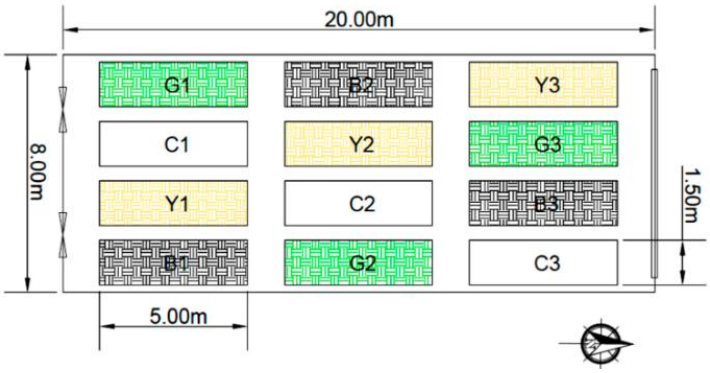

Figure 3 The distribution of the colored shading nets blocks, blocks with black shading nets (B), blocks with green shading nets (G), blocks with beige shading nets (Y), and the control blocks (C) (Adopted from Alhelal et al., 2024)

Image caption: Each shading net covered three blocks (replication) with dimensions of 5 m × 1.5 m × 3.5 m (Adopted from Alhelal et al., 2024)

6.2 Evaluation of the impact of environmental control on strawberry yield and quality

The precise environmental control technology system (covering light environment regulation, temperature and humidity management, and intelligent water and fertilizer system) has a continuous promoting effect on the formation of strawberry yield and quality improvement. LED artificial lighting technology can not only improve the yield level, but also significantly increase the content of anthocyanins, polyphenols and antioxidant activity in fruits, thereby enhancing the functional nutritional quality of strawberries (Warner et al., 2021; Pérez-Romero et al., 2024). The sensor irrigation system under hydroponic conditions dynamically optimizes the supply of water and fertilizer to achieve a synergistic improvement in resource utilization efficiency and yield (Hutchinson et al., 2025). In the organic production system, although the application of biostimulants and compost tea varies from year to year and from variety to variety, it can generally improve the yield composition and the accumulation of fruit flavor substances (Pérgola et al., 2023; Kilic, 2024; Nakielska et al., 2024; Ciriello et al., 2025).

7 Integration of Environmentally Sustainable Technologies

7.1 Potential of green energy systems in year-round strawberry cultivation

The use of renewable energy such as solar energy has become a key path to reduce the environmental load of facility strawberry production. The results of life cycle analysis show that photovoltaic (PV) systems and solar thermal-photovoltaic (PV/T) systems have shown significant advantages in energy efficiency and carbon emission reduction. Among them, photovoltaic technology is particularly outstanding, which can reduce cumulative energy consumption by 50%, and its environmental impact index is reduced by 16% and 6% respectively compared with traditional energy modes (Hosseini-Fashami et al., 2019). This type of energy configuration not only provides stable and clean power support, but also effectively alleviates the potential pressure caused by greenhouse system operation on the ecosystem. It has been verified in facility agriculture scenarios in many places (Romero-Gámez and Suárez-Rey, 2020).

7.2 Eco-friendly integrated pest and disease control system

Developing effective yet natural pest control methods is crucial for sustainable strawberry farming. Using helpful bacteria (like *Bacillus*) along with organic boosters such as humic acid can raise strawberry production by up to 79% while fighting fungal infections (Nakielska et al., 2024; Ranasingha et al., 2024). The effectiveness depends on plant types and local conditions, requiring customized solutions. Specially made compost tea both strengthens plants and blocks diseases, working especially well in organic systems that protect nature while growing crops (Pérgola et al., 2023). Unlike chemical sprays, these natural methods help keep soil microbes healthy and create better farming conditions long-term.

7.3 Innovative application of smart agricultural management platform

New digital tools are changing how strawberries get grown. Connected sensors and smart computers work together to automatically adjust temperature, moisture, light and air conditions for ideal growing. In Ecuador, the