Technical Article

Germination and development of ornamental sunflower seedlings in substrates [(1)]

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ABSTRACT

The ornamental sunflower is a growing crop in recent years due to its rapid return on investment and expressive representation in the flower market, and research on the ideal substrate for seedling production is essential to maximize information for the crop. Thus, the objective was to evaluate the germination and development of ornamental sunflower seedlings in different substrates compositions. The experiment was installed in a greenhouse, where they were put to germinate, seeds of sunflower type "Vincent's Choice" in poliestileno trays on substrates with or without addition Slow Release Fertilizer (SRF) at the dose 2 g L^{-1}. The experimental design was completely randomized with 4 treatments [T1- Charcoal + pine bark + peat + expanded vermiculite (1:1:1:1), T2- Coconut fiber + carbonized rice hull + peat + expanded vermiculite (1:1:1:1), T3- Charcoal + pine bark + peat + expanded vermiculite (1:1:1:1) + SRF, T4- Coconut fiber + Carbonized rice hull + peat + expanded vermiculite (1:1:1:1) + SRF] with 8 replicates of 8 seeds, totaling 64 seeds per substrate. It was evaluated: the percentage, index and average germination time, chlorophyll content, length, fresh and dry mass of shoot and root. It was observed that there was no difference in the percentage of germination, but T2 and T4 promoted emergency in the lowest mean time (3.19 and 3.46 days, respectively) with a higher rate of velocity (2.43 and 2.25 respectively), still, T4 presented increments with more than 50% of fresh and dry mass. Thus, it is concluded that the T4 substrate is recommended for germination and development of ornamental sunflower type "Vicent's Choice".
Keywords: *Helianthus annuus*, slow release fertilizer, seedling production, seed vigor.

RESUMO

Germinação e desenvolvimento de plântulas de girassol ornamental em substratos

O girassol ornamental é uma cultura crescente nos últimos anos devido ao seu rápido retorno de investimento e expressiva representação no mercado de flores, e pesquisas referentes ao substrato ideal para produção de mudas é essencial para maximizar as informações para a cultura. Assim objetivou-se avaliar a germinação e desenvolvimento de plântulas de girassol ornamental em diferentes composições de substratos. O experimento foi instalado em casa de vegetação, onde foram postas para germinar, sementes de girassol tipo "Vicent's Choice", em bandejas de poliestileno, em substratos acrescidos ou não de Adubo de Liberação Lenta (ALL) na dose de 2 g L^{-1}. o delineamento experimental foi inteiramente casualisado sendo 4 tratamentos [T1- Carvão vegetal + casca de pinus + turfa + vermiculite expandida (1:1:1:1), T2- Fibra de coco + casca de arroz carbonizada + turfa + vermiculita expandida (1:1:1:1), T3- Carvão vegetal + casca de pinus + turfa + vermiculita expandida (1:1:1:1) + ALL , T4- Fibra de coco + casca de arroz carbonizada + turfa + vermiculita expandida (1:1:1:1) + ALL)] com 8 repetições de 8 sementes, totalizando 64 sementes por substrato. Avaliou-se: porcentagem, índice e tempo médio de germinação, teor de clorofila, comprimento, massa fresca e seca da parte aérea e da raiz. Observou-se que não houve diferença na porcentagem de germinação, porém, T2 e T4 promoveram emergência em menor tempo médio (3,19 e 3,46 dias, respectivamente) com maior índice de velocidade (2,43 e 2,25 respectivamente), ainda, T4 apresentou incrementos com mais de 50% de massa fresca e seca. Assim, conclui-se que o substrato T4 é o recomendado para germinação e desenvolvimento de girassol ornamental tipo "Vicent's Choice".
Palavras-chave: *Helianthus annuus*, adubo de liberação lenta, produção de mudas, vigor de sementes.

1. INTRODUCTION

In Brazil, during the last years, the production of flowers and ornamental plants has become a consolidated activity and has already reached great economic importance in several Brazilian states (ANDRADE et al., 2012). The sunflower (*Helianthus annuus* L.) is one of the most prominent crops in this growth, due to its high ornamental potential, presenting agronomic desirable characteristics, such as short cycle, wide adaptability to the different edaphoclimatic conditions, rusticity and drought resistance (NASCIMENTO et al., 2016). Also, depending on the variety, there are different types of inflorescences with colors ranging from light yellow to brown (ZOBIOLE et al., 2010).

Due to its high profitability, demand for small areas, intensive production and the rapid return of invested capital, ornamental sunflower production has aroused

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great interest among producers and investors (OLIVEIRA et al., 2017). According to Curti et al. (2012), ornamental sunflower is mainly marketed as a cut flower, where this sector represents 34% of the flower and ornamental plants production chain in Brazil (JUNQUEIRA and PEETZ, 2017). In addition, according to data from IBRAFLOR (2017), the Brazilian market for ornamental plants earned more than R$ 7 billion in 2017, and the sunflower has significant importance, especially in the Easter season, where its demand is greater, since it is the flower symbol of the date (JUNQUEIRA and PEETZ, 2017).

However, in order to achieve the expected productivity, special attention is required in obtaining seedlings, as these are responsible for the good development of the plant, since when malformed can compromise the entire performance of the plant, which can increase its cycle and generate losses in production (MARTINS et al., 2013). Thus, in the germination phase, should be used substrates that provide optimal conditions for the development of the culture (NETO et al., 2016).

Currently, several substrates are available for the production of seedlings, and along with them, several researches are being developed seeking to expand their use and provide ideal formulations to different cultures (PELIZZA et al., 2013). According to Brandelero et al. (2016) these substrates must be free from pests and diseases, free of weeds and at the same time have good aeration, retention of water and nutrients. For this, there are researches to maximize the production of seedlings with the combination of substrates and slow release fertilizers (LANG et al., 2011).

Thus, the search for mixtures of substrate components is essential to maximize seedling production of ornamental species, according to Caldeira et al. (2011) the main commercial products are the base of pine bark and peat, although Silva et al. (2012) recommend blends of charred rice hull together with vermiculite and coconut fiber to have optimum plant production. In adiction, slow-release fertilizers can be used together the substrate at the time of germination. According to Dinalli et al. (2012) the basic premise for the use of slow-release fertilizers in germination trays is the continuous release of nutrients, reducing the possibility of leach losses and keeping the plant nourished constantly throughout the inicial growth period.

In this way, the present work had as objective to evaluate the germination and development of ornamental sunflower seedlings in different substrates with and without slow release fertilizer.

2. MATERIAL AND METHODS

The experiment was conducted in a greenhouse (Pad & Fan - average temperature 24º C and 60% RH average), being installed on March 25, 2017. Ornamental sunflower seeds type “Vicent’s Choice”, were put to germinate in polystyrene trays (128 cells) on different substrates with or without added Slow Release Fertilizer (SRF) at the dose of 2 g L^{-1} (formulation in Table 1). The experimental draw was completely randomized with 4 treatments with 8 replicates of 8 seeds, totaling 64 seeds per substrate:

T1- Charcoal + pine bark + peat + expanded vermiculite (1:1:1:1);

T2- Coconut fiber + carbonized rice hull + peat + expanded vermiculite (1:1:1:1);

T3- Charcoal + pine bark + peat + expanded vermiculite (1:1:1:1) + SRF;

T4- Coconut fiber + Carbonized rice hull + peat + expanded vermiculite (1:1:1:1) + SRF.

Table 1. Formulation data of slow release fertilizer

	Nutrient				
	N	P	K	Mg	S
%	16,0	2,0	4,0	1,0	19,0

Source: Manufacturer Specifications

The evaluations were carried out during the period of 20 days, being considered germinated the seeds that presented seedlings with the height of the shoot a minimum of two millimeters. Were evaluated: germination percentage, Mean Germination Time (MGT), according to Labouriau (1983), and Germination Speed Index (GSI) according to Maguire, (1962), as well as the length of shoot and root and and the fresh and dry mass according to the methodology of Hunter (1974) and also determined the chlorophyll content of leaves with the use of a manual chlorophyll meter in SPAD unit.

The results were submitted to analysis of variance (ANAVA) and Scott-Knott test at the 5% probability level for comparison of means, using the SISVAR program (FERREIRA, 2014).

3. RESULTS AND DISCUSSION

It can be observed that in the results of germination percentage that there was no significant statistical difference for any of the treatments (Table 2), it is inferred that the substrates did not influence the germination percentage of the seeds. These results differ from those obtained by Silva et al. (2017) in work with sunflower germination in commercial substrate, where values ranging from 75%

to 91% were found, and there was a statistical difference between them. In laboratory germination test, Bacaxixi et al. (2011) found an average of 70% in sunflower emergence, and Yerima et al. (2015) observed values below 80%, in germination with different substrates composed of sawdust, sand and soil. However, all results of which are much lower than those found in the present study, where possibly the substrates used were efficient in the germination process, since they are compositions commonly recommended for floriculture (KÄMPF, 2005).

Table 2. Germination Percentage (GP), Germination Speed Index (GSI) and Mean Time of Germination (MTG) of sunflower seeds in different substrates.

Treatment	GP (%)	GSI	MTG (days)
T1 – C+PB+P+EV (1:1:1:1)	92,18 a	2,00 b	3,76 b
T2 - CF+CRH+P+EV (1:1:1:1)	95,31 a	2,43 a	3,19 c
T3 – C+PB+P+EV (1:1:1:1) + SRF	93,75 a	1,78 c	4,31 a
T4 – CF+CRH+P+EV (1:1:1:1) + SRF	96,87 a	2,26 a	3,46 c
CV (%)	7,60	9,64	8,12

Averages followed by the same letter in the column do not differ from each other by the Scott-Knott test at 5% significance. C – Charcoal; PB - Pine Bark; P – Peat; EV - Expanded Vermiculite; CF - Coconut Fiber; CRH - Carbonized Rice Hull. SRF - Slow Release Fertilizer. CV - Coefficient of Variation.

Regarding GSI, it was observed that there was a difference between the treatments (Table 2), were the substrate T2 and T4 were that obtained the highest values, and the lowest result was found in T3, with reduction of 0.57 GSI (24.2%). According to Oliveira et al. (2009) seeds with high GSI values are more resistant to the adverse conditions of the medium, as they germinate faster and decrease the initial stage of development of seedling production, thus it is expected in the present study, that the substrates with higher GSI (T2 and T4) have said characteristics. This is probably because these two treatments (T2 and T4) are composed of coconut fiber, since according to Carrijo et al. (2002), this material is essential when used as a substrate in the germination of ornamental seeds, because it presents high durability, and physical properties such as density and total porosity essential in the production of seedlings. In addition, the carbonized rice bark, promotes diminishing the acidity of the substrate (Noya et al., 2017), which favors the germinative processes, and increases the GSI, and T2 and T4 present this compound in their composition.

Cabral and Castilho (2016), when comparing the ornamental sunflower germination on different substrates, observed that the treatment with peat + vermiculite + Charcoal (1:1:1) presented the best GSI result (1,10), however in the present work, this value is 38,20% below the data found, however, the evaluation time of the authors was 12 days, while in this study were 20 days of evaluation.

The Table 2 also shows that the higher the germination speed index, the lower the mean time of germination, showing that both is inversely proportional. Thus, MTG showed that the substrate T3- C+PB+P+EV (1:1:1:1) + SRF took longer to germinate (4.31 days), whereas T2 and T4 germinated in a shorter time (3.19 and 3.46, respectively). Santos and Zonetti (2009) at different temperatures for sunflower germination, observed results over 5 days, which was a high time when compared to the present work. Silva et al. (2014) observed that the substrates based on coconut fiber had a lower mean germination time for the different analyzed sunflower genotypes, the same occurs in the present study, because T2 and T4 with coconut fiber in their composition presented the best results. According to Kratz et al. (2013) coconut fiber when associated with charcoal rice bark and vermiculite, the substrate presents high porosity, drainage and aeration, which provides which allows better hydric storage in the substrate, and consequently imbibition of the seed, so the tegument is ruptured and water enters in the embryo, which causes hormone activation and subsequent emission of the radicle (TAIZ and ZEIGER, 2017). Thus, as the substrate is better aerated, the roots can breathe and absorb the nutrients necessary for its development, which possibly made MTG values smaller.

It is observed that for the root length, there was no difference between the treatments (Table 3), this is perhaps due to the fact that the volume of the cell in the germination tray can directly affect the size and architecture of the root system, limiting root growth (FRANCISCO et al., 2010) which does not differentiate one treatment from the other. In adition, the substrates used in the present work are composed of recommended materials for Brazilian floriculture (KÄMPF, 2005), and it is inferred that they presented excellent conditions for the development of the roots. And so, the values found are higher than those observed by Cabral and Castilho (2016) (8.48 to 10.48 cm) in ornamental sunflower on different substrates (Peat + vermiculite + Charcoal (1:1:1), coconut fiber, sand and vermiculite) and those observed by Silva et al. (2017) also in sunflower with results varying from 5.4 to 8.9 cm at commercial substrate. Entering, they are within the one observed by Madany and Khalil (2017) of 9 to 15 cm in experiment with sunflower in clay soil + sand (2:1).

Table 3. Mean of root length (RL), Shot length (SL) and leaf chlorophyll index in sunflower seedlings on different substrates.

Treatment	RL	SL	Chlorophyll
	----------- (cm) -----------		SPAD
T1 – C+PB+P+EV (1:1:1:1)	11,15 a	21,66 c	25,75 b
T2 - CF+CRH+P+EV (1:1:1:1)	10,23 a	21,79 c	22,16 c
T3 – C+PB+P+EV (1:1:1:1) + SRF	10,77 a	23,07 b	27,42 a
T4 – CF+CRH+P+EV (1:1:1:1) + SRF	9,99 a	25,41 a	24,82 b
CV (%)	8,39	5,13	4,92

Averages followed by the same letter in the column do not differ from each other by the Scott-Knott test at 5% significance. C – Charcoal; PB - Pine Bark; P – Peat; EV - Expanded Vermiculite; CF - Coconut Fiber; CRH - Carbonized Rice Hull. SRF - Slow Release Fertilizer. CV - Coefficient of Variation.

The shoot length showed that the treatment 4 promoted an increase of 14.26% and 9.21% in relation to T1, T2 and T3 respectively, being statistically different from all these substrates (Table 3). Wu et al. (2015), at work with an initial growth of sunflower at different salinities, found an average shoot length of 17 cm, and Madany and Khalil (2017) showed an interval of 8 to 15 cm in the seedlings. However, all these results are below those observed in the present study.

Silva et al. (2013) working with substrate plus different slow release fertilizers in the development of ornamental sunflower seedlings, did not find statistical difference in shoot length, with values varying from 10.56 to 11.98 after 19 days of germination, and concluded that the use of SRF is not essential for the production of molt. However, in the present work, there was difference in SL, and the best result was found by the substrate 4 which contains SRF in its composition.

In relation to the chlorophyll content of the leaves, it can be observed in Table 3 that the substrate T3 promoted the best result, with increases of 6.09%, 19.18% and 9.48% in relation to treatments T1, T2 and T4, respectively. However, the observed results are below that reported by Noreen et al. (2017) in sunflower treated with saline stress (30.03 to 41.57 SPAD), and those presented by Ucak et al. (2017) from 38.39 to 50.16 SPAD, in work with identification of culture genotypes. Possibly, because the plants still depended on the seed reserve, which resulted in lower levels found in the present study.

According to Taiz and Zeiger (2017), these values of chlorophyll content indirectly reflect the concentrations of leaf N and Mg. Where chlorophylls are molecules formed by complexes derived from porphyrin, having as the central atom the magnesium, connected to 4 others of nitrogen. Thus, there is a correlation between the chlorophyll index and the nutritional status of the plant (SANTOS and CASTILHO, 2015), and since the values of the present work were below the literature, it can be inferred that the seedlings are deficient in the mentioned nutrients, since possibly the nutritional reserves of the seed were in low quantities and were being running out throughout the process of germination.

As for the slow release fertilizers (on T3 and T4 substrates), their use reduces solubility problems and losses by leaching and, when associated with suitable substrates, improves nutrient uptake by plants (ROSSA et al., 2015). And this is reflected in the development of the plant, mainly in the chlorophyll content of the leaves (DAMIAN et al., 2016), which is observed in the present work in T3, however T4 also presents SRF and there was statistical difference between the two treatments (Table 3).

For the fresh root mass (Table 4), the best results were observed for T1 and T4 and both did not differ among them, these treatments presented increases of 49.12%, in comparison to the lowest values found (T2 and T3). For the dry mass results, it was also observed that T1 and T4 promoted the best results, with increments of more than 40% when compared to the lower values (T2 and T3). In work with ornamental sunflower seedlings grown on different substrates (Peat + vermiculite + Charcoal (1:1:1), coconut fiber, sand and vermiculite), were found intervals ranging from 1.54-1.85 g and 1, 13-1,34 g of fresh and dry mass, respectively (CABRAL and CASTILHO, 2016), results much higher than those found in this work. Already, in a study evaluating the biomass of fresh and dry roots in ornamental sunflower seedlings after 15 days of germination, the results were of 0.2-0.7 g and 0.01-0.06 g, respectively of fresh and dry mass (BRITO et al., 2014).

Table 4. Mean Fresh Root Mass (FRM), Dry Root Mass (DRM), Fresh Shoot Mass (FSM) and Dry shoot Mass (DSM) in sunflower seedlings on different substrates.

Treatment	FRM	DRM	FSM	DSM
	(g)			
T1 – C+PB+P+EV (1:1:1:1)	1,59 a	0,15 a	1,65 b	0,15 b
T2 - CF+CRH+P+EV (1:1:1:1)	0,70 b	0,06 b	1,37 c	0,10 b
T3 – C+PB+P+EV (1:1:1:1) + SRF	0,75 b	0,07 b	2,09 a	0,21 a
T4 – CF+CRH+P+EV (1:1:1:1) + SRF	1,26 a	0,12 a	2,14 a	0,23 a
CV (%)	50,43	67,49	8,13	31,87

Averages followed by the same letter in the column do not differ from each other by the Scott-Knott test at 5% significance. C – Charcoal; PB - Pine Bark; P – Peat; EV - Expanded Vermiculite; CF - Coconut Fiber; CRH - Carbonized Rice Hull. SRF - Slow Release Fertilizer. CV - Coefficient of Variation.

As for the fresh and dry mass values of the shoot, it was observed that T3 and T4 promoted the best results, with increments of fresh mass of 21.99% and 35.22% and dry mass of 31.82% and 54.55% in relation to T1 and T2, respectively. In a study with ornamental sunflower, it was evidenced that after 12 days of seedling emergence, the substrate composed of peat + vermiculite + Charcoal (1:1:1) presented the best result of 2.45 and 1.38 g of mass fresh and dry respectively (CABRAL and CASTILHO, 2016). Results were very high when compared to the present study (T1 and T3).

In work evaluating the germination and initial growth of sunflower var. KBSH-1, were found average values of 0.04 g dry mass of the shoot (VASHISTH and NAGARAJAN, 2010), and in the experiment with sunflowers type Azargol and Record was presented an average of 0.03 g (YARI et al., 2015), results lower than those observed in the present study.

It was observed that substrate 4 presented excellent results of fresh and dry mass of root and shoot, because it is composed of carbonized rice hull, since this compound presents high drainage capacity and contents of K and Ca, which are macronutrients essential for the development of seedlings (FONSECA et al., 2017). In addition, its mixture with other components, provide high porosity, improving the physical and hydraulic characteristics of the substrates (MELO et al., 2014). Thus, the combination of rice hull with coconut fiber and vermiculite becomes an excellent substrate for seedling development (SILVA et al., 2012). This fact was observed in substrates composed of coconut fiber + carbonized rice hull, which provided better development of the Ilex paraguariensis seedlings (KRATZ et al., 2015).

Also, in the present work, T4 had addition of the slow-release fertilizer, at the dose of 2 g L^{-1}, which possibly helped the development of sunflower seedlings, since according to Santos et al. (2018) these fertilizers are essential in the initial development of a crop, by providing a continuous availability of nutrients over time. Thus, the junction of these components caused T4 to present excellent results for the evaluated parameters.

4. CONCLUSIONS

The substrate Coconut fiber + Carbonized rice hull + peat + expanded vermiculite (1:1:1:1) + Slow Release Fertilizer (at the dose of 2 g L^{-1}) is recommended for the germination and development of ornamental sunflower seedlings type “Vicent’s Choice”.

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AUTHORS CONTRIBUTIONS

P.L.F.S. 0000-0002-1956-1030: Idea of the experiment, field analysis, data collection and analysis and interpretation, manuscript preparation, critical review and translation. **R.M.M.C.** 0000-0003-3421-7235: Work advisor, data analysis and interpretation, manuscript critical review, approval of the final version of the manuscript.

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