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STUDIES ON THE VARIABILITY OF THE PRODUCTIVITY COMPONENTS IN A COLLECTION OF PAPRIKA PEPPER LANDRACES (*CAPSICUM ANUUM* VAR. *LONGUM*)

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Abstract
The purpose of the study was to evaluate the variability of a collection of paprika peppers landraces, in order to use them in the breeding process. The study lasted two years. The biological material was collected from western Romania. The behavior of landraces is not constant from year to year. Zărand landrace was the most stable. They can be recommended as genitors the landraces: Craiva for fruit length (15.11 cm), Cermei for fruit diameter (3.06 cm) and fruit weight (38.30 g), Apateu II for the number of fruits per plant (22.26 fruits), Apateu II for fruits weight per plan (491.41 g). In respect of the drying efficiency was noted the Buzad landrace (over 20%). Considering the production of the plant and the efficiency in processing, for maintaining in the culture it is recommended the Apateu II landrace which has the highest fruit production per plant, the fruits being smaller. The variability within populations allows the selection to be applied, being medium or small for the size of the fruits and large for the weight of the fruit and the weight of the fruits on the plant. The studied collection is useful for breeding programs, but must be performed molecular analyzes.

Keywords: morphological characters, paprika pepper, variability.

1. INTRODUCTION

The breeding programs mention as important the concerns about collecting local gene sources. Such concerns exist about the different varieties of peppers. Following the study of the productive performances of the local populations, it was found that, in many situations, they are superior to the varieties (Madosa et al., 2008). In evaluating the performance of different genotypes, it must take account of the production potential and them stability.The productivity stability refers to the ability of a genotype to perform consistently, regardless of environmental conditions. Comparing some varieties with landraces, it was found that in landraces there is a high stability associated with the low influence of genotype interaction with the environment on the phenotypic expression of fruit weight. In many situations, the landraces are superior to the varieties, especially to the varieties from other ecological areas (Ciulca et al., 2010).

The studies on the variability in peppers are very diverse, considering the large number of species and varieties. Besides the use of such studies in the ibreeding processes, they are also necessary to clarify some taxonomic aspects of the separation of species and varieties. In addition to the

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morphological aspects of productivity, must also be considered characters such as the appearance of the fruit pulp or the number of seeds in the fruit (Zhigila et al., 2014)**.**
The landraces may also be sources of genes for quality improvement in terms of capsicin or vitamin C content (Tilajun et al., 2013).
In order to diversify the production, is sought the introduction of new varieties in culture. Some of the traditional varieties, such as paprika pepper in western Romania, are less and less cultivated. Thus, the local germplasm will be lost. In order to be preserved, it is necessary to evaluate it in terms of morphological characters that are easy to determine: branching of the plant, weight and total number of fruits, length and width of fruits, wall thickness, color of ripe fruits, early flowering, dark green color of the leaves, dehydration capacity. for each of these, minimum values must be set as selection criteria (Riberiro et al., 2017).
In the manifestation of the morphological and qualitys characters, very important is the culture technology. The vegetative growth reflected in the height of the plants, the length of the lateral stalk and the chlorophyll content of the leaves, they are reduced to high cultivation densities. As the density increases in culture, the number of days increases until the first flowering. They are affected by reducing the volume of fruits, the weight of the fruits, the production per plant and the number of seeds in the fruit. however, the production per hectare will increase (Aminifard et al., 2010)**.**
The density in culture also makes quality elements, reducing the content in pigments, without affecting the amount of dry matter. For the paprika pepper, these observations are extremely valuable (Cavero et al., 2001). To use density in culture as an element of production and quality optimization, must be tested the response of each genotype (Mavengahama et al., 2009). At the paprika pepper, must be carried out studies on the mechanization of the harvesting and processing works. By mechanizing these works it was found that the quality of the final product is not affected (Velazquez et al., 2019).
In order to highlight valuable populations, the morphological studies are not sufficient, also must be performed genotype studies, by modern methods that can differentiate the populations in terms of genotype value (gene expression, number of genes, etc.) (Nimmakayala et al., 2016).
In studying the pepper germplasm in Turkey, it was found that there was no relationship between geographical origin and diversity. The morphological variability is considerable among the genotypes of pepper, probably due to the circulation of the breeding or local genetic material. This is beneficial for breeding programs, but also for cultivators, who choose the population that will be cultivated according to agronomic features and resistance to stress conditions (Bozokalfa and Esiyok, 2011).
Molecular genetic markers offer the possibility of highlighting genotypes with valuable polygenic characters. The molecular methods complement the morphological assessment regarding the variability within or between populations, their degree of similarity or differentiation (Renganathan et al., 2017). The study of landraces must be made multidisciplinary. Genetic and phenotypic variability must be carefully characterized for appropriate direct and indirect use. In addition to the morphological characters involved in the production, very important is the study of quality characters, their study should be carried out at the same time. In this way, can be reached a grouping genotypes to be recommended to growers (Parisi et al., 2017). Sequencing genotyping is a modern method that accompanies phenotypic characterization. Such evaluations highlight the similarities between genotypes, the links between them, being a way of protecting breeding creations. Often, the route in cultivation of the varieties is lost, being able to consider the old varieties as the local populations (Pereira-Dias et al., 2019).

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Numerous germplasm collections are studied addressing allelic variations associated with phenotypic variations. Study of 1,352 forms of 11 *Capsicum* species from 89 countries using microsatellite markers shows that the genetic structure of this cultivated species is strongly affected by long-term human selection and that of primary or secondary diversification centers. The efficient use of gene resources must be made by compiling phenotypic and genotypic data. From here it turns out that local genetic resources are very valuable (Nicolai et al., 2013).
In obtaining the powder is very important the drying of the fruits, which can be done traditionally in the air, in the oven or by freezing. These methods influence the color of the finished product and less the biochemical content. The color is best preserved in traditional drying. The processing efficiency does not significantly depend on the drying method (Ayhan et al., 2009).

2. MATERIALS AND METHODS

The purpose of the study was to evaluate the variability of a collection of paprika, to find sources of variability needed for the breeding process, or to find valuable populations that are recommended for cultivation in the areas from which they come. The study was conducted over two years, under field conditions, following a traditional technology, without fertilization with large quantities of chemical fertilizers. The experience was organized as a collection field. The biological material was made up of landraces of paprika peppers collected from western Romania. The landraces were compared with the Arad 6 variety, an old variety, adapted to the conditions in western Romania. The experimental data were collected by biometric measurements on the morphological characters of the productivity. The statistical processing followed the intrapopulation variability, making a comparison between populations. Were determined the average (x) and the standard deviation of the average (s_x) and the coefficient of variability ($s_{\%}$) (Ciulca, 2006).

3. RESULTS AND DISCUSSIONS

The size of the fruits and their weight were different during the two experimental years, being influenced by the culture conditions.
In the first year of experimentation, the length of the fruits was between 12.97 cm in the Zărand population and 7.04 cm in the Buzad population. The diameter of the fruits was within closer limits, the minimum value being 2.08 cm for the population of Apeteu II and 3.56 cm for the population of Cermei. Fresh fruits had average weights from 17.02 g in the population of Buzad (which had the shortest fruits) to 42.77 g, in the population of Cermei. This year, the values of the coefficients of variability for each population, include the variability in the reduced or moderate category for the length of the fruits and the diameter of the fruits, great for their weight (Table 1).
In the second experimental year, the length of the fruits was between 8.21 cm in the population Belint and 17.78 cm in the population Craiva. Compared to the Arad 6 variety, three populations showed longer fruits. The diameter of the fruits showed values between 2.01 cm in the Cenad population and a maximum of 3.11 cm in the Apateu II population. For the weight of fresh fruit, the range of variation showed very wide limits, from 13.05 g to the population of Buzad, to 35.361 g to the population of Zimand. According to the coefficients of variability, the intrapopulational variability was reduced or moderate for the length and diameter of the fruit, and moderate or high for the weight of the fruit (Table 1).
Comparing the average values of the two years, there are differences from one year to the next, for all three characters. There is no uniform behavior in all populations. Some have higher grades in the first year, others in the second year. This is due to the different genotype response to the interaction

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with environmental factors. The average values are generally close. A particular behavior presented the population Zărand, which for all the characters, in the two years presented equal average values, but the coefficients of variability are different. As a result, this population has a good stability of the morphological characters of the fruit. Between the average values of the two years there were large differences in the Apateu II population (for the length and diameter of the fruit), in the Cermea population (for the diameter and weight of the fruit) and in the Arad 6 variety (for the weight of the fruit) (Table 1).

According to the averages for the experimental cycle, the longest fruits presented the population Craiva (15.11 cm), and the shortest population Buzad, which also had the fruits with the lowest weight (15.03 g). The largest diameter of the fruits was present in the Cermea population (3.06 cm), and the smallest diameters were in the Cenad and Răchita populations. The average of the fruit weight on the experimental cycle was modest to all landraces, the maximum average value was present to the Cermei population (38.30 g), population that had the largest diameter. Over 30 g also presented the Zărand and Zimand populations (Table 1).

Tabele 1. Results regarding the variability of the morphological characters of the fruits

No.	Genotype	Fruit length (cm)			Fruit diameter (cm)			Fruit weight (g)		
		$x \pm s_x$ $s_{\%}$		Average 2017-2018	$x \pm s_x$ $s_{\%}$		Average 2017-2018	$x \pm s_x$ $s_{\%}$		Average 2017-2018
		2017 year	2018 year		2017 year	2018 year		2017 year	2018 year	
1.	Arad 6 (control)	10.71±0.26 7.43	12.65±1.20 9.52	11.68	2.40±0.05 6.66	2.54±0.29 11.76	2.47	20.15±1.15 17.19	27.74±3.55 12.80	23.94
2.	Seleuş	11.14±1.28 30.38	11.43±1.15 10.05	11.42	2.45±0.09 10.45	2.48±0.33 13.35	2.46	17.10±2.17 33.69	21.21±5.80 27.36	19.15
3.	Mocirla	11.84±0.86 12.,68	10.07±1.33 13.29	10.77	2.74±0.18 11.46	2.30±0.27 11.77	2.52	20.62±3.91 32.91	17.83±6.20 34.79	19.22
4.	Apateu I	11.91±0.51 12.85	9.78±0.98 10.04	10.84	2.64±0.09 10.24	2.45±0.16 6.54	2.54	24.48±1.75 21.47	18.45±2.19 11.91	21.46
5.	Zărand	12.97±2.,11 17.10	12.97±2.22 18.10	12.97	2.93±0.33 11,56	2.93±0.42 13.65	2.93	31.18±7.92 24.57	31.18±7.66 23.82	31.18
6.	Craiva	12.45±0.40 7,31	17.78±2.16 14.61	15.11	2,77±0,10 8.47	2.91±0.32 11.10	2.84	25.38±3.28 28.95	26.02±11.23 43.16	25.70
7.	Zimand	12.05±0.43 10.25	15.35±1.69 11.05	13.70	3.01±0.16 15.79	2.90±0.29 10.15	2.95	26.07±3.86 41.90	35.61±7.69 21.60	30.84
8.	Aldeşti	10.93±1.03 28.49	11.93±1.53 12.86	11.43	2.83±0.06 6.95	2.61±0.29 11.43	2.72	25.25±1.36 16.22	24.10±6.53 27.10	24.67
9.	Apateu II	10.77±0.38 10.18	12.26±1.25 10.20	11.51	2.08±0.11 11.56	3.11±2.07 66.81	2.59	20.80±2.07 28.16	22.95±2.59 11.32	21.87
10.	Buzad	7.04±0.24 9.33	9.45±0.85 9.05	8.24	3.01±0.20 18.14	2.44±0.31 12.91	2.72	17.02±2.08 32.47	13.05±2.94 22.,56	15.03
11.	Cenad	9.98±0.66 16.43	8.86±1.28 14.47	9.42	2.35±0.17 18.10	2.01±0.13 6.81	2.18	18.35±1.39 18.58	15.11±2.84 18.81	16.73
12.	Belinț	8.70±0,.51 17.68	8.21±1.52 18.58	8.45	2.63±0.71 8.10	2.20±0.31 14.16	2.41	19.74±1.10 16.73	15.79±3.11 19.74	17.76
13.	Cermei	12.,76±0.80 19.92	14.25±1.48 10.42	13.5	3.56±0.10 9.17	2.57±0.27 10.70	3.06	42.77±3.10 23.32	33.84±5.07 14.98	38.30
14.	Pocola	11.,36±0.76 15.09	14.73±0.77 5.24	13.04	2.28±0.17 18.50	2.51±0.17 6.87	2.39	17.92±.1.93 26.39	28.66±4.18 14.59	23.29
15.	Cutina	10.,22±0.67 17.39	11.14±0.86 7.73	10.68	2.55±0.29 30.52	2.60±0.30 11.68	2.57	29.78±2.90 25.83	25.98±3.22 12.41	27.88
16.	Răchita	12.,16±0.35 8.32	13.50±0.78 5.80	12.83	2.11±0.14 20.06	2.25±0.27 12.36	2.18	21.51±2.92 30.17	20.76±4.16 20.06	21.13

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For the processing efficiency, the weight of the dried fruit is very important, which depends on the percentage of dry substance in the fruit. Was determined the weight of dried fruits prepared for milling. In the first year, the dried fruits showed values between 1.94 g in Zărand population and 5.07 g in Cermei population. In the second year the average weight of the dried fruits was between 2.92 g in the population of Cenad and 5.07 g in the population of Cermei. Between the two experimental years there are differences of the means, the most stable being the population of Cermei, which presented the same average value in both years. The average values for the experimental cycle were between 3.14 g (Seleus population) and 5.07 g (Cermei population). The best drying yield was present in the Belint and Buzad populations (over 20% by weight of the fresh fruit), the lowest yield being the Zărand population (7.82% by the weight of the fresh fruit). Within these landraces, selection can be made for increasing the dry matter content and improving the yield when processing fruit (Table 2)

Drying depends on many factors, smaller and lighter fruits have been found to have a higher dry matter content. Such behavior also has the studied landraces (Lannes et al., 2007)

Tabele 2. Results regarding the variability of fruit weight after drying

No	Gentype	Dried fruit weight (g) $x \pm s_x$ $s_{\%}$ 2017 year	2018 year	Average 2017-2018	% by fresh fruit weight	No	Genotype	Dried fruit weight (g) $x \pm s_x$ $s_{\%}$ 2017 year	2018 year	Average 2017-2018	% by fresh fruit weight
1.	Arad 6 (control)	3.26±0.27 25.04	3.51±0.41 11.67	3.83	15.99	9.	Apateu II	3.77±0.44 33.16	3.65±0.74 20.33	3.71	16.96
2.	Seleuș	2.91±0.41 37.89	3.37±0.88 2.32	3.14	16.39	10.	Buzad	3.68±0.35 25.75	3.09±0.75 24.39	3.38	22.48
3.	Mocirla	3.23+0.66 35.47	3.36±1.11 33.22	3.29	17.11	11.	Cenad	3.52±0.36 25.03	2.92±0.64 21.98	3.22	19.24
4.	Apateu I	4.91±0.42 25.93	3.57±0.86 24.07	4.24	19.57	12.	Belinț	4.13±0.38 27.91	4.34±0.43 99.09	4.23	23.81
5.	Zărand	1,94±0,66 35.47	2.94±0.62 32.32	2.44	7.82	13.	Cermei	5.07±0.83 18.96	5.07±0.81 16.06	5.07	13.23
6.	Craiva	4.95±0.32 14.73	4.36±1.09 25.05	4.65	18.03	14.	Pocola	3.48±0.57 40.68	5.02±0.91 18.14	4.25	17.76
7.	Zimand	4.73±0.68 4.05	4.67±0.96 20.72	4.70	15.23	15.	Cutina	4.35±0.45 27.94	3.94±0.44 11.30	4.14	14.84
8.	Aldești	4.77±0.21 13.23	3.45±0.78 22.79	4.11	16.65	16.	Răchita	4.17±0.58 39.47	3.02±0.68 22.61	3.59	16.99

The most complete genetic differentiation between genotypes in red pepper can use the study of a large number of characteristics. Twenty characters are mentioned and can be evaluated and processed by the cluster method. Such complex studies lead to precise recommendations through the programming of hybridization to create variability (Tirupathamma et al., 2018). Characterization of the value of a genotype must be done by means of some descriptors, among which the most used are the number of fruits per plant and their weight (Araujo et al., 2018).

In the first experimental year, the number of fruits per plant was between 14.57 in the population of Cermei and 28.16 in the population of Cenad. The combinations of these characters led to a production per plant between 262.10 g in the population of Buzad and 625.38 g in the population of Cutina. Compared to the control variety, this year, eight of the landraces obtained higher plant yields (Table 3).

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In the second year, the number of fruits per plant was lower. The limits of variability in were 6.83 fruits in Zărand population and 20.62 fruits in Apateu II population. Of the landraces, only three exceeded Arad 6 variety. The weight of the fruits per plant showed very low values, the average recorded being between 120.32 g in the population of Buzad and 473.22 g in the population of Apateu II. Compared to the control variety, only three local populations produced larger plant productions, but the differences are not noticeable (Table 3).
Variability within populations, for both characters, was high, in both years (Table 3).
According to the average values for the experimental cycle, the highest number of fruits per plant was heavy in Apateu II (22.56 fruits) and Cenad (19.68 fruits) populations. The fewest fruits showed the population of Cermei (12.14 fruits). For the weight of the fruits per plant, we noticed the populations Apateu II (491.41 g) which had the largest fruit per plant, but also the population of Cermei (475.86 g) which had the largest fruits. In Buzad, the smallest fruit production per plant (191.21 g) was recorded. From these data it can be seen that, for increasing the production of fruit per plant, can be selected the genotypes with large numbers of fruits or those with large fruits.

Tabele 3. Results regarding the variability of plant productivity components

No	Genotype	Fruits number per plant			Fruits weight per plant (g)		
		$x \pm s_x$ $s_{\%}$		Average 2017-2018	$x \pm s_x$ $s_{\%}$		Average 2017-2018
		2017 year	2018 year		2017 year	2018 year	
1.	Arad 6 (control)	22.25±2.85 37.97	12.57±0.76 14.81	17.41	448.33±66.59 48.71	348.69±40.29 49.,06	398.51
2.	Seleuș	26.28±5.54 55.81	10.00±1.26 28.28	18.14	449.38±92.77 62.17	212.10±20.80 36,77	330.74
3.	Mocirla	19.00±7.50 68.42	11.66±1.30 27.46	15.33	391.78±63.42 39.72	207.89±16.72 29.07	299.83
4.	Apateu I	14.77±1.90 38.69	11.00±2.04 37.11	12.88	361.56±41.63 39.04	202.95±18.76 27.50	282.25
5.	Zărand	19.00±7.50 68.42	6.83±2.15 77.11	12.91	592.42±63.42 39.72	212.95±68.16 84.57	404.18
6.	Craiva	22.40±5.19 51.83	9.37±0.99 30.13	15.88	568.51±95.93 44.41	243.80±19.80 31.21	406.15
7.	Zimand	15.12±3.13 58.54	11.00±1.94 39.62	13.06	394.17±65.09 54.93	391.71±41.09 44.03	392.94
8.	Aldești	20.00±2.16 32.50	15.20±3.73 54.92	17.60	505.00±49.14 33.86	366.32±72.72 70.65	435.66
9.	Apateu II	24.50±2.45 28.36	20.62±2.04 28.02	22.56	509.60±24.51 19.29	473.22±60.99 61.35	491.41
10.	Buzad	15.40±1.93 28.15	9.22±1.27 41.56	12.31	262.10±38.80 40.01	120.32±28.82 85.72	191.21
11.	Cenad	28.16±7.10 61.79	11.20±1.81 52.19	19.68	516.73±72.12 39.81	169.23±16.45 41.66	342.48
12.	Belinț	19.55±4.45 68.27	13.48±1.58 31.55	16.51	385.91±60.82 53.53	212.84±36.13 52.85	299.37
13.	Cermei	14.57±42.92 41.06	9.71±1.01 27.69	12.14	623.15±63.32 52.51	328.58±25.53 27.87	475.86
14.	Pocola	15.66±2.09 32.71	11.62±1.01 24.73	13.64	280.62±31.26 33.37	333.02±24.98 26.15	306.82
15.	Cutina	21.00±2.42 30.49	11.33±1.67 41.85	16.16	625.38±56.63 27.23	294.35±49.28 68.28	459.86
16.	Răchita	21.50±4.07 53.61	15.11±1.41 28.16	18.30	462,.46±57.13 35.25	313.68±39.13 42.01	388.07

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4. CONCLUSIONS

For the studied characters, there are differences from year to year. The behavior of landraces is not constant, some have higher average values in the first year, others in the second year. In general, the average values are close. The population of Zărand is noted as being very stable, in both years, having the same average values for all the characters. Less stable were the local population Apateu II (for the length and diameter of the fruit), the local population of Cermei (for the diameter and weight of the fruit) and the Arad variety 6 (for the weight of the fruit). Among the studied landraces, it is recommended that gebnitors, those with high average values: the landrace Craiva for the length of the fruits, the landrace Cermei for the diameter of the fruits and the weight of the fruit. For the productivity elements of the plant, the recommended landraces are: Apateu II and Cenad for the number of fruits per plant, and Apateu II and Cermei for the weight of the fruits per plant, the fruits being smaller. The intrapopulational variability is medium or small for fruit size and large for fruit weight and fruit weight per plant. The studied collection constitutes a source of genes for breeding programs, the phenotypic observations having to be supplemented with the molecular study of variability.

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