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STUDY OF SOLAR BASED VERTICAL FARMING SYSTEMS WITH RAY-TRACED DAYLIGHTING ANALYSIS AND VISUALIZATIONS

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ABSTRACT

This article explores the use of raytracing software and heat load models to optimise the growing of crops vertically and by doing so, serves to increase the plausibility of urban Vertical Farms (VFs). Crop trays are modelled using a computer aided design (CAD) software and is then imported into a raytracing software TracePro-2019. Parameters obtained from the heat load and angle calculations would be used to start the simulation. Thereafter, solar irradiance obtained would be compared to different simulations with different design parameters. For this paper, the main design variable would be the tray width and tray inclination angle. After multiple simulations, it was found that trays at the bottom are less affected by varying angles of sunlight while trays at the top receive extreme variations. It was also noted that while the shaded area increases as tray inclination increases, the solar irradiance flux on each tray increases as opposed to decreasing. This new finding led to the conclusion that an increase in the angle of attack of the solar irradiance increased the occurrence of reflected and diffused irradiance. By just tilting the trays by 20°, it allows more light to reach inwards, which would allow for a longer width of the trays. This in turn also increases the total yield of a tray in a limited space. This discovery can be utilised for the layout and arrangement for indoor VFs that relies on external solar irradiance for a light source and is proof that crop yield can be increased without adding extra energy consumption.

Highlights

- Food engineering education in solar based VF system.
- Discuss challenges faced in modern land-scarce urban agriculture farms.
- TracePro 2019 for raytracing used in conjunction with ASHRAE sunlight modelling method.
- Tray width to height ratio is highly dependent on, to maximise crop yield while retaining amount of sunlight received for indoor vertical farming.
- Tilting of crop trays towards the sunlight is the most cost effective and energy saving way to maximise solar flux and space usage.
- External direct solar irradiance flux on crop trays decreases as tray inclination angles increases, but overall solar irradiance increases as steeper angles results in increased reflected solar irradiance.
- Capturing of reflected and diffused irradiance should be prioritised rather than maximising direct irradiance.