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# STUDIES REGARDING THE VARIABILITY OF THE PLANT PRODUCTIVITY CHARACTERS OF THE BELL PEPPER (*CAPSICUM ANNUUM* VAR. *TETRAGONUM*)

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***Abstract***
*The study tracked the evaluation of the characters that contribute to the plant production in a collection of bell pepper genotypes. The experimentation was done in field, under the usual technological conditions. The data collected by biometric measurements were statistically interpreted by variance analysis and by the setting of the selection indices (S, $h^2$, ΔG). The biological material consisted of 20 landraces collected from the West of Romania. Most populations are similar to Globus variety in terms of fruit size. The Tomnatic II population is remarkable with many and small fruits, but also the Apateu I and Cenad populations which have the fruit weight on the plant significantly higher. For the fruit weight, the differences between the populations may be up to about 100 g (Şimian), which has the greatest heritability (0.83). In most populations, the heritability of this character is less than 0.50. The number of fruit per plant is influenced by environmental factors, but the expected genetic progress can be up to 5.98 fruit (Tomnatic II). The most common values are between 2 and 3 fruits. For the number of fruit per plant, few populations have a heritability of more than 0.50. The fruit weight on the plant can be improved by selection with a progress ranging from 21.43 g (Tomnatic I) to 340.73 g (Valcani). The heritability of this character is over 0.60 for nine populations. Considering these indices, the collected material is valuable for the selection process, but the selection must be longer. The studied populations of bell peppers are an important reservoir of genes for the breeding process, the variability of morphological characters being satisfactory.*

Keywords: *bell pepper, variability, productivity characters.*

## 1.INTRODUCTION

The germplasm study is very important for the breeding process. The phenotypic variability must be accompanied by genetic studies, because the restriction of the hereditary base can attract the degeneration of the cultivated populations (Geleta et al., 2005). An important reservoir of genes for bell pepper breeding programs in represented by landraces. The studies on such forms show a pronounced variability of the component characters of fruit production on the plant. The production of fruit per plant in bell pepper depends on the diameter of the fruit and not on the length of the fruit. Thus, the selection, in addition to the number of fruits, can consider also the diameter of the fruit (Madosa et al., 2010).

In the study of variability, the modern methods of assessing genetic variability are more and more applied, being much safer. Using RAPD markers, we may highlight the variability within



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populations. Varieties with variability can be recommended for selection processing (Votava and Bosland, 2002). Selection for different characters should be done not only by their values but also by their phenotypic stability. In bell pepper, the phenotypic stability of productivity is different from one variety to another. Therefore, we should pay attention to the choice of the starting material for breeding programs or of the cultivars promoted in culture (Stoffella et al., 1995).

The phenotypic variability study also aims at detecting genotypes to be used as parental forms for obtaining hybrids with strong heterosis. In their choice, the morphological studies provide the first information on the variability of germplasm. A complex morphological study contributes to good information on the value of collections (Sood and Kumar, 011). Assessing the stability of production characters is one of the most studied themes. From the study of ninety genotypes, there were found higher coefficients of phenotypic and genotypic variation for the number of fruit per plant, the average fruit weight and fruit production per plant, characters that can be handled well in the selection process (Santosh et al., 2013).

Fruit production is influenced by the interaction of genotype with the environment. In the long pepper, the most stable character is the fruit diameter, but its length and the portion of the usable part of the fruit may vary more (Todorova, 2007).

Studies made on large collections show a rather uniform behavior of characters. The most stable character is the diameter of the fruit, and for the other characters fluctuations may occur. In the case of primitive forms, such as local populations, it requires a more detailed genetic study of the genes fund to highlight the variability (Jaret and Berke, 2008).

The achievement of big yields is dependent on genotype, but technology is also very important. The application of additional measures to protect plants highlights that plant production depends on the number of fruits, their weight, the fruit diameter and the height of the plants (Thakur et al., 2017)

For the induction of variability it is necessary to know the genetic determinism of the characters. Thus, in peppers, the main characters of productivity and quality have a determinism based on additivity and dominance. This makes the selection work to be conducted successfully (Schuleler et al., 2010). The studies on the determinism of the fruit specific characters have led to the conclusion that the most genes involved in the determinism of these characters are located on chromosomes 1, 2 and 3. Such studies are important in the works of breeding, especially when the gene manipulation is done by biotechnology methods (Chunthawodtiporn et al., 2018).

After harvesting, the fruits are harvested in shorter or longer periods of time. The fruit storage capacity depends on how fruits lose less water. The loss of water during storage depends on the size of the fruit and the degree of maturation. The smaller and immature fruits lose water much faster (Diaz-Perez et al., 2007).

The density in culture also influences the degree of branching of the plant, the size of the fruit, the precocity, but it does not influence the thickness of the pericarp (Islam et al., 2011). The increase in the size of the fruit also depends on their positioning on plant. If the first fruit forms seed, the size of the fruit that forms after it will be smaller. Through the formation of the parthenocarpic fruits, the fruits are equal in size on the plant. However, the parthenocarpic fruit grow slowly and have a low content of dry substance (Heuvelink and Koprner, 2001).

## 2. MATERIALS AND METHODS

The study aimed to evaluate the possibilities of applying the selection in the processing of a collection of landraces of bell peppers. For this, we studied the main characters of plant productivity in terms of the level of variability and the calculation of some synthetic indicators which provides



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information on the possibility of applying the selection in the process of harvesting local germplasm.
The biological material consisted of 20 local populations of bell pepper collected from Western Romania (Timis, Arad and Bihor counties).
The experimenting was done in field, applying a common culture technology. The experience was performed by the randomized block method in three repetitions. During fruit harvesting, we carried out biometric measurements on the key features of the fruit and the productivity of the plant. Experimenting has taken place over two years.
The experimental data were statistically processed by variance analysis and the t test to highlight the differences between the landraces studied and the Globus control variety. Also, we have determined several selection indices: Selection differential (S), heritability (h2) and genetic progress (ΔG) (Ciulca, 2006)

## 3. RESULTS AND DISCUSSIONS

The dimensions of the fruit presented variable values within the collection, both in terms of the diameter of the fruit and its length. The length of the fruit presented the highest values in the Cenad and Ceica populations, and the largest diameters were present in the Cenad and Shimian populations.The smallest fruit was presented by the Tomnatic II population, both in diameter and length of the fruit. This was followed by the long Ohaba Lunga population for fruit length and the Valcani population for fruit diameter (Figure 1)

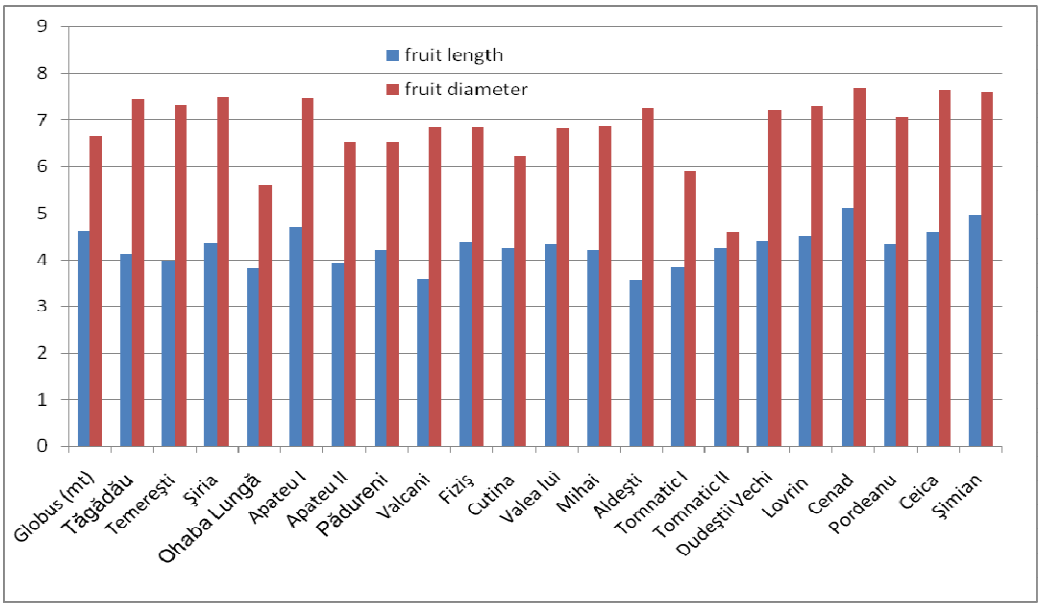


***Figure 1. Results regarding the fruit length (cm) and diameter (cm) in populations of bell pepper***

The study of the main components of the production capacity of bell pepper through the averages of the experimental years highlights the most valuable populations. Regarding the average mass of the fruit, the collected populations are not more valuable than the control variety. Only the Cenad population presented significantly higher fruits than those of the Globus variety, achieving an average fruit weight of 120.89 g. Most of the populations showed smaller fruits than the control variety but with insignificant differences. Distinctly significant negative differences were presented by the two populations of Tomnatic, which presents special plants in terms of fructification, the



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Tomnatic II has globular and small fruits, pungent taste, and Tomnatic I had typical fruit for bell pepper, but very small fruit. With regard to the average weight of the fruit, the collection presents variability, but the landraces are not superior to the witness. However, they can be considered valuable because they are close to it (Table 1.).

The number of fruit per plant is an important feature of productivity, although the size of the bell pepper is very important. As compared to the witness variety, the collection populations do not differ in this character. There is the Tomnatic II population, which has very many fruits on the plant but small. Many of the populations studied had negative differences from the control but without statistical assurance. However, it can be said that the material collected is useful for the breeding process and even important for the growers in the area, because it is not below Globus variety (Table 1).

By combining the two characters presented above, we may obtain results of the fruit weight behavior on plant. The average of the two experimental years show that it ranged from 843.45 g in the Aldeşti population (very significantly negative difference from the control) and 1102.97 g in the Siria population (distinct difference from the control). Significant yield growth per plant compared to Globus variety were present in Apateu I and Cenad populations. Significantly inferior to the control variant was the population of Dudestii Vechi.

***Table 1. Results on the average fruit weight in bell pepper***

| No | Landraces | Character | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fruit weight (g) | | Fruit number/plant | | Fruits weight/plant (g) | |
| | | Average | Comparison with the control | Average | Comparison with the control | Average | Comparison with the control |
| 1. | Globus | 83.25 | Control | 9.33 | Control | 789.53 | Control |
| 2. | Tăgădău | 96.82 | 13.57 | 10.08 | 0.75 | 1003.96 | 214.43 |
| 3. | Temereşti | 89.21 | 5.96 | 10.56 | 1.23 | 932.50 | 142.97 |
| 4. | Şiria | 10.,23 | 18.98 | 10.80 | 1.47 | 1102.97 | 313.44** |
| 5. | Ohaba Lungă | 77.90 | -5.34 | 8.37 | -0.95 | 692.20 | -97.33 |
| 6. | Apateu I | 106.08 | 22,83 | 9.48 | 0.15 | 1067.10 | 277.57* |
| 7. | Apateu II | 70.29 | -12,95 | 10.12 | 0.79 | 743.41 | -46.12 |
| 8. | Pădureni | 84.60 | 1.35 | 8.79 | -0.54 | 751.41 | -38.11 |
| 9. | Valcani | 64.79 | -18.46 | 12.43 | 3.10 | 886.93 | 97.40 |
| 10. | Fiziş | 71.84 | -11.40 | 7.97 | -1.36 | 573.70 | -215.82 |
| 11. | Cutina | 86.91 | 3.66 | 8.80 | -0.53 | 743.03 | -46.49 |
| 12. | Valea lui Mihai | 70.46 | -12.78 | 9.56 | 0.23 | 702.98 | -86.55 |
| 13. | Aldeşti | 100.04 | 16.79 | 8.75 | -0.58 | 843.45 | 53.92 |
| 14. | Tomnatic I | 43.73 | $-39.52^{0}$ | 8.51 | -0.81 | 372.72 | $-416.81^{000}$ |
| 15. | Tomnatic II | 27.15 | $-56,10^{00}$ | 35.04 | 25.71*** | 939.01 | 149.48 |
| 16. | Dudeştii Vechi | 85.88 | 2.63 | 6.43 | -2.89 | 555.80 | $-233.73_{0}$ |
| 17. | Lovrin | 102.68 | 19.43 | 9.38 | 0.05 | 1001.02 | 211.49 |
| 18. | Cenad | 120.89 | 37.64* | 8.48 | -0.85 | 1048.83 | 259.30* |
| 19. | Pordeanu | 89.28 | 6.03 | 7.66 | -1.66 | 688.64 | -100.88 |
| 20. | Ceica | 107.43 | 24.18 | 7.71 | -1.62 | 839.97 | 50.44 |
| 21. | Şimian | 104.98 | 21.73 | 7.33 | -2.00 | 770.69 | -18.84 |
| | | DL 5%= 32.12 g; DL 1%= 43.65 g; DL 0,1%= 59.17 g | | DL5%= 0.64 fruits; DL1%=1.38 fruits; DL0,1%=14.07 fruits | | DL 5%= 222.00 g; DL 1%= 301.67 g; DL 0,1%= 408.95 g | |



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The collection presents variability, but the collected populations, for the most part, are at the level of Globus variety. The large variability within populations can lead to the emergence of elite, which through longer processing of selection can lead to the creation of very valuable varieties adapted to the conditions of the West of the country. The bell pepper populations studied constitute an important reservoir of genes for the amelioration process, with a satisfactory variability of the morphological characters.

Fruit weight is a character that showed very large variations for the selection indices. Differences between the average values studied from one generation to the next, in the populations studied, are quite high, but they are largely due to the influence of the experimental years, because the character's heritability is reduced. The differences between the studied populations can reach up to almost 100 g (96.77 g in the Simian population). It also has the highest heritability (0.83). This is the only population in which the heritability is high. For the vast majority of populations, the heritability is below 0.50. The minimum values for the selection indices were recorded in the population Valcani. The Globus variety is very close to the population with minimum values of the selection indices (Table 1.).

The number of fruit per plant is a strong enough character under the influence of environmental factors. The genetic progression expected after selection can go up to 5.98 fruits (Tomnatic II population), but the most common values are between 2 and 3, the minimum being present in the Apateu II population. For the number of fruit per plant, few populations have a heritability above 0.50, the highest value being 0.76 for the Tomnatic II population, this being the most valuable material for applying the selection to increase the number of fruit per plant.

***Table 2. Selection differential values (S), heritability (h2) and genetic progress (ΔG) for fruit weight, fruit number and weight / plant, by applied selection in bell pepper***

| No | Landraces | Fruit weight (g) | | | Fruit number/plant | | | Fruits weight/plantr (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *S* | $h^2$ | *ΔG* | *S* | $h^2$ | *ΔG* | *S* | $h^2$ | *ΔG* |
| 1 | Globus (control) | 3194 | 0.24 | 7.61 | 6.47 | 0.55 | 3.57 | 256.48 | 0.52 | 172.63 |
| 2 | Tăgădău | 33.30 | 0.25 | 8.47 | 6.71 | 0.69 | 5.02 | 373.34 | 0.69 | 329.37 |
| 3 | Temereşti | 41.81 | 0.36 | 14.94 | 7.24 | 0.61 | 4.39 | 296.99 | 0.59 | 225.64 |
| 4 | Şiria 3 | 35.43 | 0.28 | 9.92 | 5.59 | 0.48 | 2.68 | 290.77 | 0.58 | 217.38 |
| 5 | Ohaba Lungă | 35.26 | 0.28 | 9.80 | 5.44 | 0.46 | 2.53 | 331.39 | 0.64 | 272.03 |
| 6 | Apateu I | 49.45 | 0.45 | 22.09 | 5.63 | 0.48 | 2.72 | 359.74 | 0.67 | 310.72 |
| 7 | Apateu II | 42.64 | 0.37 | 15.66 | 4.90 | 0.41 | 2.03 | 118.09 | 0.20 | 33.09 |
| 8 | Pădureni | 43.94 | 0.38 | 16.81 | 5.17 | 0.44 | 2.28 | 256.80 | 0.52 | 173.04 |
| 9 | Valcani | 31.69 | 0.24 | 7.45 | 6.80 | 0.58 | 3.91 | 381.61 | 0.69 | 340.73 |
| 10 | Fiziş | 35.30 | 0.28 | 9.83 | 5.64 | 0.48 | 2.72 | 148.27 | 0.28 | 58.53 |
| 11 | Cutina | 36.47 | 0.29 | 10.67 | 5.11 | 0.43 | 2.22 | 208.92 | 0.43 | 114.55 |
| 12 | Valea lui Mihai | 35.91 | 0.29 | 10.27 | 5.31 | 0.45 | 2.40 | 286.10 | 0.57 | 211.18 |
| 13 | Aldeşti | 34.49 | 0.27 | 9.26 | 6.09 | 0.52 | 3.18 | 106.43 | 0.17 | 25.21 |
| 14 | Tomnatic I | 31.80 | 0.24 | 7.52 | 5.50 | 0.47 | 2.59 | 100.16 | 0.15 | 21.43 |
| 15 | Tomnatic II | 34.51 | 0.27 | 9.28 | 8.46 | 0.76 | 5.98 | 182.93 | 0.37 | 95.43 |
| 16 | Dudeştii Vechi | 51.35 | 0.47 | 24.03 | 5.18 | 0.44 | 2.29 | 316.31 | 0.62 | 251.59 |
| 17 | Lovrin | 48.58 | 0.44 | 21.22 | 6.35 | 0.54 | 3.45 | 367.73 | 0.68 | 321.67 |
| 18 | Cenad | 57.02 | 0.53 | 30.17 | 5.47 | 0.47 | 2.56 | 344.42 | 0.65 | 289.77 |
| 19 | Pordeanu | 41.23 | 0.35 | 14.45 | 5.73 | 0.49 | 2.82 | 255.32 | 0.52 | 171.15 |
| 20 | Ceica | 57.47 | 0.53 | 30.68 | 5.37 | 0.46 | 2.46 | 242.06 | 0.50 | 154.42 |
| 21 | Şimian | 96.77 | 0.83 | 80.63 | 5.58 | 0.48 | 2.67 | 200.12 | 0.41 | 104.54 |



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The fruit weight on the plant can be improved by selection, with a progress achieved between 21.43 g (Tomnatic I population) and 340.73 g (Valcani population). The heritability of this character is mediocre, the maximum value being 0.69 (the Valcani and Tăgădău populations). However, another 7 populations have heritability values above 0.60. The collected material is valuable for the selection process, but the selection has to be applied over a longer period of time, with good efficacy even of the variants specific to the alogam plants (recurrent selection).

Studies similar to those in the work have already been carried out, and the results mentioned are similar or different. The productivity elements can fluctuate under the influence of environmental conditions. In modern cultivars, the number of fruit per plant depends on environmental conditions, but the plant size and fruit size are more stable (Jidavu et al., 2008). Some studies show that heritability and genetic progress have high values for the average fruit weight, fruit production on the plant, fruit diameter or fruit size. However, there are differences between genotypes. Plant production is mostly influenced by the number of fruit per plant and the fruit weight (Sharma et al., 2010). Among the variability parameters used in breeding, the heritability provides information on the phenotypic stability of populations. Such studies have also been carried out on peppers and it has been found that the weight of fruit and the number of fruit per plant have a high heritability (Pandey et al., 2013). The values of genotypic and phenotypic variation lead to the conclusion that the plant production is directly influenced by the number of fruits per plant, the thickness of the pericarp or precocity, these characters also having a higher heritability (Sood et al., 2011).

## 4. CONCLUSIONS

Most of the populations showed smaller fruits than the control variety but with insignificant differences. Only the Cenad population showed significantly higher fruits than those of the control variety, Globus.

For the number of fruits per plant, the Tomnatic II population, which has a particular behavior, presents very many fruits on the plant, but small in size. Other populations are of the control variety.

Fruit production on plant showed high variability. Production growths on plant compared to the control were present in the Cenad, Tomnatic II and Tăgădău populations. Large variability within populations can lead to the emergence of valuable elites.

In bell pepper, the fruit weight is a character that exhibited very large variations for the selection indices, and the number of fruit per plant is quite strong under the influence of environmental factors.For the number of fruits per plant, the Tomnatic II population is noticeable, and for the fruit dumplings, the Simian population. Given the selection indices, it can be said that the material collected is valuable, but the selection has to be applied over a longer period of time.

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