COMPARATIVE EVALUATION BY MORPHOLOGICAL BEHAVIORS AND PRODUCTIVITY OF SEVERAL GENOTYPES OF PEPPER (*CAPSICUM ANNUM* L.) WITH DIFFERENT ORIGIN

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Abstract

The main goal of the present study was to establish the morphological behaviors and productivity of some pepper genotypes with different origin with target increasing of the gene plasma diversity in this crop and their inclusion by forthcoming breeding programs. The experiments were carried out with eight genotype of pepper originating from different regions - Greece, Poland, Spain and Bulgaria. Plants were grown by using the conventional technology for Bulgaria. The morphological characteristic has been taken in phase of full botanical maturity. The productivity was determinated. The correlations between the investigated parameters were calculated. The highest weight of the fruit and thickness of pericarp were observed in line 147-2103 (Bulgaria) and in line 40-2009 (origin in Greece). The highest productivity, 4064.2 kg.da^{-1}, was recorded in genotype 27-21-2011 (Greece) and 174-2013 (Bulgaria), that are particularly promising for enriching of the gene plasma in pepper and for their inclusion in breeding programs.

Key words: *phenology, morphology, fruit, yield, correlation*

INTRODUCTION

Pepper is one of the main vegetable crops. It ranks of second place by in economic importance in Bulgaria, and in fifth worldwide. The diversity of subspecies and variants in our country are significant. At the same time the numbers of pepper cultivars in Bulgaria as well as in the world is extremely high. There are many local populations and varieties which are characterized by exceedingly good and valuable economic qualities (Cholakov, 2009).

Information on initially human knowledge about pepper dates back 7500 years back, and evidences for it's being as a plant that is deliberately cultivated has evidences is date 6000 years back, from the region of South and Central America, especially in Mexico (Bosland, P.W. 1998). According to Darbie (2005) all economically important varieties of pepper, belong to the species *Capsicum annuum* L. To this species belong, both the as well as pungent-type and the non-pungent cultivars. Different varieties are sometimes have a specific requirements for related to the cultivation technology and the agricultural practices applied during the growing season, which makes it necessary to test them in outside of the area of their origin. Through the study of 39 pepper varieties from different countries based on a number of morphological characteristics Geleta et al. (2005) emphasize the importance of origin in relation with their manifestations under different conditions.

Genetic diversity is considered as one of the criteria for the pepper selection and for the reaching of the opportunities of the breeding programs (Geleta et al, 2004). The importance and availability of rich genetic material of various origins, which to be included in selection programs is reported also from Martirosyan and Sargsyan (2014). They argue that when creating core selection collection are clustered by the duration of the main phonological phases, the morphological structure of plants and their resistance. The diversity in the breeding collection of varieties, patterns, and forms from different areas and breeding centers as Morton (2014) highlights is the basis for successful and targeted selection work. The researcher uses a number of local populations and varieties including them in different hybridization programs and on the basis of stabilization of hybrids up to 6-10 generation he achieves the effective varieties with high economic performance. In connection with identification and distinguish the differentiation of the different varieties of pepper Dewitt and Bostan (1996) develop a manual in which a wide range of currently available varieties are presented with their basic features. Besides the classic way, Ilbi (2003) emphasizes that a modern and appropriate way to identify

varieties of pepper, and one that is characterizes by high accuracy, is the application of amplified polymorphic DNA.

One of the main methods of pepper breeding, many widely used is sexual hybridization (Livesy, 2010). In this relation to it the timing and duration of flowering as well as the specifics of the flower structure must known in detail. Moreover, in the selection of this culture, according to Zhang et al. (2013), more widely applied are the methods of anther crops, artificial mutagenesis and genetic engineering.

In Bulgaria the pepper population is characterized by a wide diversity of varieties, form, shape of fruit and cultivars (Todorova 2011; Todorova and Pevicharova, 2012). The breeding programs of this crop are primarily aimed to increasing the productivity and to creation of varieties with sustainable manifestation of signs and with high adaptability (Todorova et al., 2004; Todorova et al., 2011).

The main goal of the present study was to establish the morphological behaviors and productivity of some pepper genotypes of different origin with target about increasing of the gene plasma diversity in this crop and their inclusion into future breeding programs.

MATERIAL AND METHODS

The experiments were carried out in the Experimental Fields and the laboratories of the Department of Horticulture at the Agricultural University-Plovdiv, Bulgaria in the period of 2014-2016.

The following patterns and varieties with origin from Poland, Greece, Spain and Bulgaria were investigated:

1. 5a-2014 - Spontaneous mutation in the Lipari variety, the variety originates in Spain;
2. 24 -2014 – Local population, origin from Greece;
3. 27-21-2011 – Breeding line in local population, originates from Greece;
4. 40-2009 - Local population, origin from Greece;
5. 113-89-2010 - Local population, origin from Poland
6. 114-2010 - Local population, origin from Poland
7. 147-2013 - Local population, origin from the region of Plovdiv, Bulgaria
8. 150-2014 - Local population, origin from the region of Pleven, Bulgaria

The three traditional Bulgarian cultivars as a Kurtovska kapia 1619, Bulgarski rotund and Dzhulunska shipka 1021 were used as a standard, depending on the belonging of the studied genotypes to the respective group, based on the shape of the fruit.

The plants were grown by the conventional for Bulgaria technology for middle-early field production through not pricked out seedlings. The autumn deep plowing was preceded by the fertilization with 32 $kg.da^{-1}$ triple superphosphate and 25 $kg.da^{-1}$ potassium sulphate. The soil preparing in the spring consisted of cultivation, fertilization with ammonium nitrate ate a dose of 20 $kg.da^{-1}$ and formation of the furows. The sowing of the seeds for seedlings growing was performed in unheated plastic greenhouse with a sowing rate 180 $g.da^{-1}$, as 8 g seeds were sown on square meter. The planting was carried out during the period 20 to 22 May, under the scheme 60 x 15 cm. During the vegetation all the agro-technological practices included in the technology were applied and regular care was taken for the normal development of the plants. There were three earthings. The plants were fertilized twice in the phases of mass flowering and the beginning of fruitin, with ammonium nitrate at a dose of 18 $kg.da^{-1}$. The experiments were carried out in four replicates with 7 m^2 size of the experimental plots.

Phenological observations were made of beginning and for mass: sprouting (in the days after sowing), appearance of: flower buds, flowering, fruit sets and fruiting were accounted. Beginning of the

appearance of the respective phase was reported at its onset in 10% of the plants and mass - in 70% (Dimova and Marinkov, 1999)

A morphological analysis on the five plants from each replicates were established. The following parameters were analyzed: total vegetative weight (weight of stem, branches and leaves); height of the plants; height, weight and diameter of the central stem; number and weight of branches; number and weight of leaves were measured. The weight of fruit, length and width of one fruit – measured in its largest part, thickness of the pericarp, shape, surface and coloring were investigated in mass harvest in ten fruits.

The productivity was determined, as by gathering one harvest of not ripe fruits and three harvest of ripening fruits having done. The correlation coefficient (r) between some of the mentioned above behaviors were calculated. Data of the study were subjected to analysis of variance, and the least significant differences between means was calculated by the Fisher test at $p = 0.05$. A method for ANOVA and a method for establishing the correlation coefficient are described in Fowel and Cohen (1992). The presented data are mean values from the three years of the investigation periods, because the trends were similar.

RESULTS AND DISCUSSION

The earliest sprouting (Table 1) was observed in breeding lines 5a-2014, spontaneous mutation of a Lipary variety from Spain and 40-2009 (Greece) - 14 days after sowing, followed by these with a period of 15 days - 27-21-2011, 114-2010 originating in Greece and Poland, respectively. In the above mentioned patterns and varieties the occurrence of mass germination phase was also in shorter time. Line 24-2014 is characterized by the greatest duration of this phase - 26days. Regarding the standard varieties, a shorter period onset of these two phonological phases was necessary for the variety Dzhulunska 1021, 11 and 18 days, respectively.

The earliest formation of flower buds was recorded in the plants from lines 5a-2014 - 35 days and 24 2014 - 48 days, both from Greece. The period occurrence of this phase was the longest for the 113-89-2010 pattern, originating from Poland – for 63 days. The least numbers of days, 52 days and 55 - for mass flowering and formation of flowers were also needed for lines 5a-2014 - 52 days and 24- 2014 - 55 days, respectively. In these genotypes mass formation of fruit sets was visible at the 69 and the 66 days. The most important feature of phenology in pepper is the onset of mass fruiting. In this stage the firstly have been the plants from the Polish pattern 114-2010 - 101 days, followed by line 5a-2014 - 112 days and 24 2014 (Greece) - 110 days. Sbiriciog (2010) highlights about the importance, of the duration of the separate phonological phases for evaluation of pepper genotype. The significance of phenological stages was emphasized also by Geleta et al (2004) and they have made this conclusion on the basis of established strong correlation between flowering and fruit maturity.

Pilic et al. (2013) argue that the basic assessments of the diversity of the pepper genotypes are performed according to their morphological behaviors. The total weight of the plants from the tested genotypes (Table 2) ranged from 159.0 g in pattern 114-2010 (Poland) to 446.3 g of breeding line 5a-2014 originating from the Spanish cultivar Lipari. 8 lines fell in the range from 200 g to 400 g, or these were 72.72% of all investigated. Below 200 g were 3 genotypes, representing 27.27% while in 9.09% the total weight was more of then more of 400 g. The total vegetative weight was formed mainly through the weight of the branches, and their proportion was between 35.06% (Dzhulyunska shipka 1021) to 54.89% (5-2014). The leaves are represented between 26.53% for line 24-2014 and 46.73% for the Bulgarian genotype 150-2014, respectively, while stems varied from 17.72% also for 150-2014 to 26.54% for Kurtovska kapia 1619. It is noteworthy that in a large part of the Bulgarian patterns, in contrast to those with other origins, the total vegetative weight is formed in most cases is formed from the weight of the leaves. The statistical significance is established.

The height of the plant is an important indicator directly related to the applied agro-technological practices. By this behavior, 27.3% the of genotypes fell within the range of 40 to 60 cm, at least 18.2% were those in the range of 60-70 cm, and the most - 54.5% were between 70-80 cm. The highest plants

-80.3 cm belonged to line 24- 2014 (Greece), and the lowest ones 48.0 cm were those of a variety Dzhulunska shipka 1021, followed by a line 114-2010.

Some differences were observed between the separate patterns in the results of the number of main brunches number – between 2.6 number in Kurtovska kapia 1619 and 5.0 for a genotype with origin from Greece (24- 2014). Predominant (63.6%) were those with a number 3.0 and 4.7 number. This determines that the most of the tested lines and genotypes have a cup-shaped stem of the plants.

The average weight of branches, for all genotypes set in this experiment was 116.02 g. Significantly above this value was the weight of the branches of the four variants: 245.0 g (spontaneous mutation in variety Lipari, Spain), 143.0 g (150-2014), as well as 24-2014 - 156.0 g and Bulgarski rotund 138.7 g. Less than 100 grams were the branches of the five patterns - 45.5%. These results suggest that in among these morphological features, the height and the mass of the whole plant are with the greatest variation. Between the data is established statistical significance.

Table 1. Phenological observations

Genotypes	Sprouting*		Flower buds		Flowering		Fruit sets		Fruiting	
	beginning	mass	beginning	mass	beginning	mass	beginning	mass	beginning	mass
5a-2014	14	19	35	52	57	69	65	79	89	112
24- 2014	20	26	48	55	56	66	69	74	89	110
27-21-2011	15	22	59	68	86	95	92	106	126	136
40-2009	14	25	56	68	70	84	75	91	100	115
113-89-2010	17	20	63	77	79	88	83	100	110	125
114-2010	15	18	51	65	55	73	67	78	87	101
147-2013	18	25	49	66	63	80	70	91	83	117
150-2014	18	22	58	72	70	84	75	104	95	124
Kurtovska kapia 1619	15	19	61	70	73	83	79	89	109	112
Bulgarski rotund	18	22	51	60	66	75	73	82	100	108
Dzhulunska shipka 1021	11	18	48	55	60	70	67	79	92	106
LSD (p=0.05%)	3.2	1.8	4.4	5.2	4.6	3.8	3.0	6.7	5.2	6.2

* - days after sowing

Table 3 presents the data for the morphological characteristics of the central stem of the patterns included in this investigation. The average height of all studied genotypes was 30.1 cm. The values ranged from 26.06 cm in line 114-2010 to 39.2 cm for the spontaneous mutation within the Lipari variety originating from Spain (5a-2014). These two variants have showed some thought not quite full, conformity, with the results, obtained for the height of whole plant, the first one being in the group with at the least number of members by this indicator, and the second one was in the predominant group of peppers according to their height. It can be outlined that from all investigated plants prevailed those with height of the central stem between of 20-30 cm - 72.7%, and 4 genotypes exceeded 30 cm. The established height-to-weight stem correlations in most genotypes was high and positive with the

exception of breeding line 150-2105 where the correlation was even slightly negative, r = -0.33. The highest coefficient was obtained for the Bulgarian pattern № 147-2013, r = 0.68.

The diameter of the stem varied considerably less from 11.3 mm (24-2014) to 15.3 mm for 5-2014, both genotypes originating from Greece. In over 45% of the plants, it was with the thickness of the stem was approximately 13 mm. Similarly to the weight of the whole plant, here the greater variation was also observed in the weight of the stem. The values were in the range from 33.7 g for 114-2010 (local population, origin Poland) to 82.3 g for 5a-№ 2014 (spontaneous mutation in the Spanish variety Lipari). The average weight of the central stem, of all patterns was 57.70 g. Most genotypes (five) were between 40-60 g that are amounts 45.5%, four were between 60-80 g (36.4%), a single patterns was with a stem weight above 80 g, and another one - below 40 g. i. e. 9.1% of the all samples. It is evident that the predominant weight of the stem in the studied population ranged from 40-60 g. Correlations between the weight of the stem and its diameter also have been calculated also as positive and high with the exception of the line, originating from Greece, where it was weak and negative, r = -0.24. Results are with statistically proven.

Table 2. Morphological behaviors of pepper plants

Genotypes	Weight (g)	Height (cm)	Number of main brunches	Weight of branches (g)
5a-2014	446.3	73.0	3.7	245.0
24- 2014	305.3	80.3	5.0	156.0
27-21-2011	247.0	79.0	2.7	117.0
40-2009	243.2	75.0	4.6	108.0
113-89-2010	193.6	60.3	3.7	76.0
114-2010	159.0	58.7	4.3	58.0
147-2013	197.6	58.3	4.6	71.0
150-2014	402.3	75.0	3.3	143.0
Kurtovska kapia 1619	230.9	77.3	2.6	90.0
Bulgarski rotund	301.4	63.6	4.0	138.7
Dzhulunska shipka 1021	206.7	48.0	3.0	73.6
LSD (p=0.05%)	12.3	9.68	1.07	16.32

The average number of leaves, developed on one plant was 159.83 (Table 4). The lower limit to which the values reached was 94.3 number for Bulgarski rotund, 111.0 for Kurtovska kapia 1619 and 111.3 leaves for 113-89-2010 (local population, origin Poland). Most leaves were appeared on plants from 5a-2014 (spontaneous mutation in Spanish cultivar) -381.4 number leaves and in line 24 -2014 (Greece) -218.7. Only two patterns have developed above 200 and below 110 leaves, which represents 18,2% of the entire test sample. The majority of the tested genotypes are fell in the range of 110-200 number or it is 63.6%.

The variation in the weight of leaves was also quite large, between 67.3 g for plants of Polish line 114-2010 to 188.0 g for the Bulgarian local population under number 150-2014. The average weight of leaves by the data for all genotypes in the experiment was 92.93 g. A weight above 100 g was found only in two genotypes (18,2%). The largest it was the group of plants with leaves weight of 70-90 g - 14 patterns or it that was 72.7%. The results for the number and weight of leaves indicates that the tested breeding lines, patterns and varieties are with relatively harmonious foliage, not established

excessive development of the leaves has been found and also there were also no genotypes with very weak development of the leaves. In the studied genotypes a strong positive correlation between this two behaviors was calculated, ranging from r = 0.60 for 27-21-2011 to r = 0.76 for 5a-2014. More of the differences between the genotype are proven.

Table 3. Morphological characteristics of central stem

Genotypes	Height (cm)	Diameter (mm)	Weight (g)	r - height with weight	r - weight with diameter
5a-2014	39.2	15.3	82.33	0.56	0.66
24-2014	31.4	11.3	68.3	0.64	-0.24
27-21-2011	30.6	13.7	55.0	0.52	0.71
40-2009	28.0	13.0	53.6	0.53	0.68
113-89-2010	27.6	11.3	41.6	0.58	0.59
114-2010	26.0	12.3	33.7	0.64	0.71
147-2013	31.0	11.3	45.6	0.68	0.70
150-2014	27.3	13.3	71.3	-0.33	0.68
Kurtovska kapia 1619	32.3	13.0	61.3	0.61	0.63
Bulgarski rotund	27.3	13.6	78.7	0.56	0.64
Dzhulunska shipka 1021	30.3	12.0	43.3	0.67	0.68
LSD (p=0.05%)	2.16	2.22	13.2		

The weight of the fruits (Table 5) is the most important agronomic characteristics and an indicator of the economic evaluation of a genotype that is directly related to their productivity. The average value of the test sample in regarding to this parameter is 73.51 g. The fruits of the majority of the experiment patterns are belonged to the group of large and very large, according to the definition reported by Panayotov (2014). This is determined by the fact that 45.45% were in the range of 60-80 g, 18.18% were between 80 and 100 g and 9.09% were over 100 g. Below 60 g were the fruits of the three genotypes or this is 27.27%. The fruits of the local population from the Plovdiv region with rotund shape were characterized by the highest weight, reaching to 160.5 g, followed by the variety with the same fruit shape, Bulgarski rotund -85.7 g and the increase compared to this standard variety was significantly - by 87.3%. Lighter than 20 g were only the fruits of Dzhulunska shipka 1021. It is clear that in the selected genotypes a significant variation is found in terms of the weight of the fruits, but the predominant fruits parts were between 60.0 - 80.0 g, i. e. large and very large. This is a good prerequisite after further research and monitoring of their stability to identify promising patterns for their inclusion as parental forms in future hybridization.

The length of the fruits also varied widely. It ranged from 3.6 cm for the standard variety Bulgarski rotund to 12.8 cm also for another standard variety Kurtovska kapia1 619. The average value of the sample was 9.8 cm. By the fruit length the genotypes of the groups below 10 and from 10 to 12 cm are distributed uniformly – 4 in each group (36.4%), while 27.27% were over 12 cm.

The width also varied over a wide range from 2.3 cm for Dzhulunska shipka 1021 to 10.4 cm for the local population with rotund shape. The average values was 4.56 cm. The prevailing width was between 4 to 5 cm, it occurred in 54.6%. The weight was the biggest in the fruits of rotund type,

especially in line 147-2013 - 10.4 cm. The bigger parts of the differences for morphological characteristics of the fruits between genotypes are with statistically significance.

The thickness of the pericarp determines the scope of use of the pepper. In 45.5% of the genotypes it was between 4 and 6 mm. With the most thickest perikarap, of 8.2 mm were characterized the fruit in the Bulgarian population 147-2013, followed by the local population from Greece 27-21-2011 - 7.13 mm and those of Kurtovska kapia 1619 6 mm. Relatively thicker than 5 mm was the pericarp in breeding line 24 -2014 also originating from Greece as well as in the Bulgarian rotund. This indicator has a significant impact on the weight of the fruit, and a very strong positive correlation between these two characteristics was identified.

Table 4. Morphological characteristics of leaves

Genotypes	Number	Weight (g)	r
5a-2014	381.4	119.0	0.76
24 -2014	218.7	81.0	058
27-21-2011	103.5	75.0	0.60
40-2009	135.6	81.6	0.72
113-89-2010	111.3	76.0	0.63
114-2010	112.3	67.3	0.66
147-2012	117.5	81.0	0.62
150-2014	189.3	188.0	0.62
Kurtovska kapia 1619	111.0	79.6	0.68
Bulgarski rotund	94.3	84.0	0.64
Dzhulunska shipka 1021	183.3	89.8	0.65
LSD (p=0,05%)	26.4	14.3	

The belonging to pepper to a given variety or group is mainly determined by the shape of the fruit (Panayotov, 2014). This is one of the most important approbation signs and most commonly used for identification of the varieties. In Table 6 are shows the data for characterization of the investigated new patterns and breeding lines. With conical shape of the fruit were 7 patterns or it is 87.5%, and included in this group were also the genotypes which for ease of description we define as “kapia” shaped, as well as those of type “shipka” - one of each (12.5%). One genotype was with flat, rotund fruit shape. In terms of the surface, 5 had smooth fruits or 62.5%, and 37.5% - striated surface. The longitudinal striations on the surface were predominant. From the investigated plants 75.0% or 6 pieces had red, one had yellow and one had orange coloration. It should be noted that prior to botanical maturity most of the genotypes had green color and only one, originating from Poland, № 113-89-2010 had violet.

Complete evaluation of the individual genotypes necessarily involves their economic qualities and suitability to the appropriate growing conditions. To the fullest this achieved by the established their productivity (Table 7). The yield in most of the tested genotypes was higher than the corresponding controls. In the varieties with fruit conic fruit shape with the highest yield were № 27-21-2011 and 40-2009 - lines in local populations originating in Greece, - 4064.2 kg.da^{-1} and 3653.9 kg.da^{-1}, respectively or with 25.5% and 12.8% over higher than Kurtovska kapia 1619. Next, with very similar productivity were are 5-2014 (Greece) and 150-2014 (Bulgaria). As is evident the productivity of these genotypes significantly exceeds the control Kurtovska kapia 1619. With a lower yield were

patterns from Poland - 113-89-2010 and 114-2010, approximately 7% less than the standard. The chili genotype of type "shipka" from Greece 24-2014 had a significantly higher yield than the control Dzhulunska shipka 1021 with 47.5%. The breeding line №147-2013 of the type rotund, has reached a yield of 3689.2 kg.da^{-1} or with 13.3% above that obtained for Bulgarian rotund. A difference was observed in the productivity over the years. The highest yield in most standard varieties and genotypes was obtained in 2016, and the lowest one in 2014 that could probability is due to the different climatic conditions during the study. The data for productivity are with statistically proven. Following the statements above, it could be argued that emerging as promising patterns for the enrichment of gene plasma in breeding programs are two lines with conical shape derived from local populations originating in Greece - 27-21-2011 and 40-2009 and a line from the Bulgarian population with rotund shape - 147-2013.

On Table 8 are shown the correlations between productivity and some morphological characteristics of the plants and fruits of pepper. The correlation coefficients between yield and total vegetative weight of the plants are middle to high negative. Coefficients are r = -0.40 for line 24-2014 to r = -0.70 for Dzhulunska shipka 1021. Similar results were obtained, and Douglas and Lu (1998), who describe the relationship between the weight of the plants and the obtained yield with a strong negative correlation r = - 0.667.

High correlations coefficient from r = 0.412 to r = 0.708 between a number of morphological characteristics of the pepper plant and fruits and their relation to productivity were established by Cankaya et al. (2010) in a study of 56 varieties in the Black Sea region of Turkey. The relationship between the number of branches and the productivity is low positive from r = 0.22 to r = 0.35, except in the two genotypes - 27-21-2011 and 147-2013, where it also is a low but negative. High and positive is the correlation between yield and weight of the fruit and the correlation coefficients vary between r = 0.66 for 40-2009, a breeding line in population from Greece to r = 0.78 for the Bulgarian peppers Kurtovska kapia 1619 and 147-2013. Such a positive a correlation is mentioned also by Yang et al., (1999), Feipeng and Yuji (2004) and Cankaya et al., (2010). Also high correlation is identified between the productivity and the thickness of the pericarp. As mentioned above such is also the correlation with the weight of the fruit. Ming and Wang (1988) emphasized that this feature in pepper is in an overwhelmingly strong relation with the yield.

Table 5. Morphological characteristics of the fruits

Genotypes	Weight (g)	Length (cm)	Width (cm)	Thickness of pericarp (mm)	r - weight with thickness of pericarp
5a-2014	68.0	11.8	3.5	4.9	0.60
24- 2014	57.3	12.16	4.6	5.8	0.65
27-21-2011	73.6	12.0	5.1	7.13	0.68
40-2009	96.3	13.6	4.3	3.3	0.64
113-89-2010	65.9	10.2	4.8	3.3	0.66
114-2010	54.3	9.2	3.7	3.2	0.62
147-2013	160.5	4.75	10.4	8.2	0.71
150-2014	55.5	11.5	4.1	4.5	0.62
Kurtovska kapia 1619	79.8	12.8	4.5	6.0	0.68
Bulgarski rotund	85.7	3.6	7.7	5.6	0.70
Dzhulunska shipka 1021	11.8	6.2	2.3	3.4	0.63
LSD (p=0.05%)	18.8	3.8	3.35	1.89	

Table 6. Characteristics of the fruits*

Genotypes	Shape	Surface	Coloring – before botanical/ botanical maturity
5a-2014	conical, sharp	smooth	green/dark orange
24 -2014	conical, sharp, type “shipka”	smooth, slightly striated	green/intensive orange
27-21-2011	conical, 3-walls (triangular)	slightly longitudinal striated	green/yellow
40-2009	conical, 3-walls (triangular)	smooth	green/intensive red
113-89-2010	conical, 2-3 walls, tip - sharp	smooth	violet/intensive red
114-2010	conical, very elongated, tip-rounded, 2-3-walls	slightly longitudinal striated	dark green/intensive red
147-2013	type “rotund”, 4 segments	longitudinal striated	dark green/intensive red
150-2015	conical, 3-walls (triangular)	Smooth	green/red

* Here is not included the description about standard varieties, because it is known very well

Table 7. Productivity of the investigated pepper genotypes (kg.da^{-1})

Genotypes	2014	2015	2016	Average	%
5a-2014*	2974.4	3312.3	3581.2	3289.3	101.5
24 -2014***	2304.8	2476.5	2524.0	2435.1	147.5
27-21-2011*	3986.2	4056.1	4150.4	4064.2	125.5
40-2009*	3262.2	3400.6	4298.9	3653.9	112.8
113-89-2010*	2923.8	3112.2	3000.6	3012.2	93.0
114-2010*	2818.8	2942.6	3201.1	2987.5	92.2
147-2013**	3412.9	3725.3	3929.4	3689.2	113.3
150-2014*	2998.8	3165.7	3604.4	3256.3	100.5
Kurtovska kapia 1619*	3012.2	3258.9	3443.5	3238.2	100.0
Bulgarski rotund**	3001.9	3252.6	3514.7	3256.4	100.0
Dzhulunska shipka 1021***	1499.9	1529.8	1934.7	1654.8	100.0
LSD (p=0,05%)	99.8	120.2	108.8		

Comparison: *-with Kurtovska kapia 1619, **-with Bulgarski rotund, ***- with Dzhulunska 1021

Table 8. Correlations between productivity with some morphological characteristics of the plant and fruit

Genotypes	With total vegetative weight	With number of branches	With weight of fruit	With thickness of pericarp
5a-2014	-0.56	0.35	0.72	0.47
24 -2014	-0.40	0.25	0.76	0.39
27-21-2011	-0.67	-0.28	0.69	0.54
40-2009	-0.62	0.33	0.66	0.55
113-89-2010	-0.66	0.22	0.76	0.44
114-2010	-0.45	0.26	0.68	0.50
147-2013	-0.58	-0.14	0.78	0.48
150-2014	-0.42	0.22	0.70	0.56
Kurtovska kapia 1619	-0.58	0.32	0.78	0.66
Bulgarski rotund	-0.63	0.28	0.71	0.56
Dzhulunska shipka 1021	-0.70	0.26	0.69	0.60

CONCLUSIONS

The origin of genotype has some influence on the development of pepper plants, both in terms of inter-phase periods and morphological development as well as productivity.

With the relatively short inter-phase periods were characterized patterns originating from Greece and Bulgaria.

The total vegetative weight is determined predominantly by the weight of the branches. Height of plants in most tested genotypes was in the range between 70-80 cm, while depending on the number and location of branches the shape of the plants can be described as a being of a of cup-shaped type. Strong positive correlation was found between the weight of the stem and its height and diameter, as well as between the number and the weight of leaves.

The majority of the studied genotypes are characterized by large to very large fruit, mostly in Greek and Bulgarian patterns, and relatively thick pericarp and between these two parameters formed high correlation coefficients. Most patterns have a conical shape, smooth surface and red coloring of the fruit.

With the highest productivity are local lines from populations originating in Greece 27-21-2011 and 40-2009 and from the Bulgarian population 147-2013, therefore they are particularly promising for enriching of gene plasma in pepper and for their inclusion in breeding programs in our country. Strong positive correlation was identified between productivity and weight of fruit and thickness of pericarp.

REFERENCES

Bosland, PW 1998. *Capsicums: Innovative uses of an ancient crop*. In: J. Janick (ed.), Progress in new crops. ASHS Press, Arlington, VA, pp. 479–487

Cankaya, S, Balkaya A &, Karaagac, O 2010. *Canonical correlation analysis for the determination of relationships between plant characters and yield components in red pepper (Capsicum annuum* L. var. *conoides (Mill.) Irish) genotypes*. Soanish Journal of Agricultural Science, vol. 8, no. 1, pp. 67-73.

Cholakov, D, 2009. *Pepper*. In: Cholakov, D. (ed.), Vegetable crops. Publish in Agricultural University-Plovdiv, pp. 91-110. (Bg)

Darbie, M & Granberry, N ,2005. C*ulture and varieties of pepper. Extension Horticulturist-Vegetable Crops*. In: Paul, G & Colditz, F (eds.) Extension Horticulturist Emeritus, HortPress, UK, pp. 28-36.

DeWitt, D & Bosland, PW 1996. *Peppers of the world. An identification guide*. Vege Press, New York.

Dimova, D & Marinkov, E 1999. *Experimental design and biometry*, Publish house of Agricultural University-Plovdiv, pp. 65-79. (Bg)

Douglas, RD & Lu, KH 1998. *A correlation and path-coefficient analysis of components of crested wheatgrass seed production*. Agronomy Journal, vol. 51,no. 9, pp. 515-518.

Feipeng, W & Huang, Y 2004. *Correlation and Path Analysis of the Main Agronomic Traits of Sweet Pepper*. Chinese Journal of Tropical Crops, 4, 32-40.

Fowel, J & Cohen, L 1992. *Practicle statistics for field biology*. John Wiley & Sons, New York, pp. 100-223.

Geleta, LF, Labuschagne, MT & Viljoen, CD 2005. *Genetic variability in pepper (Capsicum annuum* L.*) estimated by morphological data and amplified fragment length polymorphism markers.* Biodiversity & Conservation, vol. 14, no. 10, pp. 2361–2375

Geleta,L, Labuschagne, M & Viljoen, C 2004. *Relationship between heterosis and genetic distance based on morphological traits and AFLP markers in pepper*. Plant breeding. vol. 123, no 5, pp. 467–473.

Ilbi, H 2003. *RAPD markers assisted varietal identification and genetic purity test in pepper, Capsicum annuum* L. Scientia Horticulturae, vol. 97 no. 3-4, pp. 211-218.

Livesy, J 2010. *Pepper garden – breeding*. Main Press House, NY.

Martirosyan, G & Sargsyan, GJ, 2014. *Results of studying initial material for pepper breeding*. Acta Horticulturae, no. 1033, pp. 47-52.

Ming, H & Wang X, 1988. *Correlation and path analysis in pepper.* Journal of Northwest Sci-Tech University of Agriculture and Forest, China, no. 4, pp. 108-124.

Morton, F 2014. *Remove from marked Records Breeding open-pollinated varieties out of hybrids: peppers*. Proceedings of the 7th Organic Seed Growers Conference, Corvallis, Oregon, USA, pp. 77-78.

Panayotov, N 2014. *Pepper*. In: Michov, Kr, Panayotov, N, Filipov St, Babrikov, T, Kostadinov K & Haytova, D. Guide for practical exercises for vegetable crops and seed production. Agricultural University-Plovdiv, Bulgaria, pp. 59-73. (Bg).

Pilic, S, Jerkovic-Mujkic, A & Besta-Gajevic, R 2013. *Remove from marked Records Morphological and histological changes in two different CMV-infected pepper cultivars*. In Blesic, M (ed.) Proceedings of the 24th International Scientific-Expert-Conference of Agriculture and Food Industry, Sarajevo, Bosnia and Herzegovina, pp. 401-404

Sbirciog, G, 2010. *The study of some green pepper lines (Capsicum annuum* L. var. *grossum* Sendt.*) tested in the comparative plots for evaluation*. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Ser. Horticulture, vol.67 no.1, pp.510.

Todorova, V & Pevicharova, G. 2012. I*ZK Kalin – a new Bulgarian pepper variety for paprika. Current trends in vegetable breeding and seed production.* Proceedings of the III th International Scientific Research Conference "Traditions and perspectives", pp. 455-464.

Todorova, V, Lidansky, T & Todorov, Y 2004. *Stability and adaptability differences among green pepper cultivars*. Journal of Science Agricultural Researches, Serbia and Montenegro, vol. 65 no. 231/2, pp.27 - 36.

Todorova, V 2011. *"Kurtovska kapiya 1" – new Bulgarian pepper cultivar*. Materials of XIV International scientific-practice conference "Aagricultural Science – agricultural production, Siberia, Mongol, Kazakhstan, Bulgaria. Karsnoyarsk, pp. 15-18.

Todorova, V, Krasteva, L, Neykov, St & Chavdarov, P 2011. *DEVEN – new variety of pepper*. Crop Science, vol. XLVIII, no. 6, pp. 501 – 507.

Yang, G, Fengjin, L, Zhang, ZG & Yumin, BG 1999. *A study on genetic correlation variations of multiple quantitative characters in drying pepper*. Journal of Shanxi Agricultural Sciences, no. 4, pp. 18-26.

Zhang TX, Lin, ZK, Cao, MH, Cai, KX & Yang, JJ 2013. *Research progress of sweet pepper breeding in China*. Acta Agriculturae Jiangxi, vol. 25, no.7, pp. 44- 49.