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PHENOTYPIC DESCRIPTION OF *VIGNA UNGUICULATA* SUBSP. *SESQUIPEDALIS* ACCESSIONS AT BRGV BUZĂU

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Abstract

Vigna unguiculata subsp. sesquipedalis (yardlong bean) is a legume with high agronomic and nutritional potential, yet underutilized in Romania. This study aimed to perform a phenotypic characterization of six distinct clusters (C1-C6), each comprising 30 genetically related lines conserved at the Vegetable Genetic Resources Bank (BRGV) Buzău. Qualitative traits, including growth habit, flower, and pod color, as well as quantitative traits such as pod length, number of seeds per pod, and number of pods per node, were evaluated. Data were analyzed using cluster analysis to assess similarity and differentiation among accessions. The results highlighted one elite, E3, which exhibited superior productivity compared with the others. Pod length for E3 ranged from 16 to 22 cm, with approximately 15 seeds per pod and 2–3 pods per node. Cluster analysis confirmed the distinctiveness of E3 within the studied material. Based on its phenotypic performance, E3 is proposed for official variety registration and patenting. The identified traits recommend E3 as valuable material for breeding programs. Overall, this study provides essential phenotypic information to support the development and sustainable cultivation of yardlong bean in Romania.

Key words*: germplasm evaluation; elite selection; agromorphological traits; genetic resources conservation; breeding potential.*

INTRODUCTION

Vigna unguiculata (L.) Walp. subsp. *sesquipedalis*, commonly known as yardlong bean, is an important vegetable legume cultivated for its long, tender pods and high nutritional value. The crop is widely grown in tropical and subtropical regions, where it represents an essential source of proteins, vitamins, and dietary fiber. However, despite its agronomic and nutritional importance, it remains underutilized in European agriculture, including Romania.

Phenotypic characterization is a fundamental step in the evaluation and utilization of plant genetic resources. Morphological traits such as growth habit, flower characteristics, pod shape, and color are commonly used descriptors for distinguishing genotypes and assessing their agronomic value. As reported by Saha et al. (2013), "morphological characters play an important role in the identification and selection of superior genotypes", particularly in vegetable legumes where marketable traits are directly linked to phenotype. Similarly, studies conducted on yardlong bean genotypes showed that "significant variability exists among genotypes for morphological traits and yield components", indicating the potential for effective selection based on phenotypic performance (George and Sarada, 2015).

Moreover, it has been reported that "domestication of yardlong bean involved significant modifications in pod length and seed-related traits, reflecting strong selection for agronomic performance and consumer preferences" (Kongjaimun et al., 2012).

Yield performance in yardlong bean is strongly influenced by several interrelated traits. Previous research has demonstrated that "pod length, number of seeds per pod and number of pods per plant are major yield contributing characters," and their variation significantly affects productivity (Haque et al., 2015). In addition, "pod length is a quantitatively inherited trait controlled by multiple genetic loci, highlighting its importance as a key target in breeding programs for yield improvement" (Xu et al., 2013). In addition, it has been observed that "considerable variation was recorded among genotypes for pod length and number of pods per node", emphasizing the

importance of these traits in the evaluation of germplasm collections (Huque et al., 2012). Such variability provides a valuable basis for identifying elite genotypes with superior agronomic performance.

The assessment of genetic resources in advanced generations and diverse environments has further confirmed the importance of phenotypic evaluation. It was reported that "wide variability among genotypes for yield and its components suggests good scope for selection," especially when traits exhibit consistent expression across conditions (Hasanuzzaman et al., 2014). Moreover, clustering of genotypes based on phenotypic traits has proven effective in identifying distinct groups and superior lines, facilitating the selection of promising material for breeding programs.

In addition to morphological and yield-related traits, seed germination and viability are essential parameters for the conservation and efficient use of plant genetic resources. Germination capacity reflects the ability of seeds to produce normal seedlings under favorable conditions, while viability indicates the presence of living tissues capable of germination. Studies have shown that "germination percentage varies significantly among genotypes and is an important indicator of seed quality" (Islam et al., 2013). Furthermore, it has been emphasized that "seed viability and vigor are influenced by genetic factors as well as storage conditions", which may lead to differences in germination performance even among closely related lines (Hasanuzzaman et al., 2014).

An important aspect in seed evaluation is the possible discrepancy between viability tests and actual germination. It has been observed that "high viability does not always correspond to high germination due to the presence of dormancy or physiological constraints", highlighting the need for complementary testing methods in gene bank management. This is particularly relevant for conserved germplasm, where accurate assessment of seed quality is critical for regeneration and long-term preservation.

In the context of biodiversity conservation and sustainable agriculture, the phenotypic characterization of yardlong bean accessions is essential for identifying valuable genetic material. The Vegetable Genetic Resources Bank (BRGV) Buzău maintains a diverse collection of *Vigna unguiculata* germplasm, which requires systematic evaluation to support its utilization in breeding and cultivation.

Therefore, the present study aims to perform a detailed phenotypic characterization of *Vigna unguiculata* subsp. *sesquipedalis* accessions conserved at BRGV Buzău, with particular emphasis on morphological traits, yield components, and seed germination and viability, in order to identify superior genotypes suitable for future breeding programs and potential variety registration.

MATERIALS AND METHODS

Biological material and experimental site

The biological material analyzed consisted of accessions of *Vigna unguiculata* (L.) Walp. subsp. *sesquipedalis*, preserved at the Plant Genetic Resources Bank (BRGV) Buzău. These were grouped into six clusters (C1-C6), each comprising 30 genetically related lines.

Phenotypic characterization

Phenotypic characterization included both qualitative and quantitative traits and was performed using the international descriptors established by the International Union for the Protection of New Varieties of Plants.

The qualitative traits analyzed focused on morphological aspects such as growth habit, flower color, and pod color, while the quantitative traits included pod length, number of seeds per pod, and number of pods per node.

Biometric measurements of the seeds were performed using the WinSEEDLE system, based on high-resolution scanning and image analysis, which allows for precise measurement of seed dimensions and shape, ensuring high accuracy and reproducibility (Figure 1).

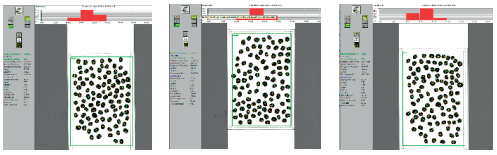

Figure 1. Seed morphometric analysis using the WinSEEDLE system

Germination determination

Given the large size and round shape of the seeds, the accordion-fold method was used, employing absorbent paper measuring 58.9 × 57.5 cm.

Substrate moistening was performed in two stages: initially to approximately 60% of water-holding capacity, followed by a second watering after 24 hours, until the optimal level was reached.

This method was used to prevent rapid water absorption and damage to the cotyledons.

The experiment was conducted in four replicates of 100 seeds each, spaced evenly (approx. 4 cm apart) on the substrate, to allow for normal seedling development and to prevent damage or secondary infections. The samples were placed in transparent plastic bags to prevent water evaporation and then incubated in a germinator at a temperature of 30°C, optimal for thermophilic species. Relative humidity was maintained at approximately 60%, and lighting was provided throughout the test.

The evaluation was conducted in two stages: germinative energy (EG) - at 5 days and facultative germination (FG) - at 10 days.

The seeds were classified into the following categories: normal seedlings - with fully developed structures capable of ensuring normal plant growth; abnormal seedlings - with major defects that prevent further development; fresh ungerminated seeds - viable but which did not germinate under test conditions; hard seeds - impermeable, with no changes during the test; dead seeds - soft, damaged, or infected, with a non-viable embryo (Figure 2).



Figure 2. Seeds on the germination tray; normal seedlings; abnormal seedlings; fresh seeds and hard seeds

To determine viability, 2,3,5-triphenyltetrazolium salts were used in a 1% solution. The principle of the method consists of highlighting living tissues by staining them carmine red through the hydrogenation process, forming a stable compound, formazan. The test consisted of 4 replicates of 100 seeds that were prepared in advance by soaking them in water for 18 hours at a temperature of 25°C. The seeds were then placed in the staining solution so that it completely covered the seeds. The test was incubated for 18 hours at 30°C in the dark. After the incubation period, the degree of staining was checked. The seeds, washed with cold water, were dried and evaluated according to ISTA evaluation criteria. Based on the degree of staining, the seeds were grouped into two categories:

- Viable seeds. These are seeds that are completely stained red or whose essential structures are stained to the extent that they can be considered a viable embryo.
- Non-viable seeds. All seeds that are not fully stained or that exhibit areas of interest with unstained, soft, or necrotic structures.
- Hard seeds. These are seeds that did not stain and did not change size following the procedure. They are considered alive but dormant (Figure 3).

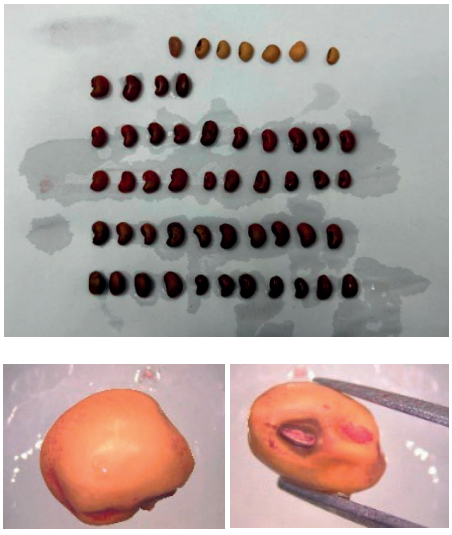

Figure 3. Seeds prior to tissue examination

RESULTS AND DISCUSSIONS

Cluster C1 - The plants are semi-erect climbers (claw-type), with a pyramidal growth habit. The leaves are light green and slightly rough. The terminal leaflet is triangular to circular. The pods are light green, cordate in cross-section, slightly curved or nearly straight, with an acute tip and a smooth or slightly rough surface. The seeds are kidney-shaped, beige in color with a brown ring around the hilum.

Cluster C2 - Climbing plants, pyramidal architecture, without anthocyanin pigmentation. The leaves are light green, with very slight or no roughness. The terminal leaflet has an intermediate shape (triangular-circular). The pods are light green, oval in cross-section, slightly curved, with an acute tip and a smooth surface. The seeds are similar to those of other clusters (kidney-shaped, beige with brown around the hilum).

Cluster C3 - Climbing plants with anthocyanin pigmentation. Medium-green leaves, without obvious roughness. Circular terminal leaflet. The pods are longer and green in color, with an oval cross-section, slightly curved, and a moderately rough surface. This cluster is distinguished by its uniformity and vigor. The seeds are kidney-shaped, with a typical color.

Cluster C4- Climbing plants with anthocyanin pigmentation and a pyramidal growth habit. The leaves are very light in color. The terminal leaflet is circular. The pods are light green, heart-shaped in cross-section, more noticeably curved, and have a concave tip. The surface is smooth. The seeds are similar to those of other clusters.

Cluster C5 - Climbing plants lacking anthocyanin pigmentation. Light green leaves with moderate roughness (most evident among the clusters). The terminal leaflet is circular. The pods are green, heart-shaped in cross-section, nearly straight, with an acute tip and a smooth surface. The seeds are wider in cross-section.

Cluster C6 - Climbing plants with a pyramidal growth habit. Light green leaves, smooth. The terminal leaflet is circular and larger than those in the other clusters. The pods are green, elliptical in cross-section, slightly curved, with a variable tip (acute to truncate). The seeds are wider.

Table 1. Comparative analysis of quantitative traits in *Vigna unguiculata* clusters (means ± statistical grouping by Duncan test, $p \leq 0.05$)

Trait/cluster	C1	C2	C3	C4	C5	C6
Terminal leaflet: size (cm)	11.5^{b}	10.9^{c}	11.3^{b}	9.9^{d}	10.6^{c}	14.0^{a}
Pod: length (cm)	15.7^{b}	13.3^{c}	17.5^{a}	17.2^{a}	13.3^{c}	-
Pod thickness (cm)	0.9^{a}	0.8^{b}	0.8^{b}	0.8^{b}	0.7^{c}	0.8^{b}
Pod : width (cm)	0.7^{a}	0.7^{a}	0.7^{a}	0.7^{a}	0.7^{a}	0.6^{b}
Seed: weight (g)	0.16^{c}	0.22^{b}	0.20^{b}	0.20^{b}	0.28^{a}	0.21^{b}
Seed: length (cm)	0.7^{c}	1.0^{b}	1.1^{a}	1.1^{a}	1.0^{b}	1.0^{b}
seed/pod	16^{b}	16^{b}	18^{a}	16^{b}	14^{c}	15^{c}
Pod yield (g)	176^{c}	169.2^{c}	228.1^{a}	139.8^{d}	206^{b}	125.1^{d}
Fresh weight of 100 seeds (g)	40^{a}	37^{c}	40^{a}	40^{a}	40.1^{a}	39^{b}

Analysis of quantitative traits reveals significant phenotypic variability among the six clusters of *Vigna unguiculata* subsp. *sesquipedalis,* a finding confirmed by the groupings obtained using Duncan's test ($p \leq 0,05$).

Regarding the length of the terminal leaflet, cluster C6 differed significantly, recording the highest value (14.0 cm) and being distinctly classified in group "a". The other clusters exhibited lower values, distributed across several statistical groups, indicating moderate diversity for this trait.

Pod length is of major agronomic interest, where clusters C3 and C4 formed the upper group ("a"), with values of 17.5 cm and 17.2 cm, respectively. These results suggest high productive potential, as pod length is a trait directly correlated with seed number and total yield.

In the case of pod width and thickness, the variations were smaller. However, cluster C1 stood out with the greatest width (0.9 cm), while cluster C6 had the smallest thickness (0.6 cm), differing significantly from the other clusters.

Individual seed weight showed clear differences between clusters, with cluster C5 being significantly higher (0.28 g, group "a"). This characteristic indicates a biological type oriented toward the formation of large seeds with high commercial potential, but not necessarily correlated with a high number of seeds per pod (Figure 4).



Figure 4. Morphological aspects of *Vigna unguiculata*: plant, leaf, pods and seeds

In terms of seed length, clusters C3 and C4 recorded the highest values (1.1 cm), which were significantly higher than those of the other variants. This trait contributes to the overall size of the seed and may influence consumer preferences.

Analysis of the number of seeds per pod shows that cluster C3 stands out significantly (18 seeds/pod), confirming its efficiency in converting resources into reproductive output. In contrast, cluster C5 had the lowest values (14 seeds/pod), highlighting a trade-off between seed size and number (Figure 5).

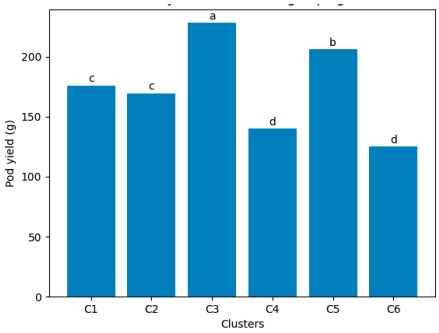

Figure 5. Pod yield with Duncan grouping

The graph highlights significant differences among the clusters of *Vigna unguiculata* subsp. *sesquipedalis*, as confirmed by Duncan's multiple range test ($p \leq 0.05$).

Cluster C3 stands out clearly, falling into the top statistical group ("a"), with the highest pod yield (228.1 g). This performance indicates high efficiency in resource allocation to reproductive organs and confirms the superior agronomic potential of this cluster.

Cluster C5 occupies the second position (group "b"), with a yield of 206 g, significantly lower than C3 but higher than the other clusters. This result suggests a trade-off between yield components, as it is known that this cluster is characterized by larger seeds but fewer per pod.

Clusters C1 and C2, classified in group "c", show intermediate values and do not differ significantly from one another. They reflect relatively stable genetic material, but without maximum performance in terms of yield.

The lowest values are recorded by clusters C4 and C6, classified in group "d", with no significant differences between them. These results indicate reduced productive potential, which limits their direct use for commercial purposes but does not exclude their value in breeding programs.

The Duncan group analysis confirms the presence of significant variability and identifies C3 as the superior genotype, followed by C5, while C4 and C6 represent the lower extremes of performance.

For 100-seed weight (TSW), cluster C3 ranked in the top group ("a") with 7.2 g, suggesting a favorable combination of seed size and density. At the opposite end, cluster C5 recorded the lowest value (5.6 g), being statistically distinct.

The most relevant agronomic indicator, pod yield, revealed very significant differences between clusters. Cluster C3 stood out clearly, with a yield of 228.1 g (group "a"), followed by C5 (206 g, group "b"). Clusters C1 and C2 formed an intermediate group ("c"), while C4 and C6 had the lowest values (group "d") (Table 2).

Table 2. Morphometric parameters of *Vigna unguiculata* seeds (n = 3 × 100 seeds)

Parametre	Media ± SD	CV (%)
Average curved length (mm)	7.66 ± 0.12	1.62
Average perimeter (mm)	22.36 ± 0.34	1.53
Aspect ratio	0.889 ± 0.014	1.59
Seed surface (mm²)	9094.44 ± 283.16	3.11
Volume (mm³)	146.32 ± 6.44	4.40
Seed length (mm)	7.41 ± 0.14	1.86
Seed width (mm)	6.08 ± 0.11	1.83

Morphometric analysis of *Vigna unguiculata* seeds (n = 3 × 100 seeds) reveals a high degree of uniformity in the biological material, as

reflected by the low values of the coefficient of variation (CV%) for all analyzed traits.

The mean curved length parameter recorded a value of 7.66 ± 0.12 mm, with a CV of 1.62%, indicating very low variability and high homogeneity in the longitudinal dimension of the seeds. This trend is also supported by the value of the average perimeter (22.36 ± 0.34 mm; CV = 1.53%), suggesting good dimensional consistency along the seed contour. The shape coefficient (0.889 ± 0.014; CV = 1.59%) indicates a relatively regular shape, close to elliptical, specific to reniform seeds. Values close to 1 reflect a high degree of roundness and morphological uniformity.

Regarding the derived dimensional parameters, the average seed area (9094.44 ± 283.16 mm²) and volume (146.32 ± 6.44 mm³) exhibit slightly higher CV values (3.11% and 4.40%, respectively), which indicates moderate variability. This is to be expected, as these parameters are cumulatively influenced by variations in linear dimensions.

Principal dimension analysis shows that seed length (7.41 ± 0.14 mm; CV = 1.86%) is slightly greater than width (6.08 ± 0.11 mm; CV = 1.83%), confirming an elongated shape specific to this species.

The length-to-width ratio (L/W) is 0.824 ± 0.008, with the lowest coefficient of variation (1.00%), indicating very high morphological stability of seed shape. This parameter is essential for characterizing seed type and can be used as a discriminatory indicator in studies of genetic variability.

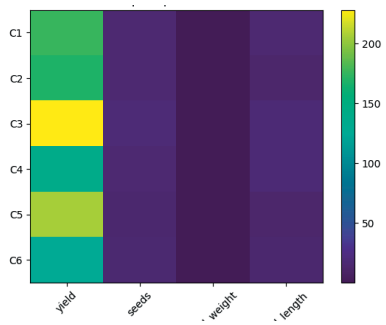

Figure 6. Heatmap of quantitative traits

The heatmap (Figure 6) provides an overview of the variation in quantitative traits across clusters, highlighting clear differences in phenotypic profiles.

Cluster C3 exhibits a distinct pattern, characterized by high values for most traits associated with yield (pod length, number of seeds, total yield), confirming its dominant position also observed in the univariate analysis. The intensity of the colors associated with this cluster indicates a concentration of high values, reflecting a balanced and high-performing agronomic profile.

Cluster C5 is distinguished by high values for seed weight but lower values for the number of seeds per pod, highlighting a distinct biological strategy. This dissociation between yield components is visible in the color contrast of the heatmap.

Clusters C1 and C2 exhibit a relatively uniform profile, with no obvious extremes, suggesting low variability and phenotypic stability. They occupy an intermediate position within the overall variation.

Cluster C4 is characterized by moderate to low values for most traits, while C6 exhibits low values particularly for yield and certain pod dimensions; thus, it grouped in the lower performance range.

Table 3. Germination Test Results

No. of repetitions	GN	GA	FS	HS	DS
1	69	6	3	7	15
2	70	4	1	17	8
3	81	0	2	8	9
4	67	3	5	15	10
M	287	13	11	47	42
%	72	3	3	12	10

*GN-normal germs; GA-abnormal germs; FS-fresh seeds; HS- hard seeds; DS- Dead seeds

The average value of 72% normal germination (GN) (Table 3) indicates acceptable germination capacity for the first year after harvest. However, the 28% gap from maximum potential is explained not so much by a loss of viability as by the presence of dormant forms. The low percentage of abnormal germinants (3%) demonstrates the effectiveness of the two-stage moistening method; by controlling water intake, imbibition stress was minimized, which in legumes frequently causes fractures of the embryonic axis or cotyledons. The most significant observation is the 12% percentage of hard seeds (HS). In seed physiology, this phenomenon is interpreted as a physical barrier imposed by the impermeable seed coat, an evolutionary survival strategy that ensures

staggered germination over time. From a technological standpoint, this 12% threshold suggests that the batch could result in uneven emergence under field conditions, necessitating an increase in the seeding rate to avoid density losses during sowing. The presence of the 3% fresh seeds (FS), which remain turgid but do not initiate the growth process, indicates a form of superficial physiological dormancy. The 10% dead seeds (DS) represent the only irreversible loss in the batch. This finding can be attributed either to mechanical damage during harvesting or to the attack of endogenous pathogens that took advantage of the optimal humidity and temperature conditions (30°C) in the germination chamber. However, the low rate of secondary contamination confirms that spacing the seeds on the bed using the PP method was an appropriate technical measure for isolating infection foci.

Interim conclusion. The results demonstrate that *Vigna unguiculata* maintains an energy-conservation strategy through hard seeds, requiring a careful interpretation of "cultivated value" that includes not only immediate germination but also biochemically confirmed viability reserve (Table 4).

Table 4. Viability test results

<table>
<tr><th colspan="2">Viable seeds</th><th colspan="2">Non-viable seeds</th><th colspan="2">Hard seeds</th></tr>
<tr><td rowspan="4">75</td><td>"bright red" coloration</td><td rowspan="4">7</td><td>white</td><td rowspan="4">18</td><td rowspan="4">The seeds show no changes in size or color compared to their original form.</td></tr>
<tr><td>1/3 of the white root</td><td>With a colored root tip</td></tr>
<tr><td><50% of the cotyledon surface is white</td><td>Necrotic</td></tr>
<tr><td>Light red tint</td><td>White growth bud</td></tr>
</table>

The "bright red" coloration confirms intense activity of dehydrogenase enzymes in the embryonic axis.

The Correlation Between Germination and the Viability Test (Tetrazolium)

The 2,3,5-triphenyl tetrazolium salt test provided deeper insight into the biological potential of the batch. Viability vs. Germination: The percentage of viable seeds (75%) is higher than the average for normal seedlings, demonstrating that some of the seeds that did not germinate in the standard test are, from a metabolic standpoint, alive. In contrast, seeds considered non-viable (with a white growth tip or necrosis on the radicle) explain the appearance of abnormal seedlings in the germination test. Practical implications and laboratory conclusions

The incidence of dead seeds (DS) and fungal attacks (observed as soft/moldy seeds) suggests the need for strict hygiene monitoring in the germination room, even under optimal lighting conditions (Figure 7).

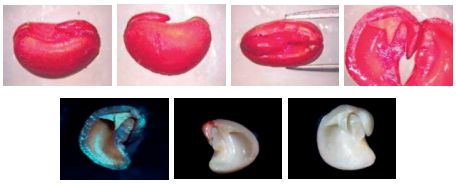

Figure 7. Viable seeds (first row) and non-viable seeds (second row)

CONCLUSIONS

The present study provided a comprehensive phenotypic characterization of six clusters (C1-C6) of *Vigna unguiculata subsp. sesquipedalis* conserved at the Vegetable Genetic Resources Bank (BRGV) Buzău, highlighting their agronomic potential and variability.

The analysis of qualitative traits revealed a relatively uniform architectural pattern, with all clusters exhibiting a climbing growth habit and a pyramidal plant architecture. However, distinct differences were observed in traits such as anthocyanin pigmentation, leaf color intensity, pod shape, and surface texture, confirming the existence of phenotypic diversity within the studied germplasm.

Quantitative trait analysis demonstrated significant variability among clusters, particularly for yield-related characters. Cluster C3 clearly stood out as the most valuable genotype, combining superior pod length, the highest number of seeds per pod, and maximum pod yield. These characteristics indicate a high efficiency in resource allocation toward reproductive structures, making C3 a strong

candidate for breeding programs and potential cultivar development.

Cluster C5 was distinguished by the highest individual seed weight, suggesting a different biological strategy oriented toward seed size rather than seed number. This highlights the presence of a trade-off between yield components, which is essential for targeted breeding objectives depending on market requirements.

The morphometric analysis of seeds revealed a high degree of uniformity, with all coefficients of variation below 5%, indicating a stable and well-conserved genetic material. The low variability in shape descriptors and dimensional parameters supports the reliability of the material for both conservation and breeding purposes.

Germination tests indicated an acceptable germination capacity (72%), while the tetrazolium viability test revealed a higher proportion of viable seeds (75%), suggesting the presence of dormancy mechanisms, particularly physical dormancy expressed through hard seeds (12%). This reflects an adaptive survival strategy but also indicates the need for pre-sowing treatments to ensure uniform field emergence.

Overall, the study confirms the existence of valuable genetic resources within the BRGV Buzău collection and emphasizes the importance of integrated phenotypic and physiological evaluation. Cluster C3, along with the elite line E3, is recommended for further testing, official registration, and inclusion in breeding programs aimed at improving yield and adaptability of yardlong bean in Romania.

REFERENCES

George, M.E., Sarada, S., 2015. Genetic analysis of yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) for vegetative and yield characters. *International Journal of Advanced Research*, 3(4): 1052–1057.

Hasanuzzaman, M., Hossain, M.K., Alam, N., Biswas, B.K., 2014. Study on genetic variability and heritability in F3 population of yard long bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) for yield and its components. *Bangladesh Journal of Agricultural Research*, 39(4): 629–640.

Haque, M.S., Azad, A., Saha, N.R., Islam, M.M., 2015. Genetic variability and correlation studies among yield and yield contributing characters of yardlong bean. *International Journal of Scientific and Research Publications*, 5(1): 1–4.

Huque, A.K.M.M., Hossain, M.K., Alam, N., Hasanuzzaman, M., Biswas, B.K., 2012. Genetic divergence in yardlong bean (*Vigna unguiculata* (L.) Walp. subsp. *sesquipedalis* Verdc.). *Bangladesh Journal of Agricultural Research*, 37(1): 9–18.

Islam, M.M., Hasanuzzaman, M., Hossain, M.K., Alam, N., 2013. Morphological traits and yield components of yardlong bean (*Vigna unguiculata* L. subsp. *sesquipedalis*). *Journal of Agricultural Science*, 5(8): 135–142.

Kongjaimun, A., Kaga, A., Tomooka, N., Somta, P., Vaughan, D.A., Srinives, P., 2012. The genetics of domestication of yardlong bean (*Vigna unguiculata* (L.) Walp. subsp. *unguiculata* cv.-gr. *sesquipedalis*). *Annals of Botany*, 109(6): 1185–1200.

Saha, N.R., Azad, A., Haque, M.S., Islam, M.M., 2013. Morphological characteristics, growth behavior, and yield potential of yard-long bean (*Vigna unguiculata* subsp. *sesquipedalis*). *International Journal of Sustainable Agriculture*, 5(2): 45–50.

Xu, P., Wu, X., Wang, B., Liu, Y., Qin, D., Ehlers, J.D., Close, T.J., Hu, T., Lu, Z., Li, G., 2013. An SSR-based linkage map of yardlong bean (*Vigna unguiculata* (L.) Walp.) and QTL analysis of pod length. *Molecular Breeding*, 31(4): 859–871.