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Cutting length effects on survival and growth of rooted cuttings of *Physalis peruviana* L

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Abstract
Physalis peruviana L. (Solanaceae) is a semi-shrub and semi-perennial plant with great potential for use in the cultivation of its fruit under greenhouse and open-field conditions. Besides that it has also the potential to be the rootstock of scion for other Solanaceous plants against pests and diseases. It is possible to set their plantation via seedlings from seed or cuttings. The most important problems to obtain rooted and uniform cuttings are the high mortality and the least rooting rates that mightily depend on plant types, cutting length and nursery practices applied. In the study, the effect of cutting length on obtaining healthy cutting-derived seedling of *P. peruviana* was studied. For this aim main stem derived branch cuttings in four lengths as 5 cm, 10 cm, 15 cm, and 20 cm were used. At the end of the 60th day, important cutting parameters (Rates of vitality, mortality, callusing, rooting and shooting; length of root; weights of root and shoot; root:shoot ratio) were calculated. The data showed that the mortality rate of 5 cm cuttings (93.3%) is the highest and the other cutting lengths showed no differences in vitality, and rooting rate. Root weight and shooting rate were maximum in 10 cm cutting with 2.07 g/cutting and 53.3% respectively. Although callusing rate, root length and root:shoot ratio did not show statistical differences in cutting length, cuttings in 10 cm gave the highest results as 30% in callusing, 21.6 cm/cutting in root length, and 1.27 in root:shoot ratio. The results showed that in the vegetative cutting step of *Physalis peruviana*, 10 cm cuttings can be preferable to longer and shorter cuttings according to the study.

Keywords: *Physalis peruviana*, cape gooseberry, cutting size, seedling, sapling, propagation

Introduction
Physalis peruviana L. is a Solanaceae family member develops as semi-shrub and semi-perennial and comprises more than 90 native species of America, with Mexico as the center of diversity (Vargas-Ponce *et al*., 2011; Ramírez *et al*., 2013)[22, 19]. Because of its valuable fruits there are some studies on field performance and yield (Mishra and Singh, 2021; Walling *et al*., 2021; Kumar *et al*., 2021; Chandra *et al*., 2021) [14, 24, 11, 6]. At the same time the plant has the potential to be a rootstock for other well-known Solanaceous seedlings against biotic and abiotic diseases especially fungi and nematodes attacks (Dhivya *et al*., 2016; Zeist *et al*., 2017; Cháves-Gómez *et al*., 2020) [8, 25, 7]. Besides the main producer countries as Colombia, Kenya, South Africa etc. (Fischer and Melgarego, 2020) [9], the plant is grown as a minor crop in some part of the other countries as a seasonal crop like India (Verma *et al*., 2022) [23] and Turkey. In this case difficulties may arise obtaining seedlings at the beginning of the growing season. Mostly seedlings or saplings are obtained via seeds or stem cuttings in one-year crop plants or perennials in agricultural facilities. Although there are some studies about the growth of *Physalis* ssp. from seedlings derived from seeds (Silva *et al*., 2016; Oliveira *et al*. 2020; Panayotov and Popova, 2016) [21, 16, 18] sometimes rooted-cuttings growth from stem or branch derived cuttings can be needed and used. According to Klinac (1986) [12] fruit development was earlier than seedling when rooted cutting was used. The propagation via cutting also need knowledge about plant types, cutting length, rooting media etc. (Cavusoglu *et al*., 2019) [5]. The parameters are highly important for plant health at growth, yield and cost. There are some studies on the importance of cutting length in commercially important fruits (Aljane and Nahdi, 2014; Kahramanoglu and Umar, 2018) [1, 10] and ornamental plants (OuYang *et al*., 2015) [17]. Based on the importance of all the issues, the aim of the study was to find out the effect of different lengths of cuttings on the features of ready to use rooted-cuttings development of *Physalis peruviana* L. under glasshouse conditions.

Materials and Methods
Source of cutting materials were taken from six donor plants these were planted in plastic high tunnel directly to the soil one year before the study derived from rooted cuttings from the same plant (Fig. 1a). The cuttings were prepared at 5 cm, 10 cm, 15 cm and 20 cm in length removing leaves just before planting (Fig. 1b). Before planting in black plastic bags full of 0,4 dm^3 volume peat each, the cuttings were classified by paying attention to being apical, middle and basal equally in each repeat. The basal end of the prepared cuttings were planted 4 cm in depth (Fig. 2). The cuttings had nodiums at least one (in average 1,2 nodiums per 5 cm, 2.1 nodiums per 10

cm, 2.9 nodiums per 15 cm and 3.7 nodiums per 20 cm cuttings). In the study which was done in the glasshouse of the Kocaeli University, Agriculture Faculty, the cuttings were planted in bags one by one, and left to grow in the glasshouse on April 9, 2018. No application was done except for irrigation to the peat directly when necessary. After two months, on June 9, 2018, vitality and mortality rate, callusing rate, rooting rate, maximum root length, root fresh weight, shooting rate, shoot fresh weight, and root:shoot ratio per cutting of all used cuttings were calculated after the substrate removing. The experiment was a completely randomized design with 3 replication consisted 10 cuttings each replication. Totally 120 cuttings were calculated. Data were analyzed to determine the effect of the treatments on measured parameters using SPSS 16.0 version (ANOVA) and means were separated using Duncan multiple range test at levels of 5% or 1%.

Results and Discussion

Analysis of variance showed that there was a significant difference between treatments in the initial length of branch cuttings used of *Physalis peruviana* at some parameters. Length of cuttings assigned to the 5 cm treatment were showed significantly the highest mortality rate (93.3%) (Table 1; Fig. 4a), lowest rooting rate (3.3%) (Table 2; Fig. 5a), root weight (0.29 g/cutting) (Table 2; Fig. 6a), shooting rate (6.7%) (Table 3, Fig. 5b) and shoot weight (0.27 g/cutting) (Table 3; Fig. 6b). However, no significant difference was found between the initial length of cutting used for callusing rate, root length, and root:shoot ratio.

Cuttings in all length (10 cm, 15 cm and 20 cm) except 5 cm, had some degree of successful vitality rate (56.7%, 46.7% and 56.7%) (Table 1), callusing rate (30%, 10% and 23.3%) (Table 1; Fig. 3a), rooting rate (40%, 23.3%, 26.7%) (Table 2), root weight (2.07 g, 1.37 g and 1.40 g/cutting) (Table 2), shoot weight (1.74 g, 1.52 g and 1.58 g/cutting) (Table 3), root:shoot ratio (1.27, 1.01 and 0.88) (Fig. 4b) respectively although the data showed no statistical difference. Data showed that statistically 10 cm cutting gave highest results in root weight (2.07 g/cutting), and shooting rate (53.3%) (Fig.3b, 3c).

There was no indication that longer cutting than 10 cm had improved vitality rate, rooting rate and shooting rate. Similar results were found in cuttings of olive (*Olea europea* L. Oleaceae) (Awan *et al*., 2012) [3] among used cuttings (15, 20, 25, 30 and 35 cm in length). In the study as cuttings got longer, their shoot number, shoot length, root number, root length and survival rate decreased. In another study 3, 6, 9, 12 and 15 cm stem cuttings in the length of *Milicia excelsa* were used and emphasized that rooting percentage, the mean number of roots, and cutting mortality tended to decline with increasing cutting length even though no statistical differences observed (Ofori *et al*., 1997) [15]. In a study on rooting of *Capparis spinosa* among used stem cuttings (10, 15 and 20 cm) (Bahrani *et al*., 2008) [4], rooting percentage decreased in 10 and 20 cm cuttings and 15 cm cuttings in length were statistically found as the best.

In some cases undesirable results can be obtained from short cuttings as was the study. Similar results were found in stem cuttings of *Tinospora crispa* belongs to the family Menispermaceae (Aminah *et al*., 2015) [2]. In the study 7.5, 15 and 22.5 cm cuttings were used and cuttings in 7.5 cm gave the lowest results in rooting and vitality. Similarly in the study on *Cuphea hyssopifolia* (Lythraceae), rooting rate, root number and root length decreased in short cutting 2 cm in length than longer cuttings (4 and 6 cm) (Sabatino *et al*., 2017) [20]. In the study about rooting of cutting of *Greyia radlkoferi* (Melianthaceae), when 5, 10, 15 and 20 cm cuttings of used, 5 cm cuttings gave the least survival rate, rooting rate and root length (Malele *et al*., 2021) [13] as were the our results.

Conclusion

The most important problems to obtain rooted and uniform cuttings are the high mortality and the least rooting rates that mightily depend on plant types, cutting length and nursery practices applied. These findings suggested that in *Physalis peruviana*, cutting length plays an important role in rooting and before going into agricultural mass production, the cutting length needs to be optimized depending on the type of plant used. The best cutting length of the used cuttings to propagate *Physalis peruviana* through branch cuttings is when 10 cm cuttings are taken in our study. This optimized cutting protocol should be used to propagate clonal material of *Physalis peruviana* for the production of healthy material with reliable activity.

Fig 1: Cutting preparation steps in *Physalis peruviana* L.; a) Stock plants with used side branches, b) Prepared cuttings in 5, 10, 15 and 20 cm at first, second, third and fourth line respectively

Fig 2: *Physalis peruviana* L. cutting planting in peat before randomly placed; a) 5 cm cuttings, b) 10 cm cuttings, c) 15 cm cuttings, d) 20 cm cuttings

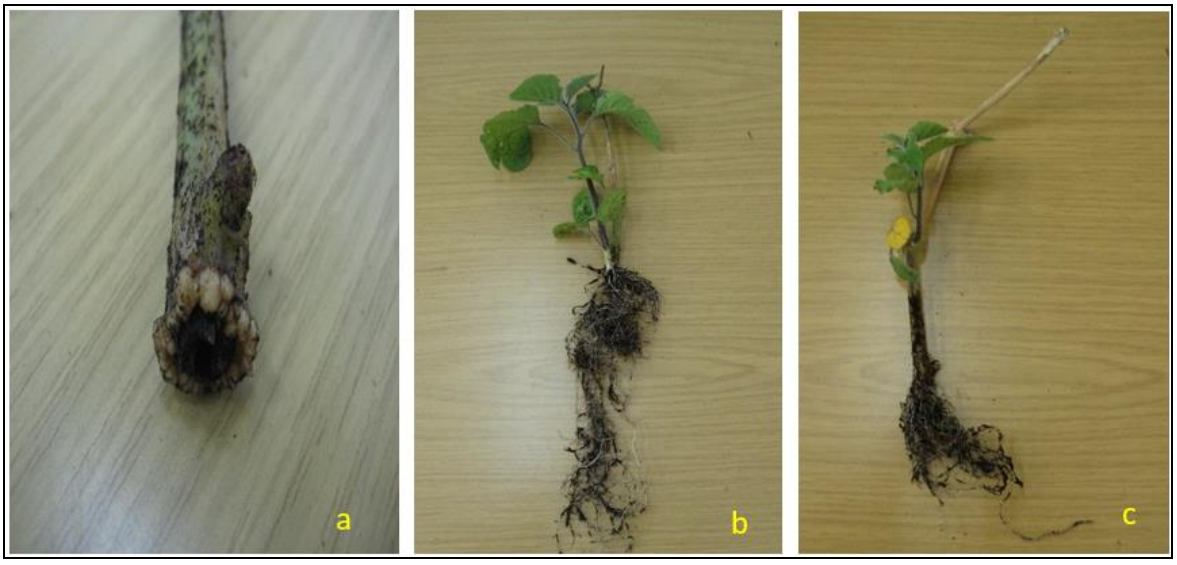


Fig 3: *Physalis peruviana* L.; a) Callusing at base of a cutting, b) Rooted-cutting from 10 cm cutting, c) Rooted-cutting from 20 cm cutting after two months with newly formed shoots

Table 1: The effect of cutting length on vitality and callusing features of *Physalis peruviana* L. after two months

Cutting Lenght	Vitality Rate (%)**	Mortality Rate (%)**	Callusing Rate (%)*
5 cm	6,7 b	93,3 a	6,7 a
10 cm	56,7 a	43,3 b	30,0 a
15 cm	46,7 a	53,3 b	10,0 a
20 cm	56,7 a	43,3 b	23,3 a
Std.Dev.	SD:±24,058	SD:±24,058	SD:±19,598

*Not significant level with the same letters, **Mean differences in the same column are significant at P≤0.01 level with different letters.

Table 2: The effect of cutting length on rooting features of *Physalis peruviana* L. after two months

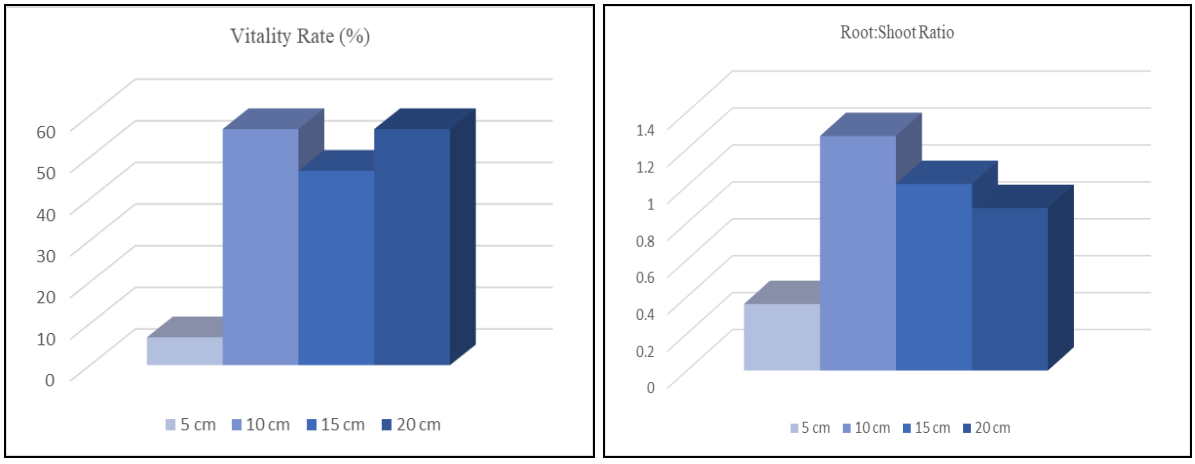
Cutting Lenght	Rooting Rate (%)**	Root Length (cm/cutting)*	Root Weight (g/cutting)**
5 cm	3,3 b	6,3 a	0,29 b
10 cm	40,0 a	21,6 a	2,07 a
15 cm	23,3 a	15,3 a	1,37 ab
20 cm	26,7 a	12,7 a	1,40 ab
Std.Dev.	SD:±16,143	SD:±9,312	SD:±0,886

*Not significant level with the same letters, **Mean differences in the same column are significant at P≤0.05 level with different letters.

Table 3: The effect of cutting length on shooting features and root:shoot ratio of *Physalis peruviana* L. after two months

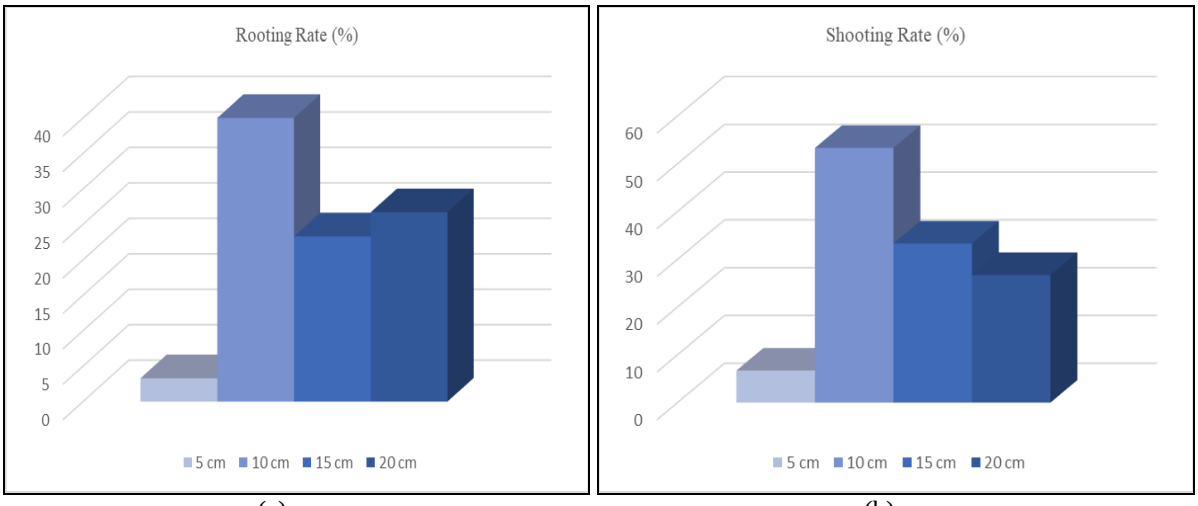
Cutting Lenght	Shooting Rate (%)***	Shoot Weight (g/cutting)**	Root:Shoot Ratio*
5 cm	6,7 c	0,27 b	0,36 a
10 cm	53,3 a	1,74 a	1,27 a
15 cm	33,3 b	1,52 a	1,01 a
20 cm	26,7 b	1,58 a	0,88 a
Std.Dev.	SD:±19,540	SD:±0,743	SD:±0,556

*Not significant level with the same letters, **Mean differences in the same column are significant at P≤0.05, ***Mean differences in the same column are significant at P≤0.01 level with different letters.



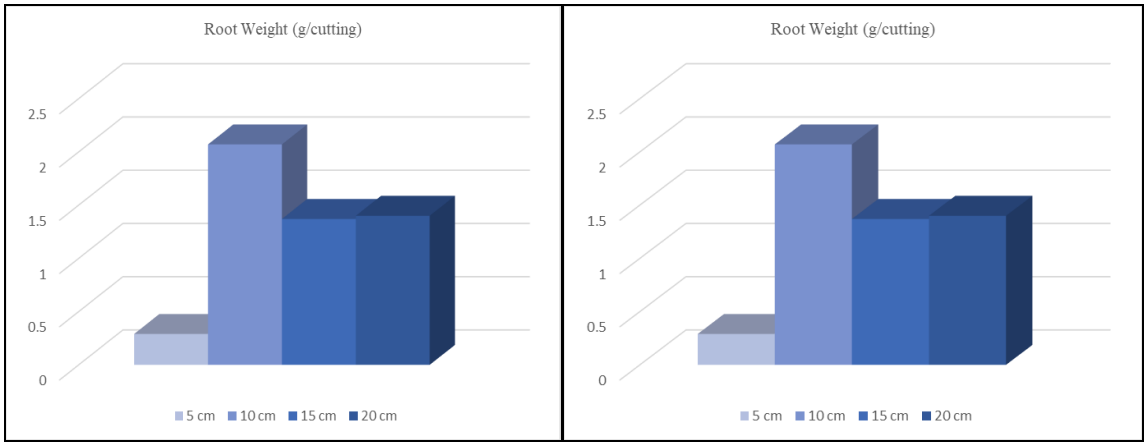
(a) (b)

Fig. 4: *Physalis peruviana* L. a) Vitality rate of cuttings, b) Root:Shoot ratio of cuttings



(a) (b)

Fig 5: *Physalis peruviana* L. a) Rooting rate of cuttings, b) Shooting rate of cuttings



(a) (b)

Fig 6: *Physalis peruviana* L. a) Root weigth per cutting, b) Shoot weigth per cutting

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