

APPLICATION OF SEED BOMB PLANTING TECHNIQUE FOR PEAT FOREST REHABILITATION

DIMAS NUR MUHAMMAD



**STUDY PROGRAM OF TROPICAL SILVICULTURE
FACULTY OF FORESTRY AND ENVIRONMENT
IPB UNIVERSITY
BOGOR
2025**



@Hak cipta milik IPB University

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

STATEMENT OF GRADUATE THESIS AND INFORMATION SOURCES AND COPYRIGHT TRANSFER

Herewith, the author declares that this graduate thesis entitled “Application of Seed Bomb Planting Technique for Peat Forest Rehabilitation” is truly my scientific work under support of my supervisors. This graduate thesis has yet to be submitted in any form to other universities. All sources of this information, which stemmed from published or unpublished manuscripts, have been mentioned in this graduate thesis and included in reference at the end of this graduate thesis.

Therefore, the author bestows the copyright of this graduate thesis to IPB University, Indonesia

Bogor, August 2025

Dimas Nur Muhammad
Student ID E4501231010



@Hak cipta milik IPB University

IPB University



IPB University
— Bogor Indonesia —

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

Perpustakaan IPB University

SUMMARY

DIMAS NUR MUHAMMAD. Application of Seed Bomb Planting Technique for Peat Forest Rehabilitation. Supervised by ADISTI PERMATASARI PUTRI HARTOYO and IRDIKA MANSUR.

Indonesia's peatlands, globally significant ecosystems critical for biodiversity and climate regulation, face severe degradation from logging, land conversion, and recurrent fires. Rehabilitating these landscapes is a major challenge due to hostile soil conditions (high acidity, low fertility) and the complex accessibility of traditional planting methods. Direct seeding offers a scalable and cost-effective alternative, but its success is often limited by the failure of seeds to germinate. Seed bomb technology, which encases seeds in a protective substrate, simulates a "buried" planting technique that shields the seed and improves its microenvironment. This technology demonstrates significant potential for peatland rehabilitation; therefore, systematic research of its effects on peatland adaptive species is necessary.

This research aimed to: (1) analyze the germination performance of forest tree seeds across different species, (2) analyze the effect of different seed planting techniques (buried and non-buried) on the germination performance of forest tree seeds, and (3) analyze the effect of different seed bomb formulations on the germination performance of forest tree seeds.

The research was conducted through a series of sequential experiments in a controlled greenhouse environment. Six forest tree species were selected: *gamal* (*Gliricidia sepium*), *gelam* (*Melaleuca cajuputi*), *merbau* (*Intsia bijuga*), *nyamplung* (*Calophyllum inophyllum*), *swamp jelutung* (*Dyera polyphylla*), and *kaliandra* (*Calliandra calothyrsus*). The study involved three main tests: (1) a germination test to establish the intrinsic viability of each species; (2) a seed planting technique test comparing buried and non-buried seeds in peat soil; and (3) a seed bomb formula test evaluating three different formulations (F1: Miko-seedcookies + adhesive solution; F2: peat soil + clay + dolomite; F3: peat soil + clay + dolomite + adhesive solution). A dropping test was also conducted to assess the physical durability of the seed bombs. Key parameters measured were germination percentage, germination capacity, mean germination time, and seedling survival rate. All data were statistically analyzed using the Aligned Rank Transform (ART) method followed by an ART-contrast post hoc test.

The germination test revealed variation among species, with *gelam* demonstrating the highest germination performance, while *nyamplung* and *swamp jelutung* were slow to emerge but showed high resilience once established. The planting technique test found no overall significant difference between buried and non-buried seeds under greenhouse conditions, although a significant interaction between species and technique was observed. In the seed bomb formula test, all three formulations effectively supported germination. *Gamal*, *gelam*, and *merbau* proved to be the most compatible with the seed bomb application. In the seed bomb dropping test, the F1 formula was significantly more resistant to impact, showing the lowest destruction index after being dropped from a height of 10 meters.

Keywords: degradation, direct seeding, germination, rehabilitation, seed bomb



RINGKASAN

DIMAS NUR MUHAMMAD. Aplikasi Teknik Tanam *Seed Bomb* untuk Rehabilitasi Lahan Gambut. Dibimbing oleh ADISTI PERMATASARI PUTRI HARTOYO dan IRDIKA MANSUR.

Lahan gambut di Indonesia merupakan ekosistem yang penting untuk keanekaragaman hayati dan pengaturan iklim global, namun lahan gambut menghadapi degradasi yang parah akibat penebangan, konversi lahan, dan kebakaran yang berulang. Rehabilitasi lanskap ini menjadi tantangan besar karena kondisi tanah yang tidak mendukung (kemasaman tinggi, kesuburan rendah) dan kompleksitas logistik metode penanaman tradisional. Penaburan benih langsung (*direct seeding*) menawarkan alternatif yang lebih terukur dan hemat biaya, namun keberhasilannya terbatas oleh ketidakmampuan benih untuk berkecambah. Teknologi *seed bomb* (bom benih), yang melapisi benih dalam substrat pelindung, mensimulasikan teknik tanam "terkubur" yang melindungi benih dan memperbaiki iklim mikronya. Teknologi ini berpotensi untuk rehabilitasi lahan gambut sehingga perlu dilakukan penelitian sistematis mengenai pengaruhnya terhadap spesies yang adaptif di lahan gambut.

Penelitian ini bertujuan untuk: (1) menganalisis performa perkecambahan dari berbagai benih spesies pohon hutan, (2) menganalisis pengaruh teknik tanam yang berbeda (terkubur dan tidak terkubur) terhadap performa perkecambahan benih spesies pohon hutan, dan (3) menganalisis pengaruh berbagai formulasi *seed bomb* terhadap performa perkecambahan benih pohon hutan.

Penelitian ini dilaksanakan melalui serangkaian percobaan yang berurutan di rumah kaca pada kondisi yang terkontrol. Enam spesies pohon hutan dipilih, yaitu gamal (*Gliricidia sepium*), gelam (*Melaleuca cajuputi*), merbau (*Intsia bijuga*), nyamplung (*Calophyllum inophyllum*), jelutung rawa (*Dyera polyphylla*), dan kaliandra (*Calliandra calothyrsus*). Penelitian ini melibatkan tiga pengujian utama, yaitu: (1) uji perkecambahan untuk mengevaluasi viabilitas setiap spesies; (2) uji teknik tanam yang membandingkan benih terkubur dan tidak terkubur di tanah gambut; dan (3) uji formula *seed bomb* yang mengevaluasi tiga formula yang berbeda (F1: *Miko-seedcookies* + larutan perekat; F2: tanah gambut + tanah liat + dolomit; F3: tanah gambut + tanah liat + dolomit + larutan perekat). Uji penjatuhan juga dilakukan untuk menilai ketahanan fisik *seed bomb*. Parameter yang diukur adalah persentase perkecambahan, daya kecambah, waktu perkecambahan rata-rata, dan persentase hidup semai. Seluruh data dianalisis secara statistik menggunakan metode *Aligned Rank Transform* (ART) yang dilanjutkan dengan uji *post hoc* kontras-ART.

Hasil uji perkecambahan menunjukkan adanya variasi antar spesies, dimana gelam menunjukkan performa perkecambahan terbaik, sementara nyamplung dan jelutung rawa berkecambah lebih lama namun menunjukkan ketahanan yang tinggi setelah berkecambah. Hasil uji teknik tanam tidak menunjukkan perbedaan yang signifikan secara keseluruhan antara benih yang terkubur dan tidak terkubur, meskipun terdapat interaksi yang signifikan antara spesies dan teknik tanam. Uji formula *seed bomb* menunjukkan ketiga formula secara efektif mendukung perkecambahan. Gamal, gelam, dan merbau terbukti paling sesuai dengan aplikasi *seed bomb*. Uji penjatuhan menunjukkan *seed bomb* dengan formula F1 secara

signifikan lebih tahan terhadap benturan, menunjukkan indeks kerusakan terendah setelah dijatuhkan dari ketinggian 10 meter.

Kata kunci: degradasi, *direct seeding*, perkecambahan, rehabilitasi, *seed bomb*

@Hak cipta milik IPB University

IPB University



IPB University
— Bogor Indonesia —

- Hak Cipta Dilindungi Undang-undang
1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
 2. Dilarang mengumumkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

Perpustakaan IPB University



@Hak cipta milik IPB University

IPB University

© Copyrights of IPB University, the Year 2025
Copyrights Protected by Indonesian Constitution

Citing all or some parts of this scientific paper without referring to the source is strictly prohibited. The citation is permitted only for education, research, articles, reports, critics, and reference purposes; and does not prejudice IPB interest.

Publishing and copying all or some parts of this scientific paper in any form without the permission of IPB is strictly prohibited.

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :

- a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
- b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.

2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

APPLICATION OF SEED BOMB PLANTING TECHNIQUE FOR PEAT FOREST REHABILITATION

DIMAS NUR MUHAMMAD

Graduate Thesis

submitted in partial fulfillment of the requirements for the degree of
Magister of Science in
Study Program of Tropical Silviculture

**STUDY PROGRAM OF TROPICAL SILVICULTURE
FACULTY OF FORESTRY AND ENVIRONMENT
IPB UNIVERSITY
BOGOR
2025**



@Hak cipta milik IPB University

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

Thesis Title : Application of Seed Bomb Planting Technique for Peat Forest Rehabilitation
Name : Dimas Nur Muhammad
Student ID : E4501231010

Approved by

Supervisor 1:

Dr. Adisti Permatasari Putri Hartoyo, S.Hut., M.Si.



Supervisor 2:

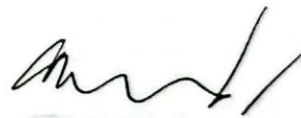
Dr. Ir. Irdika Mansur, M.For.Sc.



Acknowledge by

Head of Study Program

Prof. Dr. Ir. Prijanto Pamoengkas, M.Sc.F.Trop.
NIP. 19631206 198903 1 004



Dean of Faculty of Forestry and Environment

Prof. Dr. Ir. Naresworo Nugroho, M.S.
NIP. 19650122 198903 1 002




Examination Date: 14 July 2025

Graduation Date: 05 AUG 2025



@Hak cipta milik IPB University

IPB University



IPB University
— Bogor Indonesia —

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

Perpustakaan IPB University

ACKNOWLEDGMENT

Alhamdulillah, all sincere praise and gratefulness are offered to Allah *Subhanahu Wa Ta'ala* due to His abundance and endowment; thus, the author completed this graduate thesis as one of the requirements for the master's degree in Tropical Silviculture Study Program, Faculty of Forestry and Environment, IPB University. The research was conducted from May 2024 to January 2025, entitled Application of Seed Bomb Planting Technique for Peat Forest Rehabilitation.

The author wishes to express sincere gratitude to Dr. Adisti Permatasari Putri Hartoyo, S.Hut., M.Si., and Dr. Ir. Irdika Mansur, M.For.Sc. for spending much time, giving guidance, support, and patience in supervising the author to complete this research. The author is very grateful to the Directorate General of Higher Education, Research, and Technology, and the Ministry of Education, Culture, Research, and Technology, through the Postgraduate Research - Master Thesis Research (PTM) 2024 (contract number: 22221/IT3.D10/PT.01.03/P/B/2024) for funding this research. The author would like to thank Dr. Achmad Solikhin, S.Hut., Rince Muryunika, S.P., M.Si., Siti Jaenab, S.Hut., and Hilmi Naufal Madani, S.Hut. M.Si., for facilitating and giving valuable inputs for this research. Special thanks to the author's dearest parents, Mr. Asnal (deceased) and Mrs. Eni Sufitri S., for the abundance of love and support; may they always be under His Grace guidance and protection. Thanks to the author's colleagues, and the Fundamental Research – Regular (PFR) 2024 research team.

Finally, the author expects this graduate thesis to benefit the readers and contribute knowledge to the academic realm. Constructive criticism and advice are gladly accommodated.

Bogor, August 2025

Dimas Nur Muhammad



@Hak cipta milik IPB University

IPB University



IPB University
— Bogor Indonesia —

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.

Perpustakaan IPB University

TABLE OF CONTENTS

LIST OF TABLES	xvi
LIST OF FIGURES	xvi
I INTRODUCTION	1
1.1 Background	1
1.2 Problem Formulation	2
1.3 Research Framework	3
1.4 Research Objective	4
1.5 Benefits of Research	4
1.6 Hypothesis	4
II LITERATURE REVIEW	5
2.1 General Conditions of Indonesian Peatlands	5
2.2 Plant Species Characteristics	6
2.3 Direct Seeding Technique	7
III METHOD	10
3.1 Location and Period	10
3.2 Tools and Materials	10
3.3 Research Procedures	10
3.4 Observation and Data Collection	17
3.5 Data Analysis	18
3.6 Statistical Analysis	19
IV RESULT AND DISCUSSION	22
4.1 Germination Test	22
4.2 Planting Techniques Test	24
4.3 Seed Bomb Formula Test	28
V CONCLUSION AND RECOMMENDATION	36
5.1 Conclusions	36
5.2 Recommendations	36
REFERENCES	37



LIST OF TABLES

1	Recent studies on seed bomb application	8
2	The germination test details	11
3	The factors and levels of plantation techniques test	13
4	Seed bomb media composition	14
5	Seed bomb diameter	15
6	The factors and levels of the seed bomb formula test	16
7	Germination test results	22
8	The ANOVA test results for the seed planting technique test	25
9	The ANOVA test result on the seed bomb formula test for seed's germination	28
10	The ANOVA test result on seed bomb physical characteristic test	32
11	Soil properties analysis for seed bomb formula test in the greenhouse	34

LIST OF FIGURES

1	Research framework	3
2	The seed preparation for <i>gamal</i> (A), <i>gelam</i> (B), <i>merbau</i> (C), <i>nyamplung</i> (D), swamp <i>jelutung</i> (E), and <i>kaliandra</i> (F)	10
3	Sand sifting	11
4	Seed's arrangement for germination test: <i>merbau</i> (A), <i>nyamplung</i> (B), swamp <i>jelutung</i> (C), <i>gelam</i> (D), <i>gamal</i> (E), and <i>kaliandra</i> (F)	12
5	Filtered peat soil	13
6	Randomization layout of plantation techniques test (PS1: <i>gamal</i> , PS2: <i>gelam</i> , PS3: <i>merbau</i> , PS4: <i>nyamplung</i> , PS5: swamp <i>jelutung</i> , PS6: <i>kaliandra</i> , B: buried seed, NB: non-buried seed)	14
7	Experimental unit arrangement for planting techniques test	14
8	Seed bomb media: formula 1 (A), formula 2 (B), and formula 3 (C)	15
9	Seed bomb formula 1 (A), formula 2 (B), and formula 3 (C)	16
10	Randomization layout of seed bomb formula test (PS1: <i>gamal</i> , PS2: <i>gelam</i> , PS3: <i>merbau</i> , PS4: <i>nyamplung</i> , PS5: swamp <i>jelutung</i> , PS6: <i>kaliandra</i> , B: buried seed bomb, NB: non-buried seed bomb, F1: Miko-seedcookies + adhesive solution, F2: peat soil + clay + dolomite, and F3: peat soil + clay + dolomite + adhesive solution)	16
11	Experimental unit arrangement for seed bomb formula test	17
12	Dropping surfaces, which are asphalt (A), filtered peat soil (B), and grassland (C)	17
13	Destruction index level for dropping test	18
14	The germinated seed at day 21 after sowing for <i>gamal</i> (A), <i>gelam</i> (B), <i>merbau</i> (C), <i>nyamplung</i> (D), swamp <i>jelutung</i> (E), and day 14 after sowing <i>kaliandra</i> (F)	23
15	The abnormal sprout of I. bijuga on day 21 after planting	24
16	Germination percentage (AA) and germination capacity (AB) of seed planting technique test (B: buried seed, NB: non-buried seed) at day 21 after planting	25
17	Seedling survival rate (SSR) of seed planting technique test (B: buried seed, NB: non-buried seed) at day 21 after planting	26

- 18 Seedling on buried (*gamal* (A), *gelam* (B), *merbau* (C), *nyamplung* (D), swamp *jelutung* (E), and *kaliandra* (F)) and non-buried (*gamal* (G), *gelam* (H), *merbau* (I), *nyamplung* (J), swamp *jelutung* (K), and *kaliandra* (L)) seed at day 21 after planting 27
- 19 The average germination percentage (AA) and germination capacity (AB) for interaction factor between plant species, seed bomb planting technique, and seed bomb formula (PS1: *gamal*, PS2: *gelam*, PS3: *merbau*, PS4: *nyamplung*, PS5: swamp *jelutung*, PS6: *kaliandra*, B: buried seed bomb, NB: non-buried seed bomb, F1: Miko-seedcookies + adhesive solution, F2: peat soil + clay + dolomite, and F3: peat soil + clay + dolomite + adhesive solution) at day 21 after planting 29
- 20 Gamal seedling on buried (F1 (A), F2 (B), and F3 (C)) and non-buried (F1 (D), F2 (E), and F3 (F)) seed bomb 30
- 21 Gelam seedling on buried (F1 (A), F2 (B), and F3 (C)) and non-buried (F1 (D), F2 (E), and F3 (F)) seed bomb 30
- 22 Merbau seedling on buried (F1 (A), F2 (B), and F3 (C)) and non-buried (F1 (D), F2 (E), and F3 (F)) seed bomb 30
- 23 The average seedling survival rate for the interaction factor between plant species, seed bomb planting technique, and seed bomb formula (PS1: *gamal*, PS2: *gelam*, PS3: *merbau*, PS4: *nyamplung*, PS5: swamp *jelutung*, PS6: *kaliandra*, B: buried seed bomb, NB: non-buried seed bomb, F1: Miko-seedcookies + adhesive solution, F2: peat soil + clay + dolomite, and F3: peat soil + clay + dolomite + adhesive solution) at day 21 after planting 31
- 24 The average mean germination time for interaction factor between plant species, seed bomb planting technique, and seed bomb formula (PS1: *gamal*, PS2: *gelam*, PS3: *merbau*, PS4: *nyamplung*, PS5: swamp *jelutung*, PS6: *kaliandra*, B: buried seed bomb, NB: non-buried seed bomb, F1: Miko-seedcookies + adhesive solution, F2: peat soil + clay + dolomite, and F3: peat soil + clay + dolomite + adhesive solution) at day 21 after planting 32
- 25 The average destruction index on seed bomb physical characteristic test 32
- 26 Destruction index (%) of seed bombs made with three different formulas 33
- 27 The seed bomb condition after the dropping test for F1 treatment on hard (A), filtered peat soil (B), and grassland (C) dropping surface 33



@Hak cipta milik IPB University

Hak Cipta Dilindungi Undang-undang

1. Dilarang mengutip sebagian atau seluruh karya tulis ini tanpa mencantumkan dan menyebutkan sumber :
 - a. Pengutipan hanya untuk kepentingan pendidikan, penelitian, penulisan karya ilmiah, penyusunan laporan, penulisan kritik atau tinjauan suatu masalah
 - b. Pengutipan tidak merugikan kepentingan yang wajar IPB University.
2. Dilarang mengumunkan dan memperbanyak sebagian atau seluruh karya tulis ini dalam bentuk apapun tanpa izin IPB University.