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Initial development of physalis species under growing environments

Desenvolvimento inicial de espécies de fisális submetidas a ambientes de cultivo

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ABSTRACT

The environment can be a limiting factor for development of *Physalis* species seedlings. Thus, the aim of this present study was to evaluate the initial development of *Physalis* species when subjected to cultivation environments. The experimental design was a randomized block design, factorial 3 x 3 (three *Physalis* species being *Physalis peruviana*, *P. angulata* and *P. pubescens* x three environments, greenhouse - GRE, plastic cover with 150 micron; shading - PLS, with 75% permeability and light - SHD, full sun, in a fully open - FOP), with four repetitions, conducted between February and May/2012, at the Station of Horticulture and Biological Control "Mário César Lopes", University of Paraná State, Brazil. During the experiment, the emergence speed rate of seedlings was monitored in the initial 30 days. At 76 days after the sowing, leaf area, dry biomass of leaves, stems and roots, as well as the number leaves, plant height and stem diameter were evaluated. The SHD environment provides higher percentage of emergence of *Physalis* species seedlings studied. GRE and SHD environments were similar to the early *Physalis* development and can be used in the production of these species seedlings. Is not advisable in the initial development of *Physalis* seedlings.

KEYWORDS: exotic fruit, small fruits, greenhouse, shade, seedling production.

RESUMO

O ambiente pode ser um fator limitante para o desenvolvimento de mudas de espécies de fisális. Diante do exposto, objetivou-se com o presente trabalho avaliar o desenvolvimento inicial de espécies de fisális submetidas a ambientes de cultivo. O delineamento experimental utilizado foi blocos casualizados, em esquema fatorial 3 x 3 (três espécies de fisális, sendo *Physalis peruviana*, *P. angulata* e *P. pubescens* x três ambientes, sendo estufa - EST, com cobertura plástica transparente de 150 micras; sombrite - SBT, com 75% de permeabilidade à luz e, pleno sol - PLS, em local totalmente aberto), contendo quatro repetições, conduzido entre fevereiro e maio de 2012, na Estação de Horticultura e Controle Biológico "Professor Mário César Lopes" (Unioeste), Campus Marechal Cândido Rondon, PR. Durante o experimento, monitorou-se o índice de velocidade de emergência das plântulas nos 30 dias iniciais. Aos 76 dias após a semeadura avaliaram-se a área foliar, biomassa seca das folhas, caules e raízes, bem como o número de folhas, altura das plantas e diâmetro do caule. O ambiente SBT propicia maior taxa de emergência de plântulas das espécies de fisális estudadas. Os ambientes EST e SBT foram similares no desenvolvimento inicial de fisális, podendo ser utilizados na produção de mudas destas espécies. Não é aconselhável que o desenvolvimento inicial de mudas de fisális ocorra em PLS.

PALAVRAS-CHAVE: fruta exótica, pequenas frutas, estufa, sombrite, produção de mudas.

INTRODUCTION

Physalis (*Physalis* spp.) belongs to the Solanaceous family, which includes approximately 100 species, being classified as a herbaceous and shrubby plant, annual, depending on the species (LIMA et al. 2010). It develops as wild plant in tropical regions of America, having its center of origin the Andean countries, especially Colombia, Peru and Ecuador. In Brazil, there are reports of species such as *Physalis peruviana, P. angulata* and *P. pubescens*,

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being found in several regions, especially the North and Northeast (MUNIZ et al. 2015).

Colombia is the largest producer of this fruit, having planted area of 7.890 ha and production of 13.328 tonnes. Its cultivation has expanded in countries with tropical and subtropical climate, arousing interest in marketing *in natura* and processing of fruits (ZHANG et al. 2013). In Brazil, the cultivation of this small fruit, mainly from *Physalis peruviana*, has aroused interest in small fruit growers, due to the low cost of deployment and production, with expansion of cultivation mainly in the south of the Country (RUFATO et al. 2008, MUNIZ et al. 2011).

For the commercial cultivation of fruit species, an orchard must be obtained from seedlings with phytosanitary quality, a characteristic that is fundamental to the success of the orchard, because its quality is related to the productive potential of the plants, guaranteeing the rapid formation of the orchard, with homogeneity of crop and precocity at harvest (SBRUSSI et al. 2004, PIVA et al. 2013).

Some climatic factors can be controlled in a protected environment, which allows for the cultivation of fruit tree species in adverse temperature conditions, soil type, strong winds, evapo-transpiration, relative humidity of the air and soil, extreme solar radiation, direct effect of rains, hailstorms and high brightness (RODRIGUES et al. 2013).

The nature of the morphogenic response ahead of these factors can vary considerably between species, in accordance with the ability of acclimatization and dependence of the quantity or quality of light (TAIZ & ZEIGER 2010). The protected environments have the purpose of promoting the full development of the plants, through the synergy of weather and temperature elements, creating a favorable microclimate and offering protection against weather effects that affect the plants (ROMANINI et al. 2010).

One of the ways to obtain quality seedlings is by the cultivation of plants in a protected environment (ARAUJO et al. 2006), such as with the use of shading nets. For IANCKIEVICZ et al. (2013), the use of shading is an important technique in the formation of fruit tree seedlings, because it directly affects the growth of the plant and, later, the formation of the orchard. At certain hours of the day in which temperatures are high, the coverage may encourage the plants to carry out photosynthesis needed for its development.

In Brazil, research with this fruit is still scarce, and yet little is known about the early development of species of physalis when subjected to the control of the environment. Their study becomes important tool in determining which environment cultivation is more appropriate to start the development of seedlings and obtain material of quality and potential productivity. Considering the above, this work aimed to evaluate the initial development of seedlings of the physalis species submitted to different cultivation environments.

MATERIAL AND METHODS

The experiment was conducted between February and May 2012, in different environments, at the "Mário César Lopes", Horticulture and Biological Control Station belonging to the Center for Experimental Stations at the Universidade Estadual do Oeste do Paraná (Unioeste), Campus Marechal Cândido Rondon, PR.

The local altitude is 420 m above sea level, the latitude is 24º 46'' South, and the longitude is 54º 22' West. According to the Köppen classification, the climate of the region is the Cfa type with subtropical climate, with average annual temperatures between 22-23 ºC, average annual rainfall between 1600-1800 mm and relative humidity between 70-75% (CAVIGLIONE et al. 2000).

For use of substrate, a mixture of Dystrophic + washed sand fine granulated + organic compound (2:1:1, v v), with physical-chemical analysis showing clayey texture (456.1 g kg^{-1} clay and 455.84 g kg^{-1} of silt), 88.16 g kg^{-1} of sand, 28.71 g dm^{-3} of organic matter; pH ($CaCl_2$) = 5,61; 5.74 $cmol_c$ dm^{-3} of Ca; 2.63 $cmol_c$ dm^{-3} of Mg; 0.0 $cmol_c$ dm^{-3} of Al; 3.68 $cmol_c$ dm^{-3} of H+Al; 2.38 $cmol_c$ dm^{-3} of K; 66.87 mg dm^{-3} of P (Mehlich-1) and V (%) = 74.50 was formulated.

The soil used in this mixture was collected at the Horticulture and Biological Control Station belonging to Unioeste, in horizon A of Red Latosol Eutroferrico (EMBRAPA 2009), with clayey texture.

The seeding of species was performed by placing four seeds per experimental unit (bag of black polyethylene for changes, with dimensions of 7 cm diameter x 15 cm height x 0.06 cm thick). After 35 days of sowing the thinning of seedlings was carried out, maintaining only one per experimental unit. These were kept in each growing environment for a period of 76 days after sowing (DAS), with temperature and relative humidity monitored by data loggers (AKSO brand, model AK275), recording data every 15 minutes. The irrigation of the seedlings was performed by manual watering twice a day during the conduction of the experiment.

During the first 30 initial days the percentage of germination was monitored. After this period there was the manual count of the number of formed leaves, plant height (cm) was measured with a graduated ruler and stem diameter (mm), standard for all plants within 1 cm of the soil were measured with digital calipers. The measurements were performed every 11 days, until the end of the experiment (46 DAS). At the end of the experiment the leaf area (cm^2 $plant^{-1}$); leaf dry biomass (g), of the stem and the roots were evaluated, these being obtained by drying the material in a greenhouse, with forced air circulation, with 65 ºC, for 72 hours.

For the estimation of leaf area, the collection of part of the plant tissue of the leaf was considered, with the aid of a metal disk with known area, removing 10 discs of vegetable tissue per plot, which was taken for kiln drying, with forced air circulation at 65 °C for 72 hours. After drying, the biomass was determined (g) and, by using the ratio of biomass between leaves collected and leaf disc, held-if the calculation of leaf area by the formula:

$$La = (A*LDB/BD)$$

where:
La = leaf area,
A = Known area of disk,
LDB = leaf dry biomass and
BD = biomass sample disc.

The experimental design was completely randomized blocks, 3 x 3 factorial arrangement (3 *Physalis* species, being *Physalis peruviana, P. angulata* and *P. pubescens* x 3 cultivation environments, in greenhouse with transparent plastic cover of 150 μm – GRE; shading screens with 75% of permeability to light - SHD and full sunshine in fully open site - FOP), containing four repetitions and the experimental plot consisted of eight plants, totaling 36 experimental units.

The statistical analysis of the results was performed with the aid of SISVAR (FERREIRA 2011). Initially, the data was submitted to analysis of variance and, when presented significant difference, was submitted to the Tukey's comparison of averages test, with 5% probability.

RESULTS AND DISCUSSION

In Figure 1A the average minimum of temperature (T°C) and relative humidity (RH%) of air during the experimental period was observed. For greenhouse with transparent plastic cover of 150 μm (GRE), the absolute maximum temperature obtained during the experiment was 32,41 °C and the maximum relative humidity 92.25%. For shading with 75% light permeability (SHD), the absolute maximum recorded temperature was 26.50 °C and 94.25% maximum relative humidity of the air. For the environment in full sun in fully open place (FOP), the maximum temperature during the period reached 28,35 °C and the maximum relative humidity recorded 86,52 %.

The cultivation environments SHD and GRE showed higher humidity control, higher than FOP. For maximum temperature, the environment GRE was superior to the others. For maximum relative humidity, it was found between 23-44 and 58-61 DAS, the FOP environment showed greater oscillation. This fact might explain the lower seedling development in this environment (Figure 1A). The (Figure 1B) refers to the medium of air temperature and relative humidity, recorded in cultivation environments, being 23.93 °C in GRE, 20.64 °C in FOP and 18.84 °C in SHD. The average relative humidity for GRE was 77.18%, 70.42% for FOP and SHD. For minimum temperature was 17.5°C for GRE, 15.0 °C to FOP and 13,19 for SHD. In relation to the minimum relative humidity was 49,42% in GRE, 44,23% in FOP and 60,38% for SHD (Figure 1C).

Table 1 shows the variables analyzed for the *Physalis* species. When analyzing the values of stem diameter, stem dry biomass, emerging seedlings percentage and leaf dry biomass, there was no significant difference when the species were exposed to the same environment and can be cultivated in GRE, SHD and FOP, specifically with regard to initial development of seedlings.

Also in Table 1, the results show that the stem diameter, stem dry biomass, emerged seedlings percentage and leaf dry biomass showed statistical differences in different environments. This occurred because each environment presents different climatic conditions, being fundamental for the initial development of seedlings. Corroborating this statement, SILVA et al. (2016a) says that many factors can affect the quality of physalis seedlings, among them one of the main is undoubtedly the solar radiation incident on plants, which is directly altered according to the growing environment.

In environments GRE and SHD air temperature and humidity closer to the ideal was maintained, with less variation over the period evaluated (Figures 1A, B and C), thus favoring better development of the seedlings. Inside the cultivation environments, stem diameter and stem dry biomass had the same behavior, obtaining better results in GRE and SHD. Lower results for these two variables were observed in FOP, possibly due to the climatic conditions in this environment provided at certain times of day (temperature fluctuations and humidity), causing stress and thereby promotes slower growth of seedlings.

In general, the diameter of the stem is analyzed to indicate the survivability of the seedlings in the field (Table 1); it has a direct relationship with the photosynthesis and development of seedlings, and is a parameter for defining concentrations of fertilizer

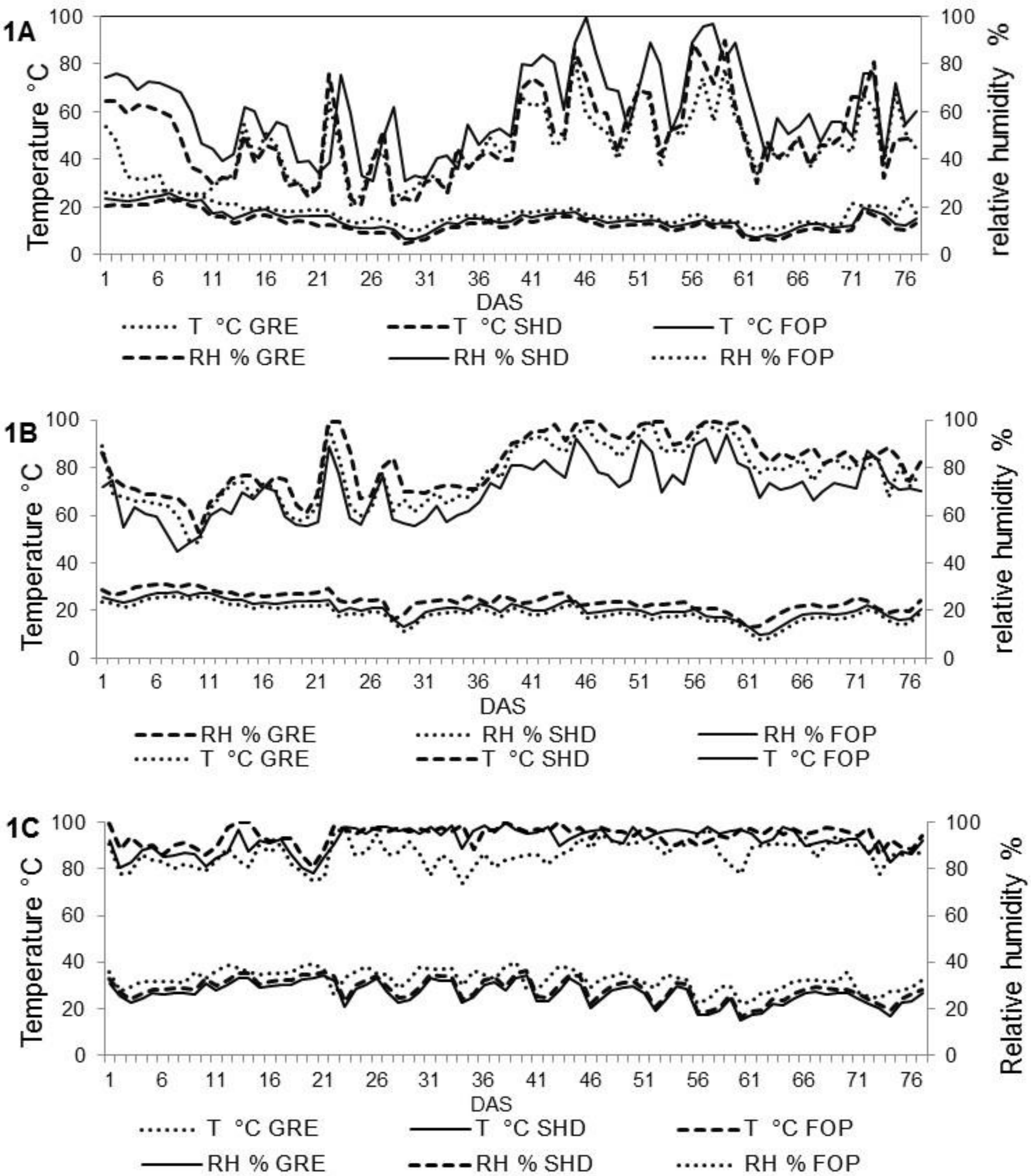

Figure 1. Temperature (T) and relative humidity (RH), registered in GRE cultivation environments, SHD and FOP for 29/02/12 to 14/05/12, in the cultivation of *Physalis* species seedlings. 1A = Average minimum of T (ºC) and RH (%), 1B = Mean of T (ºC) and RH (%), 1C = Average maximum T (ºC) and RH (%). Unioeste, Campus Marechal Cândido Rondon, PR. 2016.

Table 1. Diameter of stem (DS), dry biomas of stem (DBS), percentage of emerged seedlings (PES) and dry biomass of dry leaf matter (DBL) of *Physalis* species in cultivation environments GRE, SHD and FOP. Unioeste, Campus Marechal Cândido Rondon, PR. 2016.

Physalis species	DS (mm)	DBS (g)	PES (%)	DBL (g)
Physalis angulata	5,21^{ns}	2,88^{ns}	77,38^{ns}	3,48^{ns}
Physalis peruviana	5,09	3,07	74,99	3,49
Physalis pubescens	4,95	2,68	76,59	3,35
Means	5,08	2,88	76,32	3,44
Growing environments				
GRE	5,94a*	4,39a	65,08b	5,01a
SHD	5,48a	2,66a	100,00a	3,46b
FOP	3,83b	1,58b	63,89b	1,84c
CV (%)	9,07	12,73	11,37	16,84
Means	5,08	2,88	76,32	3,44

*Means followed by lowercase letter in the column significative differences among them, by the Tukey test at 5% probability. GRE = greenhouse with transparent plastic cover 150 microns, SHD = shading with 75% permeability to light, FOP = Total luminosity in wide open place. ^{ns} Not significant.

to be applied in the production of these. According to COSTA et al. (2009), best results from accumulation of dry biomass in the development of seedlings of yellow passion fruit occurred in greenhouse type environments, with 50% shading, opposing the results found in the present study in which greater stem biomass was found in SHD.

Higher number of emerged seedlings was obtained in SHD (Table 1), which gave a complete batch of seed germination, probably because in this environment temperature and humidity have provided the most suitable seedling emergence of *Physalis* species.

For MARCOS FILHO (2005) many factors can influence the germinative process, such as water, oxygen, temperature, light, degree of maturity, dormancy among others. According to data presented previously, SHD environment presents the best balance between temperature and relative humidity, preventing the temperature reaches extremely high values as in the GRE environment while maintaining high relative humidity, almost 10% above FOP and similar of GRE environment.

For dry biomass of leaves, the GRE environment promoted higher growth of seedlings, due to higher control of temperature and relative humidity of the air, thus allowing the seedlings perform photosynthesis for a longer period, generating higher accumulation of leaf dry biomass. This accumulation can be explained by the environment that keep the relative humidity higher and shaded, being characteristic of the species of plants with thinner leaves and exposed to these conditions (TAIZ & ZEIGER 2010).

We observed a significant interaction for number of leaves of the physalis species grown in GRE, SHD and FOP environments (Table 2). Best results were observed in *Physalis angulata* and *P. peruviana* grown in SHD environment. For *P. pubescens* best results were verified in GRE. This difference in the development of the species is given by genotype for each one and the center of origin of each one (MUNIZ et al. 2014).

In shaded environments the physalis species exhibited a greater quantity of leaves, because in these environments there is a need to increase the photosynthetic surface to maximize light absorption, corroborating MOURA et al. (2016) who, working with tamarind seedlings in environments, obtained better results in screen housing. This difference of adaptation observed among species indicates that there is plasticity in their leaves, adapting to the different conditions of shading, adjusting it to the acquisition of light, even in very limiting conditions, such as the offered by shading.

It is observed in Table 3 significant interaction for plant height of species of physalis in relation to environments. For the GRE environment the *P. angulata* species presented greater plant height in relation to the other. For SHD environment there were no differences between species, since it provided favorable conditions for seedling development without compromising the vertical elongation of plants. Although there was no difference in the height of the seedlings between *Physalis* species for SHD environment, it was under these conditions that the highest plant height was found for *P. peruviana*, *P. pubescens* and also for *P. angulata*, although this species did not differ from the GRE environment (Table 3).

This environment provides temperature and air humidity favorable for the development of seedlings of *Physalis* species, corroborating MOURA et al. (2016), in working with development of papaya seedlings, it was observed that the height of the seedlings was influenced by the environment, occurring further development in shading. Also SILVA et al. (2016a) found superior development of yellow passion fruit seedlings in film with 50% and 80% shade.

In the FOP species behaved differently, due to the conditions provided by the environment not being conducive to the initial development of seedlings, thus obtaining worse results for plant height. The FOP environment presents greater luminous intensity; there is no need for great vertical growth in search of light (SILVA et al. 2016a). In addition, the lower relative humidity observed in the FOP environment is associated with lower growth due to increased respiration and energy consumption by the plant (PAIVA et al. 2015), as well as substrate drying by the direct incidence of solar rays (MEZZALIRA et al. 2012).

In relation to dry root biomass (Table 4), the results show significant interaction between the physalis species and cultivation environments, better results being observed for seedlings of *Physalis peruviana* developed in GRE environment. For this variable, the environment with lower results for the cultivation of seedlings of *Physalis* species was in full sun (FOP).

Although in the GRE environment did not have a statistical difference of the SHD environment for the stem diameter, stem dry biomass and number of leaves, we can observe an increasing trend of these parameters in the first environment. In addition in

Table 2. Number of leafs of *Physalis* species in environments GRE, SHD and FOP. Unioeste, Campus Marechal Cândido Rondon, PR. 2016.

	Number of leafs of Physalis species			
Growing environment	*Physalis angulata*	*Physalis peruviana*	*Physalis pubescens*	Means
GRE	7,35 aB*	8,25 aAB	9,45 aA	8,35
SHD	7,90 aA	7,70 aA	7,40 bA	7,66
FOP	5,85 bA	5,80 bA	5,20 cA	5,61
Means	7,03	7,25	7,35	
CV (%)		7,42		

*Means followed by lowercase letter in the column and capital in line significative differences among them, by the Tukey test at 5% probability. GRE = greenhouse with transparent plastic cover 150 microns, SHD = shading with 75% permeability to light, FOP = Total luminosity in wide open place.

Table 3. Plant height (cm) of *Physalis* species in farming environments GRE, SHD and FOP. Unioeste, Campus Marechal Cândido Rondon, PR. 2016.

		Plant height (cm) of Physalis species		
Growing environment	*Physalis angulata*	*Physalis peruviana*	*Physalis pubescens*	Means
GRE	25,77 aA*	22,90 bB	24,12 bAB	24,26
SHD	26,21 aA	26,60 aA	26,86 aA	26,56
FOP	11,84 bA	8,01 cB	10,53 cAB	10,13
Means	21,27	49,17	20,05	
CV (%)		5,18		

*Means followed by lowercase letter in the column and capital in line significative differences among them, by the Tukey test at 5% probability. GRE = greenhouse with transparent plastic cover 150 microns, SHD = shading with 75% permeability to light, FOP = Total luminosity in wide open place.

the GRE environment results were higher for leaf biomass for the three species and for the number of leaves in *P. pubescens*. These combined results point to higher growth in this environment that allow a higher concentration of photoassimilates and consequent greater dry root biomass. The results found corroborate COSTA et al. (2011) who claims that greenhouses with the use of technology to control environmental conditions provide greater vigor and accumulation of biomass in the plants.

The leaf area of Physalis species is represented in Table 5, showing significant interaction when subjected to cultivation environments. Larger leaf areas were verified in covered environments (GRE and SHD) independent of the species. This result is due to the need to expand the leaf under low luminosity as a form of the plant to compensate or to give better use to the condition of restricted luminosity (LIMA et al. 2008). In FOP environment, the species had lower leaf area, when grown in other environments. The leaf area is considered a limiting factor; because it becomes a fruit productivity index of, given the importance of photosynthetic organs in organic production plant (SILVA et al. 2016b).

Table 6 shows the coefficients of simple correlation, where they took into consideration all the comments obtained for each variable in a generalized manner.

The NL showed significant correlation with DBS and LA, with coefficients of 0.81 and 0.85, respectively, in other words, there is evidence that 81 and 85% of the variation in the number of leaves of phisalys species can be explained by dry leaf biomass and leaf area, in cropping environments, occurring similarly for the other variables analyzed. The pH had a significant correlation with DS and LA, with coefficients of 0.83 and 0.86, respectively.

The correlation between PH/DS is a variable that indicates the quality of the seedlings to be carried to the field, since it is expected in their development.

Table 4. Biomass dry root (g) of *Physalis* species in environments GRE, SHD and FOP. Unioeste, Campus Marechal Cândido Rondon, PR. 2016.

Biomass dry root (g) of *Physalis* species				
Growing environment	*Physalis angulata*	*Physalis peruviana*	*Physalis pubescens*	Means
GRE	3,52 aB	4,85 aA	4,77 aAB	4,38
SHD	2,61 bA	2,51 bA	2,44 bA	2,52
FOP	1,61 cA	1,43 cB	1,60 cAB	1,55
Means	2,58	2,93	2,94	
CV (%)		12,30		

*Means followed by lowercase letter in the column and capital in line significative differences among them, by the Tukey test at 5% probability. GRE = greenhouse with transparent plastic cover 150 microns, SHD = shading with 75% permeability to light, FOP = Total luminosity in wide open place.

Table 5. Leaf area (cm^2) of *Physalis* species in farming environments GRE, SHD and FOP. Unioeste, Campus Marechal Cândido Rondon, PR. 2016.

Leaf area (cm^2) of Physalis species				
Growing environments	*Physalis angulata*	*Physalis peruviana*	*Physalis pubescens*	Means
GRE	15,31 aA*	17,18 aA	18,85 aA	17,11
SHD	14,03 aA	16,16 aA	12,39 bA	14,9
FOP	3,90 bA	3,41 bA	5,12 cA	4,05
Means	11,08	12,25	12,12	
CV (%)		15,21		

*Means followed by lowercase letter in the column and capital in line significative differences among them, by the Tukey test at 5% probability. GRE = greenhouse with transparent plastic cover 150 microns, SHD = shading with 75% permeability to light, FOP = Total luminosity in wide open place.

Table 6. Correlation coefficients between number of sheets (NS), height of plants (PH), diameter of stem (DS), dry biomas of stem (DBS), dried root biomass (DBR), Dry biomass of dry leaf matter (DBL), percentage of emerged seedlings (PES) and leaf area (LA).

Variables	PH	DS	DBS	DBR	DBL	PES	LA
NS	0,78*	0,76*	0,74*	0,78*	0,81*	0,17^{ns}	0,85*
PH		0,83*	0,66*	0,60*	0,70*	0,55*	0,86*
DS			0,76*	0,77*	0,76*	0,22^{ns}	0,83*
DBS				0,86*	0,90*	-0,08^{ns}	0,79*
DBR					0,79*	-0,19*	0,80*
DBL						-0,04^{ns}	0,82*
PES							0,26*

*significant at the 5% probability; ns = not significant.

The DS showed correlation with LA, with a coefficient of 0.83. The DBS showed correlation with DBR and DBL, with coefficients of 0.86 and 0.90, respectively. The DBR and DBL showed correlation with LA, with coefficients of 0.80 and 0.82, respectively.

The results obtained in this work show that for the better development of fisalis species seedlings environments should provide partial shading, with unsatisfactory plans growth in places with high luminosity, as in climatic conditions of Marechal Cândido Rondon. The research becomes necessary, being an option to producers of grains in the region. In foresight, it becomes necessary to perform work, in order to clarify some doubts, as behavior of other species in the west region of Parana, substrates and containers can be used in the formation of seedlings and cultivation environments

CONCLUSIONS

The SHD environment provides higher rate of seedling emergence of *Physalis* species studied.

The GRE and SHD environments were similar in the early development of *Physalis* and can be used in the production of seedlings of these species.

No and advised that the initial development of *Physalis* seedlings occur in FOP.

REFERENCES

ARAUJO JG et al. 2006. Efeito do recipiente e ambiente de cultivo sobre o desenvolvimento de mudas de mamoeiro cv. sunrise solo. Revista Brasileira de Fruticultura 28: 526-529.

CAVIGLIONE JH et al. 2000. Cartas climáticas do Paraná. Londrina: IAPAR. (CD-Rom).

COSTA E et al. 2009. Efeitos da ambiência, recipientes e substratos no desenvolvimento de mudas de maracujazeiro-amarelo em Aquidauana - MS. Revista Brasileira de Fruticultura 31: 236-244.

COSTA E et al. 2011. Volumes de substratos comerciais, solo e composto orgânico afetando a formação de mudas de maracujazeiro-amarelo em diferentes ambientes de cultivo. Revista Ceres 58: 216-222.

EMBRAPA. Empresa Brasileira de Pesquisa Agropecuária. 2009. Sistema Brasileiro de Classificação de solos. 2.ed. Rio de Janeiro: Embrapa. 412p.

FERREIRA DF 2011. Sisvar: a computer statistical analysis system. Ciência & Agrotecnologia 35: 1039-1042.

IANCKIEVICZ A et al. 2013. Produção e desenvolvimento da cultura de *Physalis* L. submetida a diferentes níveis de condutividade elétrica da solução nutritiva. Ciência Rural 43: 438-444.

LIMA JD et al. 2008. Efeitos da luminosidade no crescimento de mudas de *Caesalpinia ferrea* Mart. ex Tul. (Leguminosae, Caesalpinoideae). Acta Amazônica 38: 5-10.

LIMA CSM et al. 2010. Sistemas de tutoramento e épocas de transplante de *physalis*. Ciência Rural 40: 2472-2479.

MARCOS FILHO J. 2005. Fisiologia de sementes de plantas cultivadas. Piracicaba: FEALQ. 495p.

MEZZALIRA EJ et al. 2012. Desenvolvimento inicial de plântulas de maracujazeiro azedo (*Passiflora* sp.) em resposta ao ambiente e ao tempo de armazenamento das sementes. Revista Cultivando o Saber 5: 113-123.

MOURA PHA et al. 2016. Cobertura plástica e densidade de plantio na qualidade das frutas de *Physalis peruviana* L. Revista Ceres 63: 334-339.

MUNIZ J et al. 2011. Sistemas de condução para o cultivo de *Physalis* no planalto catarinense. Revista Brasileira de Fruticultura 33: 830-838.

MUNIZ J et al. 2014. General aspects of physalis cultivation. Ciência Rural 44: 964-970.

MUNIZ J et al. 2015. Physalis: Panorama produtivo e econômico no Brasil. Horticultura Brasileira 33: (Artigo de Capa).

PAIVA EP et al. 2015. Crescimento e qualidade de mudas de romãzeira ‘Wonderful’ propagadas por estaquia. Revista Caatinga 28: 64-75.

PIVA AL et al. 2013. Emergence and initial development of Cape gooseberry (*Physalis peruviana*) seedlings with different substrate compositions. African Journal of Agricultural Research 8: 6579-6584.

RODRIGUES FA et al. 2013. Caracterização fenológica e produtividade de *Physalis peruviana* cultivada em casa de vegetação. Bioscience Journal 29: 1771-1777.

ROMANINI CEB et al. 2010. Desenvolvimento e simulação de um sistema avançado de controle ambiental em cultivo protegido. Revista Brasileira de Engenharia Agrícola e Ambiental 14: 1193-1201.

RUFATO L et al. 2008. Aspectos técnicos da cultura da *Physalis*. Lages: CAV/UDESC: Pelotas UFpel. 100p.

SBRUSSI CAG et al. 2014. Maturation stages of fruit development and physiological seed quality in *Physalis peruviana*. Revista Ciência Agronômica 45: 543-549.

SILVA DF et al. 2016a. Light spectrum on the quality of fruits of physalis species in subtropical area. Bragantia 75: 371-376.

SILVA DF et al. 2016b. The production of *Physalis* spp. seedlings grown under different-colored shade nets. Acta Scientiarum. Agronomy 38: 257-263.

TAIZ L & ZEIGER E. 2010. Plant Physiology. 5.ed. Sunderland: Sinauer Associates. 782p.

ZHANG YJ et al. 2013. Chemical components and bioactivities of cape gooseberry (*Physalis peruviana*). International Journal of Food Nutrition and Safety 3: 15-24.