Original scientific paper
Originalan naučni rad
UDK: 635.652-157.63]:575.732
DOI: 10.7251/AGREN1301029K

University of Banjaluka, Faculty of Agriculture
Agro-knowledge Journal

Characteristics of Common Bean Mutant Lines and Cultivars Grown under Rainfed and Irrigated Conditions

Vladimir Krastev[1], Dotchka Dimova[1], Diana Svetleva[1], Graca Pereira[2], Kalinka Kouzmova[1], Mariana Andonova[1]

[1]*Agricultural University, Plovdiv, Bulgaria*
[2] *INRB/INIA-Elvas, Elvas, Portugal*

Abstract

The experiments were conducted in the field of Agricultural University in Plovdiv, Bulgaria. A standard method was applied for cultivation in 5 replicates. Biometric evaluation of common bean (*Phaseolus vulgaris* L.), 10 mutant lines and 10 varieties, grown under rainfed and irrigated conditions was conducted. Main traits, associated with productivity in common bean: plant height, mass of plants with pods, number of branches, height of the first pod, number of fruit branches, number of pods per plant, weight of pods with seeds, number of seeds per plant, weight of seeds and average length per 10 pods were characterised. Stronger degree of variation in studied traits was observed in genotypes grown under irrigated conditions. It was found that the studied Bulgarian varieties are promising in terms of germoplasm for their introduction in hybridisation breeding schemes as well as in application of mutagenesis and biotechnological practices. D_2-0,0125 M EMS mutant line (6) has the best manifestation of the studied traits among other mutant lines and it may be included in breeding schemes for evaluation as a new cultivar. BAT 477 cultivar (20) differs significantly by its traits from other genotypes, irrespective of the cultivation mode.

Key words: biological traits, *Phaseolus vulgaris* L., rainfed and irrigated conditions

Introduction

Some authors (Dimanov & Zapryanova, 2002) examined the impact of agrometeorological conditions on the yield and quality of different tobacco genotypes.

Among major crop species, legumes are a good source of many minerals, including iron, zinc and other essential micronutrients that are found only in low amounts in cereals or root crops (Wang et al., 2003; Blair et al., 2009).

It should be noted that in recent years, drought is increasingly becoming a major problem and compromising factor for common bean production worldwide (Beebe et al. 2008; Tera´n & Singh 2002; Ramirez-Vallejo & Kelly 1998).

Broughton et al. (2003) reported that 74% of the production of common bean in Latin America and 40% of production in Africa is subjected to moderate or heavy drought stress during development of the plants. Greater tolerance of plants to drought and improved efficiency in water use is becoming an important feature of common bean included in breeding programmes for the need of production in areas with increasing drought and other legumes (Graham & Vance 2003).

The purpose of investigation is to characterise 20 Bulgarian common bean genotypes in regards with their biological traits associated with productivity in this crop and its manifestation in rainfed and irrigated conditions of cultivation.

Materials and methods

The experiments were conducted in the field of Agricultural University in Plovdiv, Bulgaria. A standard method was applied for cultivation in five replicates.

Plant material

The numbers in parentheses after each genotype, as described in the text, are taken from Table 1. BAT 477 cultivar was obtained by exchanging germoplasm between Dobrudja Agricultural Institute, General Toshevo and CIAT, Colombia.

Tab. 1. Investigated common bean genotypes
Ispitivani genotipovi graha

№ *Br.*	Mutant lines *Mutant linije*	Selection *Selekcija*	№ *Br.*	Cultivars *Sorte*	Selection *Selekcija*
1.	D_2-0,0062 M EMS	1, BG	11.	Plovdiv 11 M	1, BG
2.	D_2-0,0031 M NEU	1, BG	12.	Plovdiv 10	1, BG
3.	D_2-0,0062 M EMS	1, BG	13.	Abritus	2, BG
4.	D_2-0,0125 M EMS	1, BG	14.	Plovdiv 2	1, BG
5.	D_2-0,0062 M EMS	1, BG	15.	Doubrudjanski ran	2, BG
6.	D_2-0,0125 M EMS	1, BG	16.	Doubrudjanski 7	2, BG
7.	D_2-0,0062 M EMS	1, BG	17.	Plovdiv 15 M	1, BG
8.	D_7-0,0125 M EMS	1, BG	18.	Plovdiv 564	1, BG
9.	D_2-0,0125 M EMS	1, BG	19.	Doubrudjanski 2	2, BG
10.	D_2-0,0031 M NEU	1, BG	20.	BAT 477	CIAT, Colombia

Note: The mutant lines and cultivars are selected in: 1 - Agricultural University, Plovdiv, 2 - Dobrudja Agricultural Institute, near the town General Toshevo.
Napomena: Mutant linije i sorte su selekcionisane u: 1- Poljoprivrednom univerzitetu, Plovdiv, 2- Poljoprivredni institut Dobrudja, blizu grada General Toshevo.

Mutant lines are stable (M_{18}-generation). They are mainly derived from Dobroudjanski 2. D_7-0, 0125 M EMS line is an exception and it was obtained from Dobrudjanski 7. Mutagenic factors etilmethan sulfonate (EMS) and N-nitroso-N'-ethyl urea (NEU) were used. Concentrations are listed at the end of the name of the mutant line. All studied genotypes are of Mesoamerican origin.

Morphological studies

Main traits, associated with productivity in common bean were studied as follows: plant height (A), weight of plants with pods (B), number of branches per plant (C), height of the first pod (D), number of fruit branches (E), number of pods per plant (F), weight of pods with seeds (G), number of seeds per plant (H), weight of seeds (I) and average length of 10 pods (J).

Statistical analysis

Data from morphological studies were analysed using NTSYS-pc programme version 2.01 b (1986-1997, Applied Biostatistic Inc.). Principal Component Analysis was used to set the deviation of the data associated with the first three principal components. Two-dimensional graphics for the studied genotypes were designed, but the signs were represented by vectors (Cruz & Viana, 1994; Sneath & Sokal, 1973). DIST coefficient was used to group genotypes using the SAHN procedure that uses UPGMA (Rolf, 1989). Phenograms for convergence between the genotypes are obtained using the TREE DISPLAY subroutine.

To determine the relative weight of studied traits at the distribution of genotypes in clusters, an analysis of the main components (Principal component Analysis) was conducted, (Philippeau, 1990).

Results and discussion

Tables 2. and 3. present the results of biometric evaluation of 20 genotypes in the full maturity phase, grown in rainfed and irrigated conditions.

Stronger degree of variation in studied traits was observed in genotypes grown under irrigated conditions. Values of the traits in studied genotypes cultivated under rainfed conditions (Table 2.) were lower than those reported for irrigated plants. BAT 477 (20) differs again from other genotypes, while traits related to productivity in common bean studied in Dobroudjanski ran (15) and Dobroudjanski 7 (16) have similar values.

The highest values of high betting on the first pod and the lowest number of fruit branches are present in D_2-0,0031 M NEU mutant line (10).

In irrigation mode of cultivation (Table 3) the cultivar BAT 477 (20) is characterised by higher weight of plants with pods, a larger number of pods and number of seeds per plant, higher weight of pods and seed and lower betting on the first bean.

A good combination of studied traits also distinguishes Abritus (13) and Plovdiv 10 (12).

D_2-0,0125 M EMS mutant line (6) has the best manifestation of biological traits among other lines and it may be included in breeding schemes for approval as a new cultivar.

Grouping of studied genotypes in the complex of reported traits, manifested in rainfed and irrigated conditions, is presented graphically with the dendrograme in figure 1 (A and B). They reflect distribution of 20 studied genotypes in clusters according to the average degree of manifestation of traits.

In rainfed conditions (Fig. 1 A), genotypes are clearly divided into 3 cluster groups. BAT 477 (20) differs significantly from other genotypes and is relatively independent in its manifestation. A range of genotypes, grouped together in a cluster due to similar traits, is included in each of the other groups.

Dobroudjanski ran (15) and Dobroudjanski 7 (16) lie more close to each other, as Dobroudjanski 7 (16) participated as parent compound in the pedigree of Dobroudjanski ran (15). Plovdiv 11 M (11), Plovdiv 10 (12) and Plovdiv 15 M (17) were also merged into one cluster group.

In irrigation mode of cultivation (Fig. 1 B), genotypes are grouped into a larger number of cluster groups, reflecting greater diversity in the traits manifestation under these conditions. Abritus (13) and BAT 477 (20) are also in one cluster group. D_2-0,0062 M EMS (1) and D_2-0,0062 M EMS (7) mutant lines are at a greater distance from them, but they are adjacent to each other.

Dobroudjanski ran (15) also differs from others and it is in a separate cluster.

All this shows that the studied genotypes are significantly affected by the mode of cultivation. More groups were formed in clustering of cultivars which were grown under irrigated conditions due to the greater diversity (variation) in the manifestation of studied traits.

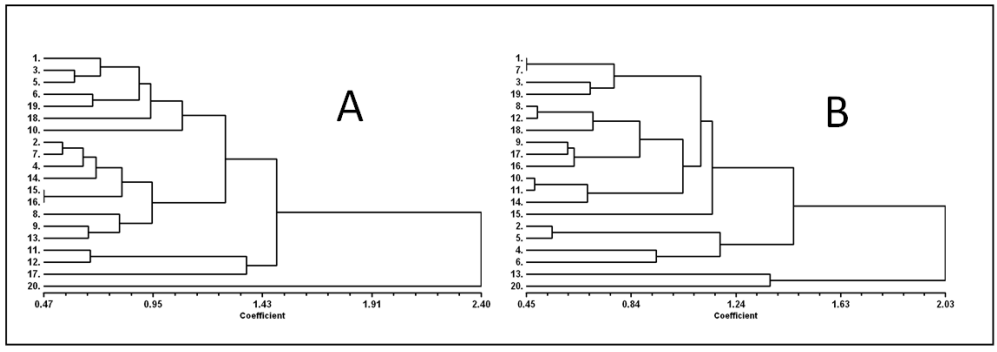

Fig. 1. Phenograms of 20 common bean genotypes, cultivated in rainfed (A, r = 0.857) and irrigated conditions (B, r = 0.852), based on the UPGMA method

Fenogrami 20 sorti graham gajenih u uslovima prirodnog vodnog režima (A, r =0.857) i navodnjavanja (B, r = 0.852) na osnovu metoda UPGMA

Tab. 2. Biometric evaluation of full mature plants grown under reinfed conditions
Biometrijska evaluacija potpuno zrelih biljaka gajenih u uslovima prirodnog vodnog režima

№ Br.	GENOTYPES *GENOTIPOVI*	Plant height *Visina biljke* cm (A)	Weight of plants with pods *Težina biljke sa mahunama* g (B)	Number of fruit branches *Broj rodnih grana* (C)	High betting on the first pod, *Visina prve mahune* cm (D)	Number of fruit branches *Broj rodnih grana* (E)	Number of pods per plant *Broj mahuna po biljci* (F)	Weight of pods with seeds *Težina mahuna sa zrnima* g (G)	Number of seeds per plant *Broj zrna po biljci* (H)	Weight of seeds *Težina zrna* g (I)	Average length of 10 pods *Prosječna dužina 10 mahuna* (J)
1.	D_2-0.0062 M EMS	42.78	24.53	4.00	9.81	3.40	7.70	13.86	29.70	9.86	9.57
2.	D_2-0.0031 M NEU	41.41	22.75	6.60	7.46	4.00	6.90	11.95	22.70	8.52	9.13
3.	D_2-0.0062 M EMS	43.27	26.88	5.40	7.69	3.70	7.00	15.66	27.10	11.14	9.98
4.	D_2-0.0125 M EMS	33.3	20.04	5.90	7.70	4.10	6.40	10.73	22.10	7.55	8.49
5.	D_2-0.0062 M EMS	39.97	21.69	4.30	7.99	3.90	9.20	14.47	31.55	9.71	9.66
6.	D_2-0.0125 M EMS	53.19	33.86	6.00	9.32	3.90	9.00	17.58	31.50	13.11	9.73
7.	D_2-0.0062 M EMS	44.85	27.65	5.90	8.95	4.00	6.90	11.04	22.00	8.48	8.75
8.	D_7-0.0125 M EMS	36.30	22.46	6.70	7.55	5.20	8.40	11.82	24.60	8.77	8.07
9.	D_2-0.0125 M EMS	40.30	24.48	7.70	7.50	3.90	8.10	12.66	29.30	9.69	8.32
10.	D_2-0.0031 M NEU	54.38	27.72	4.00	10.94	3.30	8.30	16.31	27.20	10.98	10.43
11.	Plovdiv 11 M	53.85	26.69	6.70	7.10	4.80	8.40	14.93	32.20	10.97	9.94
12.	Plovdiv 10	59.60	36.48	6.90	7.20	5.40	9.30	16.30	36.70	12.08	9.40
13.	Abritus	31.57	23.95	5.90	7.63	3.90	8.10	13.71	35.00	9.49	8.22
14.	Plovdiv 2	39.95	24.55	4.90	7.83	3.10	6.80	12.38	23.70	8.62	9.10
15.	Doubrudjanski ran	42.40	16.84	6.10	8.05	4.40	7.10	11.07	21.60	8.03	9.87
16.	Doubrudjanski 7	43.50	17.97	5.20	7.45	4.50	7.70	12.74	27.30	9.29	10.05
17.	Plovdiv 15 M	46.73	23.02	8.00	5.95	4.80	16.90	14.82	32.70	10.88	8.99
18.	Plovdiv 564	47.10	27.58	3.90	7.99	4.00	11.40	18.14	41.70	12.43	9.77
19.	Doubrudjanski 2	40.96	26.07	5.40	9.18	4.10	8.30	16.23	29.90	12.95	9.45
20.	BAT 477	41.50	55.4	4.90	6.80	5.30	12.60	20.40	58.70	13.90	8.75

Tab. 3. Biometric evaluation of full mature plants grown under irrigated conditions
Biometrijska evaluacija potpuno zrelih biljaka gajenih u uslovima navodnjavanja

№ Br.	GENOTYPES *GENOTIPOVI*	Plant height *Visina biljke* cm (A)	Weight of plants with pods *Težina biljke sa mahunama* g (B)	Number of fruit branches *Broj rodnih grana* (C)	Height of the first pod *Visina prve mahune* cm (D)	Number of fruit branches *Broj rodnih grana* (E)	Number of pods per plant *Broj mahuna po biljci* (F)	Weight of pods with seeds *Težina mahuna sa zrnima* g (G)	Number of seeds per plant *Broj zrna po biljci* (H)	Weight of seeds *Težina zrna* g (I)	Average length of 10 pods *Prosječna dužina 10 mahuna* (J)
1.	D_2-0.0062 M EMS	51.15	41.90	4.6	7.35	4.6	7.40	12.45	24.2	8.47	9.21
2.	D_2-0.0031 M NEU	54.95	37.01	6.0	6.70	5.6	10.40	21.95	41.00	16.7	9.97
3.	D_2-0.0062 M EMS	48.95	30.53	2.4	7.00	4.6	6.80	15.04	27.30	11.31	8.72
4.	D_2-0.0125 M EMS	50.33	37.53	3.9	7.43	7.4	12.30	20.93	43.00	15.97	9.17
5.	D_2-0.0062 M EMS	53.95	43.84	6.2	6.30	5.2	9.80	27.87	40.50	15.48	10.30
6.	D_2-0.0125 M EMS	43.50	47.15	5.8	9.93	7.2	11.60	25.59	34.70	17.27	9.19
7.	D_2-0.0062 M EMS	49.35	37.39	4.9	8.50	4.6	7.60	11.71	23.60	8.70	8.57
8.	D_7-0.0125 M EMS	42.82	30.78	6.0	9.50	5.4	10.10	19.43	37.30	15.02	9.59
9.	D_2-0.0125 M EMS	38.00	27.69	3.6	8.48	4.7	8.00	14.14	27.90	10.28	9.52
10.	D_2-0.0031 M NEU	54.55	37.45	3.2	9.14	5.5	9.90	19.43	34.80	13.80	10.26
11.	Plovdiv 11 M	54.20	38.92	3.8	7.95	4.9	9.00	16.47	33.80	12.34	9.93
12.	Plovdiv 10	46.76	32.83	5.6	10.01	4.2	9.90	17.94	36.50	13.86	9.35
13.	Abritus	36.85	55.98	4.4	5.60	8.1	18.00	18.95	65.40	14.84	8.64
14.	Plovdiv 2	52.40	25.70	2.4	6.25	5.2	9.60	15.70	33.40	11.61	9.85
15.	Doubrudjanski ran	48.92	28.21	3.9	12.77	4.5	7.30	13.74	22.20	10.35	9.84
16.	Doubrudjanski 7	44.95	25.05	4.4	9.05	5.0	9.70	16.28	31.10	11.71	9.90
17.	Plovdiv 15 M	39.95	32.99	3.6	10.50	3.9	8.20	18.12	31.10	12.34	9.60
18.	Plovdiv 564	45.57	40.95	4.3	7.97	5.3	10.60	20.00	40.20	13.25	9.05
19.	Doubrudjanski 2	44.00	40.60	3.9	7.47	5.2	9.30	13.30	28.90	10.80	8.41
20.	BAT 477	44.82	102.24	5.1	6.06	6.8	14.10	21.25	61.10	14.06	9.79

It is noteworthy that D_7-0.0125 M EMS mutant line (8) on both dendrogrames is located in different clusters compared to the parent variety Dobroudjanski 7 (16), which is due to different manifestations of their morphological traits.

D_2-0,0062 M EMS (1) and D_2-0,0062 M EMS (3) mutant lines are closest to the their source cultivar, i.e. Dobroudjanski 2 (19).

To assess the strength of influence of the traits in the clustering at both modes of cultivation, an analysis of main components was carried out.

Tab. 4. Principal component analysis, applied to study some biological traits in plants grown under rainfed conditions

Analiza glavnih komponenata koja je primjenjena na ispitivanje nekih bioloških osobina biljaka gajenih u uslovima prirodnog vodnog režima

Traits *OSOBINE*		Main components *Glavne komponente*		
		1	2	3
Plant height, cm *Visina biljke*	A	0,514	0,346	0,722
Number of branches per plant, g *Broj grana po biljci*	B	0,838	- 0,024	- 0,269
Number of branches per plant *Broj grana po biljci*	C	- 0,098	- 0,778	0,460
High betting on the first pod, cm *Visina prve mahune,cm*	D	- 0,172	0,853	- 0,088
Number of fruit branches *Broj rodnih grana*	E	0,468	- 0,674	0,264
Number of pods per plant *Broj mahuna po biljci*	F	0,689	- 0,359	0,088
Weight of pods with seeds, g *Težina mahuna sa zrnima*	G	0,940	0,265	- 0,104
Number of seeds per plant *Broj zrna po biljci*	H	0,901	- 0,127	- 0,341
Weight of seeds, g *Težina zrna*	I	0,922	0,210	0,005
Average length of 10 pods, cm *Prosječna dužina 10 mahuna*	J	0,199	0,741	0,498
Explained % of total variance: *Objašnjen % ukupne varijance:*		42,85	27,17	12,66

The strength of influence of traits in genotypes, grown under rainfed conditions is given in Table 4. The analysis was conducted on the third main component and it explained 83% of the total variation.

The first principal component explains 43% of the variation in the studied population. Central to clustering is the impact of the traits - weight of pods with seeds, seed weight, seed number and weight of plants with pods. The following traits: high of

betting on the first pod, number of branches, number of fruit branches and average length of 10 pods influenced the second main component.

Tab. 5. Principal component analysis, applied to study some biological traits in plants grown under irrigated conditions
Analiza glavnih komponenata koja je primjenjena na ispitivanje nekih bioloških osobina biljaka gajenih u uslovima navodnjavanja

Traits *OSOBINE*		Main components *Glavne komponente*		
		1	2	3
Plant height, cm *Visina biljke*	A	- 0,172	0,610	- 0,661
Number of branches per plant, g *Broj grana po biljci*	B	0,698	- 0,219	- 0,173
Number of branches per plant *Broj grana po biljci*	C	0,469	0,409	0,423
High betting on the first pod, cm *Visina prve mahune*	D	- 0,499	0,280	0,690
Number of fruit branches *Broj rodnih grana*	E	0,861	- 0,229	- 0,018
Number of pods per plant *Broj mahuna po biljci*	F	0,917	- 0,265	0,040
Weight of pods with seeds, g *Težina mahuna sa zrnima*	G	0,753	0,551	0,111
Number of seeds per plant *Broj zrna po biljci*	H	0,933	- 0,170	- 0,095
Weight of seeds, g *Težina zrna*	I	0,798	0,434	0,186
Average length of 10 pods, cm *Prosječna dužina 10 mahuna*	J	0,054	0,806	- 0,189
Explained % of total variance: *Objašnjen % ukupne varijance:*			19,58	12,17

For the third main component, explaining 13% of the total variation the impact of the following traits is essential: plant height, number of branches and average length of 10 pods.

The results obtained for genotypes grown under irrigated conditions are presented in Table 5.

Of the possible 10 components, corresponding to the studied traits, the analysis was also conducted only for the third because they explain about 80% of the total variation. Seed number, number of pods, number of fruit branches, weight of seeds and weight of pods with seeds are with higher degree of influence on the clustering of genotypes since their relative degree of variation correlated most strongly

with the first principal component. The first principal component explains 47% of the total variation in the study group of genotypes.

The second main component explains 20% of total variation, with the importance of the following traits: average length of 10 pods, weight of pods with seeds, number of branches and plant height.

The influence of the third main component is 13% and is mainly due to the traits as follows: high betting on the first pod, number of branches and height of plants.

Conclusion

1. Stronger degree of variation, in studied traits, was observed in genotypes grown under irrigated conditions.
2. D_2-0.0125 M EMS mutant line (6) has the best manifestation of biological traits among other lines and it may be included in breeding schemes for approval as a new cultivar.
3. BAT 477 (20) differs significantly from other genotypes.
4. The Bulgarian cultivars studied are promising in terms of germoplasm for inclusion in hybridisation schemes and the application of mutagenesis and biotechnological practices.
5. Sets of genotypes can be investigated and characterised in more detail through the joint use of cluster analysis and analysis of main components. On this basis, those genotypes that have the best combination of biological traits for breeding interest can be selected.

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Osobine mutant linija i sorti graha gajenih u uslovima prirodnog vodnog režima i navodnjavanja

Vladimir Krastev[1], Dotchka Dimova[1], Diana Svetleva[1], Graca Pereira[2], Kalinka Kouzmova[1], Mariana Andonova[1]

[1]*Poljoprivredni univerzitet, Plovdiv, Bugarska*
[2] *INRB/INIA-Elvas, Elvas, Portugal*

Sažetak

Eksperimenti su sprovedeni na polju Poljoprivrednog univerziteta u Plovdivu, Bugarska. Primjenjen je standardni metod za 5 ponavljanja. Izvršena je biometrijska evaluacija graha (*Phaseolus vulgaris* L.), 10 mutant linija i 10 sorti, gajenih u uslovima prirodnog vodnog režima i navodnjavanja. Ispitivane su glavne osobine koje se vezuju za produktivnost graha: visina biljke, masa biljke sa mahunama, broj grana, visina prve mahune, broj rodnih grana, broj mahuna po biljci, težina mahuna sa zrnima, broj zrna po biljci, težina zrna i prosječna dužina 10 mahuna. Veći stepen varijacije u ispitivanim osobinama je ustanovljen za genotipove koji se uzgajaju u uslovima navodnjavanja. Utvrđeno je da ispitivane bugarske sorte obećavaju u pogledu germplazme radi njihovog uključivanja u oplemenjivačke programe hibridizacije kao i u primjeni mutageneze i biotehnoloških praksi. Mutant linija D_2-0,0125 M EMS (6) se najbolje pokazala i može da se uključi u programe oplemenjivanja radi evaluacije kao nove sorte. BAT 477 (20) se znatno razlikuje po svojim osobinama od drugih genotipova, bez obzira na način uzgoja.

Ključne riječi: biološke osobine, *Phaseolus vulgaris* L., uslovi prirodnog vodnog režima i navodnjavanja

Diana Svetleva
E-mail address:
svetleva@yahoo.com