

offset by antagonism if water and fertilizer management drive excessive K relative to Ca (Ateş et al., 2022). Environmental conditions also modify these responses, since rainfall and temperature significantly influenced cherry quality parameters in a three-year fertilization study, emphasizing that nutrient outcomes cannot be separated from orchard water status (Santos et al., 2024).

Fertigation improves nutrient-use efficiency when timing is synchronized with developmental demand rather than applied as a large undifferentiated seasonal dose. Sweet cherry management benefits from understanding nutrient availability during blossom, fruit growth, harvest, and postharvest periods, because synchronized fertilization improves application efficiency and fruit quality (Santos et al., 2024). Although the strongest direct fertigation evidence in the supplied set comes from broader fruit-crop literature, integrated soil fertility management in perennial fruit systems consistently shows that combining inorganic fertilizers with organic inputs and microbial inoculants improves agronomic response and soil health more effectively than relying on a single nutrient source (Srivastava et al., 2021). In practice, efficient fertigation for cherry should therefore emphasize moderate, stage-specific nutrient supply and avoid indiscriminate chemical fertilization, which has been identified more generally as a cause of poor nutrient balance and lower system efficiency (Srivastava et al., 2021; Varaldo et al., 2023).

6.2 Canopy and crop load management

Canopy architecture and crop load regulate how effectively nutrient supply is converted into fruit quality because they determine light interception, carbon assimilation, and competition among fruit and vegetative sinks. Low-light stress in sweet cherry reduces leaf light capture, damages photosynthetic performance, restricts carbon assimilation, and reduces nutrient accumulation in fruit (Tang et al., 2023). At the same time, fruit yield and quality are positively related to leaf area per fruit, and heavy crop load is associated with smaller, poorer-quality cherries (Matteo et al., 2022).

A favorable canopy light environment supports fruit nutrient accumulation indirectly by sustaining photosynthesis and carbohydrate export to fruit. In sweet cherry, shading reduced fruit weight, sugar content, and vitamin C, while increasing acidity, consistent with lower assimilate availability and poorer maturation under canopy closure (Tang et al., 2023). Evidence from other fruit trees points in the same direction: fruit in better-lit canopy positions accumulated more sugars, dry matter, and secondary metabolites in apple, and exposed high-light fruit showed more favorable metabolite profiles in peach (Anthony et al., 2021; Kviklys et al., 2022). Training systems therefore matter nutritionally as well as structurally, because adequate spacing and planar canopy organization improve light interception and support higher dry matter and soluble solids under commercial cherry production (Stone et al., 2022).

Crop load regulation improves fruit uniformity by reducing competition for carbohydrates and minerals among fruit. Early crop load reduction increased fruit size and weight, and thinned trees showed less pedicel detachment, browning, and decay after 45 days of storage at 0 °C (Matteo et al., 2022). Under high crop load, an early Stage I CaCl₂ spray produced firmer fruit than later sprays, indicating that crop load also alters the effectiveness of nutrient interventions rather than only baseline fruit quality. More broadly, the negative correlations between crop load and fruit dry matter or soluble solids in sweet cherry training-system trials show that uniform quality requires balancing crop number with canopy source capacity, not simply increasing fertilizer supply (Stone et al., 2022).

6.3 Soil health and organic amendments

Soil health practices support nutrient management by improving organic matter, root activity, and the biological processes that regulate nutrient cycling. Reviews across fruit systems show that integrated use of organic fertilizers, composts, and microbial inoculants has become central to sustainable soil fertility management because it improves soil health while supporting quality production (Srivastava et al., 2021; Singh et al., 2024). These practices are especially relevant in perennial orchards, where long-term root-zone function shapes yearly nutrient uptake more than short-term fertilizer additions alone.