Title: Leaf shape, ascorbic acid content and plant growth of *spinacia oleracea* grown under different light-emitting diodes and ultraviolet radiation (UV-A) light in plant factory

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The study found that the safe and environmentally friendly light emitting diode (LED, light-emitting diode) and the Ultraviolet radical (UVA) light source, known to be effective in the production of plant pigments, affected spinach growth, leaf shape and ascorbic acid content. Different LED light sources, including red LED (R), blue LED (B), red and blue mixed light (Red LED+Blue LED (2:1)), white LED (W), red LED+UVA (RUV), and blue LED+UVA (BUV), were applied by comparing with the fluorescent lamp (FL). The length and with of leaf, petiole length and leaf number were measured four times at every 7 days after transplanting. Photosynthesis rate was measured every two weeks. On the 28th day after the transplanting, the leaf area, root length, fresh and dry weights of shoot and root and the ascorbic acid content were investigated.

All the light sources containing the R show the best growth performance; however, leaf epinasty symptom occurs under the light sources containing red LED (e.g. R and RUV) after 14 days after transplanting. From the 21 days after transplanting, the leaf epinasty symptom was also found under the RB and RBUV treatment with a significant decrease in quality. In the RUV, the length of leaf and petiole was significantly shorter, but the leaf width was significantly wider compared to the R, resulting in a lower leaf shape index. In BUV, the length of the leaf and petiole was significantly increased with no difference in the leaf width, compared to B, resulting in a higher leaf shape index.

The fresh and dry weights of shoot and root were significantly higher in the R, RUV and BUV treatments at the 28 days after transplanting, while they were significantly lower in W and FL. The leaf area was the highest in the BUV treatment, followed by the R treatment, and the specific leaf area was the highest in the RUV treatment, and the lowest in the BUV treatment. The photosynthesis rate measured on the 16th day after transplanting was significantly the lowest in the R treatment, where the leaf epinasty symptom occurred.

The ascorbic acid content of the spinach harvested on the 28th day was significantly higher in the B treatment, followed by the BUV, and significantly lower in FL and R. All the integrated data suggest that the BUV light seems to be the most suitable for growth and quality of hydroponically grown spinach. However, if spinach is used as a young leaf vegetable, it is appropriate to adjust the intensity of W LED that do not induce the leaf epinasty symptom.

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