Influence of LED lighting power on Indau (Eruca sativa (Mill.))

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Abstract. The article investigates the reaction of four varieties of Indau sowing to the power of illumination by LED lamps. Indau sowing cultivars responded positively to the increase in lighting power at different stages of development, with the exception of Sicilia, which showed a neutral reaction. The Hooday variety has tasty formed a high rosette with wide leaves and the largest average weight of one plant of 25.72 g at an illumination power of 140 μmol / m² / s. The Sicily cultivar formed standard rosettes of wide leaves weighing 16.33 g at an illumination power of 170 μmol / m² / s. The Chudesnitsa cultivar formed standard rosettes of narrow leaves weighing 19.28 g at an illumination power of 170 μmol / m² / s. Variety Dikovina formed a high rosette with wide leaves and the largest average weight of one plant 20.11 g at an illumination power of 170 μmol / m² / s.

1. Introduction
Vegetable crops are plastic that is, external and morphometric parameters, and yield change under the influence of external environmental factors. The influence of growing conditions in open and protected ground is well studied, while the influence of growing conditions in closed systems, or in factories of plants with artificial lighting, has not been studied enough [1-10].

The closed cultivation system is a facility designed for the year-round production of vegetables, vegetable seedlings and ornamental crops on vertical farms under controlled artificial conditions. To regulate and control the parameters of microclimate and nutrition, technical systems of heating, ventilation and air conditioning, hydro- and international methods of nutrition and photo culture of plants are used. Growing conditions in closed systems are characterized by negative biotic factors (microalgae, introduced beneficial or pathogenic microflora) and stable and optimal nutrition of abiotic factors (temperature and humidity conditions, CO₂ content, macro- and microelements, photoperiods), but, in comparison with the conditions of an open type or protected ground, the illumination power is lower and the spectrum is different from natural, which leads to varietal responses to growing conditions. 70% of the costs are spent on growing electricity used to illuminate the grown crop; therefore, determining the optimal power is relevant.

Indau sowing (Eruca sativa (Mill.)) Is an annual, cold-resistant, light-loving plant of the Cabbage family (Brassicaceae). Indau has a spicy, mustard taste. The plant contains alkaloids, flavonoids, vitamin C, B vitamins, mineral salts, iodine up to 700 μg / kg, iron, malic and citric acids, steroids, fatty and mustard oil are found in the seeds. Several studies have shown the potential role of phytochemicals in plants of the Brassicaceae family in the prevention of certain diseases and types of cancer; inhibition of carcinogenesis and hepatoprotective effect [4; 7].
Currently, there are no Indau cultivars bred specifically for full photo culture conditions, so the purpose of our study is to study the response of four Indau cultivars to the power of LED lighting during the growing season.

2. Materials and methods
The research took place in the phytotron of the Laboratory of Photoculture and City-Farming of the SPbGAU in 2020. All varieties are included in the State Register for growing in open and protected ground [9].

Sowing of seeds was carried out manually on the surface of the substrate. Domit nonwoven fabric was used as a substrate. Germination was carried out at 23-24 °C and 93% air humidity. Growing conditions: photoperiod was 16 hours a day, 8 hours a night; the average power of irradiation, μmol/m²/s - 80 ± 8, 110 ± 10, 140 ± 12, 170 ± 15; light spectrum - ratio of blue spectrum to red spectrum 1: 5; air temperature - 22-23 °C, air humidity - 55-65%.

The plants were fed by the aeroponic method. The composition of the nutrient solution, mg / l: N - 190, P - 26, K - 166, Mg - 9 and trace elements; The pH was maintained at 5.5-6.0, the conductivity of the solution was 1.5-2.0 mSm / cm. Planting density was 180 plants / m². The growing season from mass shoots was 39 days.

When carrying out biometric measurements (plant height, leaf width), the following guidelines were followed: “Guidelines for studying the collection of cabbage and leafy green crops (lettuce, spinach, dill)” [2] and “Methodology of field experiment in vegetable growing” [3].

The illumination power was measured with a TKA-Spektr spectrophotometer (LLC “Scientific and Technical Enterprise TKA”, St. Petersburg) at a suspension height of the lamps of 40 cm. The average illumination power was calculated according to PNST 211-2017 "Irradiation of plants with LED light sources. Measurement methods ".

The placement of variants is systematic; the studies were carried out in 3 analytical replicates and 10 biological replicates. Statistical processing of the experimental data on the average weight of one plant was carried out by the method of analysis of variance according to the Student's t-test (the significance of the difference between the means was estimated at a 5% significance level) using Microsoft Excel software. To determine the degree of influence of illumination power on the morphometric parameters and the average weight of one plant, the coefficient of determination was calculated. Average values of indicators are indicated with standard error of the mean.

3. Results
Table 1 shows the results of biometric measurements of four cultivars of Indau sowing under different illumination power at 25, 32 and 39 days from mass shoots. Table 2 presents data on the average weight of one plant of four varieties of Indau sowing under different illumination power on days 25, 32 and 39 from mass shoots.

4. Discussion
An increase in the illumination power had a strong effect on the morphometric parameters (table 1) and the average weight of Indau sowing varieties at different stages of development. According to the average weight of one plant (table 2), there are significant differences between the variants of the experiment for each variety.

The Khuday cultivar reacted in a tasty and positive way to the increase in the illumination power: with the increase in the illumination power, the plant height, leaf width and average weight per plant increased. Variety Slimy is tasty with the determining influence of the lighting power ($r^2 = 0.97$ in plant height, $r^2 = 0.42$ in leaf width, $r^2 = 0.80$ in average weight) on the 25th day it formed plants with a height of 157 to 172 mm, leaf width 31-36 mm and the average weight of one plant 1.29-2.41 g. By the end of the growing season, on the 39th day, the influence of the illumination power affected the decrease in plant height ($r^2 = 0.58$), leaf width ($r^2 = 0, 01$), average mass ($r^2 = 0.55$). The height of plants on the 39th day was 181-264 mm, leaf width - 53-69 mm, average weight - 11.50-25.72 g. Tall
plants with wide leaves and the greatest average weight were deliciously formed by the Hoodi variety at an illumination power of 140 μmol / m² / s.

Table 1. Morphometric parameters of Indau sowing at different illumination power according to counts, 2020.

| Variety name, factor A | Illumination power, μmol / m² / s, factor B | Plant height, mm | Sheet width, mm |
|------------------------|---------------------------------------------|------------------|----------------|
|                        | 25 days ±Sₓ | 32 days ±Sₓ | 39 days ±Sₓ | 25 days ±Sₓ | 32 days ±Sₓ | 39 days ±Sₓ |
| Lose weight tasty       | 80 157.3 5.1 186 5.9 181 53.8 | 31 3.6 35 2.2 53 5.5 |
| Sicily                 | 110 160 6.8 157 5.9 259 8.7 | 35 3.7 28 2.3 68 6.0 |
|                        | 140 168 8.8 166 8.0 264 20.3 | 32 3.5 22 1.7 69 10.3 |
| Sicily                 | 170 172 10.8 219 5.3 257 13.3 | 36 4.3 54 2.9 55 8.8 |
| Miracle woman          | 80 147.6 6.9 186 3.1 220 12.3 | 43 3.5 43 6.7 54 3.9 |
| Sicily                 | 110 99.0 10.0 142 11.1 245 4.6 | 34 2.8 36 4.4 55 4.1 |
| Sicily                 | 140 164 6.9 210 7.0 308 16.5 | 46 2.3 52 3.8 47 3.6 |
| Sicily                 | 170 155 8.3 171 26.8 230 17.2 | 47 2.5 47 3.0 57 4.9 |
| Dikovina               | 80 170.1 7.1 175 27.0 246 18.1 | 31 1.7 45 2.9 58 12.3 |
| Sicily                 | 110 98.2 12.8 229 23.2 246 18.6 | 24 1.6 41 3.0 48 4.3 |
| Sicily                 | 140 157 13.1 211 23.3 225 15.5 | 41 2.3 49 4.6 46 3.2 |
| Sicily                 | 170 164 16.9 210 7.0 308 16.5 | 46 2.3 52 3.8 47 3.6 |
| Sicily                 | 170 155 8.3 171 26.8 230 17.2 | 47 2.5 47 3.0 57 4.9 |

Table 2. Average weight of one Indau sowing plant at different illumination power according to counts, 2020.

| Variety name, factor A | Illumination power, μmol / m² / s, factor B | 25 days ±Sₓ | 32 days ±Sₓ | 39 days ±Sₓ |
|------------------------|---------------------------------------------|--------------|--------------|--------------|
| Lose weight tasty       | 80 1.29 0.22 3.00 0.28 11.50 1.31 |
| Sicily                 | 110 1.60 0.29 2.59 0.50 17.72 1.87 |
| Sicily                 | 140 2.41 0.35 2.54 0.43 25.72 2.81 |
| Sicily                 | 170 2.22 0.39 8.05 1.52 20.11 2.26 |
| Sicily                 | 80 0.88 0.31 0.15 0.73 0.69 0.03 |
| Sicily                 | 110 0.93 0.14 3.91 1.38 15.17 1.57 |
| Sicily                 | 140 2.95 0.44 5.59 0.70 8.67 0.89 |
| Sicily                 | 170 3.29 0.20 5.17 0.80 16.33 1.42 |
| Sicily                 | 80 1.21 0.33 4.16 0.50 10.89 1.26 |
| Sicily                 | 110 1.36 0.21 2.44 0.23 10.00 1.02 |
| Sicily                 | 140 2.95 0.44 5.59 0.70 8.67 0.89 |
| Sicily                 | 170 3.29 0.20 5.17 0.80 16.33 1.42 |
| Sicily                 | 80 0.51 0.32 0.33 0.33 0.33 |
| Sicily                 | 110 0.93 0.14 3.91 1.38 15.17 1.57 |
| Sicily                 | 140 2.26 0.32 6.10 1.03 19.28 1.66 |
| Sicily                 | 170 2.77 0.56 4.61 0.55 17.44 2.00 |
| Sicily                 | 0.31 0.39 0.40 0.40 0.40 |
| Sicily                 | 80 1.14 0.23 3.34 0.80 11.06 1.09 |
| Sicily                 | 110 0.81 0.13 1.86 0.69 12.94 1.59 |
| Sicily                 | 140 1.68 0.17 6.33 1.09 16.33 1.86 |
| Sicily                 | 170 2.38 0.29 6.06 0.75 20.11 4.20 |
| Sicily                 | 0.74 0.56 0.98 0.98 0.98 |

HCP₀.₀₅ factor A 0.06 0.17 0.17 factor B 0.06 0.17 0.17
The Sicily cultivar is tolerant of increased lighting power. The lighting conditions did not have a significant effect on the increase in plant height \( r^2 \approx 0.01-0.16 \) and leaf width \( r^2 \approx 0.04-0.29 \) during the growing season. However, the average weight of one plant was largely determined by light conditions \( r^2 \approx 0.32-0.51 \) during the growing season. The Sicily variety on the 25th day formed plants with a height of 99-164 mm, a leaf width of 34-47 mm and an average weight of one plant of 1.13-3.29 g. By the end of the growing season, on the 39th day, the plant height was 220-308 mm, leaf width - 47-57 mm, average weight - 8.67-16.33 g. Tall plants with narrow leaves and the smallest average weight cultivar Sicily formed at an illumination power of 140 μmol / m² / s, and at 170 μmol / m² / s the largest mass of one plant with a standard rosette of wide leaves was formed.

The Chudesnitsa cultivar reacted positively to an increase in the illumination power, especially by the 25th day from mass seedlings: with an increase in the illumination power, the plant height \( r^2 \approx 0.88 \), leaf width \( r^2 \approx 0.73 \) and the average weight of one plant \( r^2 \approx 0.31 \). The Chudesnitsa cultivar on the 25th day formed plants with a height of 98 to 193 mm, a leaf width of 24-56 mm and an average weight of one plant 0.93-2.77 g. By the end of the growing season, on the 39th day, the effect of lighting power decreased on plant height \( r^2 \approx 0.15 \), leaf width \( r^2 \approx 0.03 \), but increased by average weight \( r^2 \approx 0.40 \). Plant height on the 39th day was 225-272 mm, leaf width - 46-62 mm, average weight - 15.17-19.28 g. The Chudesnitsa cultivar formed tall plants with wide leaves at an illumination power of 170 μmol / m² / s, and the largest average weight of one plant was formed in plants with a standard rosette of narrow leaves at an illumination power of 140 μmol / m² / s.

Variety Dikovina reacted positively to an increase in the lighting power throughout the growing season: with an increase in lighting power, the plant height \( r^2 \approx 0.78-0.87 \), leaf width \( r^2 \approx 0.37-0.97 \) and the average weight of one plants \( r^2 \approx 0.56-0.98 \). Variety Dikovina on the 25th day formed plants with a height of 126-185 mm, a leaf width of 31-45 mm and an average weight of one plant 0.81-2.38 g. By the end of the growing season, the plant height was 223-350 mm, leaf width - 47-69 mm, average weight - 11.06-20.11 g. Tall plants with wide leaves and the largest average weight of one plant were formed by the Dikovina variety at an illumination power of 170 μmol / m² / s.

5. Conclusion
Based on the research results, the following conclusions can be drawn:

- Indau sowing cultivars reacted positively to an increase in lighting power at different stages of development, with the exception of Sicilia, which is tolerant to lighting conditions.
- The Hooday variety has tasty formed a high rosette with wide leaves and the largest average weight of one plant of 25.72 g at an illumination power of 140 μmol / m² / s.
- Variety Sicily formed standard rosettes of wide leaves weighing 16.33 g at an illumination power of 170 μmol / m² / s.
- Cultivar Chudesnitsa formed standard rosettes of narrow leaves weighing 19.28 g at an illumination power of 140 μmol / m² / s.
- Variety Dikovina formed a high rosette with wide leaves and the largest average weight of one plant 20.11 g at an illumination power of 170 μmol / m² / s.

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