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Comparison of substrates and branch parts on the growth and marketable quality of saplings of *Physalis peruviana* L.

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Abstract
In the study, effect of initial vegetative parts and potting medium on rooting and shoot growth of cuttings of *Physalis peruviana* L. were studied. For this aim two different, main stem derived branch cuttings (terminal and subterminal) and three substrates (perlite, sand and peat) were used. At the end of the 60th day, important cutting parameters (survival rate, leafy cutting rate, leaves number, rooting rate, maximum root lenght, fresh root weight and marketable sapling rate) were investigated. According to the data, rooting rate of terminal cutting (73.3%) and subterminal cutting (53.3%) in peat showed advantage than in sand and perlite although the survival rates did not show a statistical difference in cutting types or in used substrates. The lowest and highest leaf number were found in sand (3.9 leaves/cutting) and in peat (9.9 leaves/cutting) respectively at terminal cuttings after 60 days. Marketable sapling rates changed between 0% in perlite with subterminal cuttings and 73.33% in peat with terminal cuttings. The results showed that in vegetative cutting step of cultivation of *Physalis peruviana* L., terminal cuttings and peat medium can be more preferable than subterminal cuttings and perlite or sand according to the study.

Keywords: *Physalis peruviana*, golden berry, cutting propagation, peat, perlite, sand

Introduction
Physalis peruviana L. is a plant type, has important biological activities besides nutritional value and commercial importance is increasing of the cultivated plant. The *Solanaceae* family member produces small, sweetish and roundish fruit in picturesque papery calyx.
The center of *Physalis peruviana* L. origin is Andean zone (Chacón *et al*., 2016) [1]. The gooseberry currently has also been widely grown and cultivated throughout the tropic and subtropic countries (Mazorra *et al*., 2006) [2] besides main producer Colombia; South Africa, Australia, Kenya and India are also producing countries (Olivares-Tenorio, 2017) [3].
Physalis spp. are well know by Turkish farmers as invasive or introduced plants in their field crop growing area (Özaslan and Bükün, 2013; Ozaslan *et al*., 2016) [4, 5] that were introduced to the country by importing seed (Onen and Farooq, 2015) [6]. Besides the agricultural fields, *Physalis* species have been identified in N.E. Anatolia (Özhatay *et al*., 1999; Eminağaoğlu *et al*., 2008) [7, 8]. The cultural type of the fruity plant was begun to know by consumer and farmer for more than two decades in Turkey. Especially in the South and West region of Turkey firstly began to grow them. Nowadays all country more or less know this fruit and the fruit takes place well-known chain markets mostly than bazaar.
The golden berry (*Physalis peruviana* L.) seems to be a hopeful fruity plant to consume because of the contents of potential useful compounds in human health (Ramadan, 2011; Bazalar-Pereda *et al*., 2019; Demir *et al*., 2014; Licodiedoff *et al*., 2013; Valdenegro *et al*., 2012; Wu *et al*., 2005; Wu *et al*., 2006) [9-15]. At this condition, as being all vegetables, health and quality of seedlings or cuttings have major importance in nursery sector in addition to potting media in terms of cost *P. peruviana*.
Traditionally seedlings or saplings are mostly obtain by seeds or cuttings. In most cases cuttings prefer to seedlings for many reasons, even cutting age and branch parts can be give different results (Santoso and Arya-Parwata, 2014) [16]. Used substrate is also have a great importance for succesful seedling or cutting (Olaria *et al*., 2016) [17].
This article presents the data on the effect of vegetative parts and potting substrates on rooting, shoot growth and marketable cutting rate of *P. peruviana*.

Materials and Methods

The experiment was conducted in North-West region of Turkey, Kocaeli University Arslanbey Campus in between June 1-July 31, 2017 under a high plastic tunnel condition. The cuttings were obtained from the existing, healthy, two years old mother plants which was grown and protected in glasshouse (Fig. 1a) that was purchased from commercial nursery. The cuttings were prepared as terminal and subterminal after removed 1 cm tip part and all leaves just before planting in the same day (Fig. 1b, 1c). In terminal cuttings lenght was 8±1 cm (in all average 8.33 cm) consisted 2.48 nodiums (in all average) and in subterminal cuttings lenght was 10±1 cm (in all average 10.91 cm) consisted 2.75 nodiums (in all average). Used perlite, sand and peat were purchased from commercial agricultural material sellers. Each pot consisted 1 dm^3 medium (Fig. 2a, 2b, 2c). The media were pushed a pencil to create a hole then placed the bottom a third of the cuttings. Irrigation was done twice in each week along the experiment. At the end of the experiment after the 60th day, survival rate (%), leafy cutting rate (%), leaf number (leaves/cutting), rooting rate (%), maximum root lenght (cm/cutting), fresh root weight (g/cutting), and marketable sapling rate (%) were calculated for all treatment additionally for cutting types or subsrates averages. The study design as Completely Randomized Design replicated thrice and statistical analyzes were done by using SPSS 16.0 programme. The percentage data were transformed by arcsin square.

Results and Discussion

In the experiment significantly highest rooting percent of both cutting types was observed in peat among media treatments, contrary to survival rate which data in perlite show more success than sand and peat numerically (Table 1, Fig.4, Fig.5). Leafy cutting rate did not significantly affected by cutting types or media. But leaf number also was statistically more in terminal cuttings in peat (Table 3). Even according to media average leaf number of cuttings were found more in peat than sand or perlite at the end of the experiments.

Rooting rate, maximum root lenght, fresh root weight and marketable sapling rate of terminal cuttings show significantly highest results than subterminal cuttings especially in peat substrate (Table 1, Table 2, Table 4, Fig. 3a, 3b, 3c). Similarly Moreno *et al*. (2009) [18] found the highest rooting of *P. peruviana* in peat moss than used mixture of black soil and rice husks. The researchers found the rooting rate between 0-100%, root lenght between 0-37.38 cm per cutting and fresh weight of root 0-12.98 g when the cutting treated with IBA dose besides control after 90 days of experiment. The experiment mostly supported us because of our findings were between 0-73.33% in rooting rate, 0-35.50 cm in maximum root lenght and were between 0-2.4905 g in fresh root weight after 60 days. Rooting parameters at subterminal cuttings in perlite were nought although shooting parameters were not bad at all (Fig. 5). This led to a decrease in the rate of marketable saplings because growers prefer saplings or seedlings with both roots and leaves. When cutting types ignored peat substrate showed superiority in rooting and marketable sapling (Fig. 6, Fig.7)

In another study on substrate differences (Ercişli *et al*., 2002) [19] sawdust, peat+sawdust, peat, peat+perlite and perlite were used with plant growth regulators or control for kiwifruit cuttings. Rooting percentage and number of main roots per cutting were found highest in peat and sawdust or peat and perlite mixtures in their results. Although the mixtures were not being used in our study, peat addition to media led to highest results as understood.

A sudy was conducted by Olaria *et al*. (2016) [17] that aimed to find out substrate or substrate mixtures including peat alone or in combination with vermicompost and perlite, effect on seedling growth in between different varieties and in between species in the Solanaceae family. They emphasized that success of rooting or shoot parameters are highly depend on species and varieties even in the same family. Additionally tested substrates show no statistical differences in seed germination but seedling elongation of used varieties was significantly affected by used substrates especially peat or mixure with peat in their study.

Choosing true cutting location from vegetative organs of plants is another factor for obtain healthy rooted cuttings. In the study data pointed out that terminal cuttings were statistically important in rooting rate, root lenght, fresh root weight and marketable rooted cutting rate than subterminal in all used media. Similarly in a study of Santoso and Arya-Parwata (2014) [16] one, two and three years old stem cuttings of *Jatropa curcas* L. were used and they found that one and two years old cuttings are superor than three years old stem cutting and they emphasized that the cutting types might be due to the presence of higher concentration of rooting hormone in upper part of stem. Benabise (2012) [20] also studied on top, middle and bottom cuttings of *Afzelia rhomboidea* (Blanco) Vid.. All measured data as survival and rooting percentages, root number, root lenght, shoot lenght showed significantly or numerically superiority in top cuttings. The mentioned study also supports us.

Conclusion

In conclusion, the results confirmed the importance of potting substrates and choosing the right part of braches for cutting were of critical importance. The peat substrate was found to be the most suitable among those used for rooting of cuttings of *Physalis peruviana* L., however apart from substrate the other factor as cutting type must be taken into consideration. In this study the terminal cuttings show superiority in all used substrates for marketable sapling rate than the subterminal ones of golden berry.

Table 1: The data of substrate and cutting type on survival and rooting rate of *Physalis peruviana* L.

Treatment	Survival Rate (%)*			Rooting Rate (%)		
	Terminal	Subterminal	Average	Terminal	Subterminal	Average
Perlite	80.00	86.66	83.33	46,7 ab**	0,0 c	23,4 B***
Sand	60.00	73.33	66.67	40,0 ab	26,7 bc	33,4 B
Peat	73.33	80.00	76.67	73,3 a	53,3 ab	63,3 A
Average	71.11	79.99	75.56	53,3 A***	26,7 B	40,03

* Non significant difference at $P \leq 0.05$ level, ** Lower cases indicate significant difference at $P \leq 0.05$ level within table in all treatments in the parameter, *** Upper cases indicate significant difference at $P \leq 0.05$ level in cutting types and substrate avegares in the parameter.

Table 2: The data of substrate and cutting type on maximum root lenght and fresh root weight per cutting of *Physalis peruviana* L

Treatment	Maximum Root Lenght (cm/cutting)			Fresh Root Weight (g/cutting)		
	Terminal	Subterminal	Average	Terminal	Subterminal	Average
Perlite	10,54 bc**	0,00 c	5,25 B***	0,0481 c**	0,0000 c	0,0241 B***
Sand	14,02 bc	9,10 bc	11,56 B	0,1386 c	0,1253 c	0,1319 B
Peat	35,50 a	22,30 ab	28,90 A	2,4905 a	1,4150 b	1,9528 A
Average	20,01 A***	10,47 B	15,24	0,8924 A***	0,5134 B	0,7029

** Lower cases indicate significant difference at $P \leq 0.05$ level within table in all treatments in the parameter, *** Upper cases indicate significant difference at $P \leq 0.05$ level in cutting types averages and substrate averages in the each parameter.

Table 3: The data of substrate and cutting type on leafy cutting rate and leaf numbers at the and of *Physalis peruviana* L.

Treatment	Leafy Cutting Rate (%)*			Leaf Number (leaves/Cutting)		
	Terminal	Subterminal	Average	Terminal	Subterminal	Average
Perlite	80,00	73,33	76,65	4,5 d**	5,5 cd	5 B***
Sand	53,33	73,33	63,33	3,9 d	6,9 bc	5,4 B
Peat	73,33	80,00	76,65	9,9 a	7,7 b	8,8 A
Average	68,87	75,53	72,21	6,1*	6,7	6,4

* Non significant difference at 0.05 level, ** Lower cases indicate significant difference at P≤0.05 level within table in all treatments, *** Upper cases indicate significant difference at P≤0.05 level in cutting types and/or substrate avegares in the parameter.

Table 4: The data of substrate and cutting type on marketable seedling Rate of *Physalis peruviana* L.

Treatment	Marketable Cutting Rate (%)		
	Terminal	Subterminal	Average
Perlite	46,66 ab**	0,00 c	23,33 B***
Sand	40,00 ab	26,66 bc	33,33 B
Peat	73,33 a	53,33 ab	63,32 A
Average	53,32 A***	26,66 B	39,99

** Lower cases indicate significant difference at $P \leq 0.05$ level within table in all treatments in the parameter, *** Upper cases indicate significant difference at $P \leq 0.05$ level in cutting types and substrate averages in the parameter.

Fig 1: *Physalis peruviana* L. (a) The existing mother plant, (b) A main stem derived branch before preperation for cuttings, (c) Preperation of terminal and subterminal cuttings.

Fig 2: *Physalis peruviana* L. terminal cuttings in the left and subterminal cuttings in the right in each different substrates 60 days after the beginning of the experiment. (a) Perlite, (b) Sand, (c) Peat.

Fig 3: *Physalis peruviana* L. sapling growth (a) in perlite, (b) in sand, (c) in peat 60 days after the beginning of the experiment.

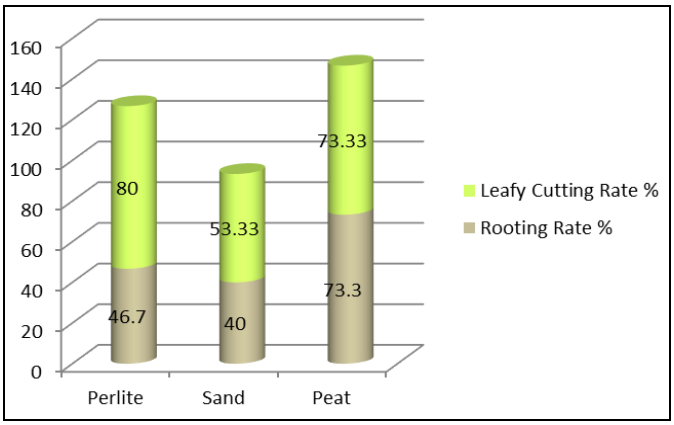

Fig 4: Leafy cutting and rooting rate in terminal cuttings of *Physalis peruviana* L.

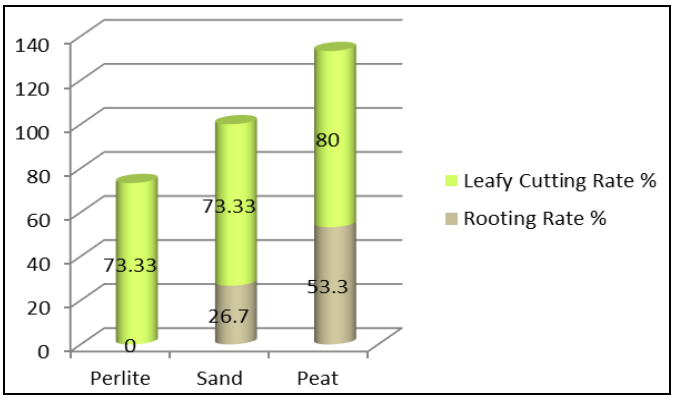

Fig 5: Leafy cutting and rooting rate in sub-terminal cuttings of *Physalis peruviana* L.

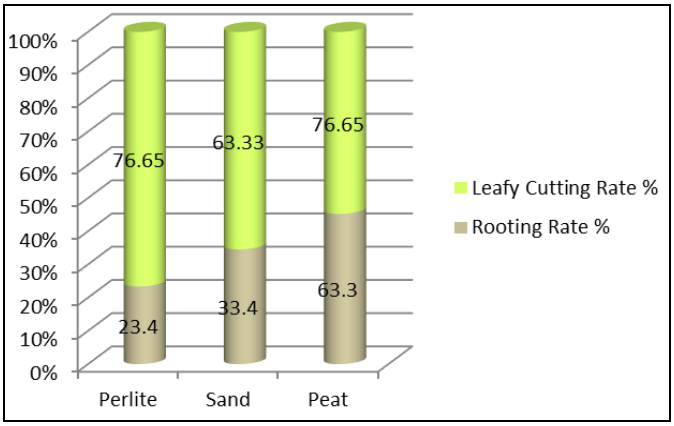

Fig 6: Leafy cutting and rooting rate in all used cuttings of *Physalis peruviana* L.

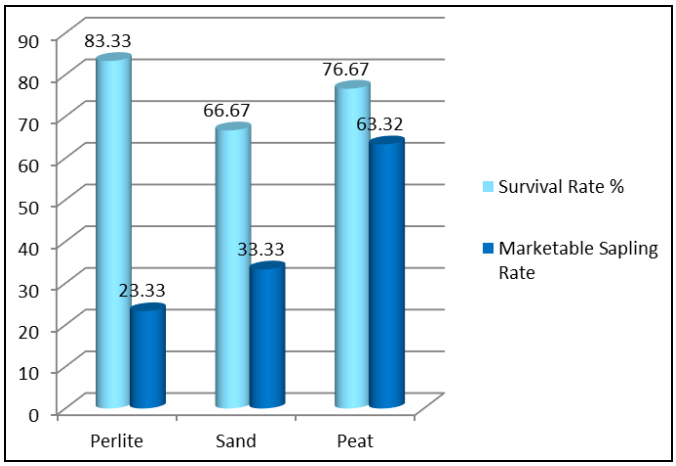

Fig 7: Survival and marketable sapling rates in avarage of terminal and subterminal cuttings in used substrates of *Physalis peruviana* L.

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