DOI: 10.36253/ahsc-16590
https://oaj.fupress.net/index.php/ahs

AHS
Advances in Horticultural Science

Supplementary materials

Continuous lighting improves the leaf quality of sweet basil (*Ocimum basilicum* L.) grown in a controlled environment

(*) Corresponding author:
martina.puccinelli@agr.unipi.it

Citation:
PUCCINELLI M., MAGGINI R., PARDOSSI A., INCROCCI L., 2025 - *Continuous lighting improves the leaf quality of sweet basil (Ocimum basilicum L.) grown in a controlled environment.* - Adv. Hort. Sci., 39(1): 21-30

ORCID:
PM: 0000-0001-7571-2393
MR: 0000-0003-2542-6561
PA: 0000-0001-9927-4017
IL: 0000-0001-9994-763X

Author contribution:
Conceptualization, AP, MP; methodology, AP, MP.; formal analysis, MP, RM; resources, AP, LI; data curation, MP; writing - original draft preparation, MP, AP; manuscript review and editing, MP, RM, AP, LI; supervision, AP.

Data Availability Statement:
All relevant data are within the paper and its Supporting Information files.

Competing Interests:
The authors declare no conflict of interests.

Received for publication 10 September 2024
Accepted for publication 24 February 2025

AHS - Firenze University Press
ISSN 1592-1573 (on line) - 0394-6169 (print)

M. Puccinelli (*), R. Maggini, A. Pardossi, L. Incrocci
Department of Agriculture, Food and Environment, University of Pisa, via del Borghetto, 80, 56124 Pisa, Italy.

Key words: Artificial light, hydroponics, LED, 24-hour photoperiod, vertical farms.

Abstract: In vertical farms, continuous lighting (CL) with lower light intensity (photosynthetic photon flux density, PPFD) is a method to reduce the investment costs for the lighting system. Continuous lighting has both negative and positive effects on crop performance, depending on the plant species. In this study, we investigated the effect of CL on plant growth and leaf quality in sweet basil (*Ocimum basilicum* L. cv. Tigullio) cultivated in a growth chamber with light emitting diode (LED) (R:B:G=3:1:1). Basil plants were grown hydroponically for 14 days with and a photoperiod of 16 h d^{-1} (control) or 24 h d^{-1} with a PPFD of 220 or 147 µmol m^{-2} s^{-1}, respectively. The same daily light integral was 12.7 mol m^{-2} d^{-1} in both treatments. Plant growth was not significantly affected by the light regime. Compared with the control, CL increased the leaf antioxidant capacity and concentration of total chlorophylls, flavonoids and phenols, and reduced the nitrate level. Continuous lighting would slightly increase or decrease electricity costs compared to 16-hour illumination, depending on the daily schedule of the standard lighting regime.

Table 1S - A summary of the studies conducted on the effect of continuous lighting on some leafy vegetables and herbs grown in a controlled environment (growth chamber or vertical farm). The photoperiod, photosynthetic photon fluence density (PPFD), daily light integral (DLI, mol m^{-2} d^{-1}), and type of light used in the experiments are shown for the regular light regime (control) and continuous lighting (CL) along with experiment duration

Crop (species)	Regular light regime (control)	Continuous lighting (CL)	Treatment duration (d)	Effect of CL on plant growth and/or leaf quality compared with the control	Reference
Amaranth (*Amaranthus tricolor* L.) microgreens	Photoperiod: 16 h d^{-1} PFFD: 250.8 and 376.8 µmol m^{-2} s^{-1} DLI: 14.5 and 21.7 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 166.6 and 247.6 µmol m^{-2} s^{-1} DLI: 14.4 and 21.5 mol m^{-2} d^{-1} Light: LED	11	**Positive**: higher FW and better and leaf quality (higher pigment concentration)	Lanoue *et al.*, 2022
Amaranth (*Amaranthus tricolor* L.), leaves	Photoperiod: 6, 12, and 18 h d^{-1} PFFD: 540 µmol m^{-2} s^{-1} DLI: 11.66, 23.33, and 34.99 mol m^{-2} d^{-1} Light: fluorescent and incandescent	Photoperiod: 24 h d^{-1} PPFD: 540 µmol m^{-2} s^{-1} DLI: 46.65 mol m^{-2} d^{-1} Light: fluorescent and incandescent	21	**Negative**: reduction of plant FW and DW, leaf antioxidant capacity, and concentration of pigments and polyphenols.	Ali *et al.*, 2009
Broccoli (*Brassica oleracea* var. *italica* Plenck), microgreens	Photoperiod: 16 h d^{-1} PFFD: 270 µmol m^{-2} s^{-1} DLI: 15.6 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PFFD: 180 and 270 µmol m^{-2} s^{-1} DLI: 15.6 and 23.3 mol m^{-2} d^{-1} Light: LED	12	**Positive**: higher yield and nutritional value (higher concentration of anthocyanins, flavonoids, carotenoids, and proline) and lower nitrate concentration. Short-term (3 d) CL before harvest	Shibaeva *et al.*, 2022
Calendula (*Calendula officinalis*), edible	Photoperiod: 16 h d^{-1} PFFD: 267 µmol m^{-2} s^{-1} DLI: 17.26 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PFFD: 200 and 400 µmol m^{-2} s^{-1} DLI: 17.25 and 34.56 mol m^{-2} d^{-1} Light: LED	Till 55 days after sowing	**Positive:** higher phenolic content, antioxidant capacity, and energy use efficiency.	Munyanont *et al.*, 2024
Chicory (*Cichorium intybus*), plants	Photoperiod: 16 and 20 h d^{-1} PFFD: 250 µmol m^{-2} s^{-1} DLI: 14.4 and 18 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 250 µmol m^{-2} s^{-1} DLI: 21.6 mol m^{-2} d^{-1} Light: LED	21	**Negative**: lower plant FW (no effect on DW).	Pennisi *et al.* 2020
Chinese cabbage (*Brassica campestris L.* ssp. *chinensis* var. *utilis*), plants	Photoperiod: 12 h d^{-1} PFFD: 200 and 300 µmol m^{-2} s^{-1} DLI: 8.64 and 12.96 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 200 and 300 µmol m^{-2} s^{-1} DLI: 17.28 and 25.92 mol m^{-2} d^{-1} Light: LED	21	**Positive**: higher plant DW.	Kang *et al.*, 2024
Collard microgreens *(Brassica oleracea var. viridis*), microgreens	Photoperiod: 16 h d^{-1} PFFD: 250.8 and 376.8 µmol m^{-2} s^{-1} DLI: 14; 21 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 166.6 and 247.6 µmol m^{-2} s^{-1} DLI: 14; 21 mol m^{-2} d^{-1} Light: LED	11	**No effect**	Lanoue *et al.*, 2022

FW= fresh weight; DW= dry weight; LED= Light-emitting diode; EFF= External electrode fluorescent light.

Crop (species)	Regular light regime (control)	Continuous lighting (CL)	Treatment duration (d)	Effect of CL on plant growth and/or leaf quality compared with the control	References
Ice Plant (*Mesembryanthemum crystallinum* L.), plants	Photoperiod: 8, 12, 16 and 20 h d^{-1} PFFD: 220 µmol m^{-2} s^{-1} DLI: 6.34, 9.50, 12.67 and 15.84 mol $m^{-2}d^{-1}$ Light: LED	Photoperiod: 24 h d^{-1} PPFD: 220 µmol m^{-2} s^{-1} DLI: 19.01 mol m^{-2} d^{-1} Light: LED	28	**No or negative effect** on plant FW and DW; smaller, thicker, darker and curlier leaves; lower leaf K content.	Xia and Mattson, 2022
Japanese mugwort (*Artemisia princeps* Pamp.) leaves	Photoperiod: 12 h d^{-1} PFFD: 130 µmol m^{-2} s^{-1} DLI: 5.62 mol m^{-2} d^{-1} Light: fluorescent	Photoperiod: 24 h d^{-1} PPFD: 130 µmol m^{-2} s^{-1} DLI: 11.24 mol m^{-2} d^{-1} Light: fluorescent	28	**Positive**: higher leaf FW and DW: increase in leaf concentration of ascorbic acid and polyphenols. Appearance of leaf browning in CL plants.	Hata and Kawamura, 2023
Kale (*Brassica oleracea* var. *acephala*)	Photoperiod: 6, 12 and 16 h d^{-1} PFFD: 500 µmol m^{-2} s^{-1} DLI: 10.80, 21.60 and 28.80 mol m^{-2} d^{-1} Light: metal halide	Photoperiod: 24 h d^{-1} PFFD: 500 µmol m^{-2} s^{-1} DLI: 43.20 mol m^{-2} d^{-1} Light: metal halide	21	**Positive**: higher plant FW and DW; increased leaf concentration of pigments.	Lefsrud *et al.*, 2006
Kale (*Brassica oleracea* var. *acephala*)	Photoperiod: 14, 16 and 20 h d^{-1} PFFD: 235, 210, and 165 µmol m^{-2} s^{-1} DLI: 11.9 mol m^{-2} d^{-1} Light: (R:B, 3:1) LED	Photoperiod: 24 h d^{-1} PFFD: 140 µmol m^{-2} s^{-1} DLI: 11.9 mol m^{-2} d^{-1} Light: metal halide	21	**Positive**: greater plant FW and DW; higher light use efficiency.	Zauli *et al.*, 2024
Lettuce (*Lactuca sativa* L.), leaves	Photoperiod: 12 h d^{-1} PFFD: 200 µmol m^{-2} s^{-1} DLI: 8.64 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 200 µmol m^{-2} s^{-1} DLI: 17.28 mol m^{-2} d^{-1} Light: LED	2-3 (pre-harvest)	**Positive**: higher leaf antioxidant capacity and concentration of pigments and phenolic compounds; lower nitrate level.	Bian *et al.*, 2016, 2018
Lettuce (*Lactuca sativa*L.), leaves	Photoperiod: 12, 16, and 20 h d^{-1} PFFD: 320 µmol m^{-2} s^{-1} DLI: 13.82, 18.43 and 23.04 mol m^{-2} d^{-1} Light: Metalhalide	Photoperiod: 24 h d^{-1} PPFD: 320 µmol m^{-2} s^{-1} DLI: 27.65 mol m^{-2} d^{-1} Light: Metalhalide	14	**Positive**: higher plant FW and DW; higher leaf chlorophylls concentration.	Inada and Yakumoto, 1989
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 12, 16, and 20 h d^{-1} PFFD: 150 and 200 µmol m^{-2} s^{-1} DLI: 6.48, 8.64, 10.8, 8.64, 11.52, and 14.4 mol m^{-2} d^{-1} Light: EEFLs	Photoperiod: 24 h d^{-1} PPFD: 150 and 200 µmol m^{-2} s^{-1} DLI: 12.96 and 17.28 mol m^{-2} d^{-1} Light: EEFLs	21	**Positive**: higher plant FW and DW; higher leaf antioxidant capacity and concentration of phenolic compounds with low PPFD.	Cho *et al.*, 2020
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 16 h d^{-1} PFFD: 120, 150, 180, and 270 µmol m^{-2} s^{-1} DLI: 6.9, 8.6, 10.4, and 15.6 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 120, 150, and 180 µmol m^{-2} s-1 DLI: 10.4, 13.0, and 16.6 mol m^{-2} d^{-1} Light: LED	18	**Positive**: higher plant FW and DW; greater leaf pigmentation in red lettuce.	Kelly *et al.*, 2020

Crop (species)	Regular light regime (control)	Continuous lighting (CL)	Treatment duration (d)	Effect of CL on plant growth and/or leaf quality compared with the control	Reference
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 16 and 24 h d^{-1} PFFD: 350 and 415 µmol m^{-2} s^{-1} DLI: 20.16 and 23.90 Light: Fluorescent	Photoperiod: 24 h d^{-1} PPFD: 350 and 216 µmol m^{-2} s^{-1} DLI: 30.24 and 22.46 Light: Fluorescent	21	**Positive**: increase in FW and DW.	Koontz and Prince, 1987
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 16 h d^{-1} PFFD: 200 µmol m^{-2} s^{-1} DLI: 11.52 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 200 µmol m^{-2} s^{-1} DLI: 17.28 mol m^{-2} d^{-1} Light: LED	30	**Positive**: higher plant FW and DW.	Liu *et al.*, 2020
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 18 h d^{-1} PFFD: 360 µmol m^{-2} s^{-1} DLI: 23.328 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 270 µmol m^{-2} s^{-1} DLI: 23.328 mol m^{-2} d^{-1} Light: LED	12	**Positive**: higher plant FW and DW leaf quality (higher sugar concentration). **Negative**: leaf chlorosis and necrosis.	Liu Jand Liu, 2022
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 18 h d^{-1} PFFD: 200, 300, and 400 µmol m^{-2} s^{-1} DLI: 12.96, 19.44, and 25.92 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PFFD: 200, 300, and 400 µmol m^{-2} s^{-1} DLI: 23.328 mol m^{-2} d^{-1} Light: LED	16 - 12	**Positive**: higher plant FW and DW leaf quality (higher antioxidants concentration).	Liu and Liu, 2024
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 16 h d^{-1} PFFD: 120 µmol m^{-2} s^{-1} DLI: 6.91 mol m^{-2} d^{-1} Light: fluorescent and LED	Photoperiod: 24 h d^{-1} PPFD: 120 µmol m^{-2} s^{-1} DLI: 10.37 mol m^{-2} d^{-1} Light: LED	31	**Positive**: higher plant DW.	Ohtake *et al.*, 2018
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 16 and 20 h d^{-1} PFFD: 250 µmol m^{-2} s^{-1} DLI: 14.4 and 18 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 250 µmol m^{-2} s^{-1} DLI: 21.6 mol m^{-2} d^{-1} Light: LED	21	**No effect** on plant FW and DW.	Pennisi *et al.*, 2020
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 16 h d^{-1} PFFD: 225 µmol m^{-2} s^{-1} DLI: 12.96 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 150 µmol m^{-2} s^{-1} DLI: 12.96 mol m^{-2} d^{-1} Light: LED	14	**Positive**: higher plant FW and DW.	Shao *et al.*, 2022
Lettuce (*Lactuca sativa* L.), red leaves, plants	Photoperiod: 16 h d^{-1} PFFD: 225 µmol m^{-2} s^{-1} DLI: 12.96 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 150 µmol m^{-2} s^{-1} DLI: 12.96 mol m^{-2} d^{-1} Light: LED	2 – 4 (pre-harvest)	**Positive**: better nutritional and flavor quality due to greater sweetness and lesser bitterness.	Shen *et al.*, 2024

Crop (species)	Regular light regime (control)	Continuous lighting (CL)	Treatment duration (d)	Effect of CL on plant growth and/or leaf quality compared with the control	References
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 14 h d^{-1} PFFD: 200 µmol m^{-2} s^{-1} DLI: 10.08 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 200 µmol m^{-2} s-1 DLI: 17.28 mol m^{-2} d^{-1} Light: LED	1-3 (pre-harvest)	**Positive** on lettuce quality: lower nitrate concentration and higher concentrations of sugars, pigments, and phenolic compounds; greater sweetness and lesser bitterness.	Yang *et al.*, 2023
Lettuce (*Lactuca sativa* L.), plants	Photoperiod: 12 h d^{-1} PFFD: 240 µmol m^{-2} s^{-1} DLI: 10.37 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 120 µmol m^{-2} s^{-1} DLI: 10.37 mol m^{-2} d^{-1} Light: LED	15	**Positive**: higher FW and DW; higher concentration of ascorbic acid.	Zha *et al.*, 2019
Mizuna (*Brassica rapa* ssp *nipposinica* (LH Bailey) Hanelt), , microgreens	Photoperiod: 16 h d^{-1} PFFD: 270 µmol m^{-2} s^{-1} DLI: 15.6 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PFFD: 180 and 270 µmol m^{-2} s^{-1} DLI: 15.6 and 23.3 mol m^{-2} d^{-1} Light: LED	12	**Positive**: higher yield and nutritional value (higher concentration of anthocyanins, flavonoids, carotenoids, and proline) and lower nitrate level. Short-term (3 d) CL before harvest increased nutrition-	Shibaeva *et al.*, 2022
Mung bean (*Vigna radiata* L.), seedlings	Photoperiod: 12 h d^{-1} PFFD: 400 µmol m-2 s^{-1} DLI: 17.28 Light: fluorescent	Photoperiod: 24 h d^{-1} PPFD: 400 µmol m^{-2} s^{-1} DLI: 34.56 Light: fluorescent	12	**Positive**: higher plant FW and leaf chlorophyll concentration.	Kumar *et al.*, 2022
Nasturtium (*Tropaeolum majus* L.), plants	Photoperiod: 16 h d^{-1} PFFD: 300 µmol m^{-2} s^{-1} DLI: 17.3 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 200 µmol m^{-2} s^{-1} DLI: 17.3 mol m^{-2} d^{-1} Light: LED	21	**Positive**: higher plant FW and DW; higher leaf antioxidant capacity.	Xu *et al.*, 2021
Pak-choi (*Brasica rapa* var. *chinensis*), plants	Photoperiod: 12 h d^{-1} PFFD: 100 µmol m^{-2} s^{-1} DLI: 4.32 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 100 µmol m^{-2} s^{-1} DLI: 8.64 mol m^{-2} d^{-1} Light: LED	30	**Positive**: higher plant FW and DW.	Harun *et al.*, 2019
Purslane (*Portulaca oleracea* L.), plants	Photoperiod: 12 and 18 h d^{-1} PFFD: 240 and 480 µmol m^{-2} s^{-1} DLI: 20.37 and 20.74 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 240 µmol m^{-2} s^{-1} DLI: 20.74 mol m^{-2} d^{-1} Light: LED	16	**Negative**: lower plant FW and DW at the same DLI; higher leaf nitrate concentration.	He *et al.*, 2023
Radish (*Raphanus sativus* L.), plants	Photoperiod: 12, 16, and 20 h d^{-1} PFFD: 320 µmol m^{-2} s^{-1} DLI: 13.82, 18.43 and 23.04 mol m^{-2} d^{-1} Light: metal halide	Photoperiod: 24 h d^{-1} PPFD: 320 µmol m^{-2} s^{-1} DLI: 27.65 mol m^{-2} d^{-1} Light: metal halide	14	**Positive**: higher plant FW and DW; higher leaf chlorophylls concentration.	Inada and Yakumoto, 1989
Radish (*Raphanus sativus* var. *radical* Pers.), microgreens	Photoperiod: 16 h d^{-1} PFFD: 270 µmol m^{-2} s^{-1} DLI: 15.6 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PFFD: 180 and 270 µmol m^{-2} s^{-1} DLI: 15.6 and 23.3 mol m^{-2} d^{-1} Light: LED	12	**Positive**: higher yield and nutritional value (higher concentration of pigments, flavonoids, and proline) and lower nitrate level. Short-term (3 d) CL before harvest increased nutritional value	Shibaeva *et al.*, 2022

Crop (species)	Regular light regime (control)	Continuous lighting (CL)	Treatment duration (d)	Effect of CL on plant growth and/or leaf quality compared with the control	References
Red beet (*Beta vulgaris L.* ssp. *vulgaris*), leaves	Photoperiod: 6, 12, and 18 h d^{-1} PFFD: 540 µmol m^{-2} s^{-1} DLI: 11.66, 23.33, and 34.99 mol m^{-2} d^{-1} Light: fluorescent and incandescent	Photoperiod: 24 h d^{-1} PPFD: 540 µmol m^{-2} s^{-1} DLI: 46.65 mol m^{-2} d^{-1} Light: fluorescent and incandescent	21	**Negative**: reduction of plant FW and DW, and leaf antioxidant capacity and concentration of pigments and polyphenols.	Ali *et al.*, 2009
Rocket (*Eruca sativa* L.), plants	Photoperiod: 16 and 20 h d^{-1} PFFD: 250 µmol m^{-2} s^{-1} DLI: 14.4 and 18 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 250 µmol m^{-2} s^{-1} DLI: 21.6 mol m^{-2} d^{-1} Light: LED	21	**No effect** on plant FW and DW.	Pennisi *et al.*, 2020
Rocket (*Eruca vesicaria* L.), leaves	Photoperiod: 12 h d^{-1} PFFD: 600 µmol m^{-2} s^{-1} DLI: 25.92 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 300 µmol m^{-2} s^{-1} DLI: 25.92 mol m^{-2} d^{-1} Light: LED	30	**Positive**: higher plant FW and DW; higher leaf concentrations of pigments and antioxidants; lower nitrate level.	Proietti *et al.*, 2021
Rocket (*Eruca vesicaria* sp. *sativa* Mill.), microgreens	Photoperiod: 16 h d^{-1} PFFD: 270 µmol m^{-2} s^{-1} DLI: 15.6 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PFFD: 180 and 270 µmol m^{-2} s^{-1} DLI: 15.6 and 23.3 mol m^{-2} d^{-1} Light: LED	12	**Positive**: higher yield and nutritional value (higher concentration of anthocyanins, flavonoids, carotenoids, and proline) and lower nitrate content. Short-term (3 d) CL before harvest increased nutritional value and decreased nitrate level.	Shibaeva *et al.*, 2022
Spinach *(Spinacea oleracea* L.), leaves	Photoperiod: 6, 12, and 18 h d^{-1} PFFD: 540 µmol m^{-2} s^{-1} DLI: 11.66, 23.33, and 34.99 mol m^{-2} d^{-1} Light: fluorescent and incandescent	Photoperiod: 24 h d^{-1} PPFD: 540 µmol m^{-2} s^{-1} DLI: 46.65 mol m^{-2} d^{-1} Light: fluorescent and incandescent	21	**Negative**: reduction of plant FW and DW, leaf antioxidant capacity, and concentration of pigments and polyphenols.	Ali *et al.*, 2009
Sweet basil (*Ocimum basilicum* L.) plants	Photoperiod: 16 and 20 h d^{-1} PFFD: 250 µmol m^{-2} s^{-1} DLI: 14.4 and 18 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 250 µmol m^{-2} s^{-1} DLI: 21.6 mol m^{-2} d^{-1} Light: LED	21	**No effect** on plant FW and DW.	Pennisi *et al.*, 2020
Sweet basil (*Ocimum basilicum* L.), microgreens	Photoperiod: 16 h d-1 PFFD: 250.8; 376.8 µmol m^{-2} s^{-1} DLI: 14; 21 mol m^{-2} d^{-1} Light: LED	Photoperiod: 24 h d^{-1} PPFD: 166.6; 247.6 µmol m^{-2} s^{-1} DLI: 14; 21 mol m^{-2} d^{-1} Light: LED	19	**Positive**: higher FW at the same DLI in green basil. No effects on red basil.	Lanoue *et al.*, 2022
Swiss chard (*Beta vulgaris L.* ssp. *cicla*), leaves	Photoperiod: 6, 12, and 18 h d^{-1} PFFD: 540 µmol m^{-2} s^{-1} DLI: 11.66, 23.33, and 34.99 mol m^{-2} d^{-1} Light: fluorescent and incandescent	Photoperiod: 24 h d^{-1} PPFD: 540 µmol m^{-2} s^{-1} DLI: 46.65 mol m^{-2} d-1 Light: fluorescent and incandescent	21	**Negative**: reduction of plant FW and DW, leaf antioxidant capacity and concentration of pigments and polyphenols.	Ali *et al.*, 2009

References

ALI M.B., KHANDAKER L., OBA S., 2009 - *Comparative study on functional components, antioxidant activity and color parameters of selected colored leafy vegetables as affected by photoperiods*. - J. Food Agric. Environ., 7: 392-398.

BIAN Z., CHENG R., WANG Y., YANG Q., LU C., 2018 - *Effect of green light on nitrate reduction and edible quality of hydroponically grown lettuce (*Lactuca sativa *L.) under short-term continuous light from red and blue light-emitting diodes*. - Environ. Exp. Bot., 153: 63-71.

BIAN Z.-H., CHENG R.-F., YANG Q.-C., WANG J., LU C., 2016 - *Continuous light from red, blue, and green light-emitting diodes reduces nitrate content and enhances phytochemical concentrations and antioxidant capacity in lettuce*. - J. Amer. Soc. Hortic. Sci., 141: 186-195.

CHO J.Y., YOO K.S., KIM J., CHOI B.J., OH W., 2020 - *Growth and bioactive compounds of lettuce as affected by light intensity and photoperiod in a plant factory using external electrode fluorescent lamps*. - Hortic. Sci. Technol., 38: 645-659.

HARUN A.N., MOHAMED N., AHMAD R., RAHIM A.R.A., ANI N.N., 2019 - *Improved Internet of Things (IoT) monitoring system for growth optimization of* Brassica chinensis. - Comput. Electron. Agric., 164: 104836.

HATA N., KAWAMURA M., 2023 - *Effect of continuous lighting on the growth and leaf chemical components of* Artemisia princeps *grown hydroponically in a plant factory condition*. - Adv. Hort. Sci., 37(2): 173-183.

HE J., GAN J.H.S., QIN L., 2023 - *Productivity, photosynthetic light-use efficiency, nitrogen metabolism and nutritional quality of C4 halophyte* Portulaca oleracea *L. grown indoors under different light intensities and durations*. - Front. Plant Sci., 14: 1-14.

INADA K., YABUMOTO Y., 1989 - *Effect of light quality, daylength and periodic temperature variation on the growth of lettuce and radish plants*. - Jpn. J. Crop Sci., 58: 689-694.

KANG Y., WU Q., PAN G., YANG H., LI J., YANG X., ZHONG M., 2024 - *High daily light integral positively regulate photosynthetic capacity through mediating nitrogen partitioning and leaf anatomical characteristic in flowering Chinese cabbage*. - Sci. Hortic., 326: 112715

KELLY N., CHOE D., MENG Q., RUNKLE E.S., 2020 - *Promotion of lettuce growth under an increasing daily light integral depends on the combination of the photosynthetic photon flux density and photoperiod*. - Sci. Hortic., 272: 109565.

KOONTZ H.V., PRINCE R.P., 1986 - *Effect of 16- and 24-hours daily radiation (light) on lettuce growth*. - HortSci., 21: 123-124.

KUMAR D., SINGH H., BHATT U., SONI V., 2022 - *Effect of continuous light on antioxidant activity, lipid peroxidation, proline and chlorophyll content in* Vigna radiata *L.* - Funct. Plant Biol., 49: 145-154.

LANOUE J., ST. LOUIS S., LITTLE C., HAO X., 2022 - *Continuous lighting can improve yield and reduce energy costs while increasing or maintaining nutritional contents of microgreens*. - Front. Plant Sci., 13: 1-17.

LEFSRUD M.G., KOPSELL D.A., AUGÉ R.M., BOTH A.J., 2006 - *Biomass production and pigment accumulation in kale grown under increasing photoperiods*. - HortSci., 41:603-606.

LIU J., LIU W., 2022 - *Regulation of accumulation and metabolism circadian rhythms of starch and sucrose in two leaf-color lettuces by red:blue ratios of LED continuous light*. - Environ. Exp. Bot., 196: 104811.

LIU W., LIU J., 2024 - *Alternating red-blue light alleviated physiological injury by reducing oxidative stress under both high light and continuous light from red-blue LEDs*. - Hortic. Env. Biotech., 65: 831-845.

LIU W., ZHA L., ZHANG Y., 2020 - *Growth and nutrient element content of hydroponic lettuce are modified by LED continuous lighting of different intensities and spectral qualities*. - Agronomy, 10: 1-11.

MUNYANONT M., LU N., RACHMA D.F., RUANGSANGARAM T., TAKAGAKI M., 2024 - *Lighting patterns regulate flowering and improve the energy use efficiency of calendula cultivated in plant factories with artificial lighting*. - Agriculture (Switzerland), 14 (12): 2208.

OHTAKE N., ISHIKURA M., SUZUKI H., YAMORI W., GOTO E., 2018 - *Continuous irradiation with alternating red and blue light enhances plant growth while keeping nutritional quality in lettuce*. - HortSci., 53: 1804-1809.

PENNISI G., ORSINI F., LANDOLFO M., PISTILLO A., CREPALDI A., NICOLA S., FERNÁNDEZ J.A., MARCELIS L.F.M., GIANQUINTO G., 2020 - *Optimal photoperiod for indoor cultivation of leafy vegetables and herbs*. - Eur. J. Hort. Sci., 85: 329-338.

PROIETTI S., MOSCATELLO S., RICCIO F., DOWNEY P., BATTISTELLI A., 2021 - *Continuous lighting promotes plant Growth, light conversion efficiency, and nutritional quality of* Eruca vesicaria *(L.) Cav. in controlled environment with minor effects due to light quality*. - Front. Plant Sci., 12: 730119.

SHAO M., LIU W., ZHOU C., WANG Q., LI B., 2022 - *Alternation of temporally overlapped red and blue light under continuous irradiation affected yield, antioxidant capacity and nutritional quality of purple-leaf lettuce*. - Sci. Hortic., 295.

SHEN W., ZHANG W., LI J., HUANG Z., TAO Y., HONG J., ZHANG L., ZHOU Y., 2024 - *Pre-harvest short-term continuous LED lighting improves the nutritional quality and flavor of hydroponic purple-leaf lettuce*. - Sci Hortic., 334: 113304.

SHIBAEVA T.G., SHERUDILO E.G., RUBAEVA A.A., TITOV A.F., 2022 - *Continuous LED lighting enhances yield and*

nutritional value of four genotypes of Brassicaceae *microgreens*. - Plants, 11: 1-14.

XIA J., MATTSON N., 2022 - *Response of common ice plant (*Mesembryanthemum crystallinum *L.) to photoperiod/daily light integral in vertical hydroponic production*. - Horticulturae, 8: 653.

XU W., LU N., KIKUCHI M., MICHIKO T., 2021 - *Continuous lighting and high daily light integral enhance yield and quality of mass-produced nasturtium (*Tropaeolum majus *L.) in plant factories*. - Plants, 10: 1-16.

YANG X., HU J., WANG Z., HUANG T., XIANG Y., ZHANG L., PENG J., TOMAS-BARBERAN F.A., OICHANG Y., 2023 - *Pre-harvest nitrogen limitation and continuous lighting improve the quality and flavor of lettuce (*Lactuca sativa *L.) under hydroponic conditions in greenhouse*. - J. Agric. Food Chem., 71: 710-720.

ZAULI I., CAROTTI L., PISTILLO A., PENNISI G., MARTIN M., CREPALDI A., GIANQUINTO G., ORSINI F. 2024 - *Indoor cultivation of baby-leaf kale under constant DLI: Increasing photoperiod with lower PPFD as a strategy to improve crop growth in an aeroponic system*. - European J. Hort. Sci., 89(5):1-10.

ZHA L., ZHANG Y., LIU W., 2019 - *Dynamic responses of ascorbate pool and metabolism in lettuce to long-term continuous light provided by red and blue LEDs*. - Environ. Exp. Bot., 163: 15-23.