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ANALYSIS OF THE DIVERSITY OF SOME HOT PEPPER (CAPSICUM ANNUUM L.) POPULATIONS FROM SOUTHWEST ROMANIA ON THE BASE OF MORPHOLOGICAL AND PRODUCTION CHARACTERS

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ABSTRACT

This study presents the characterization of 10 local hot pepper populations selected from the existing germplasm collection within the vegetable growing laboratory of the Faculty of Horticulture in Craiova regarding morphological and productivity characters. Variability analysis indicated low to high variability for most of the characters studied. The average values ranged between 5.3 cm and 10.1 cm for fruit length, between 1.12 cm and 9.38 cm for fruit diameter, between 1.96 cm and 2.86 cm for peduncle length, and for the index of shape values were between 0.69 and 7.58, indicating a conical-elongate fruit shape in most populations. Regarding the number of fruits per plant, there was a very large variation, from 9.1 fruits/plant at V1 De Mârsani to 107 fruits/plant, and the weight of the fruit was between 2.8 g and 11.1. g, and fruit production/ha varied from 3.5 t and 21.0 t/ha. The differences between the studied populations suggest that they can be used in breeding programs for this species.

INTRODUCTION

The fruits of hot peppers (*Capsicum annuum*), also known as chili, have been used since ancient times as food vegetables, flavoring ingredients, natural dyes and also in traditional medicine. Today there is a wide variety of sweet and spicy peppers that are consumed around the world in a wide variety of forms. Interestingly, the most important chili pepper globally from a commercial point of view is C. annuum with an increasing number of varieties (Dinu et al., 2013).

Pepper (*Capsicum* spp) is one of the most important vegetable and spice crops in the *Solanaceae* family. Pepper culture has played an essential role in human civilization, including human nutrition and culturally significant medicinal values (Luna-Romero et al., 2022; Yasin et al., 2023). Within the genus *Capsicum*, there are subspecies with morphologically diverse fruits and leaves, both cultivated and wild species, which have been explored for their ornamental values (Barchenger et al., 2019; Zhang et al., 2020), thus leading to the increase in demand for culinary and ornamental varieties of *Capsicum* species. The wide geographical distribution of *Capsicum annuum* L. and *Capsicum frutescens* L. species from the New World to other continents occurred

in the 16th century through Spanish and Portuguese traders and was integrated into the food habits of several countries (Dinu and et al., 2018).

At the global level, from an economic point of view, pepper production is a viable business, which supports the economy of a state but also small farmers. The production of dry pepper at the European level is 2.7%, America's (5.8%) and that of Africa by 21.2% (Anani et al., 2024). All three continents contribute almost equally to the total world production of fresh pepper (Tripodi and Kumar, 2019).

Morphological characterization of *Capsicum* germplasm is a prerequisite in a crop improvement program (Fasikaw et al., 2019; Nankar et al., 2011). Traditional phenotypic descriptors such as growth mode, flower and fruit characteristics are very important in identifying intra- and interspecific variability in pepper germplasm for important biochemical and genetic traits (Ortiz et al., 2010).

Despite the economic, cultural and morphological importance of pepper varieties, no major efforts have been made in Romania to identify morphologically diversified genotypes to be used in breeding programs. It is known that there are many analytical methods that can be used for the rapid evaluation of morphological traits in peppers, methods that allow good decision-making regarding germplasm conservation and subsequent research on accessions within germplasm collections.

The aim of this study was to investigate the morphological and production traits of 10 pepper genotypes selected from the existing germplasm collection within the vegetable growing laboratory of the Faculty of Horticulture in Craiova, originating from private farms and frequently cultivated in the southwest Romania.

MATERIAL AND METHODS

The research on the chosen experiment was carried out in the didactic field of the Faculty of Horticulture in Craiova, in the period 2022-2023. To achieve the proposed objectives, the experience was placed according to the standards required by the experimental technique. The culture was established by seedling produced in the propagating greenhouse. Planting of seedlings took place on 26.05., in an open field and harvested on 29.09. 2 rows were planted on the raised layer spaced 80 cm between strips over the ditch and 30 cm between plants per row resulting in a number of 44,000 pl/ha. 42 local populations collected from different localities in the Oltenia area were evaluated, and only 10 were selected for observations and are the subject of this study. Biometric observations and determinations were made at harvest, calculating means ± standard deviations (STDEV) and coefficient of variation (cv%).

Data of production were subjected to analysis of variance (ANOVA).The significance of the differences was estimated with the LSD multiple comparison test at the $p \leq 0.05$ level.

RESULTS AND DISCUSSIONS

The results regarding the morphological characters of the fruits as well as the production obtained in the studied genotypes demonstrated a great variability between the studied genotypes. The observations made on hot pepper fruits demonstrate that the variability in all the characters studied is in direct relation with the local population from which they come.

Hot pepper fruits are consumed fresh at technological maturity (when the fruits are green in various shades or yellow) but also at physiological maturity when the fruits are red. They can be harvested at technological or physiological maturity

when the fruit is green or red ripe, eaten fresh or can be dried, ground, stored and used as a spice or food coloring. Carotenoids are the pigments responsible for giving chili peppers their characteristic deep red color. The preservation of this color after harvesting is a key feature that governs the price of the product both fresh, dehydrated or transformed into paprika, the color of the food being an important feature for the consumer, who associates the richness of the color with the quality of the fruits and their nutritional value. Carotenoids are natural pigments that give fruits and vegetables their red, orange and yellow hues. In addition to their ability to impart color, they are also potent bioactives (Bergefurd et al., 2011).

In the local populations studied, the color at technological maturity varied from green, of different shades to yellow at V8-De Corabia and V10-SDDL 2. At physiological maturity, the fruits had a more or less intense red color with the exception of V9 -SCDL 1 and V10-SCDL 2 with orange fruits (Table 1).

Table 1

Color and shape of hot pepper fruits

Variant/ The local population	The color of the fruit at maturity		The shape of the fruit
	Technological	Physiological	
V1-De Mârșani	Dark green	Red	Cylindric
V2- De Scaiești	Dark green	Red	Conical-oblong
V3- De Teasc	Dark green	Red	Conical-pointed
V4- De Filiași	Dark green	Red	Conical-oblong with bent tip
V5- De Ișalnița	Yellow	Red	Conical-oblong with bent tip
V6- De Almăj	Dark green	Red	Conical-oblong with bent tip
V7- Șapte frați	Yellow	Red	Conical-oblong
V8- De Corabia	Dark green	Orange	Conical-oblong
V9- SCDL 1	Dark green	Red	Conical-oblong
V10-SCDL 2	Yellow	Red	Conical-oblong

Regarding the length of the fruits, the minimum value was 5.3 cm for the local population V9-SCDL 1 and 10.1 cm for the population V5-De Ișalnița (Table 2). Within this morphological element of the fruit, the coefficient of variation was between 5.27% and 17.7%, indicating a small to medium variability.

The diameter of the fruit varied more than their length. The amplitude of variation was between 1.12 cm in the local population V4-De Filiași and V7-Sapte frati 1 and 9.38 cm in the local population V1-De Mârșani. This character presented a coefficient of variation from 9.55% to 21.32% indicating a medium to high variability.

Table 2

Variability of the morphological characters of hot pepper fruits

Populations/ Indicators	The length fruit (cm)	Diameter fruit (cm)	Shape index (L/D)	The length of the peduncle (cm)
V1-De Mârșani				
Mean	6.52	9.38	0.69	2.75
STDEV	0.69	0.93	0.18	0.16
CV(%)	10.58	9.91	26.08	5.81
V2- De Scaiești				
Mean	6.60	1.32	5.00	2.29
STDEV	0.85	0.19	0.61	0.33

CV(%)	12.87	14.39	12.2	14.41
V3- De Teasc				
Mean	5.40	1.27	4.25	1.96
STDEV	0.96	0.16	0.24	0.23
CV(%)	17.7	12.59	5.64	11.73
V4- De Filiași				
Mean	8.50	1.12	7.58	1.98
STDEV	0.62	0.24	0.14	0.24
CV(%)	7.35	21.32	1.86	12.06
V5- De Ișalnița				
Mean	10.10	1.72	5.87	2.44
STDEV	0.89	0.16	0.61	0.29
CV(%)	8.86	9.55	10.39	11.81
V6- De Almăj				
Mean	9.40	1.68	5.59	2.86
STDEV	0.49	0.23	0.52	0.32
CV(%)	5.27	13.57	9.22	11.22
V7- Șapte frați				
Mean	5.60	1.12	5.00	2.18
STDEV	0.47	0.13	0.28	0.47
CV(%)	8.38	11.64	5.52	21.61
V8- De Corabia				
Mean	9.50	1.52	6.25	2.38
STDEV	0.71	0.18	0.35	0.41
CV(%)	7.44	11.77	5.66	17.43
V9- SCDL 1				
Mean	5.30	1.47	3.60	2.12
STDEV	0.52	0.14	0.31	0.33
CV(%)	9.80	9.50	8.56	15.43
V10-SCDL 2				
Mean	6.20	1.32	4.69	2.59
STDEV	0.47	0.13	0.39	0.34
CV(%)	7.57	9.88	8.41	12.98

Depending on the length and diameter of the fruit, the shape index of the fruit was calculated, which classified the fruits of the 10 local populations into four groups: local populations with cylindrical-shaped fruits (V1-De Mârșani), conical-elongated fruits (V2- From Scaiesti, V7-Sapte frati and V8-De Corabia), conical-elongated fruits with a bent top (V4-De Filiași, V5-De Ișalnița and V6-De Almaj) and pointed conical fruit (V3-De Teasc,V9 -SCDL 1 and V10-SCDL 2) (Table 1 and Table 2).

The shape index is given by the ratio between the length of the fruit and its diameter and largely indicates the shape of the fruit. At sub-unit values, it is appreciated that the fruit is globular and flattened, where the De Mârșani population falls (0.69). The other hot pepper varieties studied show shape index values of 3.60 for the SCDL 1 variety with a pointed conical fruit, but also of 4.69 for the SCDL 2 variety also with a pointed conical fruit shape, as is the case with V7- Seven brothers, which indicates that the fruit is short, and in the other varieties that have values above 5.1 the fruits are long (conical-elongated).

The length of the fruit peduncle had the lowest value in V3-De Teasc of 1.96 cm and the highest in V6-De Almaj of 2.86 cm. The coefficient of variation recorded values from 5.81% to 21.61%, indicating, in most cases, a medium variability. This

character is of practical importance because depending on its size the fruits can be erect, when the peduncle is small, or pendulous when the peduncle is larger.

The number of fruits per plant is an important character for the productive potential of a genotype. According to the recorded values, it can be seen that the 10 genotypes register a very large amplitude of variation from 9.1 fruits/plant at V1 De Mârsani to 107 fruits/plant at V9- SCDL (Table 3). The fewest fruits were presented in the De Mârșani population where the fruits are of larger size, this being also a genotype with determined growth, the other local populations fruited for a longer period of time or almost continuously until quite late autumn. The number of fruits per plant depends on the climatic conditions through the fertility of the flowers and reaching harvest maturity. Some research mentions that there are situations where only 18.81% of flowers produce fruits, and of the fruits formed, 72.41% reach harvesting maturity (Dahal et al., 2019).

Regarding the weight of the fruit, it is found that the smallest fruits were recorded in the local population V7-Sapte frat with an average weight of 2.8 g/fruit or in V10-SCDL 2 with 3.1 g/fruit. The largest fruits were reported at V5-De Ișalnița with 11.1 g/fruit. The coefficient of variation is between 7.4% and 29.96%, indicating that the variability of fruit weight within the 10 populations is medium to high, the fruit being rather uneven in weight. For the average weight of the fruit, comments are difficult to make because the variability in the collection is very high. Many consumers prefer smaller fruits, especially if they are very spicy. Of the local populations studied, six have smaller fruits, with values of 2-3 g/fruit. The existing variability within the population makes it valuable for the breeding process, useful for the breeding process being both small-fruited and large-fruited populations (Madoșa et al., 2021).

Comparing populations with a control variety is difficult to do because the diversity for fruit size and shape is high in chili peppers. Of course, the production per plant, through the economic effect it produces, is an important element (Table 3). The most productive plants were presented by the population from Almăj with 457.6 g/plant, the population from Ișalnița with 432.9 g/plant and the De Corabia genotype with 423.0 g/plant. A significant increase in the amount of fruits/plant was also recorded in the SCDL 1 population with 310.3 g/plant (Table 4).

Table 3

Variability of productivity characters in hot pepper plants

Populations/ Indicators	Average number of fruits per plant	Average fruit weight (g)
V1-De Mârșani		
Mean	9.1	8.5
STDEV	0.37	0.62
CV(%)	4.16	7.4
V2- De Scaiești		
Mean	71	3.7
STDEV	3.45	0.44
CV(%)	4.86	12.09
V3- De Teasc		
Mean	6.8	3.5
STDEV	1.27	0.36
CV(%)	18.72	10.30
V4- De Filiași		

Mean	6.2	3.4
STDEV	2.12	0.25
CV(%)	34.29	7.50
V5- De Ișalnița		
Mean	3.9	11.1
STDEV	0.69	0.39
CV(%)	17.76	3.55
V6- De Almăj		
Mean	5.2	8.8
STDEV	0.69	1.66
CV(%)	13.32	18.90
V7- Șapte frați		
Mean	10.4	2.8
STDEV	1.25	0.78
CV(%)	12.09	28.01
V8- De Corabia		
Mean	4.7	9
STDEV	0.41	1.47
CV(%)	8.77	16.42
V9- SCDL 1		
Mean	10.7	2.9
STDEV	0.76	0.86
CV(%)	7.12	29.96
V10-SCDL 2		
Mean	8.0	3.1
STDEV	0.58	0.59
CV(%)	7.29	19.22

Fruit production/ha varied from 3.5 t at V1-De Mârsani to 21.0 t/ha at V6-De Almăj (Table 4). It can be said that there was no direct correlation between the average production per plant and that obtained per hectare.

Of the 10 local populations taken in the study, nine recorded productions of over 200 g/plant but formed small-sized fruits with thin pericarp thickness, which led to a low production per unit area.

The number of fruits per plant, fruit length and width, are correlated with each other and are influenced by the interaction of genotype with planting distances. Therefore, even in the case of local populations, cultivated in areas other than those of origin, according to different technologies, the technology applied in the culture can influence the manifestation of production characters.

Table 4

Production of the 10 local populations studied

Variant/The local population	Average production of fruit per plant	Production
	(g)	t/ha
V1- De Mârșani	77.3 ^{e}	3.5 ^{d}
V2- De Scaiești	262.7 ^{c}	12.0 ^{bc}
V3- De Teasc	238.0 ^{cd}	10.9 ^{c}
V4- De Filiași	210.8 ^{d}	9.6 ^{c}
V5- De Ișalnița	432.9 ^{a}	19.9 ^{a}
V6- De Almăj	457.6 ^{a}	21.0 a
V7- Șapte frați	291.2 ^{bc}	13.3 ^{bc}
V8- De Corabia	423.0 ^{a}	19.4 ^{a}

V9- SCDL 1	310.3 [b]	14.2 [b]
V10- SCDL 2	248.0 [cd]	11.4 [c]
p< 0.05	44.78	2.61

CONCLUSIONS

Following the processing of the partial results recorded in local populations of hot peppers collected from different localities of Oltenia, significant variations were observed for the morphological elements of the fruits but also for the production obtained.

With regard to some production characters of the genotypes, the observations revealed: the average number of fruits per plant, for the local populations V2-Scaiești with 71 fruits/plant to V9-SCDL 1 with 107 fruits/plant; the average weight of a fruit, which varied from 2.9 g/fruit at V9- SCDL 1 to 11.1 g at V5-De Ișalnița; the average production of fruits obtained per plant highlighted the variant V8-De Corabia with 423.0 g/plant to V6-De Almăj with 457.6 g. Also, the average production obtained per surface unit demonstrated that there is no direct correlation between fruit production per plant and that obtained per/ha V6-De Almaj with 21 t/ha, V5-De Ișalnița with 19.9 t/ha, V8-De Corabia with 19.4 t/ha and V9-SCDL 1 with 14.2 t stand out for this production character /ha.

Fruit number per plant, fruit length and width are correlated with each other and influenced by genotype interaction. Therefore, even in the case of local populations, cultivated in areas other than those of origin according to different technologies, the technology applied in the culture and climatic factors can influence the manifestation of production characters.

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