Scientific Papers. Series B, Horticulture. Vol. LXII, 2018
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

RESPONSES ABOUT SEED FORMATION AND SEED PRODUCTION IN DIFFERENT GENOTYPES OF CAPE GOOSEBERRY (*PHYSALIS PERUVIANA* L.)

Nikolay PANAYOTOV

Agricultural University of Plovdiv, 12 Mendeleev Blvd, 4000, Plovdiv, Bulgaria

Corresponding author email: nikpan@au-plovdiv.bg

Abstract

The main goal of the present study was to be established the responses in seed formation and seed production in several genotypes of cape gooseberry (Physalis peruviana L.) with a target to predict the seed yield and its realization. The experiments were carried out in Agricultural University of Plovdiv, Bulgaria with six genotypes of the different origin. The number of seed per fruit, the percentage of normally developed seed, the weight of 1000 seeds, germination energy, germination, mean germination time, uniformity of germination, length of embryo root and hypocotyls and fresh weight and deviation in seedlings were established. The weight of seeds per kilogram fruit, the yield of fruit and seed also have been determinated. Significant variation in the numbers of seed per fruit was observed. High germination was an account of each genotype. The differences in seed production and sowing quality between genotypes were registered. These results can be applied for the prediction of seed productivity and also in the determination of the price of seed depending on the genotyping insemination characteristics.

Key words: *germination, seedlings, fruit, yield, germination time.*

INTRODUCTION

According to Geleta et al. (2005), the genetic diversity is very important in relation to increase the peculiarities of plant material in both scopes, to improve the production as well as use in breeding. The authors emphasized that the presence of more genotypes is considered as one of the criteria for the selection and for the reaching of the opportunities of the breeding programs. The importance and availability of rich genetic material of various origins, which are suitable to be included in selection activities are reported also from Martirosyan and Sargsyan (2014).

Many researches established strong genotypic response, studied a wide range of varieties in various vegetable crops (Haytova and Babricov, 2006; Haytova and Gergova, 2011; Todorova 2011; Todorova et al., 2011; Todorova and Pevicharova, 2012)

The genus *Physalis* covers on significant number of annual and perennial species, according to various authors between 70 (Christov, 2010) and 110 (Skvorcova, 1997). The most common and practical applications are three main species, namely *Physalis peruviana* L., *Physalis pruinosa* L., *Physalis ixocarpa* Brat. and *Physalis pubescens* L. (Moriconi et al., 1990; Crawford, 2004), the cape gooseberry (*Physalis peruviana* L.) being the most widely used. Christov (2010) is of the opinion that production and trade with cape gooseberry have increased over the last decades. Its cultivation in the countries of Europe has become more perspective, particularly appropriate for warmer climates and for small-scale farms (Paksi et al., 2007; Popova et al., 2010). According to this author (Christov, 2010), varieties as a product of targeted selection are practically absent and local forms and ecotypes are being grown massively, therefore it is necessary to investigate different genotypes and ecotypes under different conditions.

Experiments with a large number of genotypes of cape gooseberry outdoors and under controlled conditions are conducted by Abak et al (1994) in Chukurova, Turkey. Panayotov (2010) reports on the selection of the first variety of cape gooseberry in Bulgaria, called Plovdiv.

This researcher examines the adaptability of genotypes of *Physalis peruviana* L. with different origins, with a goal directed to identifying the most suitable for cultivation in the region of Southern Bulgaria (Panayotov, 2016). McCain (1993) and Crawford (2004) reported that cape gooseberry is propagated most commonly by seeds. Chernok (1997) confirms the thesis that this crop is grown by seeds, pointing out that its cultivation very often takes place by direct sowing on the open fields. This requires to be provided a sufficient quantity of high-quality seeds.

Therefore the scientific researches into the process of seed production are necessary and must be carried out. In terms of seed production of the cape gooseberry, the published studies in the world literature are insufficient and very few. Lawrence (1993) points out that seed production of cape gooseberry is related to genotypic belonging, on the other hand, depends on the size of plants, which affects the quantity and vitality of the pollen and hence the seed productivity.

In the larger plants, sometimes the amount of pollen is reduced, but because they develop more flowers, their number of seeds is higher, in opposite to smaller ones. In order to increase seed production, the author recommends additionally applying manual pollination to support the natural ones.

The effect of this manipulation is much higher in genotypes that develop weaker plants, as they also rely on a small number of flowers. Thomson and Wit (1987) investigated the optimal temperature regime for both the growth and the germination of the seeds of two types of physalis - *Physalis angulata* L. and *Physalis virginiana* L. var. *underglared*. They establish a strong species and genotype response, both in seed set up and seed development, as well as the temperature regime for maximum sprouting.

The main goal of the present study was to achieve a comparative evaluation of developmental features, productivity and vitality status of the seeds of different genotypes of cape gooseberry (*Physalis peruviana* L.) in relation to predicting of the seed yield and the need for a specific approach for its realization.

MATERIALS AND METHODS

The experiments were carried out in 2015-2017 years in the Scientific field and laboratories of Department of Horticulture at the Agricultural University of Plovdiv, Bulgaria with several genotypes cape gooseberry (*Physalis peruviana* L.) with different origin:

1. Variety Plovdiv - origin from Bulgaria;
2. Genotype Obrazec 1 - origin from the USA;
3. Genotype Obrazec 2 - origin from the USA;
4. Genotype Obrazec 3 - origin from the USA;
5. Genotype 08-2010 - origin from Turkey;
6. Genotype 11-2012 - origin from Germany.

The plants were grown by unpricked seedlings, produced in a plastic unheated greenhouse with sowing on March 15th. The seed rate per one hectare was 80-100 g, and per square meter was sown at 1.5 g. The planting took place between May 20-25 on furrows, on the scheme 70 x 50 cm (Panayotov and Tcorlianis, 2000). All necessary agro-technological practices were applied during vegetation. The experiments took place in four replicates with 25 plants in each and the size of the experimental plot was 9 m^2.

At the stage of full botanical maturity, all the ripe fruits were harvested and their yield was determined. The seed was extracted and the seed yield was established. The seed yield from one kilogram of fruit was studied. Separately on 5 fruits from each replicates all seeds were extracted.

The following indicators: number of seeds per fruit - determined by counting the seeds of five fruits of each replicates; percentage of fully developed seeds in one fruit (insemination) - by counting of the normally developed seeds and calculating their percentage to the total number of seeds per fruit were registered.

The linear seed sizes - length, width and thickness of seed, measured on 15 seeds with electronic calliper; weight of one seed - set on 15 seeds, weight of 1000 seeds (ISTA, 2013), in 4 replicates; germinating energy (ISTA, 2013), in 4 replicates; germination (ISTA, 2013) in 4 replicates; uniformity of germination (according to Strona, 1966); mean germination time (MGT) - in four replicates, each of 100 seeds, calculated according to the equation given below were determinated.

$$M.G.T. = \frac{\Sigma (G \times T)}{F}$$, where:

T - day in which the seed is germinated;
G - numbers of seeds that germinated in this;
F - final number of germinated seeds (Battle and Whittington, 1969).

On the day of counting of germination in, the four replicates: the fresh mass of a seedlings, by measuring all developed seedlings; length of the embryo root and of the hypocotyl - by measuring 10 seedlings from each replicates; deviations from the normal structure of the seedlings by Welington (1970) - short embryo root, lack of branches in embryo root, lack of hairs on the embryo root, undeveloped cotyledons, unopened cotyledons, lack of hypocotyl were established.

Data of the study were subjected to analysis of variance, and the least significant differences between means were calculated by the Fisher test at p = 0.05. A method for ANOVA and a method for dispersion are described in Fowel and Cohen (1992). Due to the one-way trend of the results of all vegetation, the data presented are average values in the course of three years.

RESULTS AND DISCUSSIONS

In the number of seeds setting up in one fruit the genotypic differences were established (Table 1). The variation on this index is significant, as results ranging from 61.5 for Obrazec 1 to 145.7 for genotype 11-2012. Relatively smaller numbers of seed there were developed in variety Plovdiv (73.0) and in selecting line 08-2010 (88.5) numbers. The average numbers of seeds per fruit for all tested genotypes is 90.7. The variation against this mean value between genotypes with the lowest number of seeds and the highest one is between -29.2 and +35. The difference between the highest and the lowest, established result, for the number of seeds in the experimental genotypes is even greater, almost double (64.2) numbers. The differences between the variants are of statistical significance with exception of those between Obrazec 2 and Obrazec 3 and between Ovbrazec 3 and line 08-2010.

Besides inseminating of the fruit, the quantity of fully developed seeds is of particular importance. In almost all tested cape gooseberry genotypes, most seeds are fully developed. For Plovdiv variety and Obrazec 3, they reached up to 100.0%.

Despite the highest number of seeds found in the fruit of line 11-2012, they demonstrated the least development (93.6%) of the total seed set up, reached to the stage of full formation. Both the setup and development of seed are directly related to the pollination and fertilization processes. Similarly, opinion has Lawrence (1993), who found differences in seed production of the cape gooseberry that associated with both genotypic belonging and plant development and pollination.

The weight of 1000 seeds is one of the important indicators for determining their sowing qualities. The average value for all included in this experimental genotypes was 1.06 g, and the variations in this indicator were relatively low. With the highest mass of 1000 air dry seeds is characterized Plovdiv variety (1.14 g), followed by Obrazec 3 (1.11 g). The lowest, although with a small difference was the weight of 1000 seeds of line 11-2012 (1.0 g), where was mentioned above that the highest number of seeds in one fruit was reported. There were also shown to be of a low value in the seed of Obrazec 1 (1.03 g).

Table 1. Cape gooseberry seed formation

№	Genotype	Seed number/fruit	% of normal developed seeds	Weight of 1000 seeds (g)
1	Plovdiv	73.0	100.0	1.14
2	Obrazec 1	61.5	97.7	1.03
3	Obrazec 2	99.8	97.8	1.05
4	Obrazec 3	95.9	100.0	1.11
5	08-2010	88.5	95.9	1.04
6	11-2012	125.7	93.6	1.00
	LSD p=0.05%	12.2		0.4

Besides, as a seed material, according to Zhang and Wen (1996), the cape gooseberry seeds can be used as an indicator for taxonomic identification between species and genotypes of the genus *Physalis*. In the experiments conducted, however, significant differences in seed morphology were not established (Table 2). The weight of one seed was changing to a narrow range from 1.15 mg (Obrazec 2) to 1.28 mg (Obrazec 1). A similar tendency was also observed for the width of the seed from 1.0 mm to 1.4 mm, as well as the thickness from 0.45 mm to 0.5 mm. Significant, though slight, differences are observed at the length of the seeds. On average, for the explored sample of genotypes, the length of one seed is 1.92 mm. Deviations from this mean value are from -0.21 for Obrazec 3 to + 0.23 for genotype 08-2010.

Table 2. Morphology behaviours of cape gooseberry one seeds

№	Genotype	Weight (mg)	Length (mm)	Width (mm)	Thickness (mm)
1	Plovdiv	1.23	1.99	1.2	0.5
2	Obrazec 1	1.28	1.84	1.4	0.5
3	Obrazec 2	1.15	1.86	1.2	0.45
4	Obrazec 3	1.25	1.71	1.1	0.45
5	08-2010	1.21	2.15	1.3	0.45
6	11-2012	1.17	1.99	1.0	0.45
	LSD p=0.05%	0.2	0.31	0.2	0.18

The most important indicator for sowing qualities and for seed development is their vitality (Table 3). From genotypes included in the experiment, it can be pointed out that they all have very high germinating energy between 74.0% for genotypes 11-2012 to 98.7% for Plovdiv variety. On this background, the germinating energy for Obrazec 2 and Obrazec 3 was also relatively high 95.3% and 96.7%, respectively. As Balck et al. (2008) and Copeland and McDonalds (2001) emphasized the seeds that have demonstrated higher germinating energy are with better vital performance because they have germinated for a shorter period.

Thomson and Wit (1987) reported that the seed of the cape gooseberry is characterized by high germination, and yet at the eighth week after flowering, it reaches over 90%. In this experiments the germination does not differ significantly from the values of the germination energy, indicating that most seeds are with high vitality. An exception was observed for the seeds of line 11-2012, where the germination exceeds more the data for energy with 12.7%. The highest germination was recorded for the seeds of the Plovdiv variety and for Obrazec 1 (98.7%), and the lowest one at 11-2012 (86.7%). Mathematical proof of differences is established. The statistical significance between Obrazec 1 and Obrazec 2 was not observed.

In connection with the more prices study of the seed qualities, the indicator mean germination time and uniformity of germination (Table 4) are of great importance. The mean germination time was the highest in Plovdiv variety (4.38 days), followed by the seed on genotype 08-2010 (4.44 days). The seeds of Obrazec 2 germinated most slowly, for 5.52 days. This indicates that the mean germination time is relatively high. The uniformity of germination range from 23.69% for line 08-2010 to 32.89% at 11-2012. High uniformity was established in the Plovdiv variety and also in Obrazec 2 over 29%. This data once again confirm the opinion that the cape gooseberry seeds has a good vitality and ability to germinate and that their high uniformity, as Panayotov (2015) and Black et al. (2008) maintains, it will allow them to better overcome the resistance of soil during sprouting.

The morphological characteristics of the seedling (Table 5) contribute to a more detailed clarification of the seed vitality status. In the fresh weight of the seedling of one seed, the differences are more significant.

Table 3. Germination behaviours of cape gooseberry seeds

№	Genotype	Germination energy (%)	Germination (%)
1	Plovdiv	98.7	98.7
2	Obrazec 1	93.3	96.0
3	Obrazec 2	95.3	96.0
4	Obrazec 3	96.7	98.7
5	08-2010	93.3	96.7
6	11-2012	74.0	86.7
	LSD p=0.05%	2.6	2.2

Table 4. Sowing parameters of cape gooseberry seeds

№	Genotype	MGT (days)	Uniformity (%)
1	Plovdiv	4.38	29.78
2	Obrazec 1	4.85	24.0
3	Obrazec 2	5.52	29.33
4	Obrazec 3	4.66	24.67
5	08-2010	4.44	23.69
6	11-2012	4.64	32.89
	LSD p=0.05%	1.1	6.2

The weight of the seedling indicates the possibilities of seed to germinate more easily and is very often used to determine their vigour (Copeland and Mc Donalds, 2001; Panayotov, 2015).
The values range from 14.8 mg for Obrazec 1 and line 08-2010 to 18.3 mg for Obrazec 2.
The length of the embryo root for the seed of line 11-2012 is the highest and it's reaches to 3.92 cm. Next one is those of Obrazec 3 with 3.41 cm.
Slightly developed was the embryo root of the line 08-2010 (2.89 cm).
The seedlings of Obrazec 2, Obrazec 1 and 08-2010 are characterized by the highest length of the hypocotyl 3.91 cm, 3.84 cm, and 3.78 cm, respectively.
The smallest one was in line 11-2012 (3.4 cm).
These results unambiguously show that the variation between individual genotypes is weak.

Table 5. Morphological characteristics of cape gooseberry seedling

№	Genotype	Fresh weight (mg)	Length of hypocotyl (cm)	Length of embryo root (cm)
1	Plovdiv	17.6	3.69	3.15
2	Obrazec 1	16.9	3.84	3.31
3	Obrazec 2	18.3	3.91	3.34
4	Obrazec 3	14.8	3.47	3.41
5	08-2010	14.8	3.78	2.89
6	11-2012	15.2	3.4	3.92
	LSD p=0.05%	4.2	2.6	1.9

It is normally some of the seedlings to have different deviations from their normal morphology (Table 6). The percentage of abnormally seedling grown was the highest in Obrazec 2 (15.6%), followed by line 11-2012 (12.3%). The lowest values were recorded for the Plovdiv variety. The most common types of deviation are the lack of root hair, from 22.3% for 11-2012 to 52.0% for Plovdiv, calculated towards all not well-developed seedlings which were accepted for 100%. The lack of branching in the root, take the next place, most often observed in line 08-2010 to (46.6%) and in the Plovdiv variety (36.6%). Minor deviations are associated with lack of hair on the hypocotyl, unopened cotyledons, and short embryo root.

Table 6. Deviation of normal developed seedlings (%)

Genotypes	%	Short embryo root	Lack of branches on embryo root	Lack of heirs on embryo root	Undeveloped cotyledons	Unopened cotyledons	Lack of hairs on hypocotyl
Plovdiv	10.5	0.0	36.6	52.0	0.0	11.4	0.0
Obrazec 1	13.2	17.3	24.8	31.4	0.0	15.2	11.3
Obrazec 2	15.6	9.66	15.5	36.6	22.0	15.6	0.0
Obrazec 3	11.2	9.30	10.5	30.3	3.30	46.6	0.0
08-2010	10.8	0.0	46.6	33.0	7.66	12.3	0.0
11-2012	12.3	0.0	35.0	22.3	4.20	38.5	0.0

For agronomic and economic evaluation in relation to prediction of the expected seed yield the seed quantity in one kilogram of fruits in botanical maturity was determined, and it with an average of 30.69 g (Table 7) for the studied genotypes. Most of the seeds of one kilogram of fruit were obtained in Obrazec 3 (37.95 g), and in the Plovdiv variety (34.85 g). Relatively high results were observed for line 08-2010 (31.52 g). The least one in their quantity in one kilogram of the fruit was of Obrazec 1 (20.66 g). The statistical significance of the differences between the tested genotypes is established with exception of that between Plovdiv and Obrazec 3.

The ratio between the quantity of fruit and the seeds extracted from them contributes to a complete assessment of the insemination and indicates how many fruits are necessary to be extracted in order to be obtained an adequate quantity of seeds. A high genotypic response has been observed since the values of this marker are in a very large range from 26.35 for Obrazec 3 to 48.40 for Obrazec 1, or an average for the tested population is 33.85.

The seed yield of the cape gooseberry is directly related to the yield of fruit (Table 8). The highest yield was harvested in the Plovdiv variety, it is 2245.5 kg ha^{-1}, followed by Obrazec 2 (2055.0 kg ha^{-1}). For other genotypes it is between 1581.8 kg ha^{-1} to 1668.3 kg ha^{-1} for Obrazec 3 and for Obrazec 1, respectively.

The genotypic features of cape gooseberry also occur with respect to the obtained seeds. Most seeds are obtained from Plovdiv variety with 78.2 kg ha^{-1}, followed by Obrazec 2 with 63.2 kg ha^{-1}. This mainly could be due to the higher yield of fruits and on the other hand to the relatively low ratio fruits: seeds. The least yield, 34.4 kg ha^{-1}, was recorded for Obrazec 1, the genotype with the lowest fruit productivity and a quite high ratio of fruit: seed weight. The average seed yield of the tested genotype of cape gooseberry was 55.51 kg ha^{-1}. The differences according to seed productivity between Plovdiv and Obrazec 1 and Obrazec 2 and also between Obrazec 1, and Obrazec 2 and Obrazec 3 are mathematically proven.

These results can be used to predict seed productivity and, at the same time, to determine the selling price of seeds, depending on genotypic characteristics. For samples with a lower seed yield and a higher ratio between the quantities of fruits and the seeds obtained therefrom the price is appropriate to be higher, because the input costs for fruit production are almost the same between separate genotypes. Furthermore, for those with low seed yields, there are additional costs associated with extraction of more fruits to be obtained the corresponding amount of seed.

Table 7. Productivity behaviours of cape gooseberry genotypes

№	Genotype	Seed yield/ 1 kg fruits (g)	Ratio fruit : seeds
1	Plovdiv	34.85	28.69
2	Obrazec 1	20.66	48.40
3	Obrazec 2	30.79	32.47
4	Obrazec 3	37.95	26.35
5	08-2010	31.52	31.72
6	11-2012	28.37	35.24
	LSD = 0.05%	4.4	

Table 8. Productivity of cape gooseberry

№	Genotype	Yiled of fruit (kg $ha^{-1)}$	Yiled of seed (kg ha^{-1})
1	Plovdiv	2245.5	78.2
2	Obrazec 1	1668.3	34.4
3	Obrazec 2	2055.0	63.2
4	Obrazec 3	1581.8	59.9
5	08-2010	1642.2	51.8
6	11-2012	1599.1	45.6
	LSD p=0.05%	120.1	14.0

CONCLUSIONS

Genotypic differences were found in the number of seeds in one fruit of cape gooseberry.

The percentage of fully developed seeds for all cape gooseberry lines is high. Slight differences are noted with respect to the morphological features of the seed.

The seeds of the cape gooseberry are characterized by high vitality.

More significant are the differences in the fresh weigh of the one seedling. The type of deviations from the normal development of seedling structure most often they included the lack of hairs or branchings of the embryo root.

Genotypic differences also exist in insemination. The fruit-to-seed ratio also changes in a wide range.

The average seed yield between tested genotypes of cape gooseberry is 55.51 kg ha^{-1}, and variations between individual genotypes being are significant.
The obtained results can be used on one hand to predict the expected yield of cape gooseberry seeds and on the other hand to precise the realization price, necessary for future economic analyzes and to be increased the efficiency of the seed production, depending on the genotyping insemination characteristics.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Scientific Project 15-15 of Agricultural University-Plovdiv, Bulgaria, through funding from Ministry of Education of Republic of Bulgaria.

REFERENCES

Abak K., Güler H.Y., Sari N., Paksoy M., 1994. Earliness and yield of *Physalis* (*P.ixocarpa* Brot. and *P. peruviana* L.) in greenhouse, low tunel and open field. II Simposium on Protected Cultivation of Solanacea in Mild Winter Climates. ISHS Acta Horticulturae 366: 301-306

Balck M., Bewley J., Halmer P., 2008. The Encyclopedia of Seed Science, Technology and Uses. Cromwell Press, Trowbridge, UK.

Battle P., Whittington W., 1969. The influence of genetic and environmental factors on the germination of sugar beet seed. Journal of Agriculture Science, 73: 329-335.

Fowel J., Cohen L., 1992. Practicle statistics for field biology. Publishing house John Wiley & Sons, New York.

Chernok L.G., 1997. Tomato, pepper, eggplant, physalis. Serias.-Vitality, 12: 280- 288 (Ru).

Christov Chr., 2010. Cape gooseberry - *Physalis peruviana* L. In: seeds of rare and unknown fruiuts and vegetables. www.hobi-semena.com (aveable, March, 2010) (Bg).

Copeland L., McDonald M., 2001. Seed storage. In Copeland L. (ed.), Principles of Seed Science and Technology (220-289). Chapman & Hall, New York.

Geleta L., Labuschagne M., Viljoen C., 2005. Genetic variability in pepper (*Capsicum annuum* L.) estimated by morphological data and amplified fragment length polymorphism markers. Biodiversity & Conservation, 14 (10): 2361-2375.

Haytova D., Babricov T., 2006. Comparing of new onion varieties from one year growing. Agricultural University of Plovdiv, Scientific Works, 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. Techniques and Technologies, Union of Scientists Session 11-12 November, VIII: 196-199 (Bg).

International Rules for Seed Testing, 2013. International Seed Testing Association. Bassersdorf, CH-Switzerland.

Lawrence W., 1993. Resource and Pollen Limitation: Plant Size - Dependent Reproductive Patterns in *Physalis longifolia*. The American Naturalist, 141 (2): 238-246.

Martirosyan G., Sargsyan J., 2014. Results of studying initial material for pepper breeding. Acta Horticulturae, 1033: 47-52.

McCain R., 1993. Golden berry, passion fruit, & white sapote: Potential fruits for cool subtropical areas. In Janick J., Simon E.(Eds.), New Crops, edited by, John Wiley and Sons, New York, 479-486.

Moriconi D., Rush M., Flores H., 1990. Tomatillo: A potential vegetable crops for Louisiana. In: Janick J., Simson E. (Eds.). Advances in new crops. Timber Press. Portland, 407-413.

Paksi A., Kassai T., Lugasi A., Ombodi A., Dimeny J., 2007. *Physalis peruviana* L. An alternative crop for small scale farms. Cereal Research Communications, 35 (2): 877-880.

Panayotov N., Tcorlianis S., 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. Balkan Symposium on Vegetable & Potatoes, Thessaloniki, Greece, 11 -15 Octomber, 2000. Acta Horticulture, 579: 373-376 .

Panayotov N., 2010. The first Bulgarian variety of cape gooseberry - Plovdiv. Agricultural scinece. 1: 3-6.

Panayotov N., 2015. Seed science and factors for seed production of vegetable crops. Academic Publisihing House of Agricultural Universtity - Plovdiv.

Panayotov N., 2016. Comparative evaluation by morphological behaviors and productivity on different genotype of cape gooseberry (*Physalis peruviana* L.). Agriculture & Food Science. Journal of International Scientific Publication, 4: 115-121.

Popova A., Panayotov N., Kouzmova K., 2010. Evaluation of the development of cape gooseberry (*Physalis peruviana* L.) plants under the environmental conditions of South Bulgaria. Proceeding of the Fourth International Conference on Water Observation and Information System for Decision Support BALWOIS 2010, Ohrid, Republic of Macedonia, 25 to 29 May 2010, 7 (044): 1-10.

Skvorcova R., 1997. Breeding of vegetable *Solanaceae* crops for open air field of Non-black soil of Russia. Tesiss, Thimiryasev Agriculture Academy, Moskow (Ru).

Strona G., 1966. General Seed Science of field crops. Kolos, Moscow, 235 (Ru).

Thomson C., Wit W., 1987. Germination of Cutleaf Ground cherry (*Physalis angulata*), Smooth Ground cherry (*Physalis virginiana* L.), and Eastern Black Nightshade (*Solanum ptycanthum*). Weed science, 35 (1): 58-62.

Todorova V., 2011. ‘Kurtovska kapiya 1’ - new Bulgarian pepper cultivar. Materials of XIV International scientific-practice conference Agricultural Science - agricultural production, Siberia, Mongol, Kazakhstan, Bulgaria. Karsnoyarsk, 15-18.

Todorova V., Krasteva L., Neykov St., Chavdarov P., 2011. ‘DEVEN’ - new variety of pepper. Crop Science, XLVIII (6): 501 - 507 (Bg).

Todorova V., Pevicharova G., 2012. ‘IZK 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”, 455-464.

Welington P., 1970. Handbook for seedling evaluation. ISTA, Zurich, Switzerland. 35 (2): 100-170.

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