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The influence of specific light spectrums on rooting of woody cuttings of coniferous species in nursery practice

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Abstract

Light, as a vital source of energy, is one of the factors that significantly influence development of plants. In common nursery practice, coniferous species are propagated mostly vegetatively, with rooting of woody cuttings being one of the regularly used methods. Propagation with woody cuttings is usually performed outside vegetation, i.e. during periods with insufficient quantity and quality of daylight. Artificial lighting can significantly help to solve this problem. An experiment was carried out using daylight-compensating LED systems with specific wavelengths (460nm and 670nm for alternative A; 440nm and 630nm for alternative B), the intensity was 70 µmol $s^{-1} \cdot m^{-2}$. Spectra were composed in 4:1 ratio (“Red” : “Blue”) using modules with mounted LED diodes. The experiment was performed on Thuja occidentalis 'Columna', which was artificially lit for over 12 hours along with daylight. The experiment took place in two terms: from November to March, and from February to June. The results showed differences based on the term of cutting, as well as in the artificially-lit alternatives.

Key words: LED diodes, vegetative propagation, artificial grow light, light spectra, woody cuttings, greenhouse production, Thuja occidentalis

Introduction:

Plants respond to radiation of wavelengths ranging between 400 and 700 nm. These wavelengths are known as Photosynthetically Active Radiation (PAR). The most important wavelengths for plants are located on both ends of this range. So-called “blue” part, which is located on the left end of the spectrum, affects qualitative growth, reduces elongation growth and affects the production of chlorophyll. On the other hand the “red” part, located on the right end of the spectrum, facilitates quantitative growth. It is specifically important for the development of the photosynthetic apparatus [1]. Besides radiation wavelength, the intensity of light is also crucial. Plants do not thrive if the light values are too low, extremely high radiation values can be detrimental [2]. Plants grown from seed or vegetatively propagated plants generally thrive in light conditions ranging between 30 and 100 µmol $s^{-1} \cdot m^{-2}$[3].

Materials and Methods

Two alternatives of lighting units containing LED diodes providing different spectral composition were used in the experiment. The spectra were composed as follows: alternative A had is highest absorbance at 460 nm for chlorophyll B and 670 nm for chlorophyll A, while alternative B had its highest absorbance at 440 nm for chlorophyll A and 630 nm for chlorophyll B. The lighting units were designed with LED modules in a 4:1 ratio (“Red” : “Blue”), specifically 8 pieces of blue LEDs and 32 pieces of red LEDs. The intensity of radiation was 70 μmol $s^{-1} \cdot m^{-2}$. However, intensity tends to decrease towards the centre of the source, which is clearly visible in **Fig 1**. Lights were used to extend daylight period over 12 hours. Simultaneously, the effect of natural daylight was maintained in both experiments. The intensity of natural light was higher in comparison to artificial light (LED elements), which is evident from Fig 2 and Fig 3.

Plants were assessed on a 6-point scale (no roots, formed callus, formed root, rooted, partially rooted, fully rooted). Plants labelled as viable are represented as a percentage of those labelled as “formed root”, “rooted”, “partially rooted”, and “fully rooted”. Rooting stimulators were not used to prevent distortion of results.

Results and Discussion

The results of the experiment are expressed through the percentage of successfully rooted cuttings, as well as quality and quantity of produced roots. The results proved the presumed difference between terms of cutting – in the November term there were significant differences between the alternatives and control, with A ending up as the best alternative (460 nm, 670 nm) with 19 % success rate in rooting; the poorest results were yielded in the control variant with only 2 % success rate, as illustrated in Tab. 1

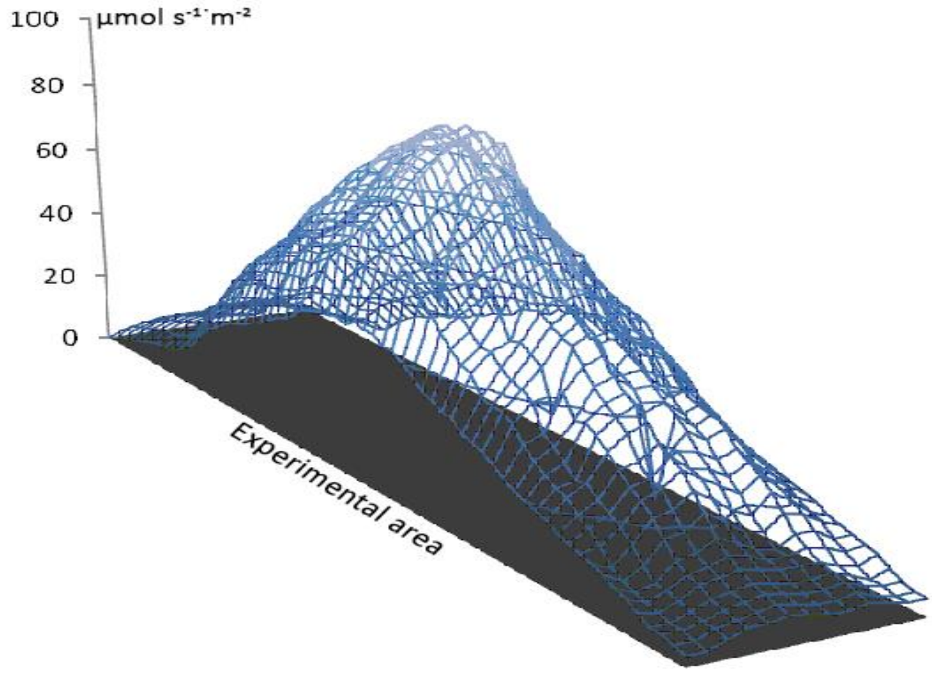

Fig 1 The light intensity of LED

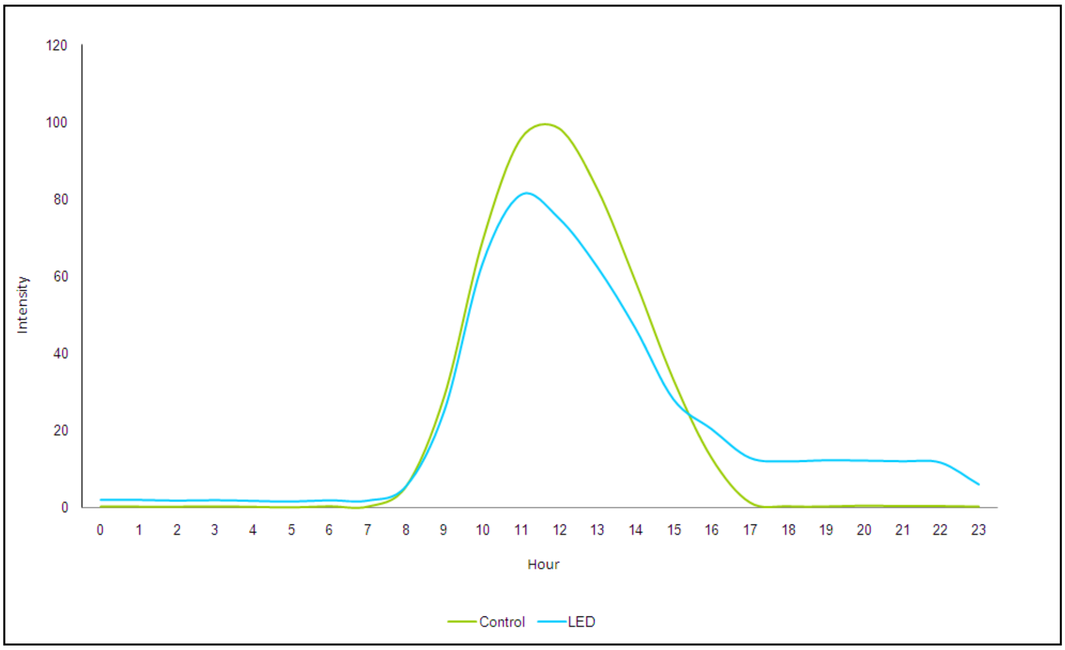

Fig 2 The average daily course of intensity irradiance from November to March ($W{\cdot}h^{-1}m^{-2}$)

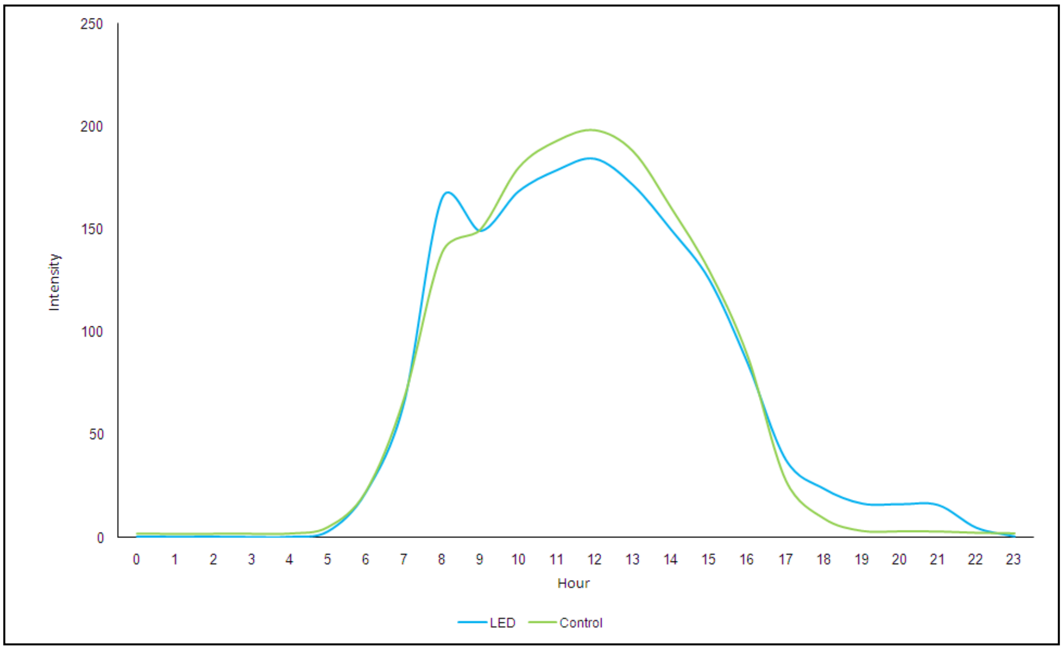

Fig 3 The The average daily course intensity of irradiance from February to July ($W \cdot h^{-1} m^{-2}$)

Tab. 1 Success rate of rooting in the period from November to March

November - March	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**
No roots	71	79	67	77	80	89	96	87	96
Created a callus	10	9	8	8	6	5	3	8	4
Created root	4	1	1	3	3	2	1	3	0
Rooted	3	1	2	0	0	0	0	1	0
Slightly rooted	1	2	1	3	1	0	0	1	0
Fully rooted	11	8	20	10	10	4	0	2	0
Viable %	19			12			2		

The second experiment, which took place between February and June, yielded a significantly higher percentage of rooted cuttings, which was due to increased intensity and more hours of natural daylight. The difference between the alternative and control groups is negligible. Alternative B performed about 10 % better than the previous one.

Tab. 2 Success rate of rooting in the period from February to June

February - June	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**
No roots	54	32	25	50	29	30	41	38	31
Created a callus	21	32	5	15	9	12	42	9	14
Created root	13	22	15	13	20	29	13	19	21
Rooted	8	8	14	5	11	16	4	15	16
Slightly rooted	0	2	14	4	7	4	1	4	3
Fully rooted	3	4	28	13	24	10	1	16	15
Viable %		43			52			42	

Conclusion

The achieved results indicate that rooting of coniferous cuttings is significantly influenced by the length of their exposure to light and very likely also by the intensity of this light. The off-season period between November and March proved unsuitable for common nursery practice, as natural lighting conditions are poor and compensatory grow lights are required.

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Summary

Světlo je jedním z faktorů, výrazně ovlivňujících vývoj rostlin, je totiž jejich nutným zdrojem energie. Ve školkařské praxi se jehličnaté rostliny rozmnožují převážně vegetativním způsobem. Jedním z těchto způsobů je i dřevité řízkování. Rozmnožování jehličnatých rostlin pomocí dřevitých řízků provádíme zpravidla mimo vegetaci, tedy v období, kdy kvalita a kvantita přirozeného denního světla není příliš vysoká. Tento problém lze vyřešit pomocí přisvětlování. V experimentu byly k přisvětlení použity LED systémy o specifických vlnových délkách (varianta A - 460nm; 670nm a varianta B - 440nm; 630nm) o intenzitě 70 μmol $\cdot s^{-1} \cdot m^{-2}$. Spektra byla sestavena v poměru 4:1 („červená“ : „modrá“) z modulů osazenými led diodami. Jako pokusná rostlina byla využita *Thuja occidentalis* 'Columna', která byla přisvětlována nad 12 hodin spolu s přirozeným světlem. Pokus probíhal ve dvou termínech od listopadu do března a od února do června. Prokázaly se rozdíly jak v termínu řízkování, tak i v přisvětlovaných variantách.

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