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SEED GERMIN ATION OF A vicennia marina (F or sk.) V ierh. BY PERICARP REMO V AL TREATMENT * HER Y PURNOB ASUKI and ED Y SETITI WID A UT AMI De par tment of Biolo g y , F aculty of Sciences and T echnolo g y Airlang g a Uni versity , Surabay a 60115, Indonesia R ecei v ed 12 No v ember 2013/Acce pted 28 Se ptember 2016 ABSTRACT Av i ce nni a m ari na i s one s pe c i e s u s e d f or bu i l d i ng c oas t al e c os y s t e m s t abi l i zat i on i n S u r aba y a s hor e s be c au s e of i t s t ole r anc e t o hig h s al i nit y l e v e l and r e s i s t anc e t o w a v e e ne r g y . T he i r e x i s t e nc e i s t hr e at e ne d b y v ar i ou s f ac t or s i . e .

l and c on v e r s i on, poll u t i on and i nt e r i s l and br i d g e e x i s t e nc e . G r o w t h of A. m ari na i s c u r r e nt l y l i mi t e d b y s e e d d or m anc y . In an e f f or t t o i nc r e as e pr opag at i on e f f i c i e nc y , s e e d vi abi l i t y and v i g or w e r e c ompar e d bas e d on c oll e c t i on d at e s and pe r i c ar p r e m o v al me t hod s .

T he r e s u l t s s ho w e d no r e l at i ons hip be t w e e n s al i nit y l e v e l s of s oak i ng w at e r or s e e d bu o y anc y and s e e d v i abi l i t y or s e e d v i g or . Col l e c t i on d at e s m a y i nf l u e nc e s e e d v i abi l i t y and v i g or . Se e d s c oll e c t e d i n Oc t obe r and N o v e m be r g e r m i nat e d m or e q u i c k l y t han t hos e c oll e c t e d i n D e c e m be r , al t hou g h t he r e w e r e no d i f f e r e nc e s i n t ot al g e r mi nat i on.

Hand - pe e l e d s e e d s g e r mi nat e d mor e s l o w l y t han s oak e d s e e d s f or al l c oll e c t i ons , bu t w i t h no d i f f e r e nc e s i n t ot al g e r m i nat i on. Se e d s c oll e c t e d i n Oc t obe r and No v e m be r g r e w mor e v i g or ou s l y t han t hos e c oll e c t e d i n D e c e mbe r .

K eyw ords : Avicennia marina , propag ation eficiency , seed viability INTR ODUCTION Avicennia marina (the g ra y mang ro v e) produces recalcitrant seeds , dispersed b y tidal cur rents . T he dispersal unit or propagule of A. marina is the fr uit, whic h usually consists of a single embr y o sur rounded b y a thin pericar p (T omlinson 1986).

T he fr uit is considered to be cr ypto vi viparous, a condition where the h ypocotyl does not enlarg e sufficiently to r upture the pericar p while attac h to the parent (Hutc hings & Saeng er 1987). Seeds of A. marina are cr ypto vi viparous and do not ha v e a d o r m a n t s t a g e r e s u l t i n g i n g e r m i n a t i o n possibility while still attac h to the parent plant (T omlinson 1986; F ar nsw or th 2000). A.

marina seeds possess a h y drophilic pericar p , whic h seed is abscised, shed upon contact with w ater (T omlinson 1986). T he seeds are dispersed tidally and ma y remain viable while af loat in agitated sea w ater for up to one year , although viability decreases o v er time (USD A 2009). T ypical A.

marina seed g er mination initiates when a propagule comes to rest on a suitable substrate suc h as tidal m ud f lat, beac h or within a Spar tina spp . marsh (Lewis 2000). T his e pig eal g er mination is first obser v ed with the extension of a g eotropic root radical into the soil where the seed comes to rest. T he h ypocotyl extends to become a v er tical stalk suppor ting the cotyledon (T omlinson 1986).

T he propagule then extends its e picotyl, from whic h the first tr ue lea v es emerg e , allo wing the plant to inde pendently photosynthesize the seed. T he cotyledons are then desiccated and abscised (T omlinson 1986). Seed g er mination is controlled b y a n umber of mec hanisms and is necessar y for g ro wth and dev elopment of the embr y o , resulting in the ev entual production of a new plant. Under unfa v orable conditions , seeds ma y become dor mant (secondar y dor mancy) to maintain their g er mination ability .

Ho w ev er , when the conditions are fa v orable , seeds can g er minate (Miransari & Smith 2014). Among f a c t o r s c o n t r o l l i n g s e e d g e r m i n a t i o n a n d dor mancy is seed pericar p remo v al (Sari et al . 2006). Seed pericar p is responsible for seed- coating dor mancy , affecting seed g er mination and s e e d l i n g e s t a b l i s h m e n t b y p r e v e n t i n g w a t e r BIOTR OPIA 3 2 6 74 83 V ol. 2 No . , 201 : - DOI: 10.11598/btb .2016.2 . .3 2 349 * C or responding author : her y-p@fst.unair .ac .id 74 a b s o r p t i o n , p r o d u c i n g c h e m i c a l i n h i b i t o r s , prev enting leaking of inhibitors from the seed and inhibiting the radical protr usion (Simpson 1990; Baskin & Baskin 1998; Og a w a & Iw abuc hi 2001; T ak os 2001; Sari et al. 2006).

T he effect of the pericar p on g er mination de pends on seed size and w ater a v ailability (Chac¢on & Bustamante 2001). R e producti v e success in plants is highly de pendent on the sur vi v al of their seeds during dispersal. T he conditions in whic h seeds reside a f t e r l e a v i n g t h e p a r e n t t r e e t o w a r d s establishment, and the adaptations of seeds for sur vi ving these conditions are cr ucial.

Seedling e s t a b l i s h m e n t i s c o n s i d e r e d d i f f i c u l t f o r mang ro v es because of the unstable and v aried substrates as w ell as tidal inf luence (T omlinson 1986). Hy drological regimes are par ticularly i m p o r t a n t i n c o n t r o l l i n g t h e s u r v i va l a n d subsequent g ro wth of the mang ro v e seedlings (Mur ra y et al . 2003). Mang ro v e habitats in Suraba ya shores are cur rently vulnerable to subsidence and sea lev el rise .

As the integ rity of coastal salt marsh in Suraba ya deg rades , A. marina habitat is threatened b y many acti vities suc h as land con v ersion, pollution and interisland bridg e existence. As a result, mang ro v e stands ma y be per manently in undated or drained; neither of whic h are conduci v e to sur vi v al and establishment.

T he objecti v es of this researc h w ere to deter mine the optimal time to collect seeds and the pericar p remo v al methods to suppor t the highest g er mination rate and to obtain the most vig orous seedling g ro wth of Avicennia marina . MATERIALS AND METHODS Seed Source Avicennia marina seeds w ere collected from mature trees near Suramadu Bridg e , Suraba ya (Fig.

1) on 15 October 2011, 15 No v ember 2011 and 15 December 2011. Fi v e hundred and fifty (550) seeds w ere transpor ted in dr y buc k ets t o t h e B i o l o g y D e p a r t m e n t o f A i r l a n g g a Uni v ersity and w ere maintained indoors at room temperature for 24 hours. T he da y of seed collection w as assigned as da y zero for all time- delineated treatments.

Seed Pr eparation T w o treatments w ere applied to the seeds , one da y after being collected. T he tw o treatments w ere: 1. seeds pre-soak ed in sea w ater ha ving v arious lev els of salinity until the pericar ps w ere self-remo v ed, and 2. hand-peeled dr y seeds . In the first treatment, there w ere 5 lev els of sea w ater salinity i.e . 0, 5, 10, 15 and 20 ppt.

Instant sea salt w as used to mak e these lev els of salinity . T en seeds w ere immersed in eac h of salinity lev el on the first da y after seeds collection (Da y 1). T he intention of seeds immersion w as to self-remo v e the pericar ps and to establish seeds Figure 1 Sampling locations for A.

marina seed har v ests (A, B , C , D and E) near Suramadu bridg e 75 Seed g er mination of Avicennia marina b y pericar p remo v al treatment – Pur nobasuki and Utami buo yancy . s Seed buo yancy w as deter mined after 48 hours . Based on the buo yancy , seeds w ere categ orized as f loaters or sink ers . In the second treatment, pericar ps of 5 seeds w ere hand-peeled on Da y 1. T he peeled seeds w ere categ orized as peeled.

After the pericar ps w ere remo v ed in the first and second treatments , the seeds w ere w eighed and measured along the long est axis . Seed Planting Prior to planting, indi vidual polybags (7.5 x 22 cm) w ere filled with planting media consisted of sphagn um moss and V er miculite mix. P olybags w ere placed in racew a y tables in a g reenhouse at t h e B i o l o g y D e p a r t m e n t o f U n i v e r s i t a s A i r l a n g g a .

T h e r a c e w a y t a b l e s w e r e k e p t submerg ed in sea w ater allo wing planting media to be saturated with seaw ater prior to planting, thus sim ulating natural g er mination conditions (Alleman & Hester 2010). Ther mometers w ere placed in betw een the submerg ed racew a y tables and at the ends of the tables . W ater temperature w as recorded within 30 min utes inter v al for the duration of the study .

Air temperature w as m a i n t a i n e d b e t w e e n 3 5 a n d 3 7 º C u s i n g ther mostat-controlled heaters and exhaust fans. T he pericar p-peeled seeds w ere placed on top of the planting media. One seed w as placed in eac h polybag located on racew a y tables . Eac h seed w as placed similarly oriented, standing v er tically to facilitate equal g ro wth of the radicle into the planting medium.

Seed Ger mination T o deter mine the effect of seed collection dates on seed g er mination, the percentag e of seeds g er mination w as compared based on seed collection dates and the seed treatments i.e . hand- peeled, f loater (0 ppt) and sink er (0 ppt). Fi v e r e p l i c a t i o n s w e r e a p p l i e d t o c o m p a r e t h e p e r c e n t a g e o f s e e d s g e r m i n a t i o n .

T h e comparison w as car ried out on Da y 48 i.e . on 15 Marc h 2012 to allo w the earliest planting of A. marina in Suraba ya coastal area. Ger mination R ate Avicennia marina produces cr ypto vi viparous p r o p a g u l e s w h i c h m e a n s t h a t e m b r y o n i c axis/h ypocotyl of the dev eloping embr y o does n o t p e n e t r a t e t h e s e e d c o a t .

T h e r e f o r e , s e e d g e r m i n a t i o n wa s r e c o r d e d w h e n t h e e picotyl's tr ue lea v es w ere visible bey ond the c o t y l e d o n (F i g . 2) . P r o p a g u l e v i a b i l i t y w a s recorded daily for the first 28 da ys for eac h treatment b y obser ving the vig or and g ro wth. Ger mination rate is deter mined b y calculating the g er mination percentag e of different time inter v al after planting and then plotting these data.

T he cum ulati v e g er mination o v er time w as compared among treatments . T he g er mination rate of eac h treatment w as calculated using for m ula as follo ws (Ranal & De Santana 2006): Ger mination P ercenta ge Ger mination percentag e is the n umber of g e r m i n a t e d s e e d s f r o m a s e e d p o p u l a t i o n .

Ger mination percentag e of seeds w as compared among treatments after 28 da ys of study . P ercentag e of seed g er mination w as calculated for eac h re plication, from whic h the a v erag e w as calculated for eac h treatment. Figure 2 Basic post-g er mination anatom y of an Avicennia marina propagule (Cr umbie 1987) Seedling V igor Seedling vig or w as quantified b y measuring seedling height (mm) and stem length (mm) from the soil surface to the ter minal bud.

Mean height of plants for eac h seed collection date w as measured three times during the g ro wing period. Seedlings from seeds collected in October w ere 76 BIOTR OPIA V ol. 23 No . 2, 2016 measured at 62, 75 and 165 Da ys Since Collected (D S C) . S e e d l i n g s f r o m s e e d s c o l l e c t e d i n No v ember w ere measured at 43, 70, 92 and 133 DSC and seedlings from seeds collected in December w ere measured at 79, 104 and 126 DSC . Seeds that had not g er minated w ere not included in the seedling vig or analysis .

Data Anal ysis Analysis of v ariance (ANO V A) and Duncan's Multiple Rang e T est (DMR T) at p< 0.05 w ere car ried out for data analysis . Data w ere analyzed using MS Ex cel and SPSS v ersion 10 to explore p o s s i b l e t r e a t m e n t v a r i a t i o n s . A N O V A w a s car ried out to deter mine the treatments effects on seed g er mination percentag e as w ell as on height and diameter of the seedlings .

DMR T w as used to compare the mean of g er mination percentag e , height and diameter in eac h pre-so wing treatment. RESUL TS AND DISCUSSION Seed g er mination is a response c haracterized b y three parameters i.e . percentag e , rate , and unifor mity (Har tmann et al. 2002). Ger mination percentag e is the n umber of g er minated seeds from a seed population.

Ger mination rate is the "speed or v elocity" of g er mination and can be expressed as the time needed for a defined percentag e of seed to g er minate . Ger mination unifor mity is a measurement of the time needed for all seeds to g er minate . T he mean w eight and length of seeds among the treatments v aried slightly (T able 1).

Ho w ev er , the larg est and the smallest seeds w ere sink ers and there w as no evidence of seed size effect among treatments . Ger mination percentag e w as not linear o v er time and became asymptotic after 40 da ys of seeds collection (Fig . 3). After 28 da ys, the hand-peeled s e e d s t r e a t m e n t h a d t h e l o w e s t (2 1 %) g e r m i n a t i o n p e r c e n t a g e (F i g . 3 a n d 4) .

Ger mination rates for the f loaters and sink ers soak ed in 0 ppt treatments w ere not different from those soak ed in other salinity lev els . Therefore , the subsequent g er mination trials only used seeds soak ed in 0 ppt salinity and hand- peeled seeds for pericar p remo v al (Fig . 3). Seed size is commonly used as an indicator of seed viability and vig or for many plant species (Murali 1997), but the relationship is highly v aried and therefore, typically abandoned as reliable indicator outside ag ricultural applications .

Seed size and buo yancy ha v e been examined in mang ro v e species as indicators of seedling perfor mance , but primarily as factors inf luencing seed dispersal (Rabino witz 1978a, 1978b , 1978c). T he studies of Rabino witz (1978a) sug g ested that the buo yancy and seed size of Avicennia and other mang ro v e species ma y deter mine the zonation of seed de position, but mak e no indication of viability and vig or .

In this study , although seed size v aried slightly, there w ere no differences in g er mination rate among seed sizes. T herefore , s e l e c t i o n o f A . m a r i n a s e e d s w e r e n o t differentiated b y size . T able 1 Mean (±SE) of seed w eight (g) and length (mm) for seeds collected in October T reatment W eight (g) Floaters Sink ers P eeled 0 ppt 4 . 1 ± 0.08 ab 3 .9

± 0.37 ab 5 ppt 4 . 4 ± 0.23 ab 3 .8 ± 0.15 ab 10 ppt 4 .1 ± 0.10 ab 4 .5 ± 0.72 a 15 ppt 3 .9 ± 0.09 ab 3 .2 ± 0.22 b 20 ppt 3 .8 ± 0.11 ab 3 .6 ± 0.24 ab P eeled - - 4 .2 ± 0.07 ab Lengt h (mm) 0 ppt 28.9 ± 0.28 a 29.1 ± 1.33 a 5 ppt 29.9 ± 0.28 a 29.4 ± 0.55 a 10 ppt 28.4 ± 0.37 a 28.7 ± 0.49 a 15 ppt 27.6 ± 0.38 a 24.7 ± 0.89 b 20 ppt 28.7 ± 0.29 a 27.3 ± 1.02 ab P eeled 29.4 ± 0.22 a Notes: Numbers follo w ed b y the same letters in the same column are not significantly different at p <0.05 77 Seed g er mination of Avicennia marina b y pericar p remo v al treatment – Pur nobasuki and Utami Ger mination rates for the f loaters and sink ers soak ed in 0 ppt treatments w ere not different from those soak ed in other salinity lev els .

Therefore , the subsequent g er mination trials only used seeds soak ed in 0 ppt salinity lev el and hand-peeled seeds for pericar p remo v al (Fig . 3). Ger mination percentag es of seeds soak ed in v arious lev els of salinity w ere not significantly different. T herefore , treatment comparison for all collected seeds only used seeds soak ed in 0 ppt salinity lev el (Fig . 4).

Mean of seed sizes v aried among treatments and collection dates , but there w ere no ob vious trends among pericar p remo v al treatments, salinity lev els or collection dates (T able 2). Ger mination rate w as relati v ely different for seeds collected in October , No v ember or December (Fig. 5). Seeds collected in October g er minated faster (78%) than seeds collected in December (11.3%) (Fig . 6).

Ho w ev er , on 15 Marc h 2012 (48 DSC), the a v erag es of g er mination percentag e w ere different among treatments (Fig . 7). Figure 3 Cum ulati v e g er mination percentag e at 48 DSC (Da ys Since Collected) for f loaters , sink ers and peeled treatments for A. marina seeds collected on 1 October 2011.

Si = sink ers exposed to 0 ppt; Fl = f loaters exposed to 0 ppt; P e = peeled seeds; Sob = combinations of seeds soak ed in v arious salinity lev els and buo yancy treatments; v er tical line indicates 28 DSC for seeds collected on 1 October 2011 Figure 4 Mean (±SE) of g er mination percentag e per treatment in 28 DSC for seeds collected on 1 October 2011. F = f loaters; S = sink ers; P = peeled seeds; the n umbers follo wing either F or S re presents salinity lev els .

Bar c har ts ha ving the same letters on top are not significantly different at p <0.05 78 BIOTR OPIA V ol. 23 No . 2, 2016 Seeds peeling to expose embr y os ha v e been car ried out b y other researc hers in different experiments (Ar rillag a et al . 1992). Seeds collected in October and No v ember g er minated sooner than those collected in December , ho w ev er , the total g er mination w as not different in 48 DSC . Seeds collected in October and No v ember g rew to similar sizes in 48 DSC and both g rew more vig orously than those collected in December .

Duration and sea w ater temperature most lik ely inf luenced the seed g er mination and g ro wth rates of seeds collected in December . Fur ther study is w ar ranted to deter mine the relationship betw een duration, sea w ater temperature and propagule perfor mance . Hand-peeled seeds g er minated later compared to seeds soak ed in v arious lev els of s a l i n i t y , b u t w i t h n o d i f f e r e n c e s i n t o t a l g er mination. T he stem length a v erag e of hand- peeled seed w as nominally g reater for all seeds collected b y 15 Marc h 2012.

Agitation of soaking seaw ater at v arious salinity lev els w as obser v ed to dela y g er mination in Avicennia ger minans (McMillan 1971). T he dela y of g er mination displa yed in peeled seeds might indicate that there w ere other stim ulus besides immobilization as an initiator of g er mination in this species, suc h as seed moisture , pericar p abscission and seed abscission.

T he potential for dela yed g er mination of cr ypto vi viparous seed is j u s t i f i c a t i o n f o r f u r t h e r i nv e s t i g a t i o n . T h i s T able 2 Mean (±SE) of seed length (mm) and w eight (g) for f loaters (0 ppt), sink ers (0 ppt) and peeled seeds for seeds collected in October , No v ember and December T reatment Collected in October No v ember December Lengt h (mm) Floaters 2 9 .6 ± 0.28 ab 3 1 .2 ± 0.29 a 28 .4 ± 0.42 b Sink ers 2 9 .4 ± 1.33 ab 2 9 .9 ± 0.34 ab 2 9 .9 ± 0.50 ab P eeled 3 1 .2 ± 0.29 a 2 9 .6 ± 0.29 ab 30 .7 ± 0.31 ab W eight (g) Floaters 3.0 ± 0.08 ab 3.3 ± 0.09 a 2.4 ± 0.13 b Sink ers 2.9 ± 0.37 ab 3.0 ± 0.09 ab 2.9 ± 0.12 ab P eeled 3.2 ± 0.07 a 3.0 ± 0.07 ab 3.2 ± 0.11 a Figure 5 Cum ulati v e ger mination percentag e for seeds collected in October , No v ember and December in 48 DSC, in 0 ppt salinity lev el.

October collection is re presented b y blac k lines; No v ember collection is re presented b y light g ray lines; December collection is re presented b y dark g ray lines . Hand-peeled seeds are re presented b y shor t dashes , f loaters are re presented b y solid lines and sink ers are re presented b y long dashes 79 Seed g er mination of Avicennia marina b y pericar p remo v al treatment – Pur nobasuki and Utami condition w as not consistent with researc h results of Hu et al.

(2009) who re por ted that remo v al of pericar p impro v ed the g er mination percentag e up to 90% from 44% in seeds of Hedysar um scoparium and 60 - 100% in seeds of Or yza sati v a (Miy oshi & Sato 1997). P ericar p remo v al did not pro vide significant effects on seedling perfor mance in ter ms of dr y masses of e picotyls and roots of seedlings .

T his result w as slightly different from the study results of Liu et al . (2012). T his might be caused b y mec hanical constraints rather than c hemical inhibitors . It is g enerally acce pted that e picotyl dor mancy of acor ns in the field is mainly caused b y inhibitors in cotyledons , embr y os or pericar ps (Liu et al .

2012). T his w as consistent with most researc h (R ober tson et al . 2006, Finney 2011) who re por ted pericar p-imposed dor mancy on seeds . O u r s t u d y s u g g e s t e d t h a t p e r i c a r p w a s responsible for seed dor mancy because seeds with intact pericar p w ere v er y dor mant; therefore , remo v al of the pericar p significantly increased g er mination percentag e and resulted in complete g er mination of viable seeds .

Figure 6 Mean (±SE) of g er mination percentag e of A. marina seeds in 48 DSC for seeds collected on 1 October 2011, 1 No v ember 2011 and 1 December 2011. Floaters are re presented b y blac k bars; sink ers are re presented b y g ra y bars; hand-peeled seeds are re presented b y white bars . Bar c har ts ha ving the same letters on top are not significantly different at p <0.05 Figure 7 Mean (±SE) of g er mination percentag e in 48 DSC for seeds collected on 1 October 2011, 1 No v ember 2011 and 1 December 2011.

Floaters are re presented b y blac k bars; sink ers are re presented b y g ra y bars; hand-peeled seeds are re presented b y white bars . Bar c har ts ha ving the same letters on top are not significantly different at p <0.05 80 BIOTR OPIA V ol. 23 No . 2, 2016 T he means of seedlings stem lengths for seeds collected in October and No v ember w ere not s i g n i f i c a n t l y d i f f e r e n t i n 4 8 D S C a m o n g t r e a t m e n t s . H o w e v e r , s e e d s c o l l e c t e d i n December had significantly shor ter seedlings stem length in 48 DSC (Fig. 8).

Rang e of sea w ater salinity in the mang ro v e habitats of Suraba ya coast is 17 - 30 ppt all year round. Sea w ater salinity can widely v ar y due to pollution, hur ricane and f lood whic h introduce larg e v olumes of sea w ater or freshw ater to the coastal estuaries .

T he studies of Rabino witz (1978 a, b , c) and McK ee (1995) indicated that the salinity lev el of the soaking sea w ater used to immerse seeds might affect viability duration during dispersal. Ho w ev er , results of this study indicated that there w ere no cor relations betw een buo yancy or salinity lev el of soaking sea w ater used to immerse seeds and seed viability or vig or.

T h i s s t u d y , h owe v e r , s u g g e s t e d t h a t s e e d s collection date might inf luence seed viability and vig or, suc h as sho wn in the g er mination of Avicennia ger minans (Finney 2011). Seeds collection date is commonly used in hor ticulture and ag riculture to predict seed viability and crop yield as w ell as to obser ve the relationship betw een seed maturity and viability (Basra 1995). Ho w ev er , cor relations betw een early and late seed collections are not consistent among species .

Seeds collected in later dates and their maturity had been sho wn to positi v ely inf luence seed quality and vig or in so ybeans Gly cine max (T eKrony et al. 1984) as w ell as other culti v ated crops and trees (Basra 1995). Maxim um seed viability and vig or occurred earlier in seed maturation for tomatoes Solanum ly copersicum (Demir & Ellis 1992).

R elationships betw een propagule and seed maturity as w ell as viability among vi viparous mang ro v e g enera are poorly defined (F ar nsw or th 2000). T his researc h indicated that salt is not needed in the soaking process to remo v e pericar p. Seeds collected in earlier date experienced quic k er g er mination and subsequently produced larg er plants at the earliest time of field planting.

Ho w ev er , long er maintenance w as required to g ro w the seedlings. Seed collected in later date p r o d u c e d s m a l l e r p l a n t s , b u t r e q u i r e d l e s s g r e e n h o u s e t i m e w i t h n o d i f f e r e n c e i n g er mination viability .

Ger mination can be dela yed for a shor t time b y hand-peeling the pericar ps from dr y seeds with equal or g reater g er mination and g ro wth rates, ho w ev er, it requires more labor (Finney 2011). CONCLUSIONS R e m o v a l o f s e e d p e r i c a r p i m p r o v e d g er mination. T here w ere no cor relations betw een buo yancy or salinity lev el of soaking sea w ater used to immerse seeds and seed viability or vig or.

Seeds collection date might inf luence seed viability and vig or. Seeds collected in October and No v ember g er minated more quic kly than those collected in December , although there w as no Figure 8 Mean (±SE) of seedlings stem length for seeds collected in October , No v ember and December in 48 DSC .

Floaters are re presented b y white bars; sink ers are re presented b y g ra y bars; hand-peeled seeds are re presented b y blac k bars . Bar c har ts ha ving the same letters on top are not significantly different at p <0.05 81 Seed g er mination of Avicennia marina b y pericar p remo v al treatment – Pur nobasuki and Utami significant difference in total g er mination.

Seeds collected in October and No v ember had similar g ro wth and both g rew more vig orously than those collected in December . Simple alterations in seed treatment can enhance seed g er mination. ACKNO WLEDGEMENTS W e thank Djok o Suw ondo for his g reat suppor t in our ?eld researc h and Prof Mitsuo Suzuki PhD .

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