes to show high levels of heterosis for yield traits. A high phenotypic diversity was recorded between the genotypes: Avans - F 822/95 (65.64 %); Vera - F 822/95 (57.05 %); Diva - Avans (50.68 %); F 1235/91 - F 822/95 (45.68 %); F 835/95 - F 822/95 (45.59 %). Crossing these phenotypically differentiated genotypes allows obtaining hybrids that possess useful gene combinations for different yield traits

Following the study, genotypes that exhibit high values of yield traits were identified, which could be considered of interest in breeding programs. Therefore, at F 822/95 line the high level of yield per plant is strongly associated with high number of pods/plant and number of grains/plant, and a medium value of TGW, respectively. Ami variety and F 835/95, F 1247/92, F 962/97 lines, recorded higher yield and values of the other traits above the experience mean.

Crossing the phenotypically differentiated genotypes like: Avans - F 822/95; Vera - F 822/95; Diva - Avans; F 1235/91 - F 822/95 ; F 835/95 - F 822/95, allows obtaining hybrids that possess useful gene combinations and show high levels of heterosis for different yield traits.

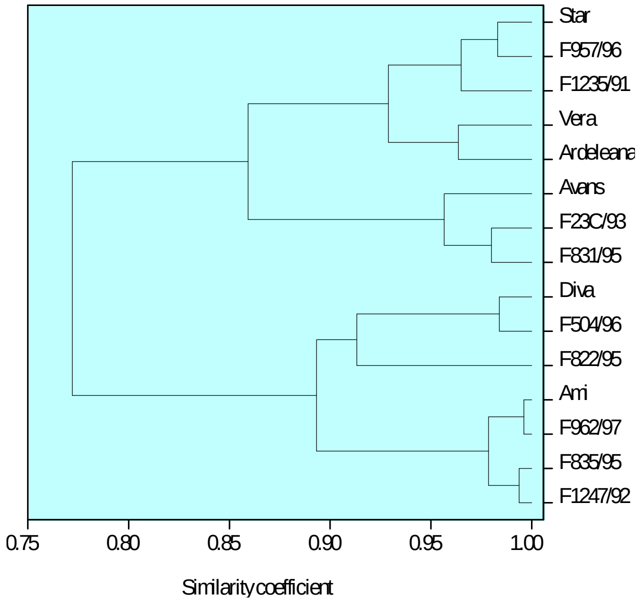

Fig. 2. UPGMA clustering of dry bean genotypes according to yield traits

Based on phenotypic similarity for the studied traits, the bean varieties and lines were grouped into two main clusters (Fig.2) between which there is a diversity of 23%. The first subcluster is composed of varieties: Star, Vera, Ardeleana, along with lines F 957/96 and F1235/91, between which there is a phenotypic similarity of 93% and which are mainly characterized by low levels of yield and other traits. Avans variety and F 23 C/93, F 831/95 lines, make up the second subcluster of the first group, showing high similarity (96 %) between themselves for studied traits, the background of their low values and large grains. At the level of this first cluster a diversity of around 14% was found.

The second cluster includes two subclusters with a phenotypic similarity of approximately 90% between them. The first subcluster is composed of the genotypes Diva, F 504/96 and F 822/95 characterized by high levels of yield and small grains size. Ami variety and F 835/95, F 1247/92 and F 962/97 lines compose the second subcluster with an average similarity of approximately 97.5%.

CONCLUSIONS

Following the study, genotypes that exhibit high values of yield traits were identified, which can be used as genes source for breeding of dry bean. Therefore, at F 822/95 line the high level of yield per plant is strongly associated with high number of pods/plant and number of grains/plant, and a medium value of TGW, respectively. This line showed significant production increases towards about 64 % of the genotypes. Ami variety and F 835/95, F 1247/92, F 962/97 lines, recorded higher yield and values of the other traits above the experience mean.

Crossing the phenotypically differentiated genotypes like: Avans - F 822/95; Vera - F 822/95; Diva - Avans; F 1235/91 - F 822/95 ; F 835/95 - F 822/95, allows obtaining hybrids that possess useful gene combinations and show high levels of heterosis for different yield traits.

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