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RESEARCH NOTE

Luminosity and sowing depth in the emergence and development of passion fruit seedlings[1]

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ABSTRACT - The propagation of passion fruit in commercial orchards is carried out by seeds. However, passion fruit seed germination occurs irregularly. The goal of this study was to evaluate the emergence and development of passion fruit seedlings under different luminosities and sowing depths. The experimental design was completely randomized with six replications of 25 seeds, with a 3 x 5 factor scheme, in which three light conditions (absence of light, presence of 12 h light and 12 h dark and the presence of light for 24 h) were combined with five sowing depths (1, 2, 3, 4 and 5 cm). The emergence test was conducted in a BOD-type germination chamber, with alternating temperatures of 20-30 °C, at intervals of 12 h and the established luminosities. The evaluated characteristics were the emergence percentage for weekly counts, the emergence speed index for 28 days; the total shoot and root length on evaluation day 28 and the individual dry weight. The lack of luminosity accelerates the emergence of passion fruit seedlings, but it produces low quality seedlings. However, the alternation of luminosity associated to a lower sowing depth helps both the emergence and the quality of seedlings produced from passion fruit 14 days after sowing.

Index terms: *Passiflora edulis* Sims, emergence test, light.

Luminosidade e profundidade de semeadura na emergência e desenvolvimento de plântulas de maracujazeiro azedo

RESUMO - A propagação do maracujazeiro azedo em pomares comerciais é realizada por sementes, no entanto, a germinação das sementes ocorre de maneira irregular. Dentre os fatores que influenciam à germinação no maracujazeiro azedo, a luminosidade atua como ativador para quebra de dormência em Passifloracea, e está diretamente ligada com a profundidade de semeadura. O objetivo no trabalho foi avaliar a emergência e o desenvolvimento de plântulas de maracujazeiro azedo sob diferentes luminosidades e profundidades de semeadura. O trabalho foi desenvolvido em delineamento inteiramente casualizado, em esquema fatorial 3 × 5, sendo três períodos de luminosidade (ausência de luz, presença de luz por 12 h e por 24 h) e cinco profundidades de semeadura (1, 2, 3, 4 e 5 cm); com seis repetições de 25 sementes por parcela. As características avaliadas foram porcentagem, índice de velocidade de emergência, o comprimento total, da parte aérea, do sistema radicular e a massa seca individual. A ausência de luminosidade acelera a emergência de plântulas de maracujazeiro azedo, porém produz plântulas de baixa qualidade. Entretanto, a alternância de luminosidade associada a menor profundidade de semeadura favorece tanto a emergência como a qualidade das plântulas produzidas de maracujazeiro azedo 14 dias após a semeadura.

Termos para indexação: *Passiflora edulis* Sims, teste de emergência, luz.

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Introduction

Passion fruit (*Passiflora edulis* Sims) is the most cultivated passifloraceae species in commercial orchards in Brazil (Morgado et al., 2015), due to its high consumption in the fruit market, for its agroindustrial purposes and high productivity on the field (Santos et al., 2014; Ferreira et al., 2016). The national production of passion fruit is around 838,244 t, of which 87.92% is produced in the northeastern and southeastern regions (AGRIANUAL, 2016). Thus, the use of passion fruit seeds with high quality standards has increased significantly in recent years, as it will turn into resistant seedlings on the field and orchards with high production (Almeida et al., 2010).

For seedling formation, seed germination must be quick and even, since the longer the seedlings spend to emerge from the soil, the greater their vulnerability to unfavorable environmental conditions (Marcos-Filho, 2005; Lima et al., 2009). Seed germination derives from a sequence of physiological events, which are influenced by intrinsic (dormancy, physiological ripeness and genetics) and extrinsic (luminosity, temperature, water availability and substrate) factors (Kleczewski et al., 2010). There is also an interaction between environmental conditions and their physiological quality; each species require a set of environmental conditions that are necessary for seeds to germinate (Carvalho and Christoffoleti, 2007).

Thus, evaluating the germination of passion fruit seeds is important to estimate the seedling emergence potential on the field in relation to the effects of luminosity (Zucareli et al., 2015). Light influences germination both by quality and by the intensity and duration of the light irradiation (Aud and Ferraz, 2012); it is fundamental to activate the phytochrome, which is a specific photoreceptor capable of inducing seed germination, since it increases the level of the active form of the gibberellin hormone (Taiz et al., 2017), with the possibility of helping the growth and development of seedlings.

According to the Rules for Seed Testing (Brasil, 2009), the germination test for *P. edulis* seeds must be conducted in the dark, with the goal to overcome dormancy. The inhibiting effect of light over germination was observed for *Passiflora cincinata* (Zucareli et al., 2009) and *Passiflora incarnata* (Zucarelli et al., 2015) seeds; there was a higher germination percentage with the absence of light. However, *Passiflora nitida* seeds appeared indifferent to the absence and presence of luminosity during germination (Passos et al., 2004).

Sowing at a proper depth ensures seed germination, emergence and seedling development (Mendonça et al., 2007; Sousa et al., 2007), since a very shallow sowing may facilitate pest attack, mechanical damages to the radicle and greater exposure to light; on the other hand, a deep sowing may hinder the emergence of seedlings because of physical impediments, increasing the time of susceptibility to pathogens and there is less light exposure (Marcos-Filho, 2005; Guedes et al., 2010).

In this context, this work had the goal to evaluate the influence of different sowing depths and photoperiods on the emergence and initial development of passion fruit seedlings.

Material and Methods

The experiment was conducted in a germination chamber at UEPE, Plant Science Department of Federal University of Viçosa, Viçosa, Minas Gerais, Brazil. Seeds were extracted from passion fruits during their full physiological ripeness, 70 days after pollination.

In order to extract the aril, the seeds were placed in a finemesh sieve and virgin lime was added (calcium hydroxide); later, they were washed under running water to remove the excess of mucilage and lime. After that, seeds were placed to dry on towel paper at room temperature (25 °C) for a period of 72 h. After drying, they were placed in paper bags and were kept in a cooled environment at 5 °C for 180 days.

The experiment was implanted in factor scheme; the photoperiod was composed by 3 levels (0, 12 and 24 luminosity hours) and the sowing depths by 5 levels (1, 2, 3, 4 and 5 cm), in the completely randomized design with six replications of 25 seeds per plot.

Seeds were sown at the established depths, spaced 2 × 2 cm apart in plastic boxes with washed and sieved sand. The boxes were arranged in a germination chamber (BOD-type) with alternating temperatures of 20-30 ºC in the pre-established photoperiod periods. Irrigations were performed daily in order to maintain the moisture of the substrate. Evaluations on the number of emerged seedlings were performed daily, starting from the appearance of the cotyledon and the first seedlings with partially or totally expanded cotyledons (Osipi et al., 2011); the emergence speed index (ESI) was calculated according to the formula proposed by Maguire (1962):

$$ESI = (G1/N1) + (G2/N2) + (G3/N3) + ... + (Gn/Nn),$$

where:

ESI = emergence speed index;

G1, G2, G3,..., Gn = number of seedlings calculated in the first, second, third and last count; and

N1, N2, N3,..., Nn = number of sowing days calculated in the first, second, third and last count.

Emergence percentages were determined on day 14, 21 and 28, and values were transformed according to the formula; after the statistical analyses, the original values were demonstrated in the results, and the differences in the statistical tests were obtained by the transformed values.

On day 28 after sowing (DAS) the total length of the seedlings was evaluated, considering the measure from the apical bud to the main root; the shoot length, considering the measurements from the hypocotyl to the apical bud; and the length of the main root, considering the measurement of the root with greater extension with the aid of a millimeter-graduated ruler, and the results were expressed in cm.seedling^{-1}. The seedlings were then placed in an air circulating oven at the constant temperature of 65 °C for 48 h and, subsequently, the individual dry matter of the seedlings was measured on an analytical scale (precision - 0.001 g), and the results were expressed in mg.seedling^{-1}.

Data were submitted to analysis of variance by F test ($p<0.05$). Averages were compared by Tukey's test at 5% probability level. In order to analyze data, the statistical software GENES was used (Cruz, 2013).

Results and Discussion

According to the analysis of variance, emergence on day 21, emergence speed index, total, shoot and main root length showed interaction between photoperiod and significant sowing depth ($p<0.05$). In passifloraceae species, Zucareli et al. (2009) and Zucareli et al. (2015) verified significant effects of the photoperiod over the germination parameters of seeds when submitted to different air thermal conditions.

Luminosity influenced the emergence of passion fruit seedlings regardless of the sowing depth, since, starting from 14 days of evaluation, the mean emergence percentage was 74, 87 and 2% with 0, 12 and 24 h of light, respectively (Table 1). Thus, it was possible to verify that the seeds exposed to dark periods presented higher emergence values in relation to the seeds exposed to continuous luminosity, inferring that passion fruit seeds need hour periods in the absence of luminosity to trigger the germination process. This information supports the recommendations from the Rules for Seed Testing (Brasil, 2009), where it is recommended that germination tests with passion fruit seeds should be conducted in the dark.

On evaluation day 14, seedling emergence presented high values at the lowest sowing depth (1 cm), differing significantly from the greatest depth (5 cm) (Table 1). However, on evaluation day 21 and 28, the percentages of emerged seedlings become similar among the sowing depths.

The difference on evaluation day 14 days may be due to the fact that the superficial layers of the soil are more exposed to temperature fluctuations, triggering the seed germination process more quickly. Souto et al. (2017) evaluating the emergence of commercial passion fruit hybrids at different temperature levels, demonstrate that on day 14 after sowing, the hybrids presented over 93% emergence at the alternating temperatures of 25-35 ºC, indicating that high temperatures contribute to the early emergence of seedlings.

In addition, the lower seedling emergence on day 14 at the greatest depths may be associated to the physical barrier imposed by soil to germination (physical limitation of seedling expansion); thus, seeds at lower depths germinated and emerged quickly, enabling the count of a greater number of seedlings than at greater depths; on evaluation day 21 and 28 there were no differences among the depths. This may be confirmed by the ESI value, which was higher at lower sowing depths.

The ESI allows following emergence along a period of time; there are low values when the higher seedling emergence occurs at the end of the evaluation period (in the case of passion fruit, for 28 days), whereas high values are obtained by a higher seedling emergence, in a shorter period of time. Generally speaking, the highest observed values were obtained when seeds were exposed to dark periods, on day 14 and 21, indicating that a constant luminosity delays the emergence of passion fruit seedlings; moreover, a higher emergence index occurred for seeds at a lower depth (1 cm).

In other *Passiflora* species, Zucareli et al. (2009) and Zucareli et al. (2015), when studying the effect of photoperiods on the germination of crato passion fruit (*Passiflora cincinnata*) and purple passion flower (*Passiflora incarnata*), detected that the highest germination percentages and seedling emergence index were reached under no-luminosity conditions.

Thus, it is recommended for passion fruit to conduct emergence tests up to 14 days in sand and absence of light; sowing was performed at the depth of 1 cm, in order to standardize the production of seedlings.

As well as for passion fruit seeds, seedling emergence was also not influenced by the sowing depth, as observed in *Tamarindus indica* L., which did not present significant differences when sown up to 3 cm deep (Almeida et al., 2010) and in *Annona muricata* with which at three different sowing depths there were no differences in seedling emergence (Mendonça et al., 2007).

Although the absence of luminosity helped the emergence of seedlings, their quality was influenced according to the used treatments. It was observed that, in the absence of light, the seedlings were etiolated; this resulted in higher total length and seedling shoot values (Table 2).

The absence of luminosity causes a hormonal imbalance, mainly with an increase in the synthesis of gibberellin, which stimulates the hypocotyl elongation, so that the plant

Table 1. Emergence averages on day 14, 21 and 28 and passion fruit emergence speed index at different sowing depths and photoperiods.

Sowing depths (cm)	Photoperiods (hours)			
	Emergence on day 14 (%)			
	0	12	24	Average
1	85	93	3	60 A
2	81	87	3	57 AB
3	68	86	0	51 BC
4	71	90	1	54 ABC
5	63	81	0	48 C
Average	74 b	87 a	2 c	
F(D) = 5.27**		F(P) = 804.60**	F(D × P) = 1.35^{ns}	CV(%) = 16.41
MSD(D/P) = ---		MSD(P/D) = ---	MSD(D) = 8.30	MSD(P) = 5.50
	Emergence on day 21 (%)			
1	91 Aa	94 Aa	75 Ab	87
2	81 ABa	89 Aa	77 Aa	82
3	66 Bb	87 Aa	73 ABab	75
4	90 Aa	95 Aa	72 ABb	86
5	84 ABa	93 Aa	55 Bb	77
Average	82	91	70	
F(D) = 3.44*		F(P) = 25.27**	F(D × P) = 2.51*	CV(%) = 14.16
MSD(D/P) = 18.61		MSD(P/D) = 15.92	MSD(D) = 10.74	MSD(P) = 7.12
	Emergence on day 28 (%)			
1	93	94	86	91 A
2	81	89	86	85 AB
3	66	87	85	79 B
4	91	95	90	92 A
5	86	93	83	87 AB
Average	83b	92a	86ab	
F(D) = 4.58**		F(P) = 4.63*	F(D × P) = 1.78^{ns}	CV(%) = 11.57
MSD(D/P) = ---		MSD(P/D) = ---	MSD(D) = 9.39	MSD(P) = 6.22
	Emergence speed index			
1	2.30 Aa	2.21 Aa	1.16 Ab	1.89
2	1.94 Ba	1.92 ABa	1.17 Ab	1.68
3	1.57 Ca	1.82 Ba	1.12 Ab	1.50
4	1.81 BCa	1.89 ABa	1.15 Ab	1.62
5	1.53 Ca	1.80 Ba	1.01 Ab	1.45
Average	1.83	1.93	1.12	
F(D) = 12.65**		F(P) = 137.26**	F(D × P) = 2.80**	CV(%) = 12.65
MSD(D/P) = 0.333		MSD(P/D) = 0.285	MSD(D) = 0.192	MSD(P) = 0.127

**,* significant at 1 and 5% probability level by F test, respectively; ^{ns} non significant at 5% probability level by F test); D (Depths); P (Photoperiods); CV (Coefficient of variation); MSD (minimum significant difference). Averages followed by the same capital letter in the column and lowercase letter on the line do not differ statistically by Tukey's test at 5% probability.

can intercept luminosity to start the photosynthetic activity (Farooq et al., 2009; Taiz et al., 2017). However, according to Paiva et al. (2016), the permanent presence of light can provide constant photosynthesis; this, in some species, may result into photo inhibition, that is, the inhibition of photosynthesis caused by excessive light, resulting in less developed seedlings. In addition, greater seeding depth stimulates greater shoot development, so that the seedling can break the surface of the substrate or the soil, as was observed for passion fruit seeds (Table 2).

Thus, more vigorous seedlings were produced in the alternating photoperiod condition, 12 hours of light/dark, for both shoot and root. This beneficial effect of the photoperiod alternation over the seedling quality can also be observed

Table 2. Total length, shoot length, main root length (RL) and individual dry matter (IDM) averages of passion fruit seedlings at different sowing depths and photoperiods.

Sowing depths (cm)	Photoperiods (hours)			
	Total length (cm)			
	0	12	24	Average
1	14.80 Aa	11.13 Bb	10.65 Bb	12.19
2	12.91 Ba	10.89 Bb	10.66 Bb	11.49
3	12.43 Ba	11.90 Aa	11.27 Aa	11.87
4	14.99 Aa	11.79 Bb	11.40 Bb	12.73
5	15.03 Aa	11.36 Bb	11.35 Bb	12.58
Average	14.03	11.41	11.07	
F(D) = 4.82**		F(P) = 81.46**	F(D × P) = 3.49**	CV(%) = 8.08
MSD(D/P) = 1.59		MSD(F/P) = 1.36	MSD(D) = 0.917	MSD(P) = 0.608
	Shoot length (cm)			
1	8.85 Ba	5.24 Ab	5.28 Bb	6.46 B
2	8.22 Ba	4.99 Ab	5.51 Bb	6.24 B
3	8.39 Ba	4.75 Ac	6.21 ABb	6.45 B
4	11.05 Aa	4.71 Ac	7.31 Ab	7.69 A
5	10.30 Aa	4.32 Ac	6.96 Ab	7.20 A
Average	9.36 a	4.81 c	6.25 b	
F(D) = 11.67**		F(P) = 281.10**	F(D × P) = 6.90*	CV(%) = 11.16
MSD(D/P) = 1.22		MSD(P/D) = 1.05	MSD(D) = 0.709	MSD(P) = 0.470
	Main root length (cm)			
1	5.94 Aa	5.88 Aa	5.37 Aa	5.73
2	4.68 ABb	5.89 Aa	5.15 Aab	5.24
3	4.03 Bb	7.14 Aa	5.05 Ab	5.41
4	3.94 Bb	7.07 Aa	4.08 Ab	5.03
5	4.73 ABb	7.04 Aa	4.39 Ab	5.38
Average	4.67	6.60	4.81	
F(D) = 1.71^{ns}		F(P) = 50.79**	F(D × P) = 5.12**	CV(%) = 15.47
MSD(D/P) = 1.34		MSD(P/D) = 1.14	MSD(D) = ---	MSD(P) = 0.512
	Individual dry matter (mg)			
1	13.24	13.63	11.64	12.84 A
2	8.99	12.71	10.38	10.69 AB
3	7.37	11.32	10.05	9.58 B
4	9.00	10.81	8.18	9.33 B
5	8.03	10.02	10.53	9.53 B
Average	9.32 b	11.70 a	10.16 ab	
F(D) = 5.91**		F(P) = 6.64**	F(D × P) = 1.15^{ns}	CV(%) = 24.60
MSD(D/P) = ---		MSD(P/D) = ---	MSD(D) = 2.385	MSD(P) = 1.580

**,* significant at 1 and 5% probability level by F test, respectively; ^{ns} non significant at 5% probability level by F test; D (Depths); P (Photoperiods); CV (Coefficient of variation); MSD (minimum significant difference). Averages followed by the same capital letter in the column and lowercase letter on the line do not differ statistically by Tukey's test at 5% probability.

by the results obtained for the dry matter (Table 2), whose seedlings obtained higher individual mass values. However, it was also possible to observe a higher dry matter value according to the increase in the sowing depth due to the greater shoot growth, in order for the substrate to break.

According to Taiz et al. (2017), the greater investment in the shoot limits the growth of roots, but when there was luminosity, for passion fruit seedlings, the length of the main root did not differ among the different sowing depths.

As it was observed for passion fruit, Paiva et al. (2016) did not observe etiolation of *Salvia hispanica* L. seedlings when using the alternating photoperiod (8 h light/ 16 h dark); this condition influenced positively the quality of the produced seedlings, due to the greater biomass accumulation.

As for the fact that the sowing depth provided an increase in the shoot length, similar results were reported by Zuffo et al. (2014) in the initial development of *Anacardium microcarpum*, the authors observed that an increase in the sowing depth promoted higher seedling height values when sowing was performed between 4 and 6 cm, as observed for passion fruit seedlings.

Through the results obtained for passion fruit seeds, luminosity and sowing depth cause different responses in the analyzed variables; the absence of luminosity helped the emergence of seedlings, but better seedling were produced under alternating photoperiod conditions.

Conclusions

The absence of luminosity accelerates the emergence of passion fruit seedlings, but it produces low quality seedlings.

The alternation of luminosity associated to a lower sowing depth helps both the emergence and the quality of seedlings produced from passion fruit 14 days after sowing.

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