

**THE POTENTIAL OF *Bacillus* sp. AND FOBIO BIOPESTICIDE WITH
MUSTARD GREEN PLANTS (*Brassica rapa* L var. *parachinensis*) AS
BIOREMEDIATION AGENTS OF HEAVY METALS CADMIUM (Cd)**

UNDERGRADUATE THESIS



Written by:

DYKHA MARETHA SETYAWAN

NPM.20025010049

**AGROTECHNOLOGY STUDY PROGRAM
FACULTY OF AGRICULTURE
UNIVERSITAS PEMBANGUNAN NASIONAL "VETERAN" JAWA TIMUR
SURABAYA
2025**

**THE POTENTIAL OF *Bacillus* sp. AND FOBIO BIOPESTICIDE WITH
MUSTARD GREEN PLANTS (*Brassica rapa* L var. *parachinensis*) AS
BIOREMEDIATION AGENTS OF HEAVY METALS CADMIUM (Cd)**

UNDERGRADUATE THESIS

Submitted to Fulfill the Requirements for Obtaining
a Bachelor of Agriculture Degree
in the Agrotechnology Study Program



Written by:

DYKHA MARETHA SETYAWAN

NPM: 20025010049

**AGROTECHNOLOGY STUDY PROGRAM
FACULTY OF AGRICULTURE
UNIVERSITAS PEMBANGUNAN NASIONAL "VETERAN" JAWA TIMUR
SURABAYA
2025**

**The Potential of *Bacillus* sp. and FOBIO Biopesticide with Green Mustard
Plants (*Brassica rapa* L var. *parachinensis*) as Bioremediation Agents for
Heavy Metal Cadmium (Cd)**

Written by:

DYKHA MARETHA SETYAWAN

NPM. 20025010049

Has been repaired on:

14 August 2025

**Submitted to Fulfill the Requirements for Obtaining
a Bachelor of Agriculture Degree
Universitas Pembangunan Nasional "Veteran" Jawa Timur**

Approved by,

Main Supervisor

Second Supervisor

Dr. Dra. Endang Tri Wahyu P., M.Si

NIP. 19641203 199103 2001

Dr. Ir. Sri Wiyatiningsih, M.P.

NIP. 19961002 199203 2001

Know by,

Dean of the Faculty of Agriculture

**Coordinator of The Agrotechnology
Study Program**

Prof. Dr. Ir. Wanti Mindari, M.P.

NIP. 19631208 199003 2001

Dr. Ir. Tri Mujoko, M.P.

NIP. 19660509 199203 1001

APPROVAL SHEET

The Potential of *Bacillus* sp. and FOBIO Biopesticide with Green Mustard Plants (*Brassica rapa* L var. *parachinensis*) as Bioremediation Agents for Heavy Metal Cadmium (Cd)

Written by:

DYKHA MARETHA SETYAWAN

NPM. 20025010049

Has been repaired on:

14 August 2025

Submitted to Fulfill the Requirements for Obtaining
a Bachelor of Agriculture Degree
Universitas Pembangunan Nasional "Veteran" Jawa Timur

Approved by:

Main Supervisor



Dr. Dra. Endang Tri Wahyu P., M.Si

NIP. 19641203 199103 2001

Second Supervisor



Dr. Ir. Sri Wiyatiningsih, M.P.

NIP. 19961002 199203 2001

PLAGIARISM STATEMENT LETTER

Name : Dykha Maretha Setyawan

NPM : 20025010049

Program : Bachelor (S1)

Faculty : Agriculture

I declare that this thesis does not contain any parts of other scientific works submitted to obtain an academic degree at a higher education institution, nor does it contain any works or opinions that have been written or published by other individuals or institutions, except those that are cited in writing in this document and listed in full in the bibliography.

I declare that this scientific document is free from plagiarism. If in the future there are indications of plagiarism in this thesis, I am willing to accept sanctions in accordance with the applicable laws and regulations.

I have made this statement truthfully without coercion from anyone and for its intended use.

Surabaya, 14 August 2025

Who made the statement



Dykha Maretha Setyawan
NPM. 20025010049

The Potential of *Bacillus* sp. and FOBIO Biopesticides with Mustard Plants (*Brassica rapa* L var. *parachinensis*) as Bioremediation Agents for Heavy Metal Cadmium (Cd)

Potensi *Bacillus* sp. dan Biopestisida FOBIO dengan Tanaman Sawi Hijau (*Brassica rapa* L var. *parachinensis*) Sebagai Agen Bioremediasi Logam Berat Kadmium (Cd)

Dykha Maretha Setyawan¹, Endang Tri Wahyu Prasetyawati^{1*}, Sri Wiyatiningsih¹

¹ Agrotechnology Universitas Pembangunan Nasional “Veteran” Jawa Timur

*) Email Correspondent: ending_tp@upnjatim.ac.id

ABSTRACT

Cadmium (Cd) contamination in agricultural land due to excessive use of fertilizers and pesticides has a detrimental impact on soil, plants, and humans. Efforts to address this issue involve bioremediation. This study aims to investigate the potential of *Bacillus* sp., the biopesticide FOBIO, and green cabbage (*Brassica rapa* L. var. *parachinensis*) as bioremediation agents for heavy metal Cd. The results of the study indicate that *Bacillus* sp. and FOBIO are capable of reducing cadmium levels after treatment. The FOBIO treatment at 4.57 mg/kg and the *Bacillus* sp. treatment at 2.48 mg/kg did not disrupt the growth of the mustard plants. The FOBIO treatment significantly increased the number of leaves, plant length, and fresh weight compared to the other treatments.

Keywords: *Bacillus* sp., biopestisida FOBIO, cadmium, bioremediation, green mustard

ABSTRAK

Pencemaran kadmium (Cd) di lahan pertanian akibat penggunaan pupuk dan pestisida berlebihan berdampak buruk pada tanah, tanaman, dan manusia. Upaya mengatasi permasalahan tersebut dengan Bioremediasi. Penelitian ini bertujuan untuk mengkaji potensi *Bacillus* sp., biopestisida FOBIO, dan tanaman sawi hijau (*Brassica rapa* L. var. *parachinensis*) sebagai agen bioremediasi logam berat Cd. Hasil penelitian menunjukkan bahwa *Bacillus* sp. dan FOBIO mampu menurunkan kadar kadmium setelah perlakuan. Perlakuan FOBIO sebesar 4,57 mg/kg dan perlakuan *Bacillus* sp. 2,48 mg/kg. pertumbuhan tanaman sawi tidak terganggu. Perlakuan FOBIO secara signifikan meningkatkan jumlah daun, panjang tanaman dan berat basah dibandingkan perlakuan lainnya.

Kata kunci: *Bacillus*, kadmium, FOBIO, bioremediasi, tanaman sawi.

FOREWORD

Praise be to Allah SWT for His abundant mercy and guidance, enabling the author to complete this thesis titled " The Potential of *Bacillus* sp. and FOBIO Biopesticide with Green Mustard Plants (*Brassica rapa* L var. *parachinensis*) as Bioremediation Agents for Heavy Metal Cadmium (Cd)"

The preparation of this thesis is an academic requirement of the Faculty of Agriculture, Universitas Pembangunan Nasional “Veteran” Jawa Timur. his process would not have been possible without the assistance of Allah SWT and the support of various parties. With sincere gratitude, I would like to express my heartfelt thanks to:

1. Mrs. Dr. Dra. Endang Triwahyu Prasetyawati, M.Si as the main supervisor as well as a substitute for parents during the thesis process. Thank you for all the time, guidance, and and direction you have provided to help me complete this thesis.
2. Mrs. Dr. Ir. Sri Wiyatiningsih, MP. As a companion supervisor, who has provided support, input, and guidance in every stage of the preparation of this thesis.
3. Mr. Dr. Ir. Tri Mujoko, MP. as the Coordinator of the Agrotechnology Study Program at the Faculty of Agriculture, Universitas Pembangunan Nasional "Veteran" Jawa Timur for providing guidance and facilitating academic needs throughout the study period.
4. Mrs. Dr. Ir. Wanti Mindari., M.P. Dean of the Faculty of Agriculture at the Universitas Pembangunan Nasional "Veteran" Jawa Timur for all forms of support and opportunities provided during the learning process at the faculty.
5. Mr. Muhammad Gufron Chakim SP. MP as a lecturer specializing in soil science greatly assisted me, particularly in the process of data analysis and laboratory work during the research.
6. My beloved family, especially my parents, siblings, and extended family, for their love, prayers, and unwavering encouragement throughout my education.

7. My fellow Agrotechnology student at Universitas Pembangunan Nasional “Veteran” Jawa Timur, especially Tri Susiyanti, Denis Fitriasari, Rafi Dwi Nugraha, and Ainur who have provided a great deal of assistance and played an important role in the research process and preparation of this thesis.

Surabaya, August 2025

Writer

TABLE OF CONTENTS

	Page
ABSTRACT	i
FOREWORD	ii
TABLE OF CONTENTS	iv
LIST OF TABLE.....	vi
LIST OF PICTURE.....	vii
I. INTRODUCTION.....	1
1.1. Background	1
1.2. Problem Formulation.....	3
1.3. Research Objectives	3
1.4. Research Benefits.....	3
II. LITERATURE REVIEW	5
2.1. Definition of Heavy Metals and Their Availability in Soil	5
2.2. Heavy Metal Cadmium (Cd).....	6
2.1. The Effect of Heavy Metal Cadmium (Cd) on Plants	7
2.2. Bioremediation	8
2.3. <i>Bacillus</i> sp. Bacteria as a Bioremediation Agent	10
2.4. FOBIO Biopesticides as Bioremediation Agents	12
2.5. Green Mustard (<i>Brassica rapa</i> L var. <i>parachinensis</i>) As a Heavy Metal Tolerant Plant	13
2.6. Hypothesis	16
III. RESEARCH METHODS	18
3.1. Place and Time of Research	18
3.2. Tools and Materials	18
3.3. Research Design.....	18
3.4. Research Preparation.....	19
3.4.1. Sterilization of Tools and Materials.....	19
3.4.2. Preparation of <i>Nutrient Agar</i> (NA) Medium	19
3.4.3. Preparation of <i>Nutrient Broth</i> Media (NB).....	19
3.4.4. Rejuvenation of <i>Bacillus</i> sp.	20
3.4.5. Preparation of Cadmium (Cd) Heavy Metal Stock Solution.....	20

3.5. Research Implementation.....	20
3.5.1. Testing the Resistance of <i>Bacillus</i> sp. to Heavy Metal Cadmium (Cd)	20
3.5.2. Mustard Seed Germination.....	21
3.5.3. Preparation of Planting Media and Application of Heavy Metals Cadmium (Cd).....	21
3.5.4. Preparation of Suspension and Application of <i>Bacillus</i> sp.....	22
3.5.5. Applications of FOBIO Biopesticide	22
3.5.6. Transplanting	22
3.5.7. Maintenance.....	22
3.5.8. Harvesting.....	23
3.5.9. Soil Sample Analysis	23
3.6. Research Parameters.....	23
3.6.1. Heavy Metal Cadmium (Cd) Levels in Soil	23
3.6.2. Mustard Plant Growth	24
3.7. Data Analysis.....	24
IV. RESULTS AND DISCUSSION	26
4.1. Heavy Metal Cadmium (Cd) Levels in Soil.....	26
4.2. Growth of Green Mustard (<i>Brassica rapa</i> L var. <i>parachinensis</i>)	30
4.2.1. Plant Length.....	30
4.2.2. Number of Leaves	31
4.2.3. Fresh Weight of Plants.....	33
4.2.4. Observation of Symptoms in Mustard Plants Contaminated with Heavy Metal Cadmium (Cd).....	34
V. CONCLUSION	36
5.1. Conclusion.....	36
5.2. Suggestion	36
BIBLIOGRAPHY	37
APPENDIX	46

LIST OF TABLE

Number	<u>Text</u>	Page
3.1.	Research Experiment Plan	19
4.1.	Cadmium (Cd) Heavy Metal Levels in Soil Before and After Treatment.....	26
4.2.	Plant Leght Result of Green Mustard (<i>Brassica rapa</i> L var. parachinensis)	30
4.3.	Leaf Number Result of Green Mustard (<i>Brassica rapa</i> L var. parachinensis)	32
4.5.	Fresh Weight Result of Green Mustard (<i>Brassica rapa</i> L var. parachinensis)	33

LIST OF PICTURE

Number	<u>Text</u>	Page
2.1.	Dynamics of Heavy Metals in Soil and Plant	6
2.2.	Symptoms of Chlorosis (arrow K) in tobacco plants due to heavy metal cadmium (Cd) stress	8
2.3.	Bakteri of genus <i>Bacillus</i>	11
2.4.	Biopesticide FOBIO	13
2.5.	Mustard Green Plants (<i>Brassica rapa</i> L var. <i>parachinensis</i>).....	14
4.1.	Results of Observation of Symtoms of Mustard Plants Contaminated with Cadmium (Cd) in the Fourth Week.....	35

Appendix

Appendix 1. Anova Test for Heavy Metal Cadmium (Cd) Levels in Soil (Before)	46
Appendix 2. Tukey Test for Heavy Metal Cadmium (Cd) Levels in Soil (Before)	46
Appendix 3. Anova Test Cadmium (Cd) Heavy Metal Levels On Soil (After)....	46
Appendix 4. Test the Cadmium (Cd) Heavy Metal Levels on the Ground (After)	47
Appendix 5. Anova Test for Plant Length in Week 1	47
Appendix 6. Tukey Test for Plant Length in Week 1	47
Appendix 7. Anova Test for Plant Length in Week 2.....	48
Appendix 8. Tukey Test for Plant Length in Week 2	48
Appendix 9. Anova Test for Plant Length in Week 3.....	48
Appendix 10. Tukey Test for Plant Length in Week 3	49
Appendix 11. Anova Test for Plant Length in Week 4.....	49
Appendix 12. Tukey Test for Plant Length in Week 4	49
Appendix 13. Anova Test for Number of Leaves in Week 1	50
Appendix 14. Tukey Test for Number of Leaves in Week 1.....	50
Appendix 15. Anova Test for Number of Leaves in Week 2	50
Appendix 16. Tukey Test for Number of Leaves in Week 2	51
Appendix 17. Anova Test for Number of Leaves in Week 3	51
Appendix 18. Tukey Test for Number of Leaves in Week 3.....	51

Appendix 19. Anova Test for Number of Leaves in Week 4	52
Appendix 20. Tukey Test for Number of Leaves in Week 4.....	52
Appendix 21. Anova Test of Wet Weight of Plants.....	53
Appendix 22. Tukey Test of Wet Weight of Plants	53
Appendix 23. Results of Cadmium (Cd) Heavy Metal Content Test Before.....	54
Appendix 24. Results of Cadmium (Cd) Heavy Metal Content Test After	56