JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

In vitro propagation of valuable Bromeliad's: A review.

Sandip Sherkar[1], Santosh Sawardekar[2] , Kedar Jangam[3], Suraj Jagtap[4]

[1] Senior researcher, [2] Associate professor, [3,4] B.Sc. students/researcher.

[1,2] Plant biotechnology Centre, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli-415712, Dist-Ratnagiri, Maharashtra State, India.

[3,4] Collage of Agricultural Biotechnology Sangulwadi Dist-Sindhudurg, Maharashtra State, India.

Abstract

Bromeliad is a plantlet having ornamental, medicinal and commercial valued. This review briefly summarizes the research study conducted on *in vitro* tissue culturing of bromeliads. Numerous factors are key for successful micropropagation such as period of explant collection, size of explants, concentration and combination of Plant growth regulators, culture medium and cultural conditions. Sequential study of experiments helpful for understanding biological, physical and physiochemical aspects that govern the *in vitro* morphogenesis of bromeliad. *In vitro* propagation is an alternative way of propagation that can working in bulk multiplication of plants in lesser time and required low space which is can be grown in any condition.

Keywords: *in vitro,* Bromeliad's, morphogenesis, problems.

Introduction

Bromeliads are flowering plants which have 77 genera with 3629 species native to tropical areas distributed throughout the world (Butcher and Gouda, 2020). About 40% of the bromeliads are found in brazil (Anonymous, 2023). In vascular epiphytes it is a biggest family in biome (Kersten, 2010). Bromeliads are known for colored leaves and their flower spikes. They are plant species which can be grown anywhere such indoor as home decorative and also outside in the environment.

The bromeliads leaf colour, leaf shape and growth can be affected by the amount of light given to the plant, considering water and moisture they belong to the tropical areas so must avoid over watering the bromeliads plantlets. The bromeliads are the plants which are free from pests. i.e. they are not usually affected by pests but mealy bugs can create problem to the plantlets.

Bromeliads provide a range of ecosystem services. It maintains biodiversity, nutrient cycling, community structure, and provisioning of food and water. Bromeliads can grow all over the year, it is not season specific. Bromeliads flowers last for last for many months, depending on the age of the plant, they require minimal care. Most bromeliads are native to tropical areas so indoor plants does best when kept away from drafts and at temperature above 55 degrees. Bromeliads can get their nutrients from their leaves.

Bromeliads even grow on rocks or trees as they use their roots for balance rather than transferring nutrients. These plants feature rosettes of spiny stiff leaves and thrive in consistent warm indoor temperatures. They require less care. They are easy to grow and produce long lasting colorful leaf crowns. These plants add significant intrigue and beauty to your home décor.

To preserve the bromeliads there are techniques likes biotechnological techniques from seed germination to slow growth and it can give the ideal condition for conservation (Simao *et al*, 2016**).** To minimize the extraction of high number of bromeliads which are rare and disappearing varieties there are techniques used which are *in vitro* techniques can be used for the propagation. *In vitro* propagation plays an important role for the bromeliad. By using *in vitro* technique's multiplication of endangered species easily achieves. Using traditional method's we can produce less number of plants. Ornamental bromeliad such as *Aechmea, Tillasanda, Alcantarea nahoumii, Aechmea fasciata*, etc. can be produced in larger number for ornamental use such as decorational purpose. By traditional methods we can produce only limited number of plantlets but by using *in vitro* techniques we can produce larger number of copies at a time.

There are some problems in *in vitro* establishment of bromeliads such as contamination of fungal and bacterial agents etc. They can largely affected by bacteria. Fungus and bacteria can destroy whole culture.

In vitro establishment problems and solutions

While establishment there are some problems are faced. The main problem faced while *in vitro* establishment is contamination in the culture medium. The contamination can be fungus, bacteria, yeasts and molds. Browning of media can caused due to oxidation of phenolic compounds it slowdowns the rate of the cell division and it can lower down capacity of regeneration of a explant that results death. Acclimatization of tissue culture plantlets, the tissue cultured plant should adaptable to external environment otherwise the plants will get shock and will die if proper environment not given. Recalcitrance – it is defined as the plants which are not able to grow in *in vitro* culture environment. Vitrifiation- It is a physical disorder or malformation can cause effect on growth of plants and its development. The factors by which it causes are Higher salt concentrations, light intensity, relative humidity, type of explants.

Table 1: Globally well-known Bromeliads literatures and their outcomes.

Sr. no.	Varieties	Medium combinations			Results		Other additives	Culture condition	Reference
		Medium	Cytokinin	Auxin	Cytokinin	Auxin			
1.	*Aechmea setigera*	Murashige and Skoog's (MS, 1962) medium	BAP 0.0 to 8.0 mgl^{-1}	-	BAP 8.0 mg L^{-1}	-	-	-	Silva *et. al.*, 2022
2.	*Alcantarea nahoumii*	MS medium	BAP 0.0 to 6.6 µM	NAA 0.5 µM	BAP 2.2 µM	NAA 0.5 µM	-	Temp. 25ºC	Silva *et. al.*, 2020
3.	*Chapada Diamantina*	MS medium	BAP 0.0 to13.20 1.0 µM	NAA 0.0-5.20 µM	BAP 5 µM	NAA 3 µM	Charcoal	Temp 25±3ºC and light 60 $\mu mol.m^{-2}s^{-1}$	Lima *et. al.*, 2019
4.	*Vriesea gigantea and philippic-oburgii*	MS medium	BAP 2.0 mg/l	NAA 0.5 mg/l	BAP 2.0 mg/	NAA 0.5 mg/l	-	Temp 26±1ºC Light 22.5 $\mu Em^{-2}s^{-1}$	Droste *et. al.*, 2005

5.	*Aechmea fasciata*	MS medium	KIN 1.0 mgL^{-1}	IAA 1 mg/l^{-1} NAA 0-2.0 mgL^{-1}	KIN 1.0 mgL	IAA 1mgL NAA 2 mgL	Charcoal	Temp 25±2ºC	Vinterhalter *et. al.*, 1992
6.	*Neoglaziovia variegata*	MS medium	BAP 2.2 to 4.4 µM KIN 2.2 to 4.4 µM	NAA 0.05-0.50 µM	BAP 4.4 µM KIN 2.2 µM	NAA 0.5 µM	-	Temp 22±1ºC Light 22 $\mu E.m^{-2}.s^{-1}$	Silveira *et. al.*, 2009
7.	*Ananas comosusl. merr*	MS medium	BA 0-7 mgL^{-1}	NAA 2 mgL^{-1}	BA 5 mgL^{-1}	NAA 2 mgL^{-1}	-	Light 16/8hrs Temp 25±2ºC	Farahani *et. al.*, 2014
8.	*Aechmea fasciata (lindl)*	MS medium	BA 5.0 mgL^{-1} ZEA 5.0 mgL^{-1} KIN 0 to 0.5 mgL^{-1}	2-4 D 2 mgL^{-1} IAA 0-0.4 mgL^{1} NAA 2.0 mgL^{-1}	BA 5.0 mgL^{-1} ZEA 5.0 mgL^{-1}	NAA 2.0 mgL^{-1} 2-4 D 2.0 mgL^{-1}	-	-	Villanueva *et. al.*, 2022
9.	*Vriesea reitzii*	MS Medium	KIN 1.0 µM BAP 4.0 µM	2-4-D - 20.0 µM 2 iP – 2.5 µM NAA 0.5 µM	KIN 1.0 µM BAP 2.5 µM	2-4-D - 20.0 µM NAA 0.5 µM iP- 2.5 µM	-	Temp 25±1ºC Light 37µE/m^2 /s 16hr	Alves *et. al.*, 2006
10.	*Vriesea fosteriana and Hiaroglyphica*	Knudson medium (1946)	-	NAA 0.2 mgl^{-1} IBA 5.0 mgl^{-1}	-	NAA 0.5 mgl^{-1} IBA 2.0 mgl^{-1}	-	-	Mercier *et. al.*, 1995
11.	*Ananas comosus L.*	MS medium	BA 5 to12.5 µM	NAA 2 to 3 µM	BA 5.0 µM	NAA 3.0 µM	Lysergic acid dieethylamide	Temp 27±2ºC	Usman *et. al.*, 2013
12.	*Cryptanthus*	MS medium	-	NAA 0.1 to 0.2 mgl^{-1} IBA 2.0 mgl^{-1}	-	IBA 2.0 mgl^{-1} NAA 0.1 mgl^{-1}	Phloroglucinol, ancymidol, fusicoccin, riboflavin, ascorbic acid	Light 6/8hrs Temp 25±2ºC Irradiance 5.0-7.2Wm^{-2}	Todorovic *et. al.*, 1995

13.	*Succulunt plants*	MS medium	BAP 1 to 2 mgl^{-1}	NAA 0.01 to 1.0 mgl^{-1}	BAP 1 mgl^{-1}	NAA 0.1 mgl^{-1}	Chlorine, sodium hypochlori-de	21ºC at day and 16 ºC at night	Gratton *et. al.*, 1999
14.	*Tiliandsia Eizii*	Knudson medium (1946)	BA 0.5 mgl^{-1}	NAA 1mgl^{-1}	BAP 0.5 mgl^{-1}	NAA 1mgl^{-1}	Glycine	-	Pickens *et. al.*, 2005
15.	*Naoregela cruenta*	MS medium	BA 4.4 to 8.8 µM	NAA 2.5µM	BA 4.4 µM	NAA 2.5µM	-	Temp 28±2ºC Light 16 hrs Irradiation 46 µmol m^2s^{-1}	Carneiro *et. al.*, 1999
16.	*Vriesea Bromelia-ds*	MS medium	BAP 0.5 mgl^{-1}	-	BAP 0.5 mgl^{-1}	-	-	Temp 27±2ºC Light 16 hrs intensity - 40 µmol m^2s^{-1}	Aranda-Peres *et. al.*, 2009
17.	*Pineapple*	MS medium	BAP 4 µl	NAA 2µl	BAP 4 µl	NAA 2µl	-	Temp 27±2ºC Light 16 hrs 37 µmol m^2s^{-1} 60% relative humidity	Vesco *et. al.*, 2001
18.	*Vriesea reitzii*	MS medium	BAP 2 to 4 µM	NAA 2 to 4 µM IAA 4µM IP-2 µM	BAP 4 µM	NAA 4 µM IAA 4 µM IP-2 µM	Gibberellic acid	Temp 25±2ºC Light 16 hrs. Luminous intensity 50-60 µmol m^2s^{-1}	Vesco *et. al.*, 2015

19.	*Passiflora edulis Sims*	MS medium	BAP 1.0 mgl^{-1}	-	BAP 1.0 mgl^{-1}	-	-	Temp 25±2ºC	Vesco, *et. al.*, 2021
20.	*Dyckia Distachya*	MS medium	-	IP 12 µM NAA 0.5 µM	-	IP 12 µM NAA 0.5 µM	Giberalic acid	Temp 25±2ºC Humidity 60±5 Light 16hrs Irradiance 60 µmol m^2s^{-1}	Pompelli, *et. al.*, 2005
21.	*Dyckia Distachiya*	MS medium	BA 4 µM BAP 2 µM	NAA 2 µM	BA 4 µM BAP 2 µM	NAA 2 µM	Paclobut-razol	-	Pompelli, *et. al.*, 2005
22.	*Bromiloi-ds*	MS medium	BAP 4 µM	NAA 2 µM	BAP 4 µM	NAA 2 µM	Gibberellic acid	Temp 25±2ºC Irradiance 50 - 60 µmol m^2s^{-1}	Guerra *et. al.*, 2014
23.	*Aechmea fasciata*	MS Medium	-	2-4-D 1.0 to 1.5 mgl^{-1} NAA 1.0 to 0.5 mgl^{-1}	-	2-4-D 1.0 mgl^{-1} NAA 1.0 mgl^{-1}	Arginine, Aspergin, Citric acid	Temp 25±2ºC	Huang *et. al.*, 2011

24.	*Guzmanie*	MS medium	-	2-4-D 1.0 to 2.0 mgl^{-1} NAA 0.5 to 1.0 mgl^{-1} IAA 0.1 to 1.0 mgl^{-1}	-	2-4-D 2.0 mgl^{-1} NAA 1.0 mgl^{-1} IAA 1.0 mgl^{-1}	-	Temp 25±2ºC Light 16 hrs Irradiance 50 µmol m^2s^{-1}	Huang *et. al.*, 2011
26	*Sphaerant-hus amarantho-ides*	MS medium	BAP 1.5 to 5.0 mgl^{-1} KN 1.0 to 5.0 mgl^{-1}	IBA 1.0 to 5.0 mgl^{-1}	BAP 4.0 mgl^{-1} KN 2 mgl^{-1}	IBA 2.0 mgl^{-1}	-	-	Devika *et. al.*, 2012
27	*Huarlia hystrix*	MS medium	BA 4.44 to 22.19 µM	NAA 0.00 to 8.06 µM	BA 22.19 µM	NAA 5.37 µM	-	Temp 25ºC Light 30 µmol m^2s^{-1}	Amoo *et. al.*, 2009
28	*Cryptanthus spp.*	MS medium	-	IBA 0.0 to 10 mgl^{-1}	-	IBA 2 mgl^{-1}	Citric acid	-	Davidson *et. al.*, 1977
29.	*Dyckia Agudensis*	MS medium	BAP 0.0 to 2.0 mgl^{-1}	IBA 0.0 to 2.0 mgl^{-1}	BAP 1.0 mgl^{-1}	IBA 1.0 mgl^{-1}	-	Temp 25±2ºC Light 16 hrs . intensity 14.3 µEm^2s^{-1}	Silva *et. al.*, 2007
30.	*Nidularium procerum*	MS medium	BAP 0.0 to 8.0 µM	NAA 0.0 to 5.4 µM	BAP 4.0 µM	NAA 2.0 µM	Naphthalene acid	Temp 25±2ºC Light 16 hrs. Intensity 28 µMm^2s^1	Silva *et. al.*, 2012

31.	*Nidularium Immocentii*	MS medium	BAP 0.0 to 8.0 µM	NAA 0.0 to 5.4 µM	BAP 8.0 µM	NAA 2.0 µM	-	Temp 25±2ºC Light 16 hrs Intensity 28 μMm^2s^1	Silva *et. al.*, 2012
33.	*Acacia auriculifo-rmis*	MS medium	BA 0.44 µM	IBA 0 to 9.84 µM NAA 0.0 to 10.74 µM	BA 0.44 µM	IBA 9.84 µM NAA 5.37 µM	-	Temp 25±2ºC Light 16hrs	Ismail *et. al.*, 2016
34.	*Billbergia zebrina*	MS medium	BA 13 µM	-	BA 13 µM	-	-	-	Martins *et. al.*, 2022
35.	*Dyckia brevifolia*	MS medium	BA 0.5 to 1.0 mgl^1 KIN 0.5 to 1.0 mgl^1	IP 1.0 mgl^1	BA 1.0 mgl^1 KIN 1.0 mgl^1	IP 1.0 mgl^1	-	Temp 25ºC Light 16hrs Intensity 37.5 µmol m^2s^{-1}	Bertsouklis *et. al.*, 2022
36	*Bromelia balansae mez*	MS medium	BAP 0 to 4 µM	NAA 1 to 4 µM	BAP 4 µM	NAA 2 µM	-	-	Faria Souza *et. al.*, 2023
37.	*Aechma vulnerable and Aechmea distincha-ntha*	MS medium	BAP 2.2 µM	NAA 0.5 µM	BAP 2.2 µM	NAA 0.5 µM	-	Temp 25±2ºC 16hrs Light Intensity 30 µmol m^2s^{-1}	Santa-Rosa, *et. al.*, 2012

Conclusion:

It is concluded that, most of asceptic cultures are initiated from newly emerging shoot propagules, apical buds and leaves. Therefore, these explants from healthy mother plant are chosen. During surface sterilization of explants, polysorbate Tween-20 treatment given to the explant to removal of proteins and which also reduces surface tension of explants, which enhances the sterilant to act more deeply on explants. Use of the contact fungicides at 200 mg/l ex. Mancozeb and systemic carbendaxim can clear the fungal contamination. Similarly, systemic bactericide can play important role in bacterial control. H_2O_2 solution play role in the removal of the waxy layer of the explant. Sodium hypochloride with reduced concentration can be used for sterilization of explant for 20 mns to 2 hours, depending upon the type of explants.

References

1. Alves, G. M., Vesco D. L., and Guerra, M. P. (2006). Micropropagation of the Brazilian endemic bromeliad *Vriesea reitzii* trough nodule clusters culture. *Scientia Horticulturae*, 110*:*(2), 204-207.
2. Amoo, S. O., Finnie, J. F., and Van Staden, J. (2009). *In vitro* propagation of *Huernia hystrix*: an endangered medicinal and ornamental succulent. *Plant Cell, Tissue and Organ Culture (PCTOC)*, 96: 273-278.
3. Anonymous, 2023. Wikipedia: Bromeliaceae. 13 Oct 2023, Time: 04:08pm. (https://en.m.wikipedia.org/wiki/Bromeliaceae).
4. Aranda-Peres, A. N., Peres, L. E. P., Higashi, E. N., and Martinelli, A. P. (2009). Adjustment of mineral elements in the culture medium for the micropropagation of three *Vriesea bromeliads* from the Brazilian Atlantic Forest: the importance of calcium. *HortScience*, 44:(1), 106-112.
5. Bertsouklis, K., and Panagaki, K. P. (2022). *In vitro* Germination and Propagation of *Dyckia brevifolia*, An Ornamental and Endangered Bromeliad. *Horticulturae*, 8:(5), 390.
6. Carneiro, L. A., Araújo, R. F. G., Brito, G. J. M., Fonseca, M. H. P. B., Costa, A., Crocomo, O. J., and Mansur, E. (1998). *In vitro* regeneration from leaf explants of *Neoregelia cruenta* (R. Graham) LB Smith, an endemic bromeliad from Eastern Brazil. *Plant Cell, Tissue and Organ Culture*, 55:79-83.
7. Davidson, S. E., and Donnan Jr, A. (1977). *In vitro* Propagation of Cryptanthus Spp. In *Proceedings of the Florida State Horticultural Society*. 90: 303-303.
8. Devika, R., Pillai, J. K., and Arockiamary, S. N. (2012). *In vitro* micropropagation Of *Sphaeranthus amaranthoides* Burm. F. *Recent Research in Science and Technology*, *4:*(4),1-4
9. Droste, A., Silva, A. M. D., Matos, A. V., and Almeida, J. W. D. (2005). *In vitro* culture of *Vriesea gigantea* and *Vriesea philippocoburgii*: two vulnerable bromeliads native to Southern Brazil. *Brazilian Archives of biology and Technology*, 48:717-722.
10. Farahani, F. (2014). Micropropagation and growth of *in vitro* pineapple (*Ananas comosus* L. Merr) in Iran. *Plant Archives*, 14(1): 337-341.
11. Faria Souza, M. J. M., Thomaz, D. V., Carneiro, L. A., de Aguiar, D. V. A., Vaz, B. G., Sousa, C. M., and dos Santos, P. A. (2023). *In vitro* micropropagation of *Bromelia balansae* Mez.: effects of light intensity and growth regulators on plant development. *Research, Society and Development*, 12: 1-26.
12. Gouda, E. J., Butcher, D., & Gouda, K. (2020). Encyclopaedia of Bromeliads, version 4. Retrieved on April 1, 2020 from http://bromeliad.nl/encyclopedia/
13. Gratton, J., and Fay, M. F. (1999). *In vitro* propagation of succulent plants. *Plant Cell Culture Protocols*, 111: 135-140
14. Guerra, M. P., and Vesco, L. D. (2010). Strategies for the micropropagation of bromeliads. *Protocols for in vitro propagation of ornamental plants*, 589: 47-66.
15. Huang, P. L., Liao, L. J., Tsai, C. C., and Liu, Z. H. (2011). Micropropagation of bromeliad *Aechmea fasciata* via. floral organ segments and effects of acclimatization on plantlet growth. *Plant Cell, Tissue and Organ Culture (PCTOC)*, 105: 73-78.
16. Huang, P. L., Liu, Z. H., Chang, M. L., and Liao, L. J. (2011). Micropropagation of the bromeliad *Guzmania 'Hilda'via* organogenesis and the effect of α-naphthaleneacetic acid on plantlet elongation. *Scientia horticulturae*, 130(4):894-898.

17. Ismail, H., Kumar, S. M., Aziah, M. Y., Hasnida, N. H., and Nor Aini, A. S. (2016). *In vitro* micropropagation of *Acacia auriculiformis* from selected juvenile sources. *Dendrobiology*, 75: 157-165.
18. Kersten, R. A. (2010). Epifitas vasculares: historico, participacao taxonomica e aspectos relevantes, com enfase na Mata Atlântica. Hoehnea, 37 (1): 9-38. doi:10.1590/S2236-89062010000100001
19. Lima, A. P. P. S., Brito, A. L., and Santana, J. R. F. D. (2020). Micropropagation of Chapada Diamantina ornamental bromeliad. *Ciência Rural*, *50*: 1-6.
20. Martins, J. P. R., de Souza Braga, P. D. C., Rossini, F. P., Conde, L. T., Cipriano, R., Falqueto, A. R., and Gontijo, A. B. P. L. (2022). *In vitro* clonal propagation of *Billbergia zebrina* (Bromeliaceae) and analysis of anatomy and physiology of regenerated plantlets. *Israel Journal of Plant Sciences*, 69: 129-139.
21. Mercier, H., and Kerbauy, G. B. (1995). The importance of tissue culture technique for conservation of endangered Brazilian bromeliads from Atlantic rain forest canopy. *Selbyana*, 16(2): 147-149.
22. Pickens, K. A., Wolf, J., Affolter, J. M., and Wetzstein, H. Y. (2006). Adventitious bud development and regeneration in *Tillandsia eizii*. *In Vitro Cellular and Developmental Biology-Plant*, *42*: 348-353.
23. Pompelli, M. F., and Guerra, M. P. (2005). Micropropagation enables the mass propagation and conservation of *Dyckia distachya Hassler*. *Crop Breeding and Applied Biotechnology*, 5: 117-124.
24. Pompelli, M. F., Fernandes, D., and Guerra, M. P. (2005). Somatic embryogenesis in *Dyckia distachya Hassler* (Bromeliaceae)-an endangered bromeliad from South Brazil. *Propagation of Ornamental Plants*, *5*(4): 192-198.
25. Santa-Rosa, S., Souza, F. V., Vidal, Á. M., Ledo, C. A. D. S., and de Santana, J. R. (2013). Micropropagation of the ornamental vulnerable bromeliads *Aechmea blanchetiana* and *Aechmea distichantha*. *Horticultura Brasileira*, *31*: 112-118.
26. Silva, S. S., de Souza, E. H., Souza, F. V. D., Nepomuceno, C. F., and de Carvalho Costa, M. A. P. (2020). Micropropagation and *in vitro* conservation of *Alcantarea nahoumii* (Bromeliaceae), an endemic and endangered species of the Brazilian Atlantic Forest. *Acta Scientiarum. Biological Sciences*, *42*: 1-10.
27. Silva, A. L. L., Costa, J. D. L., Alcantara, G. B., Carvalho, D. C., Schuck, M. R., Biasi, L. A., and Soccol, C. R. (2012). Micropropagation of *Nidularium procerum Lindm*. (Bromeliaceae). *Pak J Bot*, *44*(3), 1095-1101.
28. Silva, A. L. L., Costa, J. D. L., Alcantara, G. B., Carvalho, D. C., Schuck, M. R., Biasi, L. A., and Soccol, C. R. (2012). Micropropagation of *Nidularium innocentii Lem*. (Bromeliaceae). *Pak J Bot*, *44*(3), 1095-1101.
29. Silva, A. L. L., Dornelles, E. B., Bisognin, D. A., Franco, E. T. H., and Horbach, M. A. (2007). Micropropagation of *Dyckia agudensis* Irgang and Sobral–an extinction threatened bromeliad. *Iheringia, Serie Botânica.*, 62: 39-44.
30. Silva, T. C., Luiz, C., de Oliveira, M. T., Borghezan, M., Pescador, R., and Junior, P. C. P. F. (2022). Physiological responses of *Aechmea setigera Mart*. ex Schult. and Schult. f. (Bromeliaceae) in vitro cultured. *Journal of Biotechnology and Biodiversity*, *10*(1): 016-025.
31. Silveira, D. G., Souza, F. V. D., Pelacani, C. R., Souza, A. D. S., Ledo, C. A. D. S., and Santana, J. R. F. D. (2009). Micropropagation and *in vitro* conservation of *Neoglaziovia variegata* (Arr. Cam.) Mez, a fiber producing bromeliad from Brazil. *Brazilian Archives of Biology and Technology*, *52*: 923-932.
32. Simão, M. J., Faria, D. V., Werner, E. T., Soares, T. C. B., & Gontijo, A. B. P. L. (2016). Induction of in *vitro shoots* of *Billbergia euphemiae* E. Morren (Bromeliaceae) from leaf explants. Acta Scientiarum Biological Sciences, 38(2), 207-213. doi: 10.4025/actascibiolsci.
33. Souza, M. S. O., da Silva, E. C., Ciano, G. S. O. S., de Jacobi, C. C. B., Bonsucesso, J. A. S., and de Almeida, W. A. B. (2021). Assessment of minimum growth conditions for in vitro conservation of *Passiflora edulis Sims*. *Journal of Medicinal Plants Research*, *15*(8), 351-365.
34. Todorovic, I., and Vinterhalter, D. (1997). Factors affecting *in vitro* rooting of *Cryptanthus bromelioides* (Otto and Dietr.). 29: 143-148.
35. Usman, Inuwa S., Maimuna M. Abdulmalik, Lawan A. Sani, and Ahmed N. Muhammad. (2013). Development of an efficient protocol for micropropagation of pineapple *(Ananas comosus L. var. Smooth Cayenne). African Journal of Agricultural Research* 8(18): 2053-2056.

36. Vesco D. L., de Almeida Pinto, A., Zaffari, G. R., Nodari, R. O., Dos Reis, M. S., and Guerra, M. P. (2001). Improving pineapple micropropagation protocol through explant size and medium composition manipulation. *Fruits*, *56*(3): 143-154.
37. Vesco D. L., Pescador, R., Prado, J. P. C., Welter, L. J., and Guerra, M. P. (2014). *In vitro* propagation of *Vriesea reitzii*, a native epiphyte bromeliad from the Atlantic rainforest. *Acta Scientiarum. Biological Sciences*, *36*(3): 271-278.
38. Villanueva, E., Garrido-Aguilar, D. C., Pinzón-López, L. L., and Reyes-Ramírez, A. (2022). *In vitro* establishment and multiplication of *Aechmea fasciata* (Lindl.) Baker, a bromeliad of commercial interest. *Agro Productividad*. 15(5): 85-91.
39. Vinterhalter, B., and Vinterhalter, D. (1994). True-to-the type *in vitro* propagation of *Aechmea fasciata Baker*. Scientia Horticulturae, *57*(3): 253-263.