Dedicated To

Those individuals whose lives were tragically cut short by the devastating impact of Japanese encephalitis.

DECLARATION

I do hereby declare that the thesis entitled "Control of Japanese Encephalitis vectors by alternate wet and dry irrigation technique of monsoon rice fields: A critical assessment in severely affected areas of Sonitpur district, Assam, India" submitted to the School of Sciences Tezpur University in part fulfillment for the award of the degree of Doctor of Philosophy in Environmental Science, is a record of research work carried out by me under the supervision of **Dr. Nayanmoni Gogoi**, Department of Environmental Science, Tezpur University. No part of this work has been presented for any other degree or diploma earlier.

Date:

Place: Department of Environmental Science,

Tezpur University

Oli Zalukdar (Oli Talukdar)



DEPARTMENT OF ENVIRONMENTAL SCIENCE TEZPUR UNIVERSITY NAPAAM TEZPUR - 784028, ASSAM, INDIA

Nayanmoni Gogoi, PhD Assistant Professor Mobile: +91 - 8011036065 Email: nayanmoni@tezu.ac.in

Certificate of the Supervisor

This is to certify that the thesis entitled "Control of Japanese Encephalitis vectors by alternate wet and dry irrigation technique of monsoon rice fields: A critical assessment in severely affected areas of Sonitpur district, Assam, India" submitted to the School of Sciences Tezpur University in part fulfillment for the award of the degree of Doctor of Philosophy in Environmental Science is a record of research work carried out by Mrs. Oli Talukdar under my supervision and guidance.

All help received by her from various sources have been duly acknowledged.

No part of this thesis has been submitted elsewhere for award of any other degree.

(Nayanmoni Gogoi)

School of sciences
Department of Environmental Science

Assistant Professor

Dept. of Environmental Science
Tezpur University

Date:

Place: Tezpur University

ACKNOWLEDGEMENT

This thesis would not have been possible without help, support and inspiration of several people. I take this opportunity to convey my heartfelt gratitude and sincere appreciation to all people who have helped and inspired me during my research endeavor.

First and above all, I would like to express my heartfelt gratitude to my PhD Supervisor, Dr. Nayanmoni Gogoi for accepting me as a PhD student. This thesis is the result of her thoughtful guidance, warm encouragement, healthy criticisms, and moral support.

I earnestly thank the Honorable Vice-chancellor Tezpur University for extending necessary infrastructural facilities to carry out my research work.

I also convey my sincere regards to the senior faculty members, head of the department and other faculty members in the Department of Environmental Science, Tezpur University for their constructive comments and advice.

I also take the opportunity to thank my doctoral committee members, Dr. Satya Sundar Bhattacharya and Dr. Rupak Mukhopadhyay for their suggestions and keen monitoring of my progress. I would like to acknowledge the help received from Defence Research Laboratory (DRL, Tezpur) in various aspects of the research work.

I also thank the technical staffs of the Sophisticated Instrumentation and Analytical Centre, and Department of Environmental Science for rendering their active involvement in sample analysis.

I cannot forget the help forwarded to me by my dear lab members, in many ways.

I cannot finish without thanking my family members for their spiritual support in all aspects of my life. My sincere regards are also extended to all my friends and well wishers who supported me in this journey till the end.

I am grateful to Tezpur University for releasing research and innovation grant to for the smooth running of the research work. My sincere gratitude is also due to the Department of Science and Technology, Government of India for conferring KIRAN, WOS-B fellowship that enabled me to complete my work.

Last but not the least; I thank the Almighty for keeping me in good health and granting me the capability to proceed successfully.

Oli Talukdar)

List of Tables

Table No.	Table Title	Page No.
Table 2.1	Irrigation levels influencing the growth and development of JE vector larvae	27
Table 2.2	Role of physicochemical variables in moderating JE vector propagation	29
Table 4.1	A report on AES and JE cases, and case fatality rates (CFR) and sample positivity rates (SPR)	81
Table 4.2(a)	Age distribution of AES and JE affected population	82
Table 4.2(b)	Gender distribution of AES and JE	82
Table 4.3	Record of JE cases in different Block Public Health Center in Sonitpur in the North Bank Plain Agro Climatic Zone of Assam	82
Table 4.4	Month wise distribution of AES and JE cases in study site	84
Table 4.5	Relative density/relative abundance of mosquito species recorded in CDC light trap	85
Table 4.6	Seasonal distribution of Culex sp. in study site	86
Table 4.7	Correlation between <i>Culex vishnui</i> , <i>Culex tritaenorynchus</i> and <i>Culex vishnui</i> abundance and climate variables – rainfall and no. of rainy days	87
Table 4.8	Regression among <i>Culex vishnui</i> , <i>Culex tritaenorynchus and Culex pseudovishnui</i> abundance and relative humidity (evening and morning), temperature (max and min) and rainfall	89
Table 4.9	Association between meteorological variables and monthly total JE cases showing the lag effect at 1–3 months	89
Table 4.10	Correlation matrix showing relationship among abundance of three JEV vectors and AES and JE infections	90
Table 5.1	Calendar of agronomic practice in the experimental fields	104
Table 5.2	Basic soil physicochemical properties of experimental field during study period	104
Table 5.3	Pearson's Correlation coefficient (r value) for different parameters	127
Table 5.4	Pearson's Correlation coefficient (r value) for different parameters	132
Table 6.2	Different growth phages of rice plant in the study field	147
Table 6.3	Calendar of agronomic practice in the experimental fields	148
Table 6.4	Basic water physicochemical properties of experimental field during study period	153
Table 6.5	Pearson Correlations among physico chemical parameter of water and LAI with larval concentration	168

List of Figures

Figure No.	Figure Title	Page No.
Figure 1.1	Scientific rationale of the study – implementation of AWDI involving local varieties of rice and curtailing growth of JE vectors	7
Figure 3.1	Schematic representation of experimental design	43
Figure 3.2.(a)	Month wise average Minimum and Maximum temperature in Sonitpur district (2019-2022)	45
Figure 3:2.(b)	Month wise average rainfall and relative humidity in Sonitpur district (2019-2022)	46
Figure 3.2.(c)	Topographic map showing the investigation sites in the North bank plain agroclimatic zone, Sonitpur district, Assam	46
Figure 3.3	Field layout of experimental design:	52
Figure 3.4. (a)	Flowchart showing various strategies adopted in AWDI	54
Figure 3.4.(b)	Using pani pipe for AWDI Distribution of rainfall events (A) and number of rainy days (B)	54
Figure 3.5	during study period	69
Figure 4.1.(a)	Maximum and minimum temperature distribution	79
Figure 4.1.(b)	rainfall events and number of rainy days	79
Figure 4.2	Pictures showing collection and identification of adult mosquitoes	80
Figure 4.3	Temporal distribution of AES and JE in Sonitpur	83
Figure 5.2.1	Distribution of (a) rainfall (mm) and (b) rainy days during the study period(2020-2022)	99- 100
Figure 5.2.2	Variation of soil MC (%) during the growth period. Data are mean±standard deviation (n=3).	106
Figure 5.2.3	Variation of soil organic carbon content (%) during the growth period. Data are mean±standard deviation (n=3).	107
Figure 5.2.4	Variation of soil respiration (CO ₂ gm ⁻¹ hour ⁻¹) during the growth period. Data are mean±standard deviation (n=3)	108
Figure 5.2.5	Variation in soil pH during the growth period. Data are mean±standard deviation (n=3)	109
Figure 5.2.6	Variation of soil Available Nitrogen (kg ha ⁻¹) during the growth period. Data are mean±standarderror (n=3).	110
Figure 5.2.7	Variation of soil Available soil Phosphorus (kg ha ⁻¹)during the growth period. Data are mean±standard error (n=3).	111
Figure 5.2.8	Variation of soil Potassium content (kg ha ⁻¹) during the growth period. Data are mean±standarderror (n=3).	112
Figure 5.2.9	Variation of soil Zn content(µg g ⁻¹) during the growth period. Data are mean±standard deviation (n=3	113
Figure 5.2.10	Variation of soil Cu content (µg g ⁻¹) during the growth period. Data are mean±standarderror (n=3).	114

Figure 5.2.11	Variation of soil Mn content (µg g ⁻¹) during the growth period. Data are mean±standard deviation (n=3).	115
Figure 5.3.1	Temporal variation of Leaf Area Index of rice plant under two different agricultural practices in two different varieties.	116
Figure 5.3.2	Temporal variation of chlorophyll (mg g ⁻¹) of leaf under two different agricultural practices in two different varieties.	117
Figure 5.3.3.	Temporal variation of plant height (cm) under two different agricultural practices in two different varieties.	117
Figure 5.4.1	Temporal variation of grain yield (kg ha ⁻¹) under two different agricultural practices in two different varieties.	119
Figure 5.4.2.	Temporal variation of grain filling (%) under two different agricultural practices in two different varieties	119
Figure 5.4.3	Temporal variation of sterile spikelet under two different agricultural practices in two different varieties.	120
Figure 5.4.4.	Temporal variation of tiller number under two different agricultural practices in two different varieties	121
Figure 5.4.5.	Temporal variation of protein content (%) under two different agricultural practices in two different varieties	122
Figure 5.4.6	Temporal variation of Carbohydrate content in grain (mg ml ⁻¹) under two different agricultural practices in two different varieties.	123
Figure 5.4.7	Temporal variation of (a) potassium uptake (kg ha ⁻¹) (b) potassium harvest index under two different agricultural practices in two different varieties.	124
Figure 5.4.8	Temporal variation of (a) phosphorus uptake (kg ha ⁻¹):(b) phosphorus harvest index under two different agricultural practices in two different varieties	125
Figure 5.4.9	Temporal variation of (a) Nitrogen uptake(kg ha ⁻¹) (b) nitrogen harvest index under two different agricultural practices in two different varieties	126- 127
Figure 5.4.10	Temporal variation of (a) Zinc uptake (kg ha ⁻¹) (b) Zinc harvest index under two different agricultural practices in two different varieties	128
Figure 5.4.11	Temporal variation of (a) Copper uptake (kg ha ⁻¹) (b) Copper harvest index under two different agricultural practices in two different varieties.	129- 130
Figure 5.4.12.	Temporal variation of (a) Manganese uptake (kg ha ⁻¹) (b) Manganese harvest index under two different agricultural practices in two different varieties	130- 131
Figure 5.4.13	Temporal variation of water productivity index under two different agricultural practices in two different varieties	132
Figure 6.2.1	Distribution of rainfall events (A) and number of rainy days (B) during study period	149
Figure 6.2.2	Picture showing collection of Culex larvae from study field	152
Figure 6.3.1	Temporal variation of Dissolved oxygen of water under two different agricultural practices in two different varieties	154
Figure: 6.3.2	Temporal variation of Nitrate-Nitrogen of water under two different agricultural practice in two different variety	155

Figure 6.3.3	Temporal variation of Inorganic Phosphorus under two different agricultural practice in two different variety	156
Figure 6.3.4	Temporal variation of Temperature of water under two different agricultural practice in two different variety	157
Figure 6.3.5	Temporal variation of Total dissolve solid (TDS) under two different agricultural practice in two different variety	158
Figure 6.3.6	Temporal variation of Salinity under two different agricultural practices in two different varieties	159
Figure 6.3.7	Temporal variation of pH under two different agricultural practices in two different variety	160
Figure 6.3.8	Temporal variation of plant height in cm under two different agricultural practices in two different varieties	161
Figure 6.3.9	Temporal variation of Leaf area index (LAI) under two different agricultural practice in two different variety.	162
Figure 6.3.10	Temporal variation of Per dip larval density (%) under two different agricultural practice in two different variety	164
Figure 6.3.10(a),(b),(c)	Temporal variation of Per dip larval density (%) of three different species under two different agricultural practice in two different variety	165
Figure 6.3.11	Temporal variation of Breeding Index of larvae (Culex sp.) under two different agricultural practice in two different variety	166
Figure 6.3.11 (a),(b),(c)	Temporal variation of Breeding Index of three different species under two different agricultural practice in two different variety.	167