In vitro propagation of valuable ornamental *Aglaonema species*: A review

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ABSTRACT

Aglaonema is a colorful evergreen plant with eye-catching leaves that is suitable for interior landscaping due to its low growth requirements, tolerance to low relative humidity, and low light levels. Micropropagation techniques are advanced vegetative propagation methods that yield a large number of uniform and pathogen-free transplants in a short period of time, while requiring less greenhouse space for stock plant culture. By using micropropagation techniques, a new cultivar can be improved quickly enough to reach commercial output levels. The difficulty of establishing a sterile culture is the main cause of its inefficiency. Secondly, low rate of multiplication with slow growth rate. *In vitro* methods provide both physiologically consistent plant development and rapid multiplication. To find an efficient propagation technique, this review can help to analysis multiple micropropagation protocols, specially looking at plant growth regulators and their different levels. In order to create an effective micropropagation strategy, it is important to understand the endogenous level of PGR and supplied level to manipulate the growth of cultures. Endogenous and exogenously supplied plant growth regulator plays an important role during establishment, multiplication, rooting of cultures. In this review paper, accounts of various researches are given and also encounter the problems associated with regeneration, to enhance rate of multiplication with respect to plant growth regulators.

Key words: *Aglaonema*, *in vitro* propagation, growth regulators, ornamental foliages**.**

INTRODUCTION

The genus Aglaonema is Monocotyledon plant that belongs to the family Araceae and consists of 21 species (Zahra and Win, 2020). Their species have been used as landscape or potted ornamental plants. These are hugely popular houseplants due to their fantastic looks and easy care requirements. Aglaonema have been grown as luck-bringing ornamental plants in Asia for centuries (Chen *et al*., 2003). These perennial plants can grow along the ground and may root around the nodes of their upright, decumbent stems. Including the greatest lovely form and color combination of the leaves; examples are green and orange, green and red, green and yellow, green and white, green and pink, and so on (Mariani *et al.,* 2011). The inflorescence form known as a spadix is seen in these species (Mariani et al., 2011). Cuttings are almost always the first step in the commercial production of Aglaonema. Cutting propagation, however, might make it possible for illnesses to transfer from stock plants to cuttings. Moreover, cuttings from Aglaonema cultivars that contain endogenous pathogens in their vascular tissue may be means of disease transmission.

The most efficient method for quickly multiplying healthy plants is tissue culture. One of the main issues with ornamental aroid tissue culture—which includes Anthurium Lind, Dieffenbachia Schott, Philodendron Schott, Spathiphyllum Schott, Syngonium Schott, and Zantedeschia Spreng—is endogenous microbial contamination. The majority of Aglaonema *spp*. have been reproduced by removing the roots section from nodes or shoot basal division as the fundamental technique because to the non-simultaneous blooming and short pollen life cycle, which make sexual reproduction problematic (Ahmed *et. al*, 2018). Tissue culture of Aglaonema has not been very fruitful, and the literature currently has very little information.

The micropropagation technique is an advanced method of vegetative propagation that enables the production of a significant quantity of uniform and pathogen-free transplants within a short timeframe and limited space. This technique reduces the greenhouse space required for stock plant production and offers growers a continuous supply of tissue-cultured plantlets grown in cell plug trays throughout the year.

Problems in micropropagation establishment of *Aglaonema*

The quality and health of the plants are being impacted by several factors. Firstly, there is an issue with some plant tissues that, when harmed or injured and exposed to air, quickly become brown. This browning could be a sign of underlying environmental or physiological problems. Secondly, a variety of bacterial and fungal activities have been observed in many former explants, which may be harmful to their general development and health. Microbes often present on surfaces coat explants from different environments and locales, which may lead to contamination and stress on the plants.

Solution for micropropagation of *Aglaonema* during culture initiation:

Firstly, to reduce the browning of explants, they are immersed in an in-antioxidant solution. Solutions of 0.2% Ascorbate with benzyl adenine (BA). Secondly, Choice of explants: most of the time upper sections of the shoot twigs encompassing the apical meristem through the fourth axillary bud were isolated. This meristem gives axenic culture establishment.

Thirdly, Pre-surface sterilization, to reduce the microbial load of explants: Explants are washed under tap water for 30 minutes to remove the surface dust and to decrease contaminants. Followed by treatment with a solution of contact and systemic bactericide and fungicide (each-100mg/l) for 30 min.

Finally, To obtain axenic cultures explants treated with mercuric chloride ($HgCl_2$) and/or commercial bleach containing sodium hypochlorite to prevent the development of undesired fungal and bacterial contamination that would damage the quality and regeneration ability of the tissues.

Table1: *In vitro* propagation of various *Aglonema* varieties and cultivars with their key outcomes

Sr. No.	Variety	Explants	Surface sterilization	Medium composition			Incubations condition	Potting mixture for hardening	Results	References
				Medium used	PGR's	Solidifying agent				
1	*Aglaonema commutatum*	Shoots	$HgCl_2$ (0.3%) 15 min. NaOCl, 5.25% free chlorine at 30% for 15 min.	MS media	BA (0.0 to 8.0 mg/l). IAA/ IBA/ NAA 0.0 to 2 mg/l	Agar	2000 lux. 16 hrs. at 25 ± 2°C	Peat moss + Sand (1:1, V/V)	**Shoots formation:** BA at 8.0 mg/l. **Shoots and root formation:** NAA at 0.5 mg/l combined with 8.0 mg/l BA. **Rooting:** 1.0 mg/l of IAA or NAA	Abass, *et.al.*, 2016.
2	*Aglaonema var. Cochin*	Axillary shoot	Antracol fungicide, 70% alcohol, 50% chlorox + 2 drops of Tween-20 for 10 min explants near the root and 20% chlorox + 2 drops of Tween-20.	MS media	1.5 mg/l TDZ 3 mg/l BAP	Agar	16 h for 25°C	-	1.5 mg/l TDZ, 3 mg/l IBA	Mariani *et. al.*, 2011.
3	*Lady valentine*	Axillary shoots	70% ethanol $HgCl_2$ at 0.1% (v/v) "Tween-20" NaOCl at 10%.	MS media	NAA : 0 to 1.0 mg/l, BA : 0 to 5 mg/l, and TDZ 0 to 2.0 mg/l NAA 0 to 2.0 mg/l,	Agar	16 hr daily light and 8 hr darkness 25 ± 1°C.	Peat moss, perlite and sand (2.:1: 1, v/v/v).	Root formation : 1.0 mg/l NAA and IBA to the medium.	Hoda I.M. El-Gedawey and Samar E. Hussein 2022.

					and IBA 0 to 2.0 mg/l					
4	*Aglaonema simplex*	Shoots	-	MS media	3mg/l of 6 BAP	Agar	16 hr	-	-	Ahmad *et.al.*, 2008.
5	*Aglaonema sp*	Shoot	-	MS media	0.5 mg. l-1 NAA and 2 mg. l-1 TDZ	Agar	-	-	-	Zahara *et.al.*,2020
6	*Aglaonema commutatum*	Shoot segments with side buds.	-	MS media	BA (0-6 mg/l)	Agar	-	-	Shoot formation: 1.5 mg/L BA Shoot Shoot proliferation: BAP 2.5mg/l + NAA -/L NAA 0.05-0.1 mg/l Root formation: ½ MS + NAA 0.2-0.5 mg/L	Zhang *et.al.*, 2004.
7	*Aglaonema*	Axillary bud	NaOCl 10%	MS media	BA (0 to 30.0 mM) TDZ (0 to 20 mM)	Agar	25 ± 2 ^{0}C 12-h	-	Shoot formation : 30 mM BA Root formation : IBA at 9.8 or 19.7 mM	Chen and Yeh, 2007
8	*Aglaonema*	Shoot	70% ethanol $HgCl_2$ at 0.1% (v/v) with "Tween-20".	MS media	BA (0 to 5mg/l) IBA and NAA (0.0 to 2 mg/l)	Agar	16 hr daily light and 8 hr darkness 25 ± 1°C	mixture of the perlite 0 to 2 volume and peatmoss at 0 to 4 volume.	Multiplication: BA and NAA at 4.00 and 1.00 mg/l, respectively Root formation : IBA and NAA at 0.50 and 0.25 mg/l, respectively	Ahmed *et.al.*,2018
9	*Aglaonema*	Adventitious shoot	70% ethanol 1% NaOCl, Tween-20.	MS media	0.5mg·l^{-1} NAA and 2mg·l^{-1} TDZ 0.5–5mg·l^{-1} BA	Agar	16/8 h 25±2°C	-	-	Fang, *et.al.*, 2013.

10	*Aglaonema*	Axillary shoot explants	-	MS media	BA 0 - 7 mg·L−1, Kin; 0 - 7 mg·L−1, TDZ; 0, 0.5 to 2.0 mg·L−1, NAA 0 to 1.0 mg·L−1, IBA 0 to 1.0 mg·L−1	Agar	-	-	Shoot formation 1.5 mg·L−1 TDZ and 1 mg·L−1 NAA.	Mohammed *et.al.*, 2016.
11	*Aglaonema*	leaf bud explant	50% NaOCl for 30 min. 95% ethyl alcohol.	MS media	5 ppm NAA than 1.5 ppm Kinetin + 2.5 ppm NAA	Agar	26^0C for 10 hrs daily	-	5 ppm NAA than 1.5 ppm Kinetin + 2.5 ppm NAA.	Labasano 2020.
12	*Aglaonema*	Shoots explants	-	MS media	NAA 0.1 and 0.5 mg/l TDZ 0.5 , 1.0 and 2 mg/l	Agar	1500 lux 16 hours light and 8 hours dark that is 25 ± 2 °C	-	0.5 mg/l NAA + 2 mg/l TDZ.	Aziza *et.al.*,2021
13	*Aglaonema*	Axillary shoots	-	MS media	IAA or IBA at 0.5, 1.0 and 2.0 mg/l	Agar	-	-	-	Ahmed *et.al.*,2018.
14	*Aglaonema*	Leaves	5% Tween 20 250- 1000 mg of chitosan 0.5% nitric acid.	MS media	Brassinolide at 50 - 200 ppm chitosan at 250-1000 ppm.	Agar	-	Peat moss and sand (1:1 v:v.).	Root formation brassinolide at 200 ppm and chitosan at 500 ppm	Abul *et.al.*,2014
15	*Aglaonema*	Apical bud	10% (v/v) NaOCl Tween 20 0.1 gL-1 (w/v) ascorbic acid 70% ethanol 5, 10 and 15% (v/v) NaOCl	MS media	4.00 mgL-1 BA + 0.10 mgL-1 NAA + 0.50 mgL-1 TDZ 3.50 mgL-1 BA + 0.20 mgL-1 NAA	Agar	16 h per day. 24 ± 1 °C	peat: perlite: cocopeat (1:1:1)	Nodal formation: 4.00 mgL-1 BA + 0.10 mgL-1 NAA + 0.50 mgL-1 TDZ Leaf formation 3.50 mgL-1 BA + 0.20 mgL-1 NAA. Root formation : 3.00 mgL-1 BA + 0.20 mgL-1 NAA. Root formation : 3.50 mgL-1 BA + 0.20 mgL-	Behazd *et.al.*,2019.

									1 NAA	
16	*Aglaonema Commutatum*	Axillary buds	-	MS media	-	Agar	-	-	Callus formation: MS+0.5 mg/L TDZ+2.0 mg/L 2,4-Dand ½ MS+0.5 mg/L TDZ+2.5 mg/L 2,4-D. Callus differentiation: ½ MS+0.4 mg/L TDZ. Shoots formation: 5.0 mg/L BA+0.2 mg/L NAA and ½ MS+0.5 mg/L TDZ.	Zuopu *et.al*,2018.,
17	*Aglaonema var. Cochin*	shoots	70% alcohol 50% chlorox	MS media	1.5 ppm thidiazuron and 3 ppm BAP.	Agar	-	Moss.	1.5 ppm TDZ and 3 ppm BAP.	Mariani, 2011
18	*Aglaonema modestum*	leaves	-	MS media	-	-	-	-	-	Dong L *et.al.*, 2022.
19	*Aglaonema*	shoots	-	MS media	-	-	-	-	-	Chen *et.al.*,1969
20	*Aglaonema simplex*	Apical bud	NaOCl 0.5 to 2.5 % for 25 min HgCl2 0.5 to 1.5 g/l Tween 20	MS media	2.0 mg/l IBA. BA and Kin at 3.0 3.0 mg/l For 3.0 mg/l IBA	Agar	24 ± 2 °C. 16-h 2000 lux	1:0, 1:1, 2:1, 3:1, 4:1 and 5:1 (v/v) peatmoss and sand .	Shoot formation : 2.0 mg/l IBA. BA and Kin at 3.0 and 3.0 mg/l Root formation : 3.0 mg/l IBA.	Gehan, 2021.
21	*Aglaonema widuri*	Shoots	10% (v/v) NaOCl and Tween 20.	MS media	**BA:** 0.00 to 4.00 mg l^{-1} **TDZ:** 0.00 to 1.00 mg l^{-1} , **2-Ip:** 0.00 and 7.00 mg	Agar	24 ± 1° C and 16 h	Peat, perlite, cocopeat (1:1:1)	Shoot formation: BA and NAA 3.00 mg l-1+ 0.2 mg l Nodal formation: 4.00 mg l-1 BA + 0.10	Behazd *et.al.*, 2019..

					l^{-1} **NAA:** 0.00 to 0.40 mg l^{-1}				mg l-1 NAA + 0.50 mg l-1 TDZ. Leaf formation: 3.50 mg l-1 BA + 0.20 mg l-1 NAA. Root formation: 3.00 mg l-1 BA + 0.20 mg l-1 NAA.	
22	*Aglaonema commutatum*	Nodal explants	Tween 20 0.5% Bavistin,70% ethanol 0.1% $HgCl_2$	MS media	BA and NAA (3.0, 0.5 +2.5, 1.0 +2.0, 1.5 +1.5, 2.0 +1.0 mg/l respectively.	Agar	-	-	Shoot formation : 4.0 mg/l BA + 1.0 mg/l NAA Root formation : 0.5 mg/l IBA + 0.25 mg/l NAA.	Gadhe and kale 2023.
23	*A. commutatum Red Valentine*	Leaf	-	MS media	-	-	-	-	-	Kunlin *et.al.*, 2023.
24	*Aglaonema commutatum*	Leaf	-	MS media	-	-	-	-	-	Guohua *et.al* 2022.
25	*Aglaonema simplex*	Leaf	-	MS media	-	-	-	-	-	
26	*Aglaonema Schott'White Tip' t*	Inflorescence	NaOCl 0.5% or 1.0%	MS media		Agar	5 ± 1°C 16h.	-	Shoot formation: 5 to 10 µM Dicamba and 10 µM TDZ.	Yeh *et.al.*, 2007.
27	*Aglaonema 'White Tip*	Axillary buds	1%NaOCl.	MS media	BAP: 0 to 30 µM TDZ: 0 to 20 µM	Agar	25 – 2 °C under 12-h	4 parts sphagnumpeat:1 part perlite:1 part vermiculite -	30 mM BA IBA at 9.8 or 19.7 mM.	Chen and Yeh, 2007.
28	*Aglaonema var. Cochin*	axillary shoot explants		MS media	-	Agar			1.5 mg/l TDZ 3 mg/l BAP	Mariani *et, al.* 2011.
29	*Aglaonema sp. var. Siam Pearl, Aglaonema sp. var. Lady Valentine,*	Leaf		MS media	IAA 0,5 mg/l, 2 mg/l, 3 mg/l, 5 mg/l, and 8 mg/l and BAP 5 mg/l	Agar	-	-	Callus formation : 5 mg/l IAA, 5mg/l BAP, and 8 mg/l IAA.	Dewi *et.al.*, 2012.

	and Aglaonema sp. var. Lipstik									
30	*Aglaonema Cecilia, Aglaonema commutatum*	Shoot tips	$HgCl_2$ (0.1 %) for 5 min, NaOCl 50% for 20 min.	MS media	kin, BA or 2-ip each at 3.0 to 7.0 mg/l IAA or IBA from 0.5 to 2.0 mg/1.	Agar	-25±2 °C and 16 hr	Peat moss Vermiciilite + Perlite (1:1:0.5).	Root formation : 2-ip: 7mg/l Root formation : 2.0 mg/1 IBA.	Hussein, 2002
31	*Aglaonema*	Shoots	70% alcohol 0.25% NaOCl 0.12% 0.1% $HgCl_2$.	MS media	-	Agar	-	-	-	Salomy, 2022.

Conclusion

The propagation and cultivation of *Aglaonema* plants in controlled laboratory environments offer innovative solutions for the mass production of species with ornamental and ecological significance. To overcome conventional methods of propagation and to scale up production for commercial value it is important to understanding the levels of plant growth regulators. Endogenous level and exogenously supplied plant growth regulator plays an important role during regeneration of plantlets and these are species to specific. For multiplication *Aglaonema*, combinations of cytokinin BAP ranging from 0.25 mg/L BAP to 5 mg/l BAP which is more effective. To increase rooting response, it is important to lower down endogenous level of cytokinin, for this one passage is carried out on a lower concentration of auxins or on a growth regulator-free medium. The analysis of various studies indicates that nodal segment can be effectively used for *Aglaonema* plant *in vitro* propagation. Full-strength of MS medium and hormones like BA, NAA, and IBA are helpful for initiation and multiplication, organogenesis and root formation, respectively. During hardening temperature, light, humidity with respect to species maintained. The most effective culture condition is 25°C temperature and 16/8 light/Dark photoperiod.

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