branched-chain amino acids in tolerance. Collectively, these studies show that both the absolute low temperature (0°C vs 4 °C) and short exposures to intermediate "priming" temperatures (8°C-20 °C) critically determine whether cold acts as damaging stress or as a signal that triggers protective acclimation pathways.

8 Case Study on Temperature-Driven Yield and Quality Variations in Peach Orchards

8.1 Study area climate and orchard characteristics

The case study focuses on subtropical orchards in southern Brazil, where 'Maciel' and 'Chimarrita' peaches are grown under contrasting microclimates but broadly similar humid subtropical conditions with variable winter chill and warm springs. A database of 208 trees captured spatial variation in soil properties, leaf nutrient status, and localized weather, allowing climate variables such as chilling hours and mean temperature to be related to yield at tree scale (Moura-Bueno et al., 2026). In parallel, field work in Brazilian subtropical regions characterized fruit development of four cultivars across the season, using growing degree days (GDD) to describe the temperature regime governing fruit growth and size.

These subtropical environments are characterized by relatively mild winters that can constrain chill accumulation and by warm, often rapidly heating, springs and summers that drive fast GDD accumulation (Moura-Bueno et al., 2026). Under these conditions, cultivars such as 'Tropical' require lower GDD and produce smaller, lighter fruit, whereas 'Biuti' demands higher GDD and attains larger size, illustrating how local thermal regimes interact with genotype to shape orchard yield potential and quality profiles. Such climate-cultivar interactions frame the design of temperature-driven prediction models in the study area.

8.2 Application of temperature-based predictive models

In the Brazilian orchards, peach yield was modeled by combining climatic indicators with tree- and soil-level covariates. Random Forest, Multiple Linear Regression, and Support Vector Machine were trained using hours of chilling, mean temperature, and leaf and soil nutrient data; Random Forest gave the highest predictive performance, and chilling hours emerged as the single most relevant predictor of yield, followed by leaf K and N and mean temperature (Moura-Bueno et al., 2026). This structure embeds temperature both as a direct driver (chill and in-season means) and as a proxy for longer-term site suitability, while allowing nonlinear effects and interactions (Figure 3).

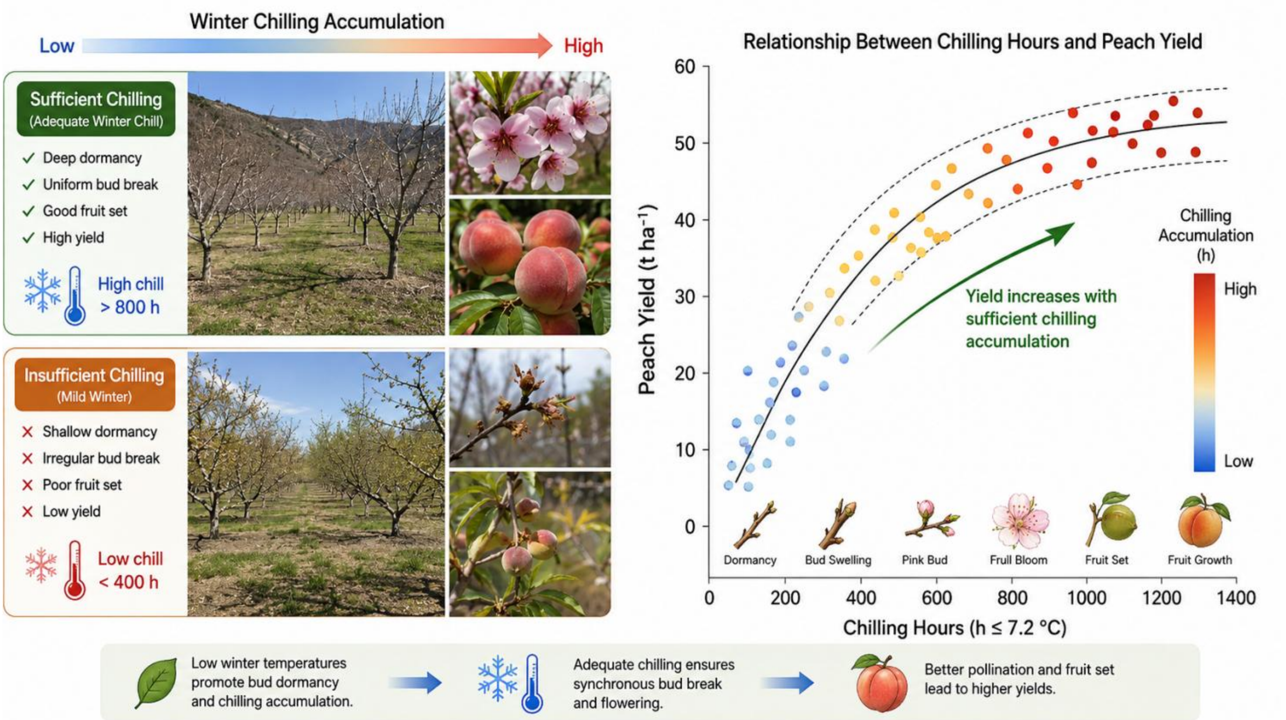

Figure 3 Relationship between winter chilling accumulation and peach yield performance in Brazilian orchards