Algorithm, yields superior crop yield predictions compared with standard SVR and other regressors (Abdel-Salam et al., 2024). Deep learning approaches also rely on systematic hyperparameter optimization and cross-validation, where careful selection of optimizers and network configurations (e.g., Bi-LSTM with Adam) enhances prediction accuracy and reduces error variability across crops, thereby improving prediction stability over time and across environmental conditions (Kumar et al., 2023).

6 Identification of Key Determinants Affecting Eggplant Yield

6.1 Contribution analysis of fertilizer inputs

Quantifying the contribution of fertilizer inputs to yield is central for identifying leverage points in eggplant production. Pot experiments with graded nitrogen (N) and phosphorus (P_2O_5) rates showed that N applications significantly affected nearly all growth and yield components, whereas P_2O_5 influenced fewer variables; yield gains were mainly driven by fruit number and fruit weight, with optimal responses at 100-150 kg/ha of both N and P_2O_5. A separate fertigation study using factorial N and K rates found that leaf area and agronomic efficiency of N declined at higher N and K levels, indicating diminishing returns and highlighting the importance of moderate N doses and balanced K supply for efficient production.

Longer-term field experiments confirm that not only fertilizer quantity but also source and combination determine yield contributions. In a four-year eggplant trial, applying 100% recommended NPK together with farmyard manure increased fruit yield by 47% compared with mineral fertilizer alone, while also enhancing soil organic carbon and available N, P, and K, and improving agronomic efficiency and nutrient recovery (Nisar et al., 2025). In multi-crop vegetable systems on organic soils, random forest models using soil, management, and meteorological features revealed little response to added P and only null to moderate response to added N in high-P conditions, suggesting that excess P is common and that fertilizer contribution depends strongly on existing soil fertility and N-P stoichiometry (Parent, 2024).

6.2 Sensitivity analysis of climate variables

Sensitivity analyses from global and regional studies provide a framework for evaluating how climate variables modulate eggplant yield response to fertilization. Non-parametric elasticity analysis for major crops showed that yields are most sensitive to mean air temperature, with precipitation exerting a smaller but still relevant influence; the sign and magnitude of temperature elasticity varied by crop and region, with many wheat and rice systems experiencing negative yield responses to warming (Liu et al., 2020). A machine-learning study of climate extremes found that growing-season mean climate and extremes together explained up to 49% of yield anomaly variance, and that temperature-related extremes were generally more influential than precipitation-related indices, although irrigation partly mitigated heat damage.

Variance-based sensitivity analysis applied to a process-based wheat model demonstrated that yield sensitivity shifts between water-controlling factors (precipitation, soil hydraulic properties) and nitrogen-controlling factors depending on which resource is limiting under a given climate-soil-management scenario (Hao et al., 2024). In arid and semi-arid Jordan, combining machine learning with Sobol' indices showed that climate-related variables explained a large fraction of yield variance for sensitive crops like wheat, whereas more resilient crops such as barley exhibited much lower climate-driven variance, underlining the crop- and context-specific nature of climate sensitivity (Xu et al., 2025).

6.3 Identification of dominant yield-limiting factors

Disentangling dominant yield-limiting factors requires integrating fertilizer response with plant nutritional physiology and climate constraints. Nutrient-solution omission experiments in eggplant showed that withholding individual macronutrients reduced vegetative growth, dry matter, and photosynthesis, with nitrogen and calcium identified as the most growth-limiting elements despite potassium being most demanded quantitatively (Flores et al., 2015). Greenhouse studies on N and P_2O_5 rates further indicated that yield was more affected by N than by P, with excessive doses reducing performance, suggesting that sub-optimal N supply or imbalanced N:P ratios can act as primary yield constraints even when total fertilizer input is high