

water use efficiency at about 75% FC, with both lower and higher soil moisture leading to reduced productivity, indicating an optimum soil moisture band for yield formation (Ouma et al., 2024).

### 2.3 Relationship between humidity conditions and plant health

Eggplant health is strongly influenced by humidity through its effects on fungal and bacterial disease development. In humid subtropical environments, high relative humidity and moderate temperatures were associated with substantial incidences of *Phomopsis* fruit rot and *Cercospora* leaf spot, with fruit rot increasing roughly tenfold over 30 days under mean temperatures around 23.7 °C and 55.5% relative humidity, and leaf spot rising fivefold when average temperature was 18.2 °C with morning humidity near 88%. Broader reviews of eggplant fungal diseases emphasize that environmental factors-particularly moisture and temperature-interact with host genetics to drive pathogenesis and yield loss, underscoring humidity as a key variable in risk-based yield prediction (Kaniyassery et al., 2022).

For *Alternaria* leaf spot, field monitoring across sowing dates showed disease intensity to be positively and significantly correlated with both maximum and minimum temperatures, but negatively correlated with morning and noon relative humidity; rainfall also showed a negative (though non-significant) association with disease intensity (Sharma et al., 2025). Other pathosystems, such as *Verticillium* wilt under greenhouse conditions, demonstrate that disease severity significantly reduces early and total yield and plant biomass, while irrigation frequency (and thus soil moisture regime) also affects plant performance, indicating that combined humidity, soil moisture, and pathogen pressure must be integrated into plant health and yield models.

## 3 Interaction Between Fertilization and Climate Factors in Yield Formation

### 3.1 Coupling effects of water and fertilizer management

Water-fertilizer coupling directly shapes crop growth environments by synchronizing soil moisture and nutrient availability, thereby affecting yield formation, resource use efficiency, and environmental impacts (Xing et al., 2024). In eggplant systems under mulched drip irrigation, factorial combinations of irrigation levels and nitrogen rates show that both water, nitrogen, and their interaction significantly alter evapotranspiration, yield, and water productivity, with mild water deficit plus moderate nitrogen achieving the highest yield and water productivity (Zhou et al., 2023). Similar coupling principles have been generalized across crops, where appropriate water-fertilizer ratios enhance soil physical structure, microbial activity, and nutrient mineralization, thus improving crop performance while reducing fertilizer loss and environmental pressure.

Studies in cold and arid oasis environments further indicate that eggplant yield, fruit quality, and water- and nitrogen-use efficiency are jointly governed by irrigation-nitrogen interactions, with mild water deficit (60%-70% field capacity) and moderate nitrogen rates outperforming both lower and higher inputs (Li et al., 2025). These results align with broader reviews of water-fertilizer coupling, which report that optimized coupling improves soil structural stability, microbial diversity, and enzyme activity, and that intelligent drip fertigation systems can enhance water use efficiency while lowering nutrient leakage and pollution risks (Xing et al., 2024). Together, this evidence highlights water-fertilizer coupling as a key mechanism through which management and climate-modulated water supply co-determine yield.

### 3.2 Climate-dependent fertilizer efficiency

Fertilizer efficiency is strongly modulated by climatic conditions, particularly temperature and rainfall regimes that influence nitrogen uptake pathways, losses, and crop demand. Long-term simulations for wheat-maize rotations under future climate scenarios show that, even with unchanged cultivars, warming and altered rainfall patterns reduce annual nitrogen use efficiency by about 15%, with manure-amended systems partly buffering these negative impacts by sustaining soil organic matter and nutrient supply. In rice systems, meta-analysis across climatic gradients finds that mean seasonal temperature and precipitation, along with fertilizer N rate and soil properties, jointly explain regional differences in agronomic efficiency, N recovery, and reactive nitrogen losses, underscoring that identical fertilizer rates can perform very differently under contrasting climates (Cai et al., 2022).