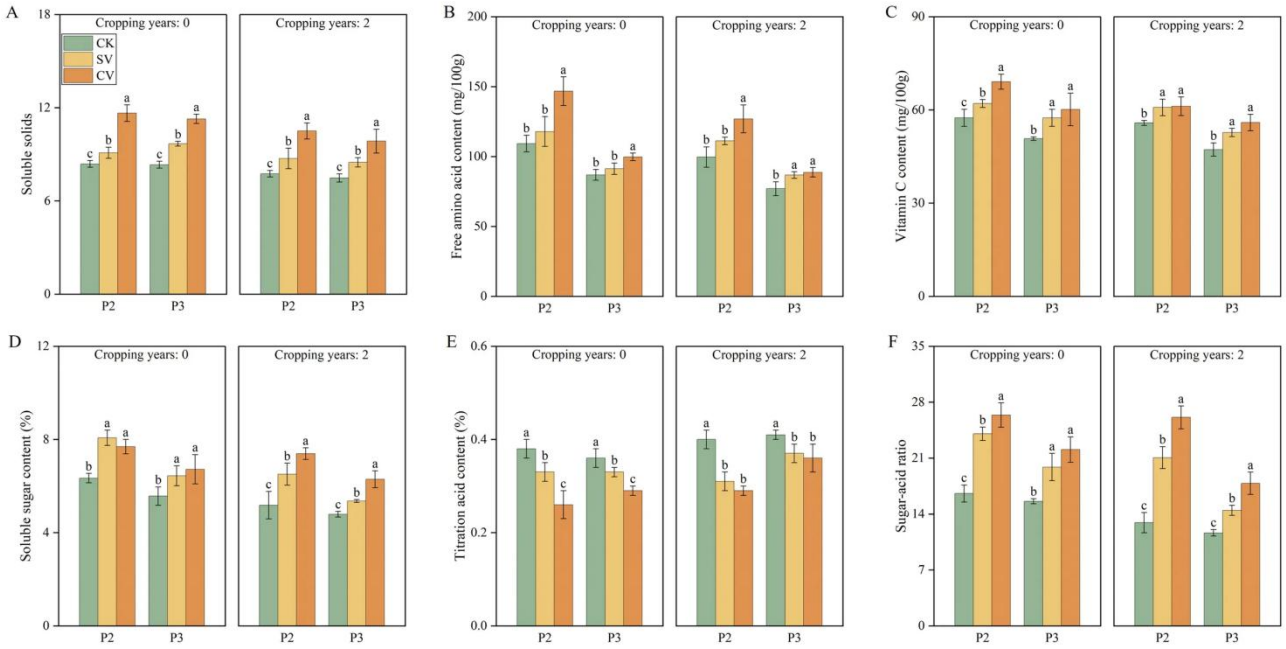

Figure 2 Effects of vermicompost on soluble solids (A), free amino acid content (B), vitamin c content (C), soluble sugar content (D), titration acid content (E) and sugar-acid ratio (F) in different periods. Letters indicate significant differences in the effects of different vermicompost treatments on this indicator at different time periods, with a significance level of $p < 0.05$. P2 and P3 represent peak fruiting period and the senescence phase respectively. Abbreviations for treatment: Control (CK), sludge vermicompost (SV) and cattle manure vermicompost (CV) (Adopted from Bai et al., 2025)

Compared with the traditional fixed formula, the nutrient management model based on growth stage regulation significantly improved strawberry production performance. In terms of yield, total yield per plant increased by about 20%, with the highest increase reaching 26% under horticultural substrate conditions. The peak fruiting stage was advanced by about one week. In terms of physiological performance, the optimized treatment significantly improved photosynthetic capacity during both vegetative growth and flowering stages. Regarding fruit quality, the sugar-acid ratio increased by about 41%, and vitamin C content increased by about 34%, reaching up to 74.1 mg/100 g.

8 Challenges and Future Prospects

8.1 Limitations of current substrate technologies

Although substrate cultivation technology has become relatively mature, its long-term sustainability and system resilience are still constrained by multiple factors. Peat remains the dominant material in commercial strawberry substrates, but peatlands are non-renewable on a practical timescale, and their extraction leads to serious problems such as increased carbon emissions and habitat destruction. Even in regions where peat resources are relatively abundant, it is widely recognized that peat cannot be rapidly regenerated. Therefore, efforts are being made to reduce its carbon footprint through practices such as artificial cultivation of sphagnum moss and partial substitution with local materials like sawdust, bark, and compost.

The reuse of peat, coir, and wood fiber has, to some extent, reduced pressure on resource extraction and waste disposal. Under properly adjusted fertigation management, these substrates can be reused for up to three cycles without significant reductions in yield or physical properties (Vandecasteele et al., 2024; Woznicki et al., 2024). However, reuse also introduces new issues, including nutrient accumulation (especially increases in nitrogen and calcium and depletion of potassium), changes in cellulose content, and the buildup of pathogenic fungi. Therefore, disinfection (such as steam treatment) and nutrient rebalancing are necessary to maintain system stability (Hu et al., 2025).

The disposal and end-use of spent substrates remain major challenges. Rockwool, widely used in greenhouse horticulture, has low organic carbon content and limited value as a soil amendment. It also tends to accumulate