Thermal-Based Vulnerability Mapping of Yellow Stem Borer in Rice Fields of Punjab, Pakistan

Division: RS/GIS, Agriculture division
Duration: 2020-25.
Location: SATEYE Company Headquarters, Lahore, Pakistan.

Executive Summary:

SATEYE Company carried out a detailed study to map areas in Punjab, Pakistan, that are most vulnerable to attacks by the yellow stem borer (YSB), a serious pest of rice. Since YSB development strongly depends on temperature, the company used satellite-derived thermal data and geographic analysis to determine when and where the pest is most likely to lay eggs, hatch, and grow. By analyzing thermal images across the rice-growing season, SATEYE identified vulnerable zones at different stages of the pest's life cycle from egg laying, through larva, to pupa. The findings show that large portions of the rice area become increasingly vulnerable as temperatures rise, indicating optimal times and places for intervention. This work equips farmers, agricultural planners, and policymakers with actionable information to time pesticide use more precisely, reduce crop losses and make pest management more efficient.

Other Partners:

Introduction:

SATEYE Company recognized that pest management in rice cultivation can be significantly improved using modern remote sensing techniques. The yellow stem borer (YSB), a major rice pest in South Asia, especially in Pakistan, causes serious yield losses when its life cycle is not properly managed. Traditional control strategies often rely on fixed crop calendars or repeated pesticide use without full awareness of the dynamics of YSB population under variable temperature conditions. However, the development of YSB especially egg laying, hatching, larval growth and pupal stages depends heavily on temperature. As temperatures change across time and space, so does the risk of YSB attacks. To address this, SATEYE Company set out to identify vulnerable zones in rice-growing districts of Punjab (including Lahore, Gujranwala, Sheikhupura, Hafizabad and Nankana Sahib) by combining satellite thermal data, GIS tools, and pest ecology knowledge. By mapping the temperature distribution over time, SATEYE aimed to predict where and when YSB is most likely to thrive, so that preventive actions could be targeted more effectively.

Methodology:

The methodology employed by SATEYE Company was centered on using satellite thermal imagery and GIS analysis to estimate pixel-based surface temperatures across the study region, and then linking these temperatures to the life cycle of YSB. The company acquired Landsat 8 thermal band data at six time points during the rice growing period (from early April to late June), which corresponded to key stages in the YSB life cycle. These satellite images were processed to convert raw satellite data into irradiance, then into temperature values at a spatial resolution of 100 m per pixel. By applying temperatures from both thermal bands of Landsat 8, SATEYE obtained a reliable temperature value for each pixel.

Once the spatial temperature grid was created, SATEYE applied a vegetation mask to isolate rice-covered areas, using supervised classification of land cover. This step ensured that only areas actually planted with rice were considered in the vulnerability analysis. Then, using known biological thresholds for YSB development (for example, minimum and optimum temperatures for egg laying, hatching, larval survival, and pupal development), the company mapped out how many eggs a female YSB might lay in different zones given the observed temperatures. For each date, the GIS analysis delineated zones that were favorable or unfavorable for different YSB developmental phases.

For additional validation, SATEYE selected specific field sites in the study area where in-situ observations were made: traps and temperature/humidity meters measured local pest density and conditions. Egg counts and larval/pupal presence were checked directly in those areas, then compared with the vulnerability predicted by thermal maps. Finally, statistical regression was used to examine how strongly egg-laying rates correlated with temperature values across the study area, confirming the link between temperature and YSB reproduction.

Outcomes:

As a result of its analysis, SATEYE Company produced spatial maps showing how vulnerability to YSB varies across both time and space. On April 3, for example, about 73% of the vegetated rice area was already in a temperature range in which a female YSB could lay between 100–143 eggs. By April 19, as temperatures rose, this vulnerable area expanded to about 96% of the study region, with potential egg-laying rates increasing to 148–176 eggs per female. Later, on May 5, about 5,377 km² of the rice area fell into the temperature zone favorable for egg hatching, while on May 21 and June 22, significant parts of the area were identified as being vulnerable during larval evolution and pupal development, respectively. Some parts of the landscape, especially near built-up or urban areas, showed particularly high temperatures and correspondingly elevated risk for YSB development.

Ground validation confirmed the satellite-based predictions: in the chosen field sites, egg densities and larva/pupa observations closely matched what the thermal vulnerability maps

had forecasted, with around 95 percent agreement. Statistical analysis revealed a very strong correlation between temperature and egg-laying rates, suggesting that temperature can be a reliable predictor of YSB risk.

These outcomes provide powerful guidance for risk-based pest management. By using the vulnerability maps, SATEYE recommends that pesticide application be more precisely timed: spraying should be focused on zones and periods where the risk is highest, rather than applying uniformly or strictly following traditional calendars. This targeted approach could reduce unnecessary chemical use, lower costs for farmers, and minimize environmental impact. Furthermore, the maps offer a strategic tool for extension services and policymakers, helping them develop adaptive management plans that proactively address areas most at risk for YSB outbreak, thereby safeguarding rice yields and improving crop resilience under changing climatic conditions.