

## Abstract

*Alternanthera* species are perennial herbs or shrubs. *A. sessilis* 'Green' and *A. ficoidea* are weeds, *A. sessilis* 'Red' is a medicinal herb while *A. brasiliana* and *A. bettzickiana* are ornamental plants. All these species are introduced from tropical America except *A. sessilis*, which is indigenous to Malesia.

The time taken for a single flower to develop from a bud to young seedling for the red and green leaf form of *A. sessilis* is 19–40 and 21–50 days respectively while it is 31–99 days in *A. brasiliana*.

The anther is bisporangiate and the wall development is of the Monocotyledonous and occasionally Dicotyledonous type. Simultaneous cytokinesis during microsporogenesis resulted in mostly tetrahedral and rarely isobilateral or decussate tetrads. The mature pollen grains are shed at the three-celled stage.

The ovule is campylotropus, crassinucellate and the micropyle is formed by the inner integument only. The nectar glands are located at the inner base of the filament in all the species studied except in *A. brasiliana*. The development of the embryo sac conforms to the monosporic *Polygonum* type. The fertilization is porogamous and the endosperm development is of the *ab initio* Nuclear type. The embryo development in *A. sessilis* follows the transitional form between the Chenopodiad-type and Solanad-type.

Present study in the breeding system and embryology show that *A. brasiliana* is an obligate apomict due to cytoplasmic male sterility and early egg cell abortion. Absence of fibrous thickening in the endothecium caused anther indehiscence while absence of ubiquitin granules and early tapetum degeneration caused microspore abortion. The adventive nucellar embryo is without suspensor and the endosperm development is of the autonomous type. Polyembryony is occasionally noted.

*Alternanthera bettzickiana* is a sterile plant due to cytoplasmic male sterility and egg cell abortion. Neither coenocytic microspores nor the normal microspore tetrads develop into mature pollen grains despite the presence of the tapetum and ubiquinol granules.

Pollen grains of *Alternanthera* are dodecahedral, isopolar and small. Apertures of *A. sessilis* and *A. ficoidea* are pantoporate with twelve round pores, whereas the pollen grains of *A. paronychioides* have eighteen oval pores. These pores are covered by rectangular, sinuous or elongated ectexinous bodies. The sexine is metareticulate and tectum perforate with unevenly distributed perforations at the top and base of the mesoporia, except in the pollen grains of *A. ficoidea*, in which the perforations are distributed unevenly along the microspines at the top of the mesoporia only.

In *A. sessilis*, the optimum sucrose concentration for pollen germination in the 'Red' and 'Green' is 16% and 14–18% respectively. Pollination experiments revealed that the breeding system is facultative xenogamy and the 'Red' and 'Green' could interbreed. Thus, the result of morphology, embryology, palynology and breeding system show that *A. sessilis* 'Red' and 'Green' are of the same species.

Both the sexually derived embryo and adventive embryo are characterized as dicotyledonous, curved and annular. The seed coat is made up of the outer layer and a small part of the inner layer of the outer integument. The seeds show epigeal germination.

## Abstrak

Spesies *Alternanthera* adalah saka herba atau pokok renek. *Alternanthera sessilis* berdaun hijau dan *A. ficoidea* adalah rumpai; *A. sessilis* berdaun merah adalah herba perubatan manakala *A. brasiliana* dan *A. bettzickiana* adalah tumbuhan hiasan. Semua spesies ini diperkenalkan dari Amerika Tropica kecuali *A. sessilis*.

Masa yang diambil untuk bertumbuh dari putik ke anak benih muda dalam *A. sessilis* berdaun merah dan hijau adalah 19–40 dan 21–50 hari masing-masing. Manakala, *A. brasiliana* memerlukan 31–99 hari untuk proses yang sama.

Anter adalah bisporiangiat dan perkembangan dinding anter mematuhi jenis monokot, jenis dikot sekali sekala diperhatikan. Sitokinesis serentak semasa microsporogenesis membentuk kebanyakannya tetrad tetrahedral dan jarang 'isobilateral' atau 'decusate'. Debunga matang dibentuk di peringkat tiga sel.

Ovul ialah kampilotropus, krasinusetat, bitegmik, dan mikropil dibentuk daripada integumen dalam sahaja. Kelenjar nektar terletak di pangkal dalaman filamen semua spesies kecuali *A. brasiliana*. Perkembangan pundi embrio mematuhi jenis monosporik *Polygonum*. Persenyawan adalah jenis porogamus dan perkembangan endosperma adalah jenis *ab initio* Nukelus. Perkembangan embrio dalam *A. sessilis* mematuhi bentuk peralihan antara jenis Chenopodiad dan Solanad.

Kajian sistem pembiakan dan embriologi menunjukkan bahawa *A. brasiliana* adalah spesies apomik yang disebabkan oleh kemandulan sitoplasmik dalam mikrospora dan pengguguran awal sel telur. Ketiadaan penebalan berserabut dalam endotesium menyebabkan anter tidak dehis. Pengguguran mikrospora adalah disebabkan oleh ketiadaan granul ubisch dan kemerosotan awal tapetum. Embrio

nuselar adventif adalah tanpa suspensor dan perkembangan endosperma mengikuti jenis autonomi. Poliembrioni diperhatikan sekali sekala.

*Alternanthera bettzickiana* adalah tumbuhan steril yang disebabkan oleh kemandulan sitoplasmik dalam mikrospora dan pengguguran sel telur. Kedua-dua mikrospora sinositik dan tetrad mikrospora tidak membentuk debunga matang walaupun tapetum dan granul ubisch diperhatikan.

Debunga *Alternanthera* adalah dodekahedrik, isopolar dan kecil. *Alternanthera sessilis* dan *A. ficoidea* mempunyai 12 liang bulat manakala debunga *A. paronychioides* mempunyai 18 liang bujur. Liang-liang ini diselaputi oleh jasad ektexinus yang bersegi empat. Eksin adalah metaretikulat dengan 'perforation' tersebar di seluruh mesoporia, kecuali dalam debunga *A. ficoidea* dimana 'perforation' tersebar secara tak sekata di atas mesoporia sahaja.

Kepekatan optima sukrosa untuk percambahan debunga adalah 16% dan 14–18% dalam *A. sessilis* berdaun merah dan hijau masing-masing. Ujikaji pendebungaan menunjukkan sistem pembiakan *A. sessilis* adalah xenogami fakultatif. *Alternanthera sessilis* berdaun merah dan hijau adalah daripada spesies yang sama kerana mereka boleh berkacuk dan menghasilkan buah.

Kedua-dua embrio yang terhasil secara seksual dan embrio adventif adalah jenis dikot, melengkung dan annulus. Salut biji benih terdiri daripada lapisan luar dan sebahagian kecil daripada lapisan dalaman integumen luar. Benih menunjukkan percambahan epigeal.

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## List of Symbols and Abbreviations

i.e.	id est (that is)
cm	centimetre
<i>et al.</i>	et alia (and other)
E	equatorial diameter
g	gram
KLU	The University of Malaya Herbarium
KEP	The Forest Research Institute Malaysia Herbarium
UKMB	The University of Kebangsaan Malaysia Herbarium
SING	The Singapore Herbarium
L	liter
LM	light microscope
ml	millilitre
µm	micrometre
µl	microlitre
mm	millimetre
n.a.	not available
P	polar length
R.P.M.	rotation per minute
SEM	scanning electron microscope
var.	variety (botany)
s.n.	sine numero
–	long dash
&	and
°C	degree Celsius
%	percentage
<	less than
>	more than

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