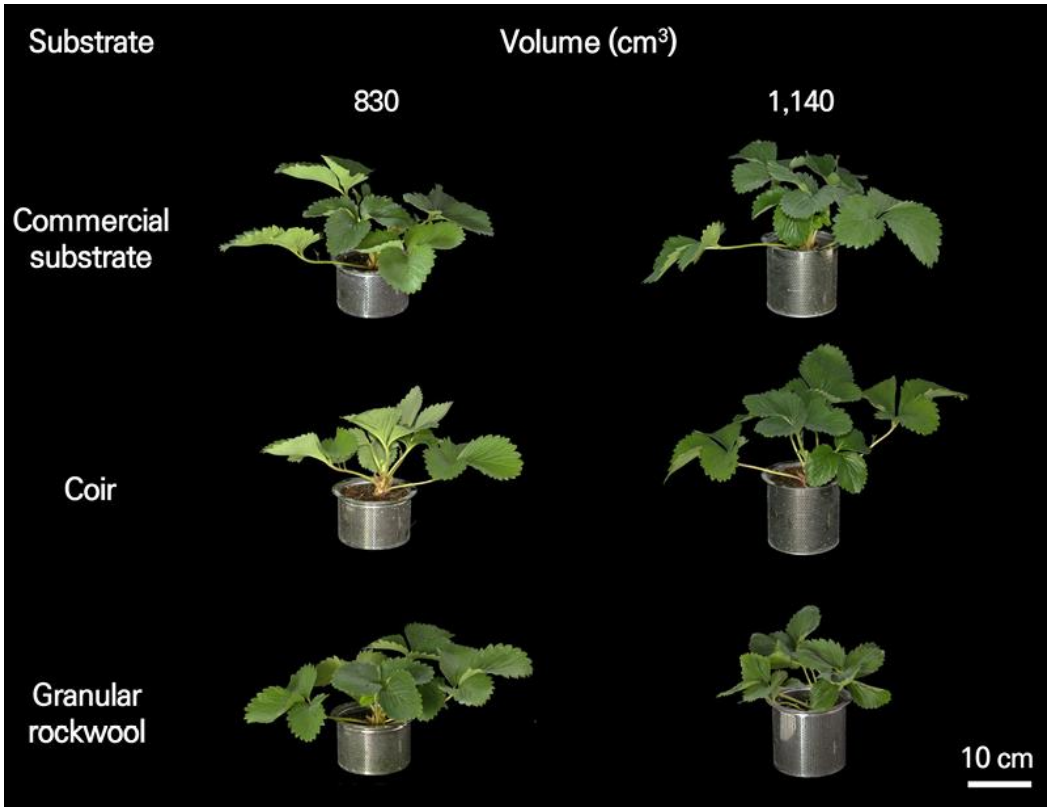

Figure 1 Plants grown with two different pot volumes (830 and 1 140 cm^3) with three different substrate types (commercial substrate, coir, and granular rockwool) treatment 63 days after transplant (Adopted from Lee et al., 2023)

3.2 Inorganic substrates

Common inorganic substrates include perlite, vermiculite, and rockwool, as well as other mineral materials such as tuff and volcanic rock. Perlite is highly porous and has very low bulk density, which helps improve drainage and aeration. When mixed with peat, vermicompost, or plant compost (e.g., perlite:peat = 1:1, perlite:vermicompost = 3:2, perlite:compost = 4:1), it can significantly enhance vegetative growth, leaf area, nutrient accumulation, yield, and fruit quality compared to substrates with poor aeration (El-Sayed et al., 2016).

Vermiculite has higher water-holding capacity and CEC than perlite. Coir-vermiculite and coir-vermiculite-perlite mixtures, compared with sand culture, can increase petiole length, canopy size, root biomass, and total soluble solids (TSS), indicating that vermiculite improves water and nutrient retention without seriously reducing aeration when used in proper proportions.

Rockwool is a uniform and inert substrate with excellent control over root-zone moisture. In greenhouse soilless systems, rockwool can promote earlier transition to reproductive growth in strawberry and produce more fruits and higher total yield than coir. In contrast, coir is more favorable for vegetative growth, and there is little difference between the two in terms of sugar content and fruit firmness. Granular rockwool has very high water retention, and improper irrigation management may lead to water stress and restricted root growth.

Volcanic rock (tezontle), used alone or mixed with coir at a 1:1 ratio, produced more fruits per plant as well as larger berries and higher individual fruit weight than soil cultivation. This suggests that properly graded mineral substrates, when combined with precise water and nutrient management, can match or even exceed organic substrates in yield performance (Lekavičienė et al., 2025).

3.3 Mixed substrate systems

Mixed substrates combine organic components that supply water, nutrients, and biological activity with inorganic components that provide structural stability and improved aeration, creating a synergistic effect. Coir-perlite (4:1) and peat-perlite (4:1) mixtures performed better than pure tuff or tuff-organic mixtures in terms of photosynthesis,