

SCIENTIFIC ARTICLE

Germination and survival of *Aechmea gamosepala* on different substrates

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Abstract

The State of Parana is one of the Brazilian regions with the highest incidence of extraction of bromeliads, among the factors for the occurrence of this situation, they highlight a great demand for this species as ornamental flowers and the easy access to forests, few cultivation ponds and difficulties for farmers in cultivation processes, especially in the early stages of cultivation. The species *Aechmea gamosepala* Wittmack stands out among the species of this group of ornamental plants (Bromeliaceae) with strong commercial appeal and consequently of extraction. Given this context, a study was carried out to evaluate the germination and survival of seeds of the species. Five alternative types of substrates easily accessible to farmers were tested: coconut husk fiber, Plantmax®, earthworm humus, humidified Pinnus husk and sieved agricultural land. The experiment was conducted in a completely randomized design with 4 replications and 25 seeds per experimental unit at room temperature in a greenhouse, with sprinkler irrigation for a period of 90 days. The mean time for the onset of germination was 6.95 days, averaging 74.8% at the peak of germination, but there were no significant statistical differences between the treatments. For the seedling survival, humidified Pinnus husk substrates (70.8%) and coconut fiber house (80.4%) proved to be the best substrates for *Aechmea gamosepala* Wittmack.

Keywords: floriculture, flowers, ornamental plants, gardening, seedling production.

Resumo

Germinação e sobrevivência de *Aechmea gamosepala* em diferentes substratos

O Estado do Paraná é uma das regiões brasileiras de maior incidência do extrativismo de bromélias, entre os fatores para a ocorrência desta situação, destaca-se a grande procura desta espécie como planta ornamental e o fácil acesso às florestas, a existência de poucos viveiros de cultivo e dificuldades dos produtores nos processos de cultivo especialmente nos estágios iniciais da cultura. Entre as espécies deste grupo de plantas ornamentais destaca-se a *Aechmea gamosepala* Wittmack. (Bromeliaceae) com forte apelo comercial e por consequência de extrativismo. Diante deste contexto, realizou-se um estudo visando a avaliar a germinação e sobrevivência de sementes da espécie. Foram testados cinco tipos alternativos de substratos de fácil acessibilidade ao produtor rural: fibra de casca de coco, plantmax®, húmus de minhoca, casca de pinus umidificada e solo agrícola peneirado. O experimento foi realizado em delineamento inteiramente casualizado, com 4 repetições e 25 sementes por unidade experimental, à temperatura ambiente, em casa de vegetação, com irrigação por aspersão por um período de 90 dias. O tempo médio de início de germinação foi de 6,95 dias, com média de 74,8% no ponto máximo de germinação, porém não foram observadas diferenças estatísticas significativas entre os tratamentos. Para sobrevivência de plântulas os substratos de casca de pinus umidificada (70,8%) e a fibra de casa de coco (80,4%) se mostraram como os melhores substratos para *Aechmea gamosepala* Wittmack.

Palavras-chave: floricultura, plantas ornamentais, jardinagem, flores, produção de mudas.

Introduction

The prospect of new ornamental plants from native species expands the product offering to the market of flowers (Tognon et al, 2016), in this context stands out the bromeliads, which annually have dozens of new species

inserted in the ornamental plant trade (Pulido et al., 2018; Negrelle and Anacleto, 2019).

Bromeliads are classified as tropical plants, and many species are easily found at the entire length of the Brazilian territory (Pimentel and Maciel 2018), mainly in the Atlantic Forest, where they are found in abundance (Reitz, 1983).

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The use of bromeliads as ornamental plants was intensified in Brazil after the seventies with the introduction of this group of plants in landscaping projects, finding great acceptance among the population and also among architects and landscapers (Negrelle and Anacleto, 2019).

In this period, there were few existing production nurseries, and the habit of extraction of the species in their own habitat for marketing was created due to the high demand and easy access to these plants in the forest environment (Anacleto et al., 2008).

The extraction of bromeliads for commercial purposes is also registered in the States of Rio de Janeiro, Bahia, Espírito Santo and Santa Catarina, however Parana is the region where this practice had greater adherence, especially among the vulnerable and impoverished communities who saw in the facilitated extraction the possibility of obtaining income (Negrelle and Anacleto, 2019).

The number of species suffering extractive action is high, however it stands out *A. gamosepala* (*Aechmea gamosepala* Wittmack.), which, according to Anacleto and Negrelle (2013), is among the ten most extracted and marketed in Parana.

The species *A. gamosepala*, used since the 1970's as an ornamental plant, is versatile and can be epiphytic, terrestrial or rupicolous; as an adult, it has an average of 18 leaves and average height of 55 cm, flowering from May to December; it is classified as heliophytic, but fits perfectly to diffused light, and food sources can come from the peltate scales on the leaves. The species feeds perfectly through the roots, and it also removes dietary sources of the existing phytotelma in the interweaving of its leaves; an important factor is the low endemological note for insect larvae (Reitz, 1983), which, according to Anacleto et al. (2008) may represent a facilitator in the marketing processes of the species.

According to Anacleto and Negrelle (2013), the commercial success of *A. gamosepala* in part is due to its hardiness and ease of cultivation, and also due to its distinctive coloring that ranges from lilac to purple, and the form and beauty of its flowers, which has good acceptance among consumers and merchants, also receiving attractive price in the retail and wholesale market; this combination of factors, besides facilitating trade, has also contributed to the high extractive action of the species.

Studies conducted by Anacleto and Negrelle (2013) revealed that while visiting bromeliads extractors in the State coastline, in all cases the species was extracted and marketed by people in socially vulnerable conditions with no major sources of income (Negrelle and Anacleto, 2019).

Thus, the cultivation of the species of sexual propagation is the most accepted commercial method by producers on the coast of Parana (Anacleto and Negrelle, 2019), however, specifically as regards the species *A. gamosepala*, as well as other species of bromeliads, the success of this breeding system depends on the type of substrate, which, according to Anacleto et al. (2008) must provide conditions similar to those found in the natural environment of occurrence of bromeliads, and it must be easily accessible, environmentally friendly and provide low-cost producer.

Research developed by Muraro et al. (2014) related to alternative substrates for bromeliad cultivation, revealed that for the species *Vriesea incurvata* Gaudich. (*Bromeliaceae*) reported that substrates formulated with tree fern or pine husk, coconut fiber or cushion were the substrates that showed the best results. Thus, the domestication of asexual propagation process and the choice of the best substrate for *A. gamosepala* can facilitate the deployment of crops on a commercial scale and mitigate the strong extractive pressure on the species.

In this context, this study aimed to evaluate seed germination and seedling survival of *Aechmea gamosepala* Wittmack in five different types of substrates considering the low cost, environmental issues and accessibility to producers on the coast of Parana.

Material and Methods

In January 2016, a descriptive exploratory research was initially performed with three producers who traditionally cultivated the species *A. gamosepala* in order to assess the ornamental potential of the species and its acceptance by consumers, the technological conditions of the seedling production systems and the germination forms in the field.

After the previous stage, there was an experiment to evaluate the viability of the collected seeds, as they presented different stages of physiological ripeness. For this, the seeds were divided into Types A, B and C based on the color of the integument. They were planted in plastic containers, tray-type (20 x 10 x 5 cm) in cotton. The trays were kept at room temperature and with sprinkler irrigation, and they were laid to germinate 25 seeds per tray in 4 replications of each ripeness stage.

The germinated seeds were counted daily when they presented the emission of the primary root with length greater than or equal to 2 mm until the end, 21 days after installation, when the potential germination of the different stages of physiological ripeness of the seeds were evaluated.

Later, an experiment was set up to analyze the germination and seed survival of *A. gamosepala* on different substrates, conducted in a greenhouse in the city of Paranaguá (25° 50' S and 48° 30' to 48° 35' W).

The location of the experiment had no temperature control, however, in the coastal plain of Parana dominates the Köppen's Af type climate, described as Superhumid Tropical, with hottest month average temperature above 22 °C and the coldest month exceeding 18 °C, with no dry season and free from frost. The average annual rainfall is around 2,000 mm, possibly reaching 3,000 mm (Embrapa and Iapar, 1984).

For this experiment, *A. gamosepala* were used, collected from 45 plants, randomly selected in three properties with tradition in the cultivation of other species of bromeliads. From each of these selected plants they collected between 10 and 15 types of berry fruits.

The seeds were collected based on the results obtained from interviews with three farmers who cultivated this species over ten years and reported that during the sowing of the species, given the difficulty of germination, they

collected all the floral scape with the existing berries, regardless of the physiological maturation point.

The collection of fruits, according to the Proposal by Anacleto et al. (2008) occurred in three levels of ripeness, while separately the removal of the seeds was performed, proceeding to be washed in flowing water until complete removal of the mucilage covering. Later, the seeds were dried on shadow over newsprint for a week, and ended this period, the seeds were placed on the substrates to germinate.

For each treatment tested were employed four replications containing 25 seeds per experimental unit. Sowing was done in tray-type plastic boxes (20 x 10 x 5 cm) with perforated bottom to prevent accumulation of water.

All treatments were deployed on the same day (01.26.2016), and the seeds were deposited on the bed of the previously moistened substrate to prevent burial, and following the usual procedure of horticultural cultivation

among small farmers on the coast of Parana, the experiment was settled at room temperature, making irrigation with automated spray every 4 hours for 3 minutes, and all treatments and replicates were exposed to the same conditions of humidity, temperature and light.

Germination was tested in five types of easy accessibility substrates in the coastal area: coconut husk fiber, Plantmax®, earthworm humus, humidified Pinnus husk and sieved agricultural land, and the statistical design used in the analysis was completely randomized with 5 treatments and 4 replications.

The substrates were sent for chemical analysis (Table 1) given that the results of the analysis revealed that all substrates met the minimum nutritional prerequisites required by bromeliads, and similarly to what observed by Anacleto et al. (2008), given that irrigation, lighting and temperature were homogeneous for all treatments, it was possible to observe differences in the resulting germination percentage due to the type of substrate.

Table 1. Results of chemical parameters analyzed from the tested substrates.

Parameters Substrates		Plantimax	Sieved land	Sawing	Pinnus husk	Earthworm humus
pH	--	6.6	6.7	5.6	5.6	8.9
EC*	dS m ⁻¹	3.4	0.5	1.2	0.9	2.5
N-Nitrate	mg L ⁻¹	213	22	7	69	8
Phosphorous		4.4	0.1	12.7	0.3	10.9
Chloride		101	1	234	4	554
Sulfur		146	16	2	21	17
Potassium		728	81	346	148	810
Sodium		81	6	137	17	191
Calcium		151.90	26.00	0.30	44.80	10.20
Magnesium		97.30	11.30	4.60	27.90	22.90
Iron		0.10	0.70	0.10	0.20	0.60
Manganese		0.01	0.01	0.01	0.01	0.01
Zinc		0.01	0.01	0.04	0.03	0.03
Aluminum		0.10	2.20	0.20	0.30	0.20

*Electric conductivity

The entire monitoring period was 90 days, with checks every two days. As described by Oliveira et al. (2018), the average germination percentage (x%), and the average germination time (t) were determined after the monitoring period. These calculations were made considering the period from the beginning of the experiment to the germination peak. The percentage of seedling survival was determined considering the total number of seeds germinated at the peak of germination and the final number of living seedlings on the 90th day of monitoring, and the homogeneity of variances was verified by Bartlett test, and

the comparison of the average germination was performed by Tukey's test, both at 5% probability.

Results

The interviewed producers (n=3) reported that the species *A. gamosepala* has relevant capacity as an ornamental plant, and the main characteristic that brings this condition is the color of the flowers, which can vary from shades of pink or lilac to purple, the durability of the inflorescences, which can exceed two

months in ornamental conditions, the ability to adapt the diffuse light, which is traditionally found in the domestic environment, and undemanding plant in cultural and nutritional treatment.

Still according to all respondents in cultivation processes of this kind of species, the greatest difficulties were attributed to two factors: the low germination rates (approximately 20% of the seeds disposed on the land), as well as the difficulty of obtaining seeds, as when the physiological ripeness of the berries starts, it is attacked by a large number of insects, ants, small frugivorous animals

and birds that feed from the fruit due to the sweet mucilage concentration existing in the berries.

The results revealed that the physiological maturation is paramount in the *A. gamosepala* germination process, as the field experiment revealed that the seed type 1C (Figure 1) showed no germination, and seed type 1B showed low levels of germination (n=3%), a factor not feasible to perform statistical analysis, so the only seed that has proved workable for cultivation processes has been classified as type 1A, which showed germination rates always higher than 68% in different substrates (Figure 1A).



Figure 1. Three visual levels of physiological ripeness of *A. gamosepala* adopted in bromeliads germination crops in the coast of Parana. Stages of maturation: A>B>C.

Thus, for the germination of seed for cultivation of *A. gamosepala*, they must be separated by the characteristic color of ripeness which, according Reitz (1983), changes between red and intense purple (Figure 1A).

The average germination time was 6.95 days; there was no difference between the tested substrates, indicating that for the germination process, all substrates proved viable.

The results for the point of maximum germination of *A. gamosepala* seeds (Table 2) showed that 18.7 days were the average time when all substrates showed the greatest number of germinated seeds averaging 74.8%. Despite the numerical variations, there were no statistical differences among the evaluated substrates.

Table 2. Maximum point of germination and survival of *A. gamosepala* submitted to different substrates.

Substrates	Maximum point germination (MPG)	% MPG	Average Survival (AS)	% AS
Coconut husk fiber	20.8 a	83.2 a	20.1 a	80.4 a
Plantimax	16.5 a	66.0 a	13.0 d	52.0 d
Earthworm humus	17.5 a	70.0 a	11.3 e	45.2 e
Humidified Pinnus husk	20.8 a	83.2 a	17.7 b	70.8 b
Agricultural land	18.0 a	72.0 a	13.9 c	55.6 c
Overall mean	18.7	74.8	15.0	60.8

Means followed by the same letter are not statistically different from each other (Tukey $p < 0.05$).

After the peak of germination, mortality of *A. gamosepala* seedlings was observed among most of the evaluated substrates, with the highest mortality rate being registered for treatment with earthworm humus.

The highest values of survival at the end of the monitoring period were obtained with coconut husk fiber (80.4%) and humidified Pinnus husk (70.8%) with a significant difference among these substrates (Tukey, $p < 0.05$), and the lowest values were obtained with earthworm Humus soil and Plantmax (Table 2).

Discussion

The extractive exploration of bromeliads in Parana occurs more sharply than in other regions due to high life and easy access to the plants in a natural environment, especially in the Atlantic forest. According to Pereira et al. (2010) and Pulido et al. (2018) there is an urgent need to develop methods for the production of bromeliad seedlings with low environmental impact and low cost, providing extractors and small farmers a viable alternative for propagation and facilitating the practice of these crops on a commercial scale, reducing the extraction pressure.

Specifically as regards the species *A. gamosepala*, the adoption of satisfactory germination methods can stimulate the deployment of crops, as according to respondents ($n=3$ producers), a major problem in establishing farming systems on a commercial scale for this species is precisely the low germination rates under field conditions.

Producers in the planting season traditionally collect all the floral stems, resulting in getting fruit at different stages of ripeness; in the case of *A. gamosepala*, the low species germination rates in the field apparently are more associated with inadequate management of the collection of fruits than with the species ability of germination, which was also reported by Molizane et al. (2013) for the species *Aechmea bromeliifolia* (Rudge) Baker and *Vriesea paraibica* Wawra.

The collection of bromeliads seeds with the purpose of sexual propagation must then be made as to the ideal point of physiological ripeness, and the identification of this point in field is possible based on the coloring of the fruit (Figure 1A).

The management in the collection of *A. gamosepala* seeds then needs to be carried out selectively, prioritizing the collection of the fruit in the ideal point, which would result in high quality physiological seeds and consequently in higher germination values; It is noteworthy that it is possible to identify the ideal point in the field based on the coloring of fruits (Figure 1A), as further described by Molizane et al. (2013), that specifically in the case of this species, the ideal point of ripeness is described as the coloring ranging from red and deep purple.

Sowing seeds collected on the optimum point of ripeness resulted in good germination rates, given the fact that the lowest rate observed among the analyzed treatments was less than 66%; in this context, if the seed collection is done correctly, the species show high rates of seed viability, which enhances the production of asexual species. Pereira

et al. (2010) reported germination percentages of 75% with the species *Nidularium innocenti*, with temperatures ranging 20-30°C, and Anacleto et al. (2008) reported results of germination of *Aechmea nudicaulis* (L.) Griseb above 80%, which confirms a good index for the species *A. gamosepala*, since the germination occurred at room without temperature control.

In this context, if the seed collection is done correctly, this method can represent an efficient production in commercial nurseries; besides, this process can be enhanced, given that according to Reitz (1983), the species has high natural seed production, so it can then represent a viable alternative to small farmers, as indicated by Anacleto and Negrelle (2013).

The best survival rates presented by substrates of Coconut husk fiber and humidified Pinnus are associated with roughness and permeability, similar to that observed in their natural habitats where bromeliads in phorophytes with rough trunks have better grip, providing stability for their fixing, thus avoiding the sliding of the seed to the soil and grounding that hinders germination. According to Anacleto et al. (2008), the substrate to be used in bromeliads germination should have good nutritional capacity, being permeable and porous to prevent accumulation of water and to facilitate germination. In studies by Muraro et al. (2014) using different substrates to replace the tree fern, they found better development which showed good water retention with many pore spaces in its constitution. The development of bromeliad seedlings depends on the type of substrate, which should be favorable to settle the roots due to the presence of microsities. Microsities, besides serving as support and facilitator for fixture, also store water and oxygen for the development of the plants in these early stages. According to Muraro et al. (2014), in native forests, factors such as diameter was the variable that most showed variations in the richness of bromeliads, and phorophytes with persistent husk and rough texture indicated a higher concentration of species.

Thus, the substrates based on humidified Pinnus husk and coconut husk fiber, due to having the best physical properties, seedlings, density and porosity showed better performance between treatments.

The opposite situation was observed in the plantmax substrates, earthworm humus and agricultural soil which, despite its higher water holding capacity and chemical characteristics (Table 1), did not provide favorable environment for to the seedlings anchoring, which did not prevent the infiltration effect of daily irrigation after the emission of leaf primordia. This confirms the preference of the plant to porous substrates, but with good water retention, which also corroborates the results shown by Muraro et al. (2014), who found that low-density substrates, high permeability and aeration show the best survival rate for bromeliad seedlings.

Also allied to the best results shown as substrates in *Aechmea gamosepala* germination, the Pinnus husk (Anacleto et al, 2008; Anacleto and Negrelle, 2013) and the trade of green coconut generate tons of vegetable waste, resulting in high costs for the municipalities of the coast

of Parana in the correct disposal of this waste (Anacleto et al, 2008) in this context, the use of Pinnus husk and coconut husk as an agricultural substrate in the production of bromeliads, in addition to improving the seedling production process, can also assist in the mitigation of the environmental problem in the region.

Conclusions

The ideal stage for seed collecting in field is when the integument displays coloring from red tones to dark purple.

The species *Aechmea gamosepala* presented early germination on average at 6.95 days, and the point of maximum germination was reached at 18.7 days after planting with averages of 74.8% germination.

Among the substrates tested in this work, the humidified Pinnus husk and coconut hulk fiber are the most recommended for the survival of seedlings in the first 90 days after germination of seeds of the species *Aechmea gamosepala*.

Author Contribution

A.A.⁰⁰⁰⁰⁻⁰⁰⁰³⁻¹⁰⁵⁰⁻⁴⁶⁴³: installation of the experiment, Adviser of work, analysis and interpretation of data, critical review of the article, approval of the final version of the article. **L.F.R.**⁰⁰⁰⁰⁻⁰⁰⁰¹⁻⁷⁹⁷⁴⁻⁴⁴⁵⁶: field analysis, data collection and analysis, interpretation, preparation and writing of the article, critical review, manuscript review. **R.S.R.**⁰⁰⁰⁰⁻⁰⁰⁰²⁻⁰⁴⁹⁰⁻⁰⁶⁴²: idea of the experiment, installation of the experiment, field analysis, data collection and analysis, interpretation, preparation and writing of the article.

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