



## Why Indoor Nurseries Matters

1. As weather patterns become increasingly unpredictable, it is more challenging to rely on outdoor nurseries for consistent seed germination and the production of strong, healthy seedlings.
2. More farms are turning to indoor nurseries, which provide greater control over seedlings' early growth. By maintaining optimal growing conditions, indoor nurseries can produce uniform, high-quality seedlings regardless of external weather conditions.
3. However, this shift comes with a trade-off. Indoor nurseries typically consume more electricity than outdoor systems, with air-conditioning (temperature/humidity control) and LED lighting being the main cost drivers. Without careful optimisations, these higher energy requirements can significantly increase operating costs and erode farm profitability.

## What We Set Out to Examine

This study aims to identify the optimal balance between nursery temperature and lighting conditions that can improve crop yields while keeping electricity costs manageable.

The study addresses 2 key questions:

1. Do nursery conditions at the seedling stage influence final harvest performance?
2. What combination of temperature and lighting duration maximises yields for Xiao Bai Cai (XBC) and Cai Xin (CX)?

## Our Approach

1. Seeds of XBC and CX (commonly used local varieties) were sown in coco pellets and kept in controlled growing chambers for 16 days<sup>a</sup>. For comparison, seeds were also grown in greenhouse nursery conditions (ebb and flow system).
2. At the nursery stage, we applied different temperature (26, 28, 30°C) and photoperiods (12, 16 hours) using controlled growth chambers (Table 1). All other conditions were kept constant (i.e., relative humidity, nutrients, light intensity of white LED grow lights delivering 290  $\mu\text{mol}/\text{m}^2/\text{s}$  PPFD<sup>b</sup>).
3. After the nursery stage, seedlings were transplanted into a commercial-scale greenhouse using nutrient film technique (NFT) hydroponic channels and grown for 21 days with the electrical conductivity (EC) of 2.0 mS/cm controlled by an automatic dosing system.

## Measurements

We measured fresh weight, dry weight, and plant height at two key stages: day 16 (before transplanting) and day 37 (at harvest). The entire experiment was repeated three times to ensure reliable results.

**Table 1** Nursery temperature and photoperiod treatments

Temperature (°C)	Photoperiod (hours)
26	12
26	16
28	12
28	16
30	12
30	16



a: XBC and CX seedlings are recommended to be transplanted between 14-16 days after sowing. Younger seedlings (~10 days) experience more transplanting shock with higher mortality. Beyond 17 days, elongation and overcrowding worsens, negatively impacting downstream marketability. Growers should monitor seedlings quality balanced with operational needs when determining the optimal nursery period.

b: Sáros, L., Boros, I. F., Csambalik, L., Székely, G., Jung, A., & Balázs, L. (2020). Horticultural lighting system optimization: A review. *Scientia Horticulturae*, 273, 109631. <https://doi.org/10.1016/j.scienta.2020.109631>

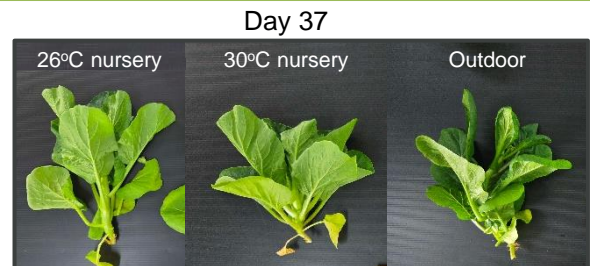
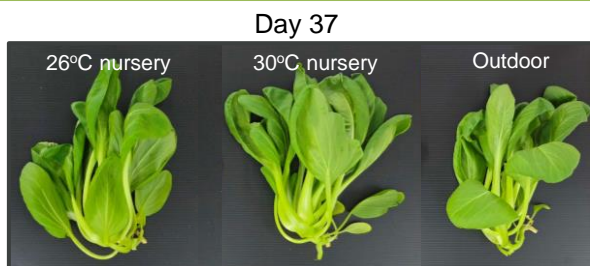
# Optimising nursery conditions is a cost-effective way to improve yield

## What We Discovered

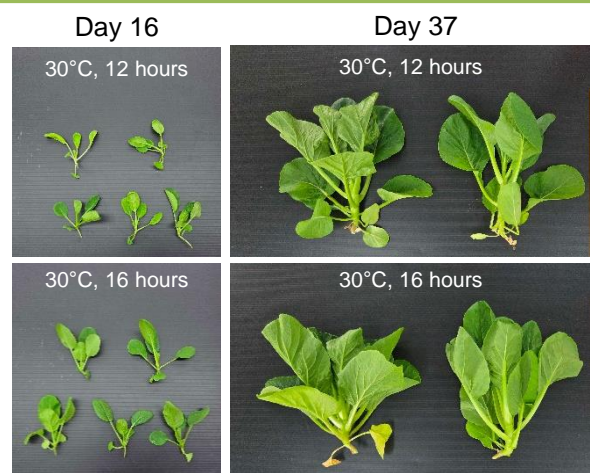
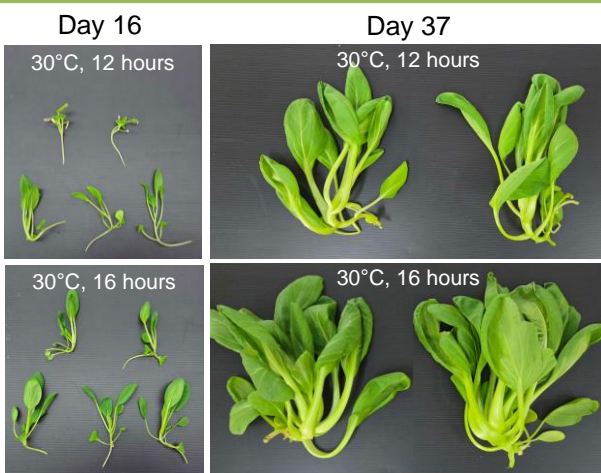
- Indoor nurseries significantly improve yields.** Indoor nurseries operated with a 16-hour photoperiod consistently achieved more than 15% higher yields compared to outdoor nurseries for both XBC and CX, demonstrating the inherent value of protected nurseries.
- Greater temperature flexibility enables cost saving.** No significant difference in final harvest weights were observed between seedlings grown at 26°C and those grown at 30°C during the nursery period. This indicates that indoor nurseries can be operated at higher temperatures (28–30°C) without compromising yields, reducing cooling requirements and operating costs.
- Photoperiod plays a critical role in yield outcomes.** At 30°C indoor nursery conditions, extending daily lighting from 12 to 16 hours increased harvest yield by over 30%, highlighting the substantial returns from optimising photoperiod.
- Small improvements at the nursery stage translate into large gains at harvest.** The trials showed that every 0.1g increase in seedling fresh weight resulted in a 2.7–5.4g increase in final harvest yield for XBC and a 1.1–2.7g increase for CX. This demonstrates that optimising nursery conditions is a highly cost-effective way to improving overall crop productivity.

### Xiao Bai Cai

### Cai Xin



Indoor nurseries yield >15% more than outdoor nurseries with 16 hours lighting.



At 30°C indoor nursery conditions, 16-hour light duration increased yield by >30% compared to 12-hour light duration

Temperature (°C)	Light duration (hours)	XBC (g)	CX (g)
26	12	49.3 <sup>ab</sup>	40.9 <sup>bcd</sup>
26	16	69.1 <sup>c</sup>	56.3 <sup>e</sup>
28	12	44.8 <sup>ab</sup>	30.4 <sup>a</sup>
28	16	52.1 <sup>b</sup>	48.3 <sup>cde</sup>
30	12	43.5 <sup>a</sup>	34.6 <sup>abc</sup>
30	16	70.0 <sup>c</sup>	53.1 <sup>de</sup>
Greenhouse conditions		44.9 <sup>ab</sup>	35.9 <sup>ab</sup>

**Table 2** Average yield (g) per plant for each treatment (n = 30 per treatment, crop, trial). Treatments with the same lowercase letter are not statistically different ( $p > 0.05$ ).

➡ Harvest yields from nurseries operating at 26°C vs 30°C showed no significant difference.

➡ Harvest yields from nurseries operating at 16 hours photoperiod are significantly higher compared to 12 hours.

## Troubleshooting Common Issues

- 1. Energy Allocation:** Prioritise energy use on lighting rather than cooling. A 16-hour photoperiod delivers measurable returns, whilst heavy reliance on air-conditioning provides comparatively lower returns and can often be achieved with good ventilation design.
- 2. Inconsistent seedling quality:** Monitor nursery environmental conditions closely on a daily basis. Small variations at the seedling stage can translate into large differences in final yields, due to the strong relationship between seedling weight and harvest yield.
- 3. Ventilation challenges:** Where natural ventilation is insufficient to maintain temperatures around 30°C, consider mechanical ventilation (e.g., exhaust fans) as a more cost-effective alternative to air-conditioning.
- 4. Scaling up:** Begin by testing these nursery conditions on a small section of the farm before expanding. While the principles apply across scales, site-specific adjustments may be required.
- 5. Photoperiod – temperature optimisation:** For farms drawing grid electricity, consider operating LED lighting during night-time hours. Avoid daytime operations (9am–5pm), when heat generated by LEDs coincides with peak ambient temperatures, making it more challenging and costly to maintain temperatures below 30°C.

## Implementation Steps

Here are some practical tips to get started.

- 1. Setting up temperature control:** Install adequate ventilation to maintain nursery temperatures around 30°C. This may include exhaust fans, intake vents, and circulation fans. Monitor temperatures regularly and adjust ventilation as needed to maintain stable conditions.
- 2. Lighting setup:** Install LED grow lights with timers set to a 16-hour photoperiod. Ensure even light distribution across all seedling trays. While extended lighting increase electricity use, the associated yield gains (up to ~30%) make this a cost-effective investment.
- 3. Environmental monitoring:** Use digital thermometers and humidity meters to track nursery conditions. Ensure adequate air circulation to prevent excessive humidity build-up (<90% relative humidity) to allow transpiration for better seedling health.
- 4. Transition planning:** Once seedlings are established, transplant them into the main growing system and increase nutrient concentrations (around 2.0 mS/cm EC, adjusted accordingly to crop requirements) for the remaining growth cycle.



The Singapore Food Agency (SFA) had recently announced the \$70mil Agri-food Cluster Transformation (ACT) Fund 2 which supports capability development, productivity improvements, and infrastructure upgrades. Farms can leverage the Capability Upgrading component of the ACT Fund 2 to adopt energy-efficient equipment and technologies from SFA's pre-qualified list. This will help farms improve energy efficiency and manage production costs to strengthen long-term resilience.



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### About the Author

Yi Chieh is from the Agriculture Technology Department, Agrifood Technology Division, with a background in engineering and agriculture. His current research includes production processes optimisation and digital agriculture.



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Best practices guide for crop cultivation covering other topics can be found here.