Abstract

In the recent years, Japanese encephalitis (JE) is surfacing as a fatal disease in many regions of the Northeast India. According to the Directorate of Health Services (DHS), Assam, Sonitpur is one of the risk areas of JE epidemics in Assam. The Sample Positivity Rate (SPR) for JE of Sonitpur district was 18.35% during 2009 to 2016, which indicates its high endemicity (Borah et al., 2018). JE vectors primarily include water birds, pigs and *Culex* mosquitoes. *Culex vishnui, Culex pseudovishnui,* and *Culex tritaeniorhynchus* are the three prominent JE mosquito vectors that breed in open water bodies such as pools, ditches, and irrigated or waterlogged paddy fields. People residing in the vicinity of these locations are at immediate risk of acquiring JE infection. The National Vector Borne Disease Control Programme (NVBDCP) under DHS, Assam has implemented several measures such as vaccination, fogging, distribution of mosquito nets, introduction larva eating fishes, and sensitization and immunization programmes to control JE. The JE vaccination campaigns were successfully conducted in 27 districts of Assam, especially emphasizing children aged 1 – 15 who are considered as more prone to vector-borne diseases. Nonetheless, health officials continue to receive reports of JE cases in Assam; as a result, areas affected by JE are increasing in number. Epidemiological investigations were conducted by NVBDCP in the villages; however, comprehensive investigations and implementation of innovative JE vector control measures will help in productive vector management in the affected areas especially rice fields. Numerous studies on the JE vector and its mitigation are available in the literature. JE eradication initiatives are being implemented at a national as well as global scale. JE sensitization programmes are successfully conducted, but people are not fully able to benefit from these programmes due to communication and geographical barriers; thus, preventive measures or clinical management of JE in remote areas are sometimes ineffective. JE abatement measures necessitate a sustainable outlook and a scientific approach through comprehensive investigation and implementation of innovative techniques to reduce JE. In a country like India, rice is a staple food and hence JE cases are more common in India.

In this research endeavor, the nature, ecology, dispersal and sustainable management of JE was studied in Sonitpur because this region has an agrarian economy and belongs to the North Bank Plain Agroclimatic Zone, Assam. The rice fields in

Sonitpur are breeding grounds for JE vectors i.e., *Culex* mosquitoes, and the frequency of occurrence of Acute Encephalitis Syndrome (AES) and JE infections are significant in Sonitpur. The NCVBDC in collaboration with Integrated Disease Surveillance Program (IDSP) and District Malaria Office (DMO) have reported significant number of AES and JE cases in many sub-centers under Sonitpur, Assam. Therefore, considering the dominance of rice cultivation and prevalence of JE epidemics in Sonitpur, an innovative method named, "alternate wet and dry irrigation" (AWDI) is emphasized in this thesis. Therefore, the main goal of the thesis is to eradicate the growth and proliferation of JE vectors in the rice fields and at the same time manage freshwater consumption and increase lowland rice yield by applying innovative AWDI technique in the study area. Addressing the management of JE disease in Sonitpur as urgency, this thesis identifies the research gaps in understanding the role of environmental factors in modulating the populations of JE vectors as well as the rice grain quality and yield in relation to ecohydrological variable and nutrient content while applying AWDI method. This thesis equally focuses on the epidemiological data on JE, characterization of the major JE vector species, identification of the root causes of rapid transmission of JE virus. The findings will help in sensitizing the people about JE endemics and prevent the silent and unnoticed danger of JE vectors that may soon spread from NE India to other regions of the world, while implementing AWDI as an innovative JE control tool.

The complete study has been divided into three major phases. Phase 1 encompasses the study of mosquito density which will reveal the most abundant mosquito vectors of JE which are of medical importance, in the study area, where epidemiological data are collected from district malaria office (DMO). Data is compiled and calculated for CFR, SPR and average. Furthermore, the study also includes the spatiotemporal scenario of the occurrence of the disease in that locality where the identification of most prominent JE vector was done and calculated relative density. Phase 2 evaluates the effect of environmental factors on growth and development of three most important vectors of JE which favors to breed in paddy cultivation. Phase 3 assesses the application of AWDI in the rice field. And its influence on yield quality and soil and water environment where alteration of physicochemical parameters of both soil and water due to treatment effect (AWDI) in two different varieties of rice (B11 and Ranjit Sub1) were studied and its influence in larval development were evaluated.

The findings revealed that AWDI curtailed JE vector populations when fields were treated with AWDI techniques. Concurrently AWDI positively influences rice yield compared to traditional farming practices with promising yield benefits that will be helpful for the farmers. Comparative study using the two commonly cultivated rice varieties, B11 and Ranjit Sub 1, showed both positive and negative influences on yield due to the adoption of AWDI. Improvement in nitrogen uptake was evident in present study due to AWDI. Protein and carbohydrate content of grains improved due to implementation of AWDI during the study period. AWDI is a suitable option over conventional irrigation practices, however, factors such as variety of cultivars, timing of application of AWDI, depth of inundation and use of fertilizer should be considered while implementing AWDI.

Study of epidemiology of the Japanese Encephalitis disease and assessment of effect of environmental factors on growth and development of Japanese Encephalitis vector in the study area revealed that *Culex vishnui* is the most frequently occurring JE vector species that concentrated during the period pre-monsoon to post-monsoon High relative abundance of *Culex vishnui* was also reported in the month of July, correlating to rainy days, temperature and humidity ($R=0.949$, $p< 0.05$).

Application of eco-technical alternate wet and dry irrigation practices in rice field i.e., vector breeding sites at spatiotemporal scales revealed that it can increase the organic matter content of soil in comparison to conventional method of rice cultivation. Similarly improvement in soil respiration and nutrient uptake were also evident. In the current investigation, a substantial rise in WPI was observed ($p_T<0.05$).

The application of AWDI method in rice cultivation has shown notable effects on both rice yield and the populations of Japanese Encephalitis (JE) vectors. In contrast to conventional farming practices, which may lead to higher populations of pest vectors, AWDI has demonstrated the capability to inhibit these vectors while simultaneously enhancing rice yield, a promising advantage for farmers. This investigation on AWDI showed its effectiveness in improving nitrogen uptake throughout the duration of the study. Enhanced nitrogen levels not only contribute to better growth conditions but also positively affect the nutritional quality of the grains produced. Specifically, the research noted improvements in both protein and carbohydrate content of the harvested grains, which could further enhance food security by providing higher quality produce to

consumers. When transitioning to AWDI methods, various factors must be considered to ensure successful implementation and maximize benefits. These factors include the choice of fertilizer, the depth of inundation, the specific rice variety used, and the timing of irrigation application. Proper management of these variables is crucial to harness the advantages of AWDI fully and adapt it effectively to local agricultural practices. However, the use of AWDI presented both beneficial and detrimental effects on production outcomes. While certain aspects of the cultivation process improved, the dual nature of these results suggests that farmers may need to carefully consider the choice of rice variety when implementing AWDI procedures. This strategy allows for optimizing yield while managing the potential drawbacks associated with specific rice types under AWDI conditions.

The investigation has also revealed a significant increase in water productivity index (WPI) among specific rice varieties, demonstrating their potential for enhanced water usage efficiency under varying environmental conditions. The enhancements in water efficiency across these rice varieties highlight their capability to thrive under diverse conditions, which is essential for sustainable agricultural practices given the increasing variability in climate and water availability.The advancements observed in these rice varieties underscore the importance of selective breeding and innovation in improving agricultural resilience. By focusing on varieties that show a marked increase in WPI, farmers can cultivate crops that are better suited to withstand water scarcity and maximize yield potential. Overall, the substantial rise in WPI throughout these rice varieties not only contributes to the efficiency of agricultural water use but also sets a precedent for future research aimed at developing crop varieties that can optimize water resources in the face of environmental challenges.

The important inferences drawn from this thesis investigation and the scope for future research are:

1) AWDI can effectively curtail JE vectors populations when fields are treated with wet and dry techniques, therefore, common rice varieties in Assam like B11 and Ranjit Sub 1 etc. can be cultivated under AWDI to control JE infestations and at the same time improve rice yield
2) AWDI increases the water productivity at the field level by reducing seepage and percolation during the crop-growth period and improves the field

physicochemical properties and rice grain filling rate, thus, AWDI can replace conventional irrigation technique to address Target 4 of Sustainable Development Goal 6 and meet global food security.