COMPARATIVE EVALUATION BY MORPHOLOGICAL BEHAVIORS AND PRODUCTIVITY ON DIFFERENT GENOTYPE OF CAPE GOOSEBERRY (Physalis peruviana L.)

Nikolay Panayotov

Agricultural University of Plovdiv, 12 "Mendeleev" Str., Plovdiv, Bulgaria

Abstract

The main goal of the present study was to establish the morphological behaviors and productivity of different genotypes of cape gooseberry (Physalis peruviana L). The experiments with six genotype of cape gooseberry with different origin were carried out. Plants were grown by the conventional technology for Bulgaria with sowing in the middle of March and transplanting in the middle of May on scheme 70 x 50 cm. In phase of full botanical maturity the morphological characteristic was done. The height and weight of central stem; number and weight of branches; number and weight of leaves; number and weight of fruits of one plant were investigated. The productivity was determinated. The correlations between the investigated parameters were calculated. With the biggest height and weight of stem were the plants with origin from Turkey. The number of branches was the highest in Obrzaec 3 with origin from the USA. The highest productivity was recorded form variety Plovdiv, while the lowest one from genotype 11-2012 that originate from Germany.

Key words: *vegetative, fruit, productivity, morphology, correlation*

INTRODUCTION

The genus physalis covers approximately 100 annual and perennial species used for their fruit. The most widespread is *Physalis peruviana* L., followed by *Physalis pruinosa* L., *Physalis ixocarpa* Brat. and *Physalis pubescens* L. (Moriconi et.al. 1990, M. Crawford, 2004).

In order to identify the different species and determine their taxonomic identities are investigated numerous morphological and anatomical characteristics of separate organs. Main trend primarily of all of these studies is to reveal significant differences for systematic differentiation.

Li and Tores (1997) reported that some of the anatomical characteristics of stem allow themselves to be used to distinguish between some of the species and varieties of *Physalis angulata, Physalis lagascae, Physalis peruviana* and *Physalis pubescens,* arguing and they emphasised that only in *Physalis peruviana* L. in the stem was observed the presence of spongy zone. In other studies, the same authors Li and Torres (1997a) revealed the possibility of finding the belonging to the genus Physalis, as well as to separate variety by the number of vascular vessels in the central part of the petiole, the type of stomata and trichomes and density of the pappus. Garcia (1997) indicates that individual species and varieties differ also by vasiculars on the top and bottom side of the leaves, the length of the pappus on the underside of leaves and length and stomata index and the thickness of mesophilic tissue.

Haytova and Babricov (2006) and Haytova and Gergova (2011) established strong genotypic response studied a wide range of varieties in various vegetable crops.

Specific morphology-anatomical features of the fruit between different species and varieties according to Dyki et al. (1997) are the type of waxy cells on the surface, the presence or absence of hairs, the type of epidermal cells, and pericarp, available-vascular vessels. Zhang and Wen (1996) in this direction included also the surface of the seed coat.

Comparatively good productivity of plants even on poor soils, its easy growing, low requirements for water and fertilizer make cape goosebery as attractive crop (McCain, 1993). Christov (2010) pointed out that the perspectives for the production and marketing of cape gooseberry increased in recent decades. According to him varieties as a product of purposefully breeding are very few and widely

cultivated forms and local ecotypes. The author reported that in Bulgaria it has already been developed breeding work in this crop. Panayotov (2010) announced about the selection of the first in Bulgaria variety of cape gooseberry named Plovdiv.

The main goal of the present study was to establish the behaviors and productivity of several genotypes with different origin of cape gooseberry (Physalis peruviana L).

MATERIAL AND METHODS

The experiments were carried out in 2012 – 2014 in the Experimental field of Department of Horticulture at the Agricultural University-Plovdiv with the following genotypes:

- variety Plovdiv - origin from Bulgaria;
- Obrazec 1 - origin from the USA;
- Obrazec 2 - origin from the USA;
- Obrazec 3 - origin from the USA;
- 08-2010 - origin from Turkey;
- 11-2012 - origin form Germany.

The seeds were sown in plastic non-heating green house by 1.5 g/m^2 and the rate of sowing per hectare was 80 g/ha. On 20 May the non-prickle seedlings were planted by scheme 70 × 50 cm (Panayotov и Tcorlianis, 2000) on the experimental plots of 10 m^2, in four replications. Through the vegetation periods all agricultural practices were performed.

The following morphological characteristics, measured on 15 plants taken randomly of each replications: height of central stem, weight of central stem, number of branches, weight of branches, number of leaves, weight of leaves in stage of fruiting were established. Total leaves-stem vegetative weight also was calculating as sum of weight of stem, branches and leaves. The number of fruits and weight of fruit (in mass harvest) were determined. The total yield was obtained. Three harvests in full botanical maturity were performed.

The correlation coefficient between some of the mentioned above behaviors were calculated. Data of the study were subjected to analysis of variance, and least significant differences between means were calculated by the Fisher test at p = 0.05. A method for ANOVA and method for establish 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 height of the stem in the tested genotypes of cape gooseberry (Table 1) ranged from 149.6 cm for Obrazecl 1 to 200.3 cm in 08-2010. McCain (1993) and Sarkar et al. (1993) pointed out that, depending on growing conditions and applied technology height of the stem of cape gooseberry can reach up to 2 m. The difference between the highest and lowest value _ of this indicator was 50.7 cm. The average value determined between the measurements at all test samples was 171.8 cm. With the highest weight of stem are characterized genotype Obrazec 3l originating from the USA - 320.3 g, while with smallest weight was variety Plovdiv - 150.1 g. The average value was 255.1 g. The relationship in the development of stem between its height and weight is significant. This is evident in the established correlation. This relationship between two features is strong and positive with correlation coefficients of r = 0.52 (Obrazec 1) to r = 0.62 (Plovdiv). An exception was observed only for genotype Obrazec 2, where the correlation was also positive but middle with r = 0.48. It has been found a statistical significance of differences in these two characteristics.

Main morphological characteristic of of cape goosberry, closely related to the potential productivity, is branching of the plants (Skvorcova, 1997). The author pointed out that branching was simpoidal. Any enhanced formation of the branches is due to greater competition of the top meristem to reproductive organs. The number of branches (Table 2) was between 12.5 and 19.0, for Plovdiv and for Obrazec 3, respectively. Average for the test sample the cape gooseberry plants have developed 16.53 number of branches. The differences are mathematical proved. The variation in the feature weight of branches was stronger. The values range from 835.4 g of Plovdiv to 1613.15 g of 08-2010. This may be defined and the identified weak to middle correlation. The correlation is weak in Plovdiv, and for Obrazec 2 and 08-2010 r = 0.36, 0.39 and the 0.38, respectively to middle for Obrazecl 1 (r = 0.42) and 11-2012 (r = 0.44).

Table 1. Morphological characteristics of stem of cape gooseberry

№	Genotypes	High of stem (cm)	Weight of stem (g)	r
1	Plovdiv	166.4	150.1	0.62
2	Obrazec 1	149.6	237.3	0.52
3	Obrazec 2	179.3	275.3	0.48
4	Obrazec 3	170.4	320.3	0.55
5	08-2010	200.3	311.9	0.56
6	11-2012	165.0	235.7	0.60
LSD p=0.1%		9.3	12.2	

Table 2. Branches of the stem of cape gooseberry

№	Genotypes	Number	Weight (g)	r
1	Plovdiv	12.5	835.4	0.36
2	Obrazec 1	18.5	1730.1	0.42
3	Obrazec 2	17.5	1395.2	0.39
4	Obrazec 3	19.0	1000.3	0.40
5	08-2010	15.1	1613.15	0.38
6	11-2012	16.6	1444.5	0.44
LSD p=0.1%		3.2	102.5	

The development of the leaves is a very important parameter in cape gooseberry. Chernok (1997) and Christov (2010) emphasized that many great leaf mass makes difficult the harvest and its excessive increase is not desirable. Data on the number of leaves are presented in Table 3. At least leaves have developed plants of Obrazec 3 - 660.7 pieces. The values of this morphological characteristics are highest in genotype 11-2012 - 1109.0, and the average for all test samples of the genotypes the number of leaves was 949.78. Almost a similar situation was observed with regard to the other studied sign - the weight of leaves. It was the greatest at 11-2012 - 1045.1 g and the lowest for Obrazec 3 - 300.3 g. This trend defines the strong correlation between these two characteristics. The correlation for all genotypes is strong and positive, correlation coefficients range from r = 0.76 for Obrazec 2 and r = 0.86 in Plovdiv and 08-2010. The differences between genotypes regarding the number and mass of leaves are with statistically significance.

Table 3. Morphological behaviors of leaves of cape gooseberry

№	Genotypes	Number	Weight (g)	r
1	Plovdiv	818.5	410.5	0.86
2	Obrazec 1	1246.9	957.8	0.88
3	Obrazec 2	835.2	585.6	0.76
4	Obrazec 3	660.7	300.3	0.80
5	08-2010	1028.4	989.4	0.86
6	11-2012	1109.0	1045.1	0.79
LSD p=0.1%		123.3	48.6	

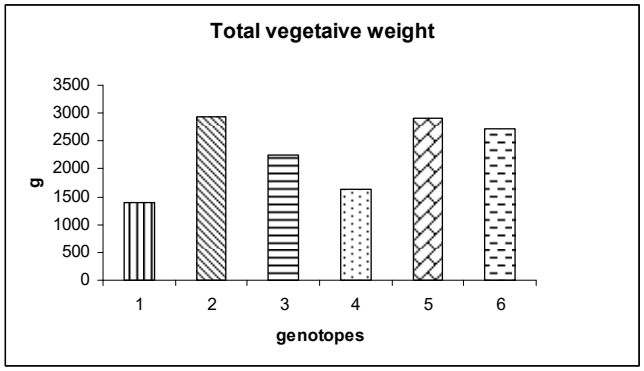


Figure 1. Total leave-stem vegetative weight of cape gooseberry plants (g)

1-Plovdiv, 2-Obrazec 1; 3- Obrazec 2, 4-Obrazec 3, 5-08-2010, 6- 11-2012

The total vegetative weight is an indicator that gives a very good idea of the overall development of plants and their living status. Data for total vegetative weight are present in Figure 1. The plants of Obrazec 1 developed most leaf-stem weight up to 2952.2 g, followed by genotype 08-2010 (2914.5 g) and 11-2012 (2725.3 g). With the small weight were the plants from variety Plovdiv - 1396.0 g. The weight of branches has the largest share in the formation of overall vegetaivna weight at all genotypes, between 53.0% in 11-2012 and 61.84% in Obrazec 2. The least part for this indicator toke the weight of the stem _ 8.11% for Obrazecl 1 up to 19.86% for Obrazec 3, the both genotypes originating from the United States. The leaves weight occupies an intermediate position, its share goes from 18.52% for Obrazec 3 to 38.34% for genotype 11-2012.

Plants of cape gooseberry formed relatively large number of fruits (Table 4). Most were in variety Plovdiv - 266.5 pieces, followed by those per 11-2012 - 157.8 pieces. Average for all tested genotypes the number of fruit per plant was 166.31. Significant deviations from this average, except in variety of Plovdiv, where the excess was with approximately 100 pieces, also was observed for Obrazec 2 - with approximately 30 fruits less Weak was the variation in other studies sign of the morphology of the fruit, its average weight. Its average values among all tested genotypes included in the study was 2.32 g. Significantly above this value was the weight of the fruit of variety Plovdiv, nearly 0.76 g and reached 3.08 g. With the smallest weight are characterized the fruits of Obrazec 3 - 1.82 g. The differences are mathematically proven. Between these two characteristics there is a very high dependence. The correlation coefficients are high and the correlation is strong and also positive with values of r = 0.88 for Obrazec 1 to r-0.79 in Obrazec 3.

The effectiveness of the agro-technological practices is best assessed through plant productivity (Table 5). It can be noted that the highest productivity features in most of the investigated genotype was

observed in 2013. Higher fruiting in between all varieties and genotypes indicated Plovdiv. Averaged three years values displayed that the yield was the highest for Plovdiv - 221.5 kg/da. The increase compared to the genotype with the least fruiting (11-2012) is with 54.573%. The lowest productivity was registered for 11-2012 – 143.3 kg/da. In all the years and genotypes the highest yields obtained in 2012 in Plovdiv – 235.6 kg/da, while the lowest one was observed for 11-2012 in 2013 – 132.5 kg/da. Statistical significances of the differences between the variants are established.

Table 4. Fruits of cape gooseberry

№	Genotypes	Number	Weight (g)	r
1	Plovdiv	266.5	3.08	0.81
2	Obrazec 1	142.5	2.38	0.88
3	Obrazec 2	136.6	2.44	0.86
4	Obrazec 3	140.7	1.82	0.79
5	08-2010	153.8	2.02	0.80
6	11-2012	157.8	2.19	0.83
LSD p=0.1%		6.2	0.81	

Table 5. Productivity of cape gooseberry (kg/da)

№	Genotypes	2012	2013	2013	average
1	Plovdiv	235.6	228.5	200.4	221.5
2	Obrazec 1	196.5	200.0	175.6	190.7
3	Obrazec 2	210.8	204.3	182.8	199.3
4	Obrazec 3	156.8	168.2	120.0	148.3
5	08-2010	178.1	168.8	145.6	164.2
6	11-2012	142.5	155.2	132.5	143.3
LSD p=0.1%		18.4	12.3	16.5	12.9

On Table 6 is shown the correlation between productivity and some morphological characteristics of the plants of cape gooseberry. The correlation coefficients between yield and total vegetaivna weight of the plants are weak to middle negative from r = -0.28 for Obrazec 1 to r = -0.39 for 11-2012. These results could be due on the above mentioned conclusion, reported from Chernok (1997) and Christov (2010), that very big vegetative weight is not appropriate for the harvesting and also that delayed the maturity and the obtaining of standard fruits are less.

Very clear genotypic response about the correlation between the number of branches and productivity was established. In variety Plovdiv and Obrazec 3 albeit weak it was positive. i. e. r = 0.19 and r = 0.12, respectively. While negative and middle this correlation dependence was calculated for Obrazec 1 r = -0.33 and for 08-2010 r = -0.46. In Obrazec 2 (r=-040) and 11-2012 (r=-0.42) was also middle and negative. According Skorcova (1999) formation of the branches is determined to greater competition of the top meristem to reproductive organs. Thus, the system of branching on the one hand creating the high potential productivity, but on the other hand retains the maturation of the fruit. Therefore, the perspective are these genotype that are with simultaneity ripening and with determinate growth. The established negative correlation may have been related precisely to the fact, distinguished

by that researcher, that branching is associated with the ripening, which is reflected to the obtaining of lower standard yield of ripped fruits. Therefore, the presence of a greater number of the branches leads to reducing productivity, which defines negatively the weak correlation between these two characteristics.

Positive and strong correlation was obtained between the number and weight of fruit and yield. Correlation between productivity and the number of fruits ranged from r = 0.60 for Obrazec 1 to r = 0.72 for Obrazec 2 and 08-.2010. A stronger yield is determined by the weight of the fruit. In for this indicator the correlation coefficients are with higher values - r = 0.80 (Obrazec 3) to r = 0.90 (Obrazec 2). These dependencies can serve as the breeding of cape gooseberry as well as in its cultivation.

Table 6. Correlation dependences (r) between yield and some morphological indexes

№	Genotypes	Total vegetative weigh	Number branches	Number fruits	Weigh fruit
1	Plovdiv	-0.34	+0.19	0.65	0.88
2	Obrazec 1	-0.32	-0.33	0.60	0.82
3	Obrazec 2	-0.36	-0.40	0.72	0.90
4	Obrazec 3	-0.33	+0.12	0.68	0.80
5	08-2010	-0.28	-0.46	0.72	0.89
6	11-2012	-0.39	-0.42	0.65	0.86

CONCLUSIONS

In the morphological development of plants of cape gooseberry was established clear _ genotypic response.

The height of the stem varies from 149.6 cm for Obrazec 1 to 200.3 cm at 08-2010, and its weight was from 150.1 g for variety Plovdiv (Bulgaria origin) to 320.3 g for genotype Obrazec 3 originating from the United States. The correlation between them is strongly positive.

With more developed branches are the plants of a variety of Plovdiv and genotip Obrazets 3. Their weight is characterized by greater variability. The midle positive correlation between these signs was established.

The highest number of leaves with the highest weight were developed from genotypes Obrazec 1 and 11-2012, as there is a strong positive correlation between them.

The total vegetative weight was the highest in Obrazec 1, followed by that of 08-2010, as the main in its formation parts takes the weight of branches.

With the highest fruit weight and with the biggest number of fruits per plant are characterized variety Plovdiv and the correlation is also strongly positive.

Highest productivity demonstrated variety Plovdiv, followed by Obrazec 2. Strong positive correlation on the yield exists mostly with the weight and with the number of fruits.

Established correlations are important for breeding in cape gooseberry. Suitable genotypes that are recommended to be include for more successfully carrying out breeding programs are varieties of Plovdiv and Obrazec 2.

REFERENCES

Chernok, LG 1997. *Tomato, pepper, eggplant, physalis*. Ser.-Vitality 12, 280- 288. (Ru)

Christov, Chr 2010. *Cape gooseberry - Physalis peruviana* L. In: *Seeds of small and unknown fruits and vegetables*. *www.hobi-semena.com.* (Bg)

Crawford, M 2004. *West Australian Nut and Tree Crops Associacian*. Yearbook Australian University 27, 42-51.

Dyki, B, Jankiewicz, LS, Staniaszek, M 1997. *Anatomy and surface micromorphology of tomatilo (Physalis ixocarpa Brot.)*. Acta Societatis Botanicorum Poloniae. 66 (1), 21-27.

Fowel, J & Cohen, L 1992. *Practicle statistics for field biology* (pp100-223). John Wiley & Sons, New York.

Garcia, ML 1997. *The use of principal component analysis for the selection of foliar anatomical variables of interest in taxonomy of four species of Physalis (Solanaceae)*. Pittiera, 26, 49-64.

Haytova, D, Babricov, T 2006. *Comparing of new onion varieties from one year growing*. Agricultural university – Plovdiv, Scientific Works vol. LI, 65-68. (Bg)

Haytova, D, Gergova A 2011. *Biological behavior of patissons, grown in culture by seedlings.* Scientific research on the Union of scientists in Bulgaria-Plovdiv, series C. Technics and Tachnologies, vol.VIII., Union of Scientists Session 11-12 November 2010, 196-199. (Bg)

Li, MG & Tores, EF 1997. *A comparative study of the stem anatomy in four species of the genus Physalis (Solanaceae).* Anales de Botanica Agricola, 4, 11-22.

Li, MG & Tores, EF 1997a. *Leaf anatomy of the four species of the genus Physalis (Solanaceae).* Anales de Botanica Agricola, 4, 23-32.

McCain, R 1993. *Goldenberry, passion fruit, & white sapote: Potential fruits for cool subtropical areas*. In: Janick, J., Simon, J.E (Eds.), *New Crops* . (pp. 479–486). John Wiley and Sons, New York.

Moriconi, DN, Rush, MC, Flores, H 1990. T*omatillo: A potential vegetable crops for Louisiana*. p.407-413. In:J.Janick and J.E.Simson (eds.). Advances in new crops.Timber Press. Portland.

Panayotov N 2010. *The first Bulgarian variety cape gooseberry – Plovdiv*. Agricultural Science, 1, 3-6. (Bg)

Panayotov, N, Tcorlianis, St 2000. *The effect of type of seedlings and of the planting scheme on productivity and quality of tomatilo (Physalis peruviana L.) grown under Bulgarian condition*. Acta Horticulture, 579, 373 - 376 .

Sarkar, TK, Chattopadhyay, TK 1993. C*orrelation studies on cape gooseberry (Physalis peruviana L.)*. Annals of Agricultural Research 14, 211–214.

Skvorcova, RV 1997. *Breeding vegetable crops from Solanaceae for open air field*. (PhD Thesis). Moskow. (Ru)

Zhang, Z & Wen, J 1996. *Characters of leaf epidermis and seed coats in Physalsi (solanaceae) from China and its systemic significance*. Acta Botanica Yunnancia, 18 (4), 419-423.