

STUDY OF VARIABILITY ON MAIN QUANTITATIVE CHARACTERISTICS OF *PHASEOLUS VULGARIS* IN ORGANIC FARMING SYSTEM

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INTRODUCTION

Phaseolus vulgaris, commonly known as bean, is a large genus of annual vegetables in the pea family that are primarily native to Central America and South America, with a few species native to North America. Columbus reportedly introduced some plants of this genus to the Mediterranean in 1493 when he returned from his second voyage to the New World.

The common bean is a warm season legume that does better under subtropical and temperate conditions. It can be found in tropical areas but does not do well under very wet conditions, which cause fungal attacks and flower drop. It can be advantageously replaced by cowpea *Vigna unguiculata* in such conditions (Wortmann, 2006).

Scientists, farmers, and vegetable growers around the world have shown over the past few decades that the use of high-quality seeds increases agricultural production. Importance of quality seed is determined by characteristics such as biological and genetic value, varietal and physical purity, high germination, vigor and health.

Maintaining the biological purity of legume varieties and producing the necessary quantities of seeds, involves the use of seed production methods that take into account the following factors: plant biology, ecological conditions, genetic basis of the variety. The efficiency of the seed production system is reflected in the quantity and quality of production. The main purpose in choosing a seed production system must be to preserve the characteristics that characterize the variety (Popa, 2010).

Ensuring the preservation of future sources is a big challenge for plant geneticists and breeders. Seed gene banks are intended to enable the conservation of the world's crop genetic diversity against the genetic erosion of crops as an unintended consequence of the global uptake of new high-yielding green revolution agricultural varieties (Peres, 2016).

Seed gene banks are facilities dedicated to the medium-term storage, i.e., for a few decades in storage at 5–10°C, or long-term storage, i.e., for

many decades in storage at $-18 \pm 3^{\circ}\text{C}$, of samples of seeds as a means of conserving crop or species diversity. A seed gene bank conserving crop variety is often called a gene bank as the seed samples, are used as a source of genes conferring desirable characteristics (Hay, 2017).

In the North-East and central area of Moldova are known over 150 local populations of climbing beans (Munteanu et al., 1989).

Using this valuable germplasm content, a number of four varieties of climbing garden beans were made through the specific amelioration works: Auria Bacăului, Violetă de Iași, Verba and Dragomir. These varieties represent the official assortment for this culture in Romania (Stan, Munteanu., 2003).

The present paper presents the study of quantitative characters for the Auria Bacăului climbing garden bean variety and is based on the scientific results obtained on the field.

Studies on the main elements of productivity of these varieties have shown that they are very productive, with a high-quality pod, the varieties are resistant or sufficiently resistant to abiotic and biotic stressors and also, these varieties have a high suitability both for field and protected areas cultivation (Ruști, 2007).

MATERIAL AND METHODS

The paper aims to present a study on the variability of the main quantitative characteristics of the Auria Bacăului climbing bean variety and its significance for the selection works.

The objectives of the experiment are the following: production of basic seed material with biological and phytosanitary properties corresponding to international quality standards and quantitative requirements at national level; maintaining the biological value and production capacity of the Auria Bacăului bean variety.

The variety through its use in cultivation or seed processing is directly or indirectly subjected to processes and factors that lead to the degradation of the initial features by losing the defining

characteristics.

The main factors that may cause the loss of variety traits are classified into genetic factors and ecopedological factors. Genetic factors are: uncontrolled hybridizations, application of inadequate differentiation methods, mutations, genetic drift. Ecopedological factors can be: seed production in different ecological conditions, mechanical aggregates.

Conservative selection is a process that involves maintaining the agronomic value within the limits corresponding to each variety. One of the most important aspects of this process is to set the limits of variability, it can help preserve the initial defining characters for a particular variety.

This paper aims to study the variability of quantitative characters and establish its limits of variability of a variety of climbing garden beans, namely Auria Bacăului.

In order to achieve these objectives, other intermediate analyzes were necessary, such as the analysis and knowledge of the variety of climbing garden beans, but also the realization of a synthesis of the research carried so far in order to maximize the cultivation systems.

The bean variety Auria Bacăului was created in 1985 at the Vegetable Research and Development Station Bacău with the destination of field and greenhouse cultivation. The variety is indicated in field cultivation especially for less dry and hilly areas (Munteanu and Fălticeanu, 1993).

The plant has a voluble stem with 3-4 medium branches. The foliage has a greenish-yellow or green color and the leaflets are medium in size. The flowers are colored in light purple-cyclamen and are gathered in inflorescences ranging from 7-11.

The pods have a semi-curved tip and are large and wide, the seeds are barely visible. Their color is golden yellow. The seeds are beige-purple, large, elliptical-reniform.

This variety is part of the group of climbing garden bean varieties and is classified as semi-early, with a vegetation period of 130-150 days. The first pods appear about 50 days after sowing.

The researches were carried out within the Vegetable Research and Development Station Bacău in the period 2018 - 2019.

The experiment was located on a polished cambic chernozem, medium evolved with loamy-sandy texture, with a pH between 6.2 - 6.7 and a content in humus of 2.5 - 3.5%. The field was specially arranged with 2 m high trellis, placed at 1.8 m between rows.

On each row of trellis, 2 rows of climbing beans were sown, at 0.4 m between rows and 0.2 m between plants per row. Sowing was carried out bean by bean on May 5 at a depth of 5 - 6 cm. The establishment of the CSD field was carried out by sowing separately in layered blocks varying according to the number of pods per plant.

In 2019, the conservative selection scheme based on the individual selection method in the choice field (CF) and the line selection in the descendant selection field (DSF) was used. The field of study of descendants (DSF) included 152 lines from the elites harvested from the field of choice (CF) 2018. The grouping was done by classes. The study took the main quantitative characters for climbing beans - Auria Bacăului:

- The length of the pod
- The width of the pod
- The number of pods per plant
- The number of beans on the pod
- The weight of the pod
- Number of beans per plant

Lines susceptible to pathogens, earlier or later or those that did not meet the standard variation limits were excluded. At technological maturity, survey samples were performed on 500 plants (from 50 to 50 individuals). At these tests, the number of pods per plant, the length of the pod and the width of the pod were determined.

At physiological maturity, the number of beans in the pod, the number of beans per plant and the number of beans per plant were determined. Based on the first survey sample, 500 elites were marked and from these were eliminated those plants that presented low values for the characters analyzed in the second survey sample. The retained elites corresponded to the range of arithmetic mean (\bar{X}) \pm and the standard deviation (S).

After systematizing the information contained in the experience data and highlighting the contribution of different sources of variability by analyzing the variation, we proceeded to the interpretation of the results obtained.

The genetic analysis of the quantitative characters was made by the multiplication method, the selection of the material being made by retaining the individuals included in the selection interval given by the average \pm 1 standard deviation.

By statistical-mathematical processing of the data obtained from the measurements performed, the limits of variation of the quantitative characters for the Auria Bacăului climbing bean variety were calculated, as follows:

- Arithmetic mean (\bar{X}): $\bar{X} = \frac{\sum_{i=1}^n x_i}{n}$

In which: x_i - the sum of the values of some individual characters

n - the number of individuals

- Standard deviation of the mean (S):

$$S = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n}}$$

In which: x_i - the sum of the values of some individual characters

\bar{x} - average

N - number of individuals

- Coefficient of variability (S%): $S\% = \frac{s}{x} 100$
In which: s - standard deviation
x - average

- Variation limits: $x_{\min} - x_{\max}$
In which: x_{\min} - the minimum value
 x_{\max} - the maximum value

The Vegetable Research and Development Station is located in the part northeast of Bacău. Also, the experimental field of the resort is located in the interfluvium Bistrița - Siret about 4 km north of their confluence, on a river terrace with an altitude of 5 - 7 m.

The average annual temperature is above 9°C in the southern half and below 9°C in the northern half. During the winter, the penetration of continental cold air masses from the east and northeast determines in Bacău during January an average of -4.1°C, in some years the deviations from normal can be significant.

In summer, on the other hand, due to the penetration of warm continental air from the south and east, the average temperature of August reaches 21.4°C. Also, in some years and the average of July can fluctuate, reaching values of 22.7°C.

Regarding the precipitations in the area, annually there are approximately 414.7 - 541.8 l / sqm, distributed approximately evenly during the vegetation period of the vegetables, which allows their cultivation in good conditions. In the conditions of 2019, the following precipitation values were registered totaling 470 l / sqm only during the bean vegetation period.

From the data recorded by the Bacău Meteorological Station, it results that the winds have a relatively high frequency, the winds blow for a period of approximately 265 days, and approximately 100 days are calm. The winds blow irregularly from all directions, the prevailing air currents from the northwest.

From the data presented above it results that within the Vegetable Research and Development Station Bacău are favorable conditions for the growth and favorable development of climbing beans and as a result a very good conservative selection can be achieved and also obtaining the basic seed of Auria Bacăului.

RESULTS AND DISCUSSIONS

The experiments were performed in conditions of a particularly hot year with average temperatures above 19°C during June - the first decade of September, with rainfall above the multiannual average of June, July and August and prolonged drought until the end of September.

Table 1. The main phenophases of the Auria Bacăului climbing bean variety in 2019

No.	Phenophase	Period	Duration of phenophase (no. days)	Thermal balance (°C)
1	Sowing - risen	05.05 – 13.05	8	89.3
2	Risen - flowering beginning	14.05 – 25.06	43	858.7
3	Flowering beginning - the appearance of the first pod	26.06 – 03.07	8	197.4
4	The appearance of the first pods - technological maturity	04.07 – 30.07	13	280.4
5	Technological maturity - physiological maturity	18.07 – 26.08	38	820.5
6	The total period vegetation	05.05 – 26.08	101	2246.3

It can be seen that the sowing-risen phenophase: had a duration of 8 days, the thermal balance being 89.3°C. Risen phenophase - flowering beginning: it was carried out between 14.05 - 21.06, with a period of 43 days and the thermal balance totaling 858.7°C. The phenophase started to bloom - the appearance of the first pod: it lasted 8 days, during this period the thermal balance amounted to 197.4°C. Phenophase the appearance of the first pods - technological maturity: it lasted approximately 13 days and the thermal balance was 280.4°C. Technological maturity - physiological maturity was performed between 18.07 - 26.08 the duration of the phenophase being 38 days and the thermal balance totaling 820.5°C. The obtained results reveal that the total vegetation period of the bean plants was 101 days and the thermal balance of 2246.3°C (Table 1). Study of the variability of quantitative characters for the climbing bean variety - Auria Bacăului revealed the following results (table 2).

Table 2. The variability of quantitative characters

No.	The studied character	X	S	S%	Limits of variation	Meaning S%
1	Pod length (cm)	21.75	2.47	11.36	18 - 27	Average variab
2	Pod width (cm)	1.83	0.17	9.68	1.5 – 2.3	Small variab.
3	No. pod on the plant	37.1	9.02	24.31	20 – 55	High variab
4	No. beans in pods	7.86	0.96	12.25	6 – 10	Average variab
5	The weight of the pod	19.03	1.75	9.202	13.5 – 25.2	Small variab
6	No. beans per plant	237.9	65.67	27.605	100 - 350	High variab

The length of the pod varied between $-K=18$ and $+K=27$ cm. Its average length was 21.75 cm, within the limits of variation specific to the variety. The degree of dispersion of the individual values (S) compared to the arithmetic mean (21.75 cm) was 2.47 representing an average value compared to normal.

The coefficient of variability (S%) had the value of 11,369 having as significance an average variability. The histogram of the character “number of pods per plant” for the Auria Bacăului variety in the field of study of descendants is presented in figure 1.

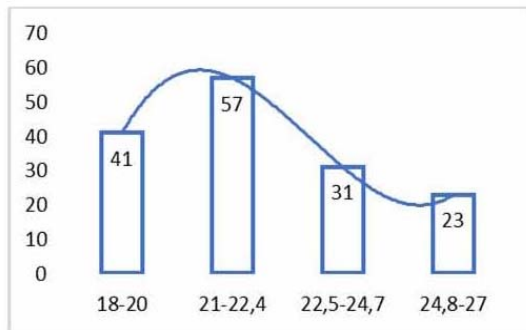


Figure 1. Histogram of the “pod length” character for the Auria Bacăului variety in the field of study of the descendants

The histogram presents a slightly asymmetrical shape at the class intervals 22.5 - 24.7 / 24.8 - 27 this is due to the pedological conditions, respectively the non-uniformity of the cultivation plot and the rains signaled during the pod binding period.

The width of the pod varied between $-K=1.5$ and $+K=2.3$ cm, the average of the individual values of the pods was 1.83 cm being specific to the variety. The standard deviation of the mean (S) had a low value being 0.17 revealing a slightly asymmetrical bell opening.

The coefficient of variability (S%) had a value of 9,682 meaning a small variability. The histogram of the “pod width” character for the Auria Bacăului variety in the field of study of the offspring is presented in figure 2. It is observed that the histogram has an asymmetrical shape for the intervals of class 2.1 / 2.2 / 2.3, this is due to the rains that fell during the binding period of the pods and the disturbance of the normal flowering and binding process.

It is observed that the pods with a width of 1.7 - 1.9 represent the majority share with 61.8%, the other pods having a share of the width below 13%.

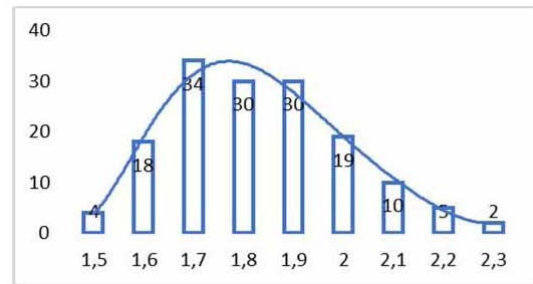


Figure 2. Histogram of the “pod width” character for the Auria Bacăului variety in the field of study of the descendants

Number of pods per plant had an arithmetic mean of 37.1. The variation limits of this character were between $-K = 20$ and $+K = 55$. The standard deviation was large revealing a large dispersion of the individual values of the distribution 9.02. As a result, the coefficient of variability (s%) had a high significance, 24,318 due to the non-uniformity of the crop plot and the climatic conditions with abundant rainfall during the flowering and binding period of the pods. The histogram of the character “number of pods per plant” for the Auria Bacăului variety in the field of study of the descendants is presented in figure 3. It is observed that the histogram shows a slight asymmetry at the level of class intervals 23 - 25/26 - 28/29 - 31.

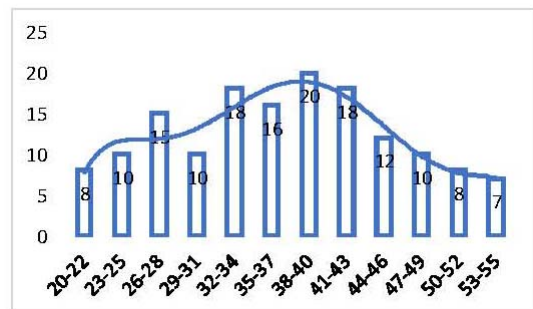


Figure 3. Histogram of the character “number of pods per plant” for the Auria Bacăului variety in the field of study of the descendants

This character was studied in the maturity stage of the seeds at the level of the whole plant.

The number of pods at the plant level is a defining element in assessing the productivity of the variety.

Through the collected data, the productivity assessment can be made. It is observed that the classes 32-34 / 35-37 / 38-40 / 41-43 had a percentage of values of over 10% characterizing the Auria Bacăului variety as very productive. The number of pods is over 32 pods per plant.

The number of beans in the pod was within the variation limit of $-K=6$ and $+K=10$, the arithmetic mean was around 7.86 beans per pod. The dispersion of the results around the average was very small 0.96 significance (S%) having an average variability. The histogram of the character “number of beans per pod” for the Auria Bacăului variety in field of study of the descendants is presented in figure 4.

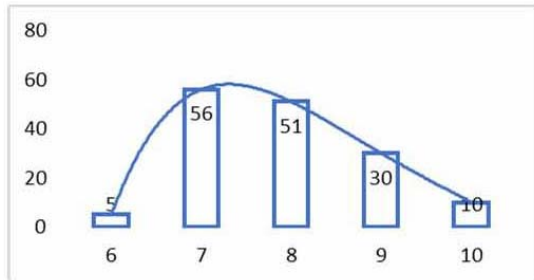


Figure 4. Histogram of the character “number of beans in the pod” for the Auria Bacăului variety in the field of study of the descendants

The histogram has an asymmetrical shape, most of the observations having a number of 7 beans in the pod. It is observed that the pods had over 7 beans in the pod (96.7%) of which 36.8% 7 beans in the pod and 33.6% represent 8 beans in the pod.

The weight of the pod varied between $-K=13.5$ and $+K=25.2$ grams per pod, the average being 19.03 grams per pod, the standard deviation was reduced - 1.75 the significance of the coefficient of variability being small. The histogram of variation of the character “weight of the pod” is presented in figure 5.

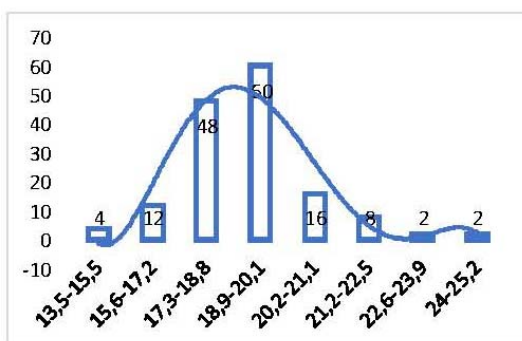


Figure 5. Histogram of the character “weight of the pod” in the Auria Bacăului variety in the field of study of the descendants

Analyzing the obtained results, a pronounced asymmetry is observed for the class intervals 13.5-15.5 / 21.2-22.5 / 22.6-23.9 / 24-25.2. This is due both to the agrochemical non-uniformity of the plot and to the unfavorable climatic conditions with

excess precipitation during the flowering period. The frequency of the values of each class interval. It is observed that the highest frequency had the class range 18.9-20.1 with a percentage of 39.5% and the class range 17.3-18.8 with 31.6%.

Number of beans per plant varied between $-K=100$ and $+K=350$ with an average of 237.9 beans per plant. The standard deviation (S) was 65.67, the significance of the coefficient of variability (S%) being high.

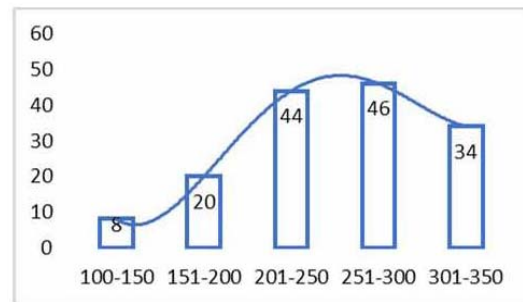


Figure 6. Histogram of the character “number of beans per plant” for the Auria Bacăului variety in the field of study of the descendants

It is observed that the curve shows a pronounced asymmetry in the area of the class range 100 -150 number of grains per plant. Most values were obtained in the class ranges 251 -300 with a percentage of 30.2%, the class range 201 -250 with a percentage of 28.9% and the class range 301 - 350 with 22.4%.

CONCLUSIONS

The presented results show the study of the most important characters for productivity of the Auria Bacăului variety. This cultivar is the main variety of climbing beans in the cultivated assortment of Romania. This variety was obtained following the research carried out at the Bacău Vegetable Research and Development Station in 1985 by Prof. Dr. Engr. Munteanu Neculai. According to its description, Auria Bacăului is a high production variety, semi-early, with very high suitability for cultivation in unprotected and protected areas.

Following the observations made, it can be concluded that there were no plants not typical of the variety. Through the morphological analysis of the bean plants, the specific characteristics of the Auria Bacăului bean variety were observed. The pods of this variety are large and wide, relatively straight or slightly curved with slightly obvious seeds and the tip of the pod semi-curved. The beans are large, elliptical-reniform, and the color of the pods is golden-yellow.

The quantitative characteristics taken in the

study highly reflect the productivity of the variety. Knowing the level of variability of these characters is very important for establishing the identity and balance of the variety in culture. The agronomic value of a studied variety cannot be established without a thorough knowledge of the limits within which the main elements of productivity represented by the quantitative characteristics vary from the initially established form of a variety.

Following the study and the results obtained, it can be stated that the main quantitative characteristics of the Auria Bacăului climbing bean variety vary within normal limits, being balanced in culture, with a high agronomic value. Also, the fact that this variety was not divided into subpopulations indicates its high stability.

ABSTRACT

This is a study of quantitative characters for the Auria Bacăului climbing garden bean variety and is based on the scientific results obtained in the field.

This paper aims to study the variability of quantitative characters and establish its limits of variability of a variety of climbing garden beans, namely Auria Bacăului. In order to achieve these objectives, other intermediate analyzes were necessary, such as the analysis and knowledge of the variety of climbing garden beans, but also the realization of a synthesis of the research carried so far in order to maximize the cultivation systems.

Climbing bean crops are widespread in Romania, but the cultivated areas are relatively small, in gardens and in micro-farms. The cultivation of climbing beans does not have the appropriate suitability to be mechanized, for this reason its practice on large areas in the industrial system has not developed to the extent of the proper use of its production capacity. The results of the experiment are clearly interpreted on the basis of statistical indices, tables and histograms of variation, paying close attention to the interpretation of the results.

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REFERENCES

1. HAY F. R., THOMAS B., MURRAY B. G., AND MURPHY D. J., 2017 - "Seed Banks," 2017 in *Encyclopedia of Applied Plant Sciences*, pp. 327–333, Academic Press, Oxford, United Kingdom, 2nd edition.
2. MUNTEANU N., FALTICEANU M., 1993 - *Studiul unor caractere cantitative la soiul de fasole de grădină „Aurie de Bacău”* [Study of quantitative characters in the variety of "Aurie de Bacău" garden beans], I.C.L.F. Vidra, Vol. XII.
3. MUNTEANU N., TIMOFTE V. TIMOFTE E., 1989 - *Variante tehnologice pentru cultura fasolei urcătoare*. Cercetări agronomice în Moldova [Technological variants for culture climbing beans. Agronomic research in Moldova], vol. 4, Iași.
4. PERES S., 2016 - "Saving the gene pool for the future: Seed banks as archives," *Studies in History and Philosophy of Science Part C Studies in History and Philosophy of Biological and Biomedical Sciences*, vol. 55, pp. 96–104.
5. POPA D. L., 2010 - *Cercetări privind agrobiologia speciei P. coccineus în vederea optimizării cultivării*. Teză de doctorat USAMV Iași [Research on agrobiology of *P. coccineus* species in view cultivation optimization. USAMV doctoral thesis Iași].
6. RUSTI G., 2007. *Cercetări privind îmbunătățirea tehnologiei de cultură a fasolei de grădină urcătoare (Phaseolus L. var. Communis)*. Teză de doctorat USAMV Iași [Research on improving bean growing technology climbing garden (*Phaseolus L. var. Communis*). Doctoral thesis USAMV Iași].
7. WORTMANN, BRINK, M. & BELAY, G., 2006 - *Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale*, Wageningen, Netherlands.

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