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STUDY OF UNSTABLE PHENOTYPIC BEAN SEEDS

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Abstract

Since 2010, at the Vegetable Research and Development Station (V.R.D.S.) Buzău there was initiated a program in order to preserve and valorize local bean population (Phaseolus vulgaris L.) from Eastern and South – Eastern Romania. In 2020, the germplasm collection contained over 450 accessions. This paper presents the study of 3 climbing bean accessions seeds sown. For each accession sown, there were taken into study 9 new biotypes harvested. The seeds sown represented the control variant for the analysis of the harvested biotypes. The seeds were evaluated in what it concerns quantitative and qualitative characteristics. The main colors of the control seeds were brown (V_1 - medium, V_2 - light and V_3 - dark). The seeds harvested presented a lot of colors including white (on entire graine - 1.3.; 1.4.; 2.6.; 3.1 or as secondary color 1.5.; 1.7.; 1.8.; 2.7.; 3.3.). The mean weight of 100 seeds varied between 36.52 g (1.4.) and 70.95 g (1 Mt). The results obtained, corroborated by diversity of color and shape of the seeds harvested, show the presence of cross-pollination of climbing bean plants and increase the value of the bean germplasm collection.

Key words*: cross-pollination, germplasm collection, new biotypes, Phaseolus vulgaris L.*

INTRODUCTION

In Eastern and South-East Romania there are favorable conditions for growing common bean production, as well as a great tradition in cultivation (Ruşti and Munteanu, 2008). Collecting and conserving biodiversity, in what it concerns bean, represents one of the main activity objectives for the Vegetable Research and Development Station (V.R.D.S.) Buzău.

Thus, in 2010 started the collecting of local bean population from the main vegetable areas in Romania. Bean germplasm collection of V.R.D.S. Buzău contains over 450 accessions.

Similar researches were made in Romania by Rădulescu (1940), Munteanu (1985), Stan et al. (1993 and 1995), Leonte et al. (2004), Riviș and Nedelea (2008), Giurcă and Murariu (2009), Danci et al. (2010) and Madoșa et al. (2010 and 2011).

Normally, in Romania, the bean (*Phaseolus vulgaris* L.) is considered a self-pollinated plant. Ali et al. (2020) also has the same opinion. Olaru (1982) and Ciofu et al. (2003) agree with Ali et al. (2020), but they do not exclude cross-pollination. In a normal crop Bliss (1980) and Ruști and Munteanu (2008) estimate that bean is highly self-pollinated, and only 0.2-0.5% cross-pollinated. In Puerto Rico, Vakili (1976), quoted by Bliss (1980), reports that carpenter bees (*Xylocopa brasilianorum* L.) were responsible for levels as high as 15 to 20% cross-pollination. In what it concerns some accessions, over time, the phenotypic instability phenomenon has been more intensive because of some particularities concerning flower (Figure 1) morphology (Debouck and Hidalgo, 1986).

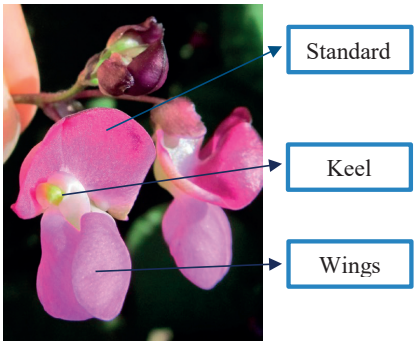


Figure 1. Bean flower morphology (about Teodorescu, 2016)

Studying flower aspect at accessions that presented a high variability percent there was observed that stigma and anthers were no longer protected by the keel. Under the pressure of different insects (especially bees) the stigma get

out of the keel and have contact with the full of pollen bees feet from another flower or it comes off and leaves free the stigma and the anthers (Figure 2). The style turning over inside the keel is foreclosed by the brush of hairs near the stigma and also because of the style scrolling degree.

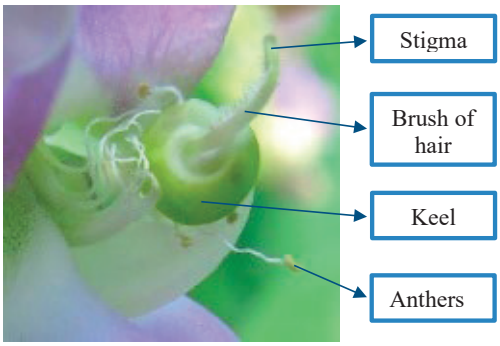


Figure 2. Stigma and anthers were no longer protected by the keel (about Teodorescu, 2016)

At the proveniences that present such flower morphology, the pollination is allogamy and can be made by insects - entomophily and by wind - anemophily (Teodorescu, 2016).
The aim of this paper was to present the effects of cross-pollination within a bean germplasm collection in climatic conditions from Eastern and South-Eastern part of Romania.

MATERIALS AND METHODS

The study was carried out in V. R. D. S. Buzău, Romania (45°9′N and 26°49′E) in 2020.
The biological material (climbing accessions) was cultivated according to the common production technology recommended for this area by the specialty literature (Munteanu et al., 1989; Ciofu et al., 2003; Ruşti and Munteanu, 2008). Therefore, the experimental variants were the following:

V_1		V_2		V_3	
1 Mt	35 B	2 Mt	47 BBD	3 Mt	48 B
1.1.	35 BB	2.1.	47 BBDA	3.1.	48 BA
1.2.	35 BD	2.2.	47 BBDC	3.2.	48 BB
1.3.	35 BE	2.3.	47 BBDD	3.3.	48 BC
1.4.	35 BF	2.4.	47 BBDF	3.4.	48 BE
1.5.	35 BG	2.5.	47 BBDG	3.5.	48 BF
1.6.	35 BH	2.6.	47 BBDH	3.6.	48 BG
1.7.	35 BI	2.7.	47 BBDI	3.7.	48 BI
1.8.	35 BJ	2.8.	47 BBDJ	3.8.	48 BJ
1.9.	35 BK	2.9.	47 BBDK	3.9.	48 BK

This germplasm collection was cultivated in green - house covered with polyethylene. The green house's ventilation space permitted the access of insects.
The determination of plants, pods and seeds characteristics were made according to U.P.O.V. guideline (2015), C.P.V.O. protocol (2009) and color scale (Genchev and Kiryakov, 2005). For characterization, there were used 10 seeds from each accession, according to *Handbook on evaluation of Phaseolus germplasm* (De la Cuadra et al., 2001).
Length determination was made in mm measured in parallel with the hilum, width was measured from the hilum to the opposite side and thickness was measured perpendicular on width in cross section (Figure 3).

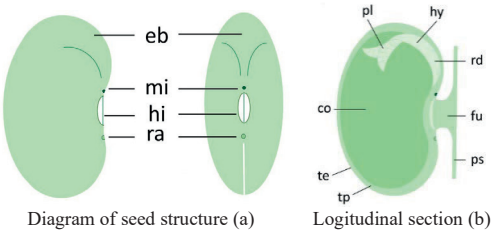


Diagram of seed structure (a) Logitudinal section (b)

Figure 3. Seed Structure of a Dicotyledon **(a)**: eb - embryo bulge; mi - micropyle; hi - hilum; ra - raphe and **(b)**: pl - plumule; hy - hypocotyl; rd - radicule; co - cotyledon; fu - funicle; ps - pod; te - testa; tp - testa perenchyma (about Chen et al., 2021)

A more detailed overview of the plumule – radicle complex includes epicotyl and primary leaves (Debouck and Hidalgo, 1986). Rădulescu (1940) quoted by Olaru (1982) pays particular attention to the coloring area around hilum, otherwise the hilum is always white, the edge surrounding the hilum may have a different coloration with various intensity (absent, weak, medium and strong) to the rest of testa and also it is interrupted at the micropyle and caruncle.
Caruncle (raphe) represents a heart - shaped lift having the tip facing the end of the seed. The stripe of the caruncle represents a narrow band which leaves from the top of caruncle, it extends to the end of the seed - were it ends like a swallow`s tail, and it has a variable length (Figure 4).
According to Descriptor for *Phaseolus vulgaris* (IBPGR, 1982), van Schoonhoven A. and Pastor-Corrales (1994) and Debouck D. (2009) 100 seeds mass were randomly chosen for

measuring seed mass (small - less than 25 g, medium - 25 g to 40 g and large - more than 40 g).

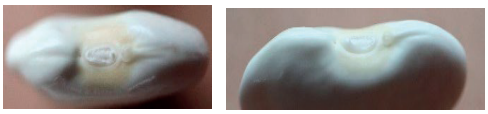


Figure 4. Aspects of the embryo bulge, micropyle, hilum, caruncle and the stripe of the caruncle (about Teodorescu, 2024)

In order to determine seeds weight there was used an electronic balance reading to 0.0001 g (Partner WAS220/x).

The experimental design was a randomized block with 3 replicates for each variant. The seeds sown represented the control variant for the analysis of the harvested biotypes. In order to analyze the results analysis of variance and multiple comparison method Duncan's test were used (Harter, 1960; Săulescu and Săulescu, 1966).

There was used coefficient of variation (CV) because it allows the direct comparison of data sets variation (Ireland, 2010). The coefficient of variation in a single sample with observations is defined as CV = *s/m,* where *m* is mean and *s* is standard deviation (Forkman, 2009). Variability appreciation according to the CV values (Munteanu and Fălticeanu, 2008; Giurcă and Murariu, 2009) was made this way: low variability (CV < 10%), mean (CV = 10- 20%) and high (CV > 20%).

RESULTS AND DISCUSSIONS

In 2020, most of the accessions cultivated presented a high degree of instability.

This paper presents quantitative (100 seed weight, length, thickness and width) and qualitative (shape, seed color, veining and hilum ring - intensity and color) characteristics of seeds harvested to 9 biotypes in comparation with seeds sown (Figure 5).

Figure 5. Brown - main color of the control seeds

The main colors of the control seeds were brown (V_1 - medium, V_2 - light reddish and V_3 - dark). The secondary color was also present at V_1 (black - in streaks), V_2 (reddish brown - in streaks and in patches) and V_3 (reddish brown - in patches).

In what it concerns V_1, (Table 1) it presents maximum values at 1Mt (weight - 70.96 g and thickness - 7.31 mm), 1.1. (length - 17.01 mm), and 1.8. (width - 9.85 mm) and all minimum values at 1.4. (weight - 37.05 g; length - 12.51 mm; width - 6.82 mm and thickness - 5.68 mm CV had a value of 16.15% (bigger than 10% - mean variability) only regarding weight.

Table 1. Main quantitative characteristics of the seeds V_1

V_1	100 seeds mass (g)	Seeds dimensions (mm)			Length/ Width	Width/ Thickness
		Length	Width	Thickness		
1 Mt	70.96 a*	16.04 b	9.23 b	7.31 a	1.74	1.26
1.1.	67.49 a	17.01 a	9.05 b	6.62 bcd	1.88	1.37
1.2.	58.82 bc	13.98 ef	8.88 bc	6.94 abc	1.57	1.28
1.3.	64.48 ab	15.68 bc	8.84 bc	6.68 bc	1.77	1.32
1.4.	37.05 d	12.51 g	6.82 e	5.68 e	1.83	1.20
1.5.	52.73 c	14.16 ef	8.27 d	6.93 abc	1.71	1.19
1.6.	56.39 c	15.07 cd	9.28 b	6.18 d	1.62	1.50
1.7.	64.73 ab	14.73 de	8.93 bc	7.10 ab	1.65	1.26
1.8.	58.82 bc	15.06 cd	9.85 a	6.49 cd	1.53	1.52
1.9.	56.55 c	13.82 f	8.52 cd	6.99 abc	1.62	1.22
Mean	**58.80**	**14.81**	**8.77**	**6.69**	**1.69**	**1.31**
Stand. var.	9.50	1.28	0.81	0.48	0.11	0.12
CV%	16.15	8.61	9.22	7.21	6.71	8.92
Max.	70.96	17.01	9.85	7.31	1.88	1.52
Min.	37.05	12.51	6.82	5.68	1.53	1.19
	LSD 5% = 6.5887 LSD 1% = 9.0360 LSD 0.1% = 12.2989	LSD 5% = 0.7522 LSD 1% = 1.0316 LSD 0.1% = 1.4042	LSD 5% = 0.4281 LSD 1% = 0.5871 LSD 0.1% = 0.7991	LSD 5% = 0.4617 LSD 1% = 0.6332 LSD 0.1% = 0.8619		

*Different letters between variants denote significant differences (Duncan's test, $p<0.05$).

The CV in what it concerns all quantitative characteristics had a value between 6.71% (length/width) and 9.22 %(width); this shows a low variability for the other parameters analyzed.

The appearance of a large number of biotypes represents the result of the presence of numerous insects in the crop (Figure 6).

According to U.P.O.V. guideline (2015), C.P.V.O. protocol (2009) and also to the color scale (Genchev and Kiryakov, 2005), at accessions with kidney – shaped seeds shape, it is recommended to evaluate also degree of curvature (weak, medium or strong)

Same shape with 1 Mt (kidney) it also found at 1.1., 1.3. and 1.8. The predominant main color at V_1 (Table 2) was brown, except 1.3., 1.4. (white) and 1.9. black.

The predominant secondar color (Figure 7) to this variant was black (1Mt, 1.2., 1.6. and 1.7.)

The shape of the secondary striped color was the most frequently met (1Mt, 1.3., 1.6., 1.7. and 1.8.).

Figure 6. Insects present in the crop and flowers after their visit (Teodorescu, 2024).

Table 2. Main qualitative characteristics of the seeds V_1

V_1	Seeds shape[1]	Color			Hilum ring	
		Main	Secondar	Shape of secondar	Intensity	Color
1 Mt	kidney[2] w	brown	black	in streaks	absent	–
1.1.	kidney s	L brown	–	–	weak	brown
1.2.	elliptic	beige	black	in streaks	medium	reddish brown
1.3.	kidney s	white	–	–	absent	–
1.4.	elliptic	white	–	–	absent	–
1.5.	elliptic	L brown	white	embryo bulge – in patches	strong	brown
1.6.	elliptic	brown	black	in streaks	medium	reddish brown
1.7.	elliptic	reddish brown	black white	in streaks in patches	weak	D reddish brown
1.8.	kidney w	L brown	brown white	in streaks in patches	weak	brown
1.9.	elliptic	black	L brown	in fine in patches	absent	–

[1]Shape of median longitudinal section; L=light; D=dark.
[2]Degree of curvature for kidney - shaped only: weak (w), medium (m) and strong (s).

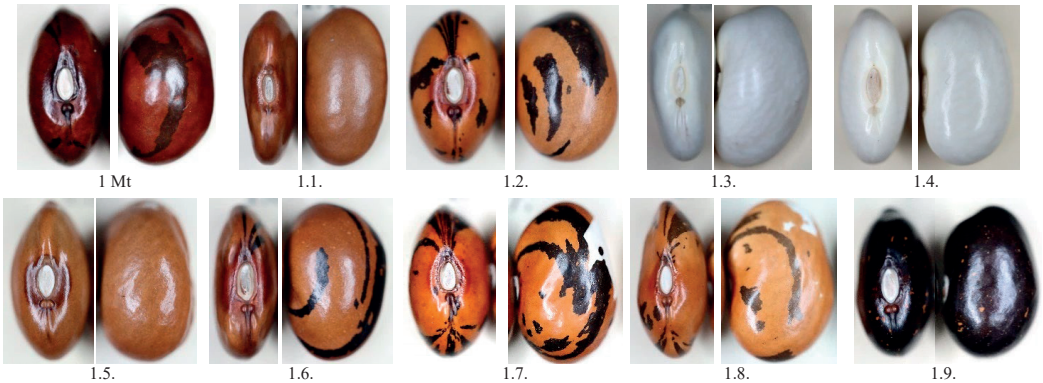


Figure 7. Aspects of qualitative characteristics of the seeds V_1

In what it concerns V_1, the differences in color of the hypocotyl were evident from the first development stages of plants. (Figure 8 a and b). 1.5. draws attention because the secondary color is localized in the embryo bulge area and also because the color hilar ring was strong (Figure 8 c and d). The difference between 1.7. and 1.8. is given by the secondary color in streaks (Figure 8 e). The funicle color varied within this variant from white (Figure 8 f) to brown (Figure 8 g). In the field, sometimes (harveast), the brightness was high.

a b c d e f g

Figure 8. Aspects of crop and seeds belong to V_1: a and b - differences in anthocyanin coloration of the hypocotyl; c - white secondary color on embryo bulge area at 1.5.; d - strong coloration of hilar ring of 1.5.; e - comparation between the secondar color in streaks to 1.7. and 1.8.; f - white funicle at 1.3. and g - brown funicle at 1.1.

At V_2 (Table 3), the two highest values were registered at the control variant (weight - 54.67g and width - 8.98 mm) and two minimum values at 2.8 (weight - 38.61 g; length - 11.41 mm). The mean weight value was 45.50 g and more than half of the new biotypes were below this value (2.7. - 44.47 g; 2.5. - 43.56 g; 2.6. - 40.58 g; 2.4. - 39.65 g and 2.8. - 38.61 g). A mean variability is also observed in what it concerns the weight (11.39%).

Table 3. Main quantitative characteristics of the seeds V_2

V_2	100 seeds mass (g)	Seeds dimensions (mm)			Length/ Width	Width/ Thickness
		Length	Width	Thickness		
2 Mt	54.67 a*	14.41 bc	8.98 a	6.35 a	1.60	1.42
2.1.	48.49 bc	14.59 ab	8.62 b	6.28 a	1.69	1.37
2.2.	51.29 ab	15.19 a	8.65 b	6.26 ab	1.76	1.38
2.3.	46.17 bc	12.90 d	8.70 ab	6.58 a	1.48	1.32
2.4.	39.65 de	12.65 d	8.47 bc	5.32 d	1.49	1.59
2.5.	43.56 cde	14.39 bc	8.27 cd	5.52 cd	1.74	1.50
2.6.	40.58 de	12.17 d	8.22 cd	5.85 bc	1.48	1.40
2.7.	44.47 cd	13.76 c	7.91 e	6.22 ab	1.74	1.27
2.8.	38.61 e	11.41 e	8.08 de	6.41 a	1.41	1.26
2.9.	47.48 bc	12.90 d	8.70 ab	6.45 a	1.48	1.35
Mean	**45.50**	**13.44**	**8.46**	**6.12**	**1.59**	**1.39**
Stand. var.	5.18	1.21	0.33	0.42	0.13	0.10
CV%	11.39	9.03	3.91	6.84	8.36	7.23
Max	54.67	15.19	8.98	6.58	1.76	1.59
Min	38.61	11.41	7.91	5.32	1.41	1.26
	LSD 5% = 5.2321 LSD 1% = 7.1755 LSD 0.1% = 9.7666	LSD 5% = 0.7235 LSD 1% = 0.9923 LSD 0.1% = 1.3506	LSD 5% = 0.2865 LSD 1% = 0.3929 LSD 0.1% = 0.5348	LSD 5% = 0.3930 LSD 1% = 0.5390 LSD 0.1% = 0.7336		

*Different letters between variants denote significant differences (Duncan's test, $p<0.05$).

The kidney shape (2.2., 2.4., 2.5. and 2.7.) with a weak degree of curvature predominates at V_2 (Table 4). The other biotypes had an elliptic (2Mt, 2.1. and 2.3.) or circular to elliptic (2.3., 2.6. and 2.9.) shape.

The main color of control variant (light reddish brown) was found at 2.1. 2.8. The other three biotypes (2.2., 2.5. and 2.9.) had various shades of beige as their main color.

The white color (Figure 9) was present at 2.6. as main color and at 2.7. as secondary color (on half of grain).

A strong veining and difference in color of caruncula (raphe) can be observed at 2.6.

Weight at V_3 (Table 5) had the lowest values at 3.7. (47.65 g) and the highest values at control variant – 1 Mt (60.45 g).

Table 4. Main qualitative characteristics of the seeds V_2

V_2	Seeds shape[1]	Color			Hilum ring	
		Main	Secondar	Shape of secondar	Intensity	Color
2 Mt	elliptic	L reddish brown	reddish brown	in streaks and in patches	very weak	brown
2.1.	elliptic	L reddish brown	D brown	in streaks and in patches	weak	brown
2.2.	kidney [2] w	beige	mauve	in streaks and in patches	weak	yellowish
2.3.	circular to elliptic	L brown	grey	in very fine in patches	medium	brown
2.4.	kidney w	L brown	brown	in streaks and in patches	strong	brown
2.5.	kidney w	beige	reddish brown grey	in patches in fine patches	strong	orange
2.6.	circular to elliptic	white	brown	above the micropyle	absent	–
2.7.	kidney w	café au lait	white	half of grain	medium	brown
2.8.	elliptic	L reddish brown	reddish brown	in streaks and in patches	absent	–
2.9.	circular to elliptic	beige	grey	in very fine patches	strong	orange

[1]Shape of median longitudinal section; L = light; D = dark.
[2]Degree of curvature for kidney - shaped only: weak (w), medium (m) and strong (s).

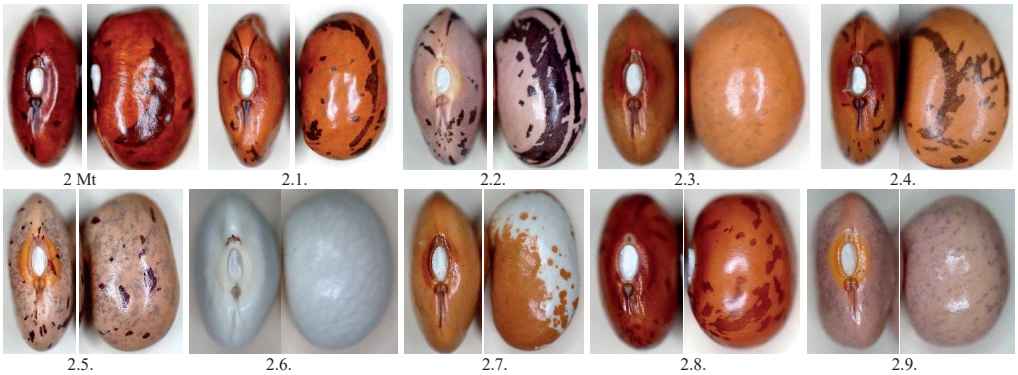


Figure 9. Aspects of qualitative characteristics of the seeds V_2

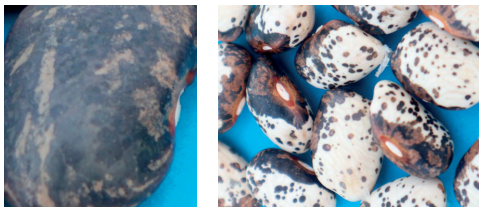
According to van Schoonhoven A. (1994), seeds belonging to this variant had a large size (more than 40 g). Seeds length registered the maximum value at 3.2 (16.76 mm) and the minimum value at 3.4. (13.36 mm). The coefficient of variation values for all parameters studied at V_3 were less than 10% (weight - 9.45% was the highest value), indicating low variability.

Table 5. Main quantitative characteristics of the seeds V_3

V_3	100 seeds mass (g)	Seeds dimensions (mm)			Length/ Width	Width/ Thickness
		Length	Width	Thickness		
3 Mt	60.45 a*	16.23 ab	8.45 b	6.13 c	1.92	1.38
3.1.	48.78 d	14.55 c	7.64 cd	6.07 cd	1.90	1.26
3.2.	60.35 a	16.76 a	8.93 a	6.29 c	1.88	1.42
3.3.	56.59 abc	13.64 d	8.67 ab	6.72 b	1.57	1.29
3.4.	53.56 bcd	13.36 d	8.38 b	7.37 a	1.59	1.14
3.5.	51.58 cd	16.44 ab	7.83 c	5.67 d	2.10	1.38
3.6.	58.92 ab	16.12 ab	8.45 b	5.68 d	1.91	1.49
3.7.	47.65 d	14.75 c	7.46 d	5.66 d	1.98	1.32
3.8.	49.11 d	14.08 cd	7.56 cd	6.16 c	1.86	1.23
3.9.	49.32 d	15.84 b	7.91 c	5.63 d	2.00	1.40
Mean	**53.63**	**15.18**	**8.13**	**6.14**	**1.87**	**1.33**
Stand. var.	5.07	1.25	0.51	0.56	0.17	0.10
CV%	9.45	8.21	6.29	9.09	8.92	7.84
Max	60.45	16.76	8.93	7.37	2.10	1.49
Min	47.65	13.36	7.46	5.63	1.57	1.14
	LSD 5% = 5.4448 LSD 1% = 7.4671 LSD 0.1% = 10.1636	LSD 5% = 0.7474 LSD 1% = 1.0250 LSD 0.1% = 1.3952	LSD 5% = 0.3346 LSD 1% = 0.4589 LSD 0.1% = 0.6246	LSD 5% = 0.4141 LSD 1% = 0.5679 LSD 0.1% = 0.7730		

*Different letters between variants denote significant differences (Duncan's test, $p<0.05$).

The most common shape to this variant (Table 6) was kidney (3 Mt, 3.1., 3.2., 3.5., 3.6., 3.9.), but it was met elliptical (3.3., 3.4.) and rectangular shape (3.7., 3.8.).
The combinations: main color beige, secondary color gray in patches (3.2.) or main color white, secondary colors brown and black on half the seed (3.3.) are much more suggestive in the field (Figure 10) that in the laboratory (Figure 11).



3.2. 3.3.

Figure 10. Aspects of seeds in the field

Table 6. Main qualitative characteristics of the seeds V_3

V_3	Seeds shape[1]	Color			Hilum ring	
		Main	Secondar	Shape of secondar	Intensity	Color
3 Mt	kidney[2] m	D brown	reddish brown	in patches	very weak	D brown
3.1.	kidney m	white	–	–	absent	–
3.2.	kidney m	beige	grey	in patches	medium	brown
3.3.	elliptic	white	brown and black	on half of grain	medium	brown
3.4.	elliptic	brown	black	in patches	absent	–
3.5.	kidney m	D beige	grey	in very fine patches	medium	reddish brown
3.6.	kidney s	brown	grey	in fine in patches	weak	brown
3.7.	rectangular	D mauve	–	–	absent	–
3.8.	rectangular	D reddish brown	L brown	in patches	absent	–
3.9.	kidney s	grayish brown	–	–	medium	L reddish brown

[1]Shape of median longitudinal section; L = light; D = dark.
[2]Degree of curvature for kidney - shaped only: weak (w), medium (m) and strong (s).

3 Mt 3.1. 3.2. 3.3. 3.4.
3.5. 3.6. 3.7. 3.8. 3.9.

Figure 11. Aspects of qualitative characteristics of the seeds V_3

CONCLUSIONS

In what it concerns weight of the seeds the maximum values were registered at control variants.
Various intensities of anthocyanin coloration of the hypocotyl show that the sown seeds were uniform only from a phenotypic point of view.
Under these conditions, the percentage of cross-pollination determined by insects cannot be specified.
A complete phenotypic characterization of bean seeds must include their quantitative and qualitative evaluation.
All biotypes will be cultivated to determine the characteristics of the plant. Only those that meet the breeding objectives will be kept and introduced into germplasm collection.

REFERENCES

Ali, A., Sher, A.K., Sardar, A., Naushad, A., Shah, M.K., Izhar, H., Taufeeq, A., Abdul, B., Haneef, R. (2020). *Morphological and biochemical characterization of locally available kidney beans*. *Pure and Applied Biology, 9*(1): 528–537. http://dx.doi.org/10.19045/bspab.2020.90058

Bliss, F.A. (1980*). Common bean*. In Hybridization of Crop Plants (Madison, WI, USA: American Society of Agronomy, Crop Science Society of America), p.273–283.

Ciofu, R. et al. (2003). *Tratat de legumicultură*. Ceres Publishing House. Bucharest. Romania.

Chen, Nicolas W.G. et al. (2021). Common bacterial blight of bean: a model of seed transmission and pathlogical convergence. *Mol Plant Pathol*. 2021;22:1464 – 1480. DOI: 10,1111/mpp,13067.

Danci, O., Corneanu, M., Petcov, A., Sarac, I., Buzdugan, E., Gămăneci, Gh. and Feţanu, B. (2010). Interpopulation Variability and Correlations between the Quantative Characters of *Phaseolus vulgaris* L. Landraces. *Annales of the University of Craiova, Agriculture, Montanology. Cadastre Series. Vol. XL*/2: 113–123.

Debouck, D. (2009) Key access and utilization descriptors for bean genetic resources. Bioversity International, Roma, Italy, Centro International de Agricultura Tropical (CIAT). http://www.bioversityinternational.org/ fileadmin /_migrated/ uploads/tx_news/Key_access _and_utilization_ descriptors_for_ bean_genetic_ resources _1346.pdf

Debouck, D. and Hidalgo, R. (1986). Morphology of the Common Bean Plant; Study Guide to be Used as a Supplement to the Audiotutorial Unit on the Same Topic (Cali, Colombia: Centro Internacional de Agricultura Tropical).

De la Cuadra, C., De Ron, A. M. and Schachl, R. (2001). *Handbook on evaluation of Phaseolus germplasm*, Edited by: PHASELIEU - FAIR - PL97-3463, Misión Biológica de Galicia (CSIC).

Forkman, L. (2009). Estimator and Tests for Common Coefficients of Variation in Normal Distribution. *Communications in Statistics – Theory and Methods. Volume: 38*, Number: 2, p. 233–251.

Genchev, D. and Kiryakov, I. (2005). Color scales for identification characters of common Bean (*Phaseolus vulgaris* L.). Dobroudja Agricultural Institute – General Toshevo. Bulgaria.

Giurcă, D. M. and Murariu, D. (2009). Aspects concerning the variability of certains morphological descriptors to some common bean (*Phaseolus vulgaris*) local landraces coming from Maramureş. *Lucrări Ştiinţifice, vol. 52, Seria Agronomie*, p. 168–173. http://www.revagrois.ro/PDF/2009_1_170.pdf

Harter, H.L. (1960). Critical values for Duncan's new multiple range test. *Biometrics, 16*(4): 671-685. https://doi. org/10.2307/2527770

Ireland, C. (2010). *Experimental statistics for agriculture and horticulture* – modular texts, 15–22 pg. CABI INTL Editure.

Leonte, C., Simioniuc, D., Simioniuc, V. (2004). Studiul unor populatii de fasole de gradina, colectate recent, in conditiile de la S.D.E. Iasi. *Revista Lucrari stiintifice. Seria Agronomie, vol. 47*.

Madoșa E., Ciulca S., Ciulca Elena Adriana, Velicevici Giancarla, Avadanei C., Batea N. (2010). Studies regarding the variability of pods number per plant in a landraces collection of common bean (*Phaseolus vulgaris* L.). *Journal of Horticulture, Forestry and Biotechnology, 14*(2).

Madoșa, E., Velicevici, G., Ciulca, S., Bitea, N. D., Avadanei, C., Ciulca, A. (2011). Studies regarding the value of a garden beans (*Phaseolus vulgaris* L. var. *nanus*) local landraces collection concerning the number of pods per plant. *Journal of Horticulture, Forestry and Biotechnology, 15*(4).

Munteanu, N. (1985). Câteva aprecieri asupra unor populaţii locale de fasole de grădină. *Cercetari Agronomice in Moldova, rezultate - recomandari. vol. 4*(72).

Munteanu, N., Timofte, V. and Timofte, E. (1989). Variante tehnologice pentru cultura fasolei urcătoare. *Cercetari Agronomice in Moldova, rezultate – recomandari, vol. 4*(88), p. 105–113.

Munteanu, N. and Falticeanu M. (2008). *Genetica si ameliorarea plantelor ornamentale.* "Ion Ionescu de la Brad" Publishing House. Iasi. Romania.

Olaru, C. (1982). *Fasolea*. Scrisul romanesc Publishing House. Craiova Romania.

Rădulescu, I. M. (1940). Contributiuni la cunoasterea sistemica a fasolei din Romania. Monitorul oficial si imprimeriile statului. Imprimeria nationala Bucharest. Romania

Riviș, I. and Nedelea, G. (2008). Studies regarding the variability of some morphological characters for a collection of dwarf common bean local landraces (*Phaseolus vulgaris* L.). *Journal of Horticulture, Forestry and Biotechnology. Seria a XII*-a. USAMV Timisoara. Romania.

Ruști, G. and Munteanu, N. (2008). *Cultura fasolei de gradina urcatoare.* "Ion Ionescu de la Brad" Publishing House. Iasi. Romania.

Săulescu, N.A., and Săulescu, N.N. (1966). *Câmpul de experienţă*. 2nd ed. Agro-Silvică Publisher House, Bucharest.

Stan, N., Savitchi, P., Munteanu, N., Ungureanu, G. et al. (1993). Studiul principalelor caractere in cadrul unor populatii de fasole de gradina (*Phaseolus vulgaris* L. var. *communis*) in vederea crearii de noi soiuri. *Lucrari Stiintifice. vol. 36. Seria Horticulture.* Universitatea Agronomica „Ion Ionescu de la Brad". Iasi. Romania.

Stan, N., Savițchi, P., Munteanu, N., Ungureanu, G. and Stan, T. (1995). Contribuţii la diversificarea sortimentului de soiuri la fasolea de grădină urătoare (*Phaseolus vulgaris* L. conv. *vulgaris*). *Cercetari Agronomice in Moldova, rezultate - recomandari. vol. 38*, p. 168–171.Iasi. Romania.

Teodorescu, E. (2016). Study concerning the variability of the main climbing bean characteristics under the environmental conditions of South-Eastern Romania. *XXIX IHCH, Proc. Int. Sym. on Plant Breeding in Horticulture, Acta Hortic*., 1127. DOI:10.17660/ActaHortic.2016.1127.78

Teodorescu, E. (2024). Comparative study between the sown seeds and the harvested seeds from climbing bean. *Proc. IX South-Eastern Europe Symposium on Vegetables and Potatoes, Acta Hortic*., 1391: 215–222.
DOI:10.17660/ActaHortic.2024.1391.30

Van Schoonhoven, Aart, Pastor-Corrales, Marcial A. (1994). Standard System for the Evaluation of Bean Germplasm. Centro Internacional de Agricultura Tropical, Columbia.

***C.P.V.O. - Community Plant Variety Office (2009). French bean (*Phaseolus vulgaris* L.) – Protocol for distinctness, uniformity and stability tests, TP/012/3.

****Descriptor for Phaseolus vulgaris* (1982). International Board for Plant Genetic Resources, AGPG: IBPGR/81/1. Rome.

***U.P.O.V. - International Union for the Protection of new Varieties of Plants. 2015. French bean *(Phaseolus vulgaris* L.) – Guideline for the conduct of tests for distinctness, uniformity and stabilty, TG/12/9.