Climate variability and change are increasingly recognized as major drivers of year-to-year yield fluctuations across a wide range of crops. Analyses of long-term data link changes in temperature, rainfall, and the length of the rainy season to substantial variations in yields, with higher temperatures and drought often reducing productivity, while adequate or increased rainfall can partially offset these negative effects (Chioti et al., 2022). At the same time, recent work has demonstrated that combining environmental variables (such as temperature, precipitation, and evaporation) with fertilizer use data in predictive models can greatly improve crop yield forecasting performance, supporting more informed agronomic decisions (Burdett and Wellen, 2022; Krishnadoss and Ramasamy, 2024). Despite this progress, there is a notable gap regarding eggplant-specific yield prediction frameworks that jointly consider fertilization practices and climate variables, even though eggplant is sensitive to both soil fertility and temperature stress, including low-temperature constraints in certain seasons (Osman et al., 2021; Badshah et al., 2024).

This study addresses these gaps by developing a predictive framework for eggplant yield based on fertilization and climate variables, with the goal of supporting climate-smart nutrient management. Building on evidence that data-driven and machine learning models (such as random forests, ensemble approaches, and neural networks) can accurately capture complex, nonlinear relationships among weather, input use, and yields in other crops and regions, this work tailors such concepts to eggplant systems. The specific objectives are to quantify the combined and individual effects of fertilization regimes and key climate factors (e.g., temperature and rainfall) on eggplant yield, construct and evaluate predictive models that use these variables to estimate yield, and identify the most influential features governing yield variability to inform practical management guidelines. By integrating fertilization and climate information into a unified predictive approach, the study aims to contribute a scalable tool and empirical insights that can enhance fertilizer recommendations, reduce climate-related yield risks, and ultimately support more sustainable and resilient eggplant production.

2 Influence of Climate Variables on Eggplant Production

2.1 Effects of temperature variability on yield formation

Open-field work using growing degree days (GDD) shows that eggplant accessions requiring fewer accumulated heat units to first fruiting achieve higher productivity; in a Caribbean environment without temperature extremes (<15 °C or >35 °C), yields above 80 t ha^{-1} were obtained, indicating that thermally suitable sites allow full yield potential expression (Pacheco et al., 2019). Greenhouse studies reveal curvilinear temperature responses of fruit number and total yield, with lower yields when temperatures deviate from an optimum that depends on light intensity, reinforcing the non-linear nature of temperature-yield relationships.

Physiological research indicates that temperatures below about 17 °C slow growth, and near 10 °C induce metabolic disturbances, impairing membrane stability, water relations, chloroplast development, and photosynthetic efficiency, all of which ultimately reduce fruit set and yield (Shimira and Taşkın, 2022). Conversely, excessive heat accelerates development and can depress fruit set in vegetable crops, shortening the period for photoassimilate accumulation and causing yield loss, so yield prediction must account for both cold and heat stress windows around the crop’s optimal growth range.

2.2 Impact of rainfall and soil moisture on crop productivity

A multi-year field trial in a moderate climate showed that eggplant yield depended strongly on both air temperature and total rainfall, with the highest yields obtained when high mean temperatures coincided with evenly distributed rainfall; periods of very low or absent rainfall shortened the harvest period and delayed first fruiting. In the Colombian Caribbean, rainfall largely met crop evapotranspiration, supplemented by irrigation to maintain soil at field capacity, and under these favorable moisture conditions no critical drought episodes occurred, supporting high yields across genotypes.

Deficit irrigation studies using field capacity (FC) as a benchmark demonstrate that, under subsurface infiltration irrigation, reducing soil moisture from 80% to 60% FC during early and mid stages can be tolerated with limited yield reduction, but deficits during the prime fruit stage markedly decrease yield and plant growth traits (Li et al., 2024). Complementary deficit drip irrigation work on sandy clay loam soils found maximum yield and irrigation