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POST-HARVEST LIFE OF HYACINTHS FORCED BY DIFFERENT COLOURS OF ARTIFICIAL LIGHT

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Abstract. Three cultivars of *Hyacinthus orientalis* L. were forced in pots under artificial light using fluorescent lamps which emitted white, blue, green, yellow and red light. Daily light dose was 0.54 mol·m^{-2} (25 μmol·m^{-2}·s^{-1} × 6 h). Significant effect of light colour on postharvest longevity and quality of plants was observed. The post-harvest longevity of hyacinths depends, among others, on the length of the flowering period and it is the longest after the application of white and blue light colour. Red light decreased flower life and deteriorated the ornamental value. The rigidity of inflorescence shoots depended on the cultivar, but in all flowers, it was significantly lower than it is recommended in market turnover for flowering plants grown in pots. It also refers to leaves, whose elongation is the greatest under lamps with red colour. In the 'Fondant' cultivar, elongation caused a maximal flabbiness of inflorescence shoots and leaves.

Key words: *Hyacinthus orientalis* L., fluorescent lighting, postharvest longevity, inflorescence and leaf elongation, stem and leaf stiffness

INTRODUCTION

Studies carried out in controlled conditions in a growth room indicate that under fluorescent lamps with blue and red colour, hyacinths bloom the earliest. Plants forced under blue light are shorter than the remaining ones and they have shorter leaves. In red light, hyacinths produce longer inflorescences, but they are more flabby [Śmigielska and Jerzy 2010].

From bulbs cooled for 12 weeks at the temperature of +9°C, one can obtain good quality hyacinths flowering in January. In such case, one must apply light with quantum irradiance of 25 μmol·m^{-2}·s^{-1} for 6 hours per a day and night, or light with quantum irradiance of 12.5 μmol·m^{-2}·s^{-1} for 12 hours per a day and night. These values are lower than the value of 5000 mW·m^{2} (≈ 23 μmol·m^{-2}·s^{-1}) used for 12 hours per a day and night by Templing and Verbruggen [1977], but they are sufficient for hyacinths forced in the

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period from December to February. The values proposed by Templing and Verbruggen, quoted above, correspond to the daily light dose of 0.99 mol·m^{-2}, while in our experiment, the dose of light was 0.54 mol·m^{-2}, being almost by half smaller.

The post-harvest life of hyacinths forced by different colours of artificial light has not been investigated yet. The cognition of the effect of light colour exerted on the elongation of post-harvest life of hyacinths flowering in pots was the objective of studies presented in this paper.

MATERIAL AND METHODS

Three cultivars of hyacinths (*Hyacinthus orientalis* L.), 'Anna Marie', 'Fondant' and 'White Pearl' were selected for the studies. Bulbs with 19–20 cm circumference were cooled for 12 weeks at the temperature of +9°C and from the 10th of January 2008, their forcing was started in the growth room. Pots with bulbs were placed on shelves under fluorescent lamps (Philips TLD with 36 W power): white colour 33 (370–700 nm), blue colour 18 (400–580 nm), green colour 17 (360–630 nm), yellow colour 16 (500–650 nm) and red colour 15 (600–700 nm) (fig. 1). Quantum irradiance at the height of plant tips amounted to 25 μmol·m^{-2}·s^{-1}, day light was applied for 6 hours, air temperature amounted to 16–18°C and relative air humidity was 64–70%. Ten plants from one cultivar were placed under lamps with a definite colour of light.

The date of the appearance of the first flower in the inflorescence was accepted as the beginning of plant flowering. On that day, which at the same time determined the readiness of plants for harvesting, measurements of the inflorescence length and the length of the longest leaf were carried out.

The date of the change of colour and the wilting of the first flowers in the inflorescence was accepted as the termination of plant flowering. On that day, all flowers in the inflorescence were counted and the post-harvest longevity of plants was estimated. The length of the inflorescence coming out of bloom and the length of the longest leaf were measured. The length increase of the inflorescence and the longest leaf were estimated. The rigidity of inflorescence stem and leaf rigidity were classified in 1–4 scale: (1) very flabby, (2) flabby, (3) stiff, (4) very stiff.

Results were statistically elaborated by the method of the analysis of variance, separately for each cultivar and the significance of differences was estimated with the use of Duncan's test at the level of $\alpha = 0.05$.

RESULTS

The beginning of flowering was successively observed with a one day difference between the cultivars: 'White Pearl' (22nd of January), 'Anna Marie' (23rd of January) and 'Fondant' (24th of January).

Coming out of bloom connected with colour change of the flowers and the wilting of the first flowers in the inflorescence started in all three cultivars under the lamps with red light. Then, the inflorescence of plants grown under lamps with yellow and green light started to come out of bloom, and finally, the plants forced under lamps with blue and white light ceased to flower (tab. 1). The post-harvest life of the latter plants was the longest.

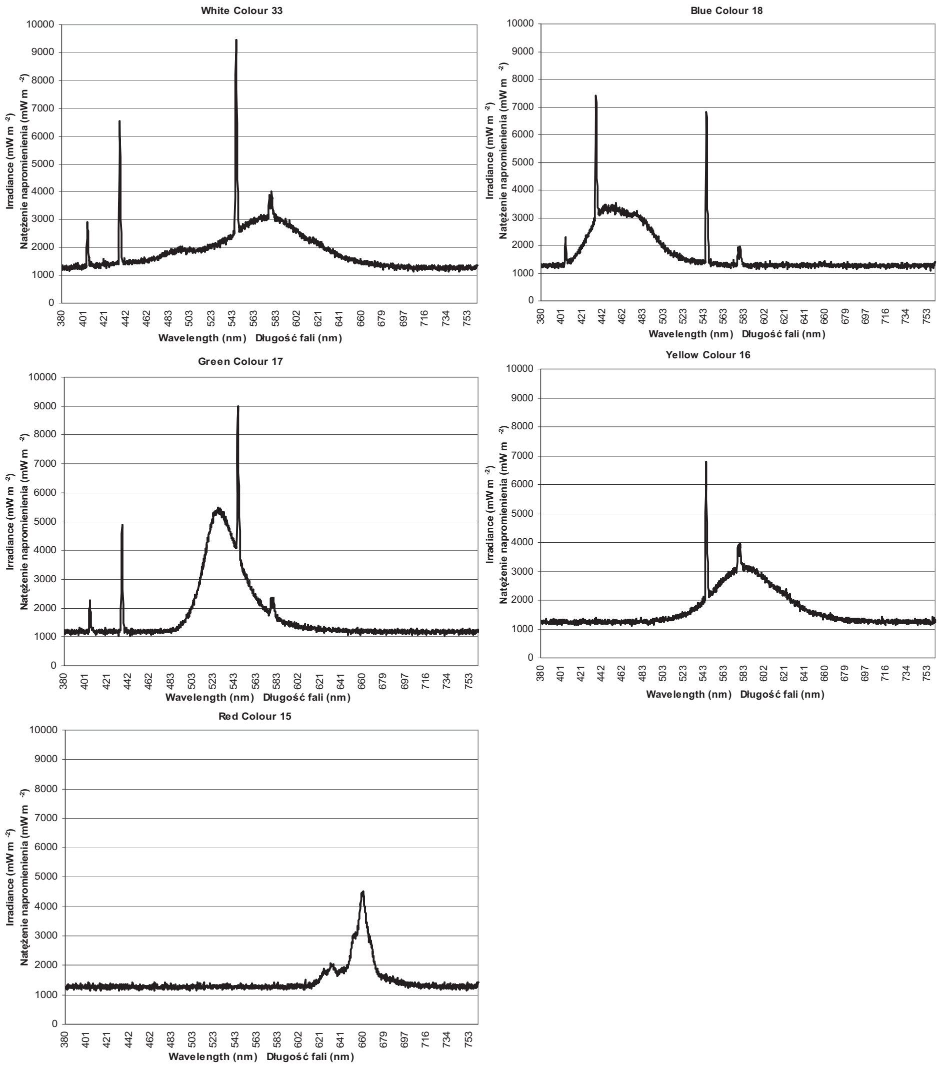

Fig. 1. Spectral characteristic of the fluorescent lamps Philips TLD 36 W
Rys. 1. Charakterystyka widmowa lamp fluorescencyjnych Philips TLD 36 W

The number of flowers in one inflorescence was not depended on the light colour (tab. 1).

Table 1. Postharvest longevity of three hyacinth cultivars forced in pots under fluorescent lamps with different colours of light
Tabela 1. Trwałość pozbiorcza trzech odmian hiacyntów pędzonych w doniczkach pod lampami fluorescencyjnymi o różnej barwie światła

Forced plants Pędzone rośliny		Light colour – Barwa światła				
		white biała	blue niebieska	green zielona	yellow żółta	red czerwona
‘Anna Marie’	Ready for harvest (date) Gotowość roślin do zbioru (data)	23.01	23.01	23.01	23.01	23.01
	Flowering period (days) Okres kwitnienia (dni)	15.6 c	15.8 c	13.9 b	13.7 b	12.2 a
	Number of flowers Liczba kwiatów	47.2 *a*	47.3 *a*	50.1 *a*	47.6 *a*	49.6 *a*
‘Fondant’	Ready for harvest (date) Gotowość roślin do zbioru (data)	24.01	23.01	24.01	24.01	23.01
	Flowering period (days) Okres kwitnienia (dni)	14.1 c	14.9 c	13.1 b	13.0 b	11.9 a
	Number of flowers Liczba kwiatów	45.2 *a*	47.0 *a*	47.0 *a*	47.2 *a*	45.5 *a*
‘White Pearl’	Ready for harvest (date) Gotowość roślin do zbioru (data)	22.01	22.01	22.01	23.01	22.01
	Flowering period (days) Okres kwitnienia (dni)	13.6 c	13.8 c	12.5 b	12.5 b	11.2 a
	Number of flowers Liczba kwiatów	55.7 *a*	58.6 *a*	57.8 *a*	58.3 *a*	58.1 *a*

Means followed by the same letters do not differ significantly
Średnie oznaczone tą samą literą nie różnią istotnie

In all three cultivars of hyacinths, the increase of inflorescence length was the greatest under lamps with red light (tab. 2). Rigidity of inflorescence stem was there the poorest. They were estimated as flabby (‘Anna Marie’ and ‘White Pearl’) and even as very flabby (‘Fondant’). Rigid and very rigid stems were observed under lamps with blue and white colour of light. In the ‘White Pearl’ cultivar, the stems of inflorescences coming out of bloom under lamps with green and yellow colour were rigid as well.

The length of the longest leaf increase in the period of plant flowering was the greatest in the ‘Fondant’ cultivar growing under lamps with red light (tab. 3). In the blue light, all cultivars produced short and rigid leaves. The increase of their length in the period of plant flowering was the smallest. On the other hand, the leaves of ‘Fondant’ cultivar growing under red light lamps were very flabby.

DISCUSSION

Bach et al. [1997] and Suh [1997], in their works devoted to the forcing of tulips in artificial light, pay attention to the type of light source and its role in the morphological process. Red light as well as blue light control flowering time and length of flower buds. The longest flower buds produced ‘Apeldoorn’ cultivar using red light (647–770 nm). Suh [1997] found that blue and far-red light as well as darkness increase the length of the first and second internode in that cultivar. Growth of the last internode is stimulated by darkness and by red and blue light treatments. Woźny and Jerzy [2004 a and b] reported that blue light delayed flowering of forced tulips, while red light accelerated flowering but reduced the number of flowering bulbs. Significant influence on the quality of tulips was observed under high quantum irradiance level, at 25 μmol·m^{-2}·s^{-1} and long, 12-hour day. Tulips forced under red light had the longest shoots and flower buds and the greatest weight. The blue light improved stems and leaves rigidity and thereby increased the decorative value of tulips.

Table 2. Inflorescence elongation of three hyacinth cultivars forced in pots under fluorescent lamps with different colours of light
Tabela 2. Elongacja kwiatostanu u trzech odmian hiacyntów pędzonych w doniczkach pod lampami fluorescencyjnymi o różnej barwie

Inflorescence Kwiatostan		Light colour – Barwa światła white biała	 blue niebieska	 green zielona	 yellow żółta	 red czerwona
'Anna Marie'	Length increase (cm) Przyrost długości (cm)	9.2 a	9.4 a	9.7 a	10.7 b	11.1 c
	Final length (cm) Długość końcowa (cm)	18.8 *a*	18.6 *a*	19.4 *b*	20.3 *b*	21.2 *c*
	Stem stiffness (1-4) Sztywność pędów (1-4)	(3)	(3)	(2)	(2)	(2)
'Fondant'	Length increase (cm) Przyrost długości (cm)	11.0 b	11.2 b	11.7 b	10.2 a	13.2 c
	Final length (cm) Długość końcowa (cm)	19.4 *a*	19.8 *a*	19.7 *a*	19.5 *a*	21.7 *b*
	Stem stiffness (1-4) Sztywność pędów (1-4)	(2)	(3)	(2)	(2)	(1)
'White Pearl'	Length increase (cm) Przyrost długości (cm)	7.0 b	6.3 a	6.4 a	7.3 b	9.1 c
	Final length (cm) Długość końcowa (cm)	21.3 *a*	21.0 *a*	20.8 *a*	21.1 *a*	22.5 *b*
	Stem stiffness (1-4) Sztywność pędów (1-4)	(4)	(4)	(3)	(3)	(2)

Stem stiffness scale: (1) very flabby, (2) flabby, (3) stiff, (4) very stiff
Skala sztywności pędów: (1) bardzo wiotkie, (2) wiotkie, (3) sztywne, (4) bardzo sztywne

Studies carried out by Piszczek et al. [1996] indicated that narcissuses forced in conditions of artificial lighting were higher than narcissuses forced in the greenhouse, they produced longer leaves and a greater weight. The rigidity of shoots, however, was slightly weakened and the leaf colour became lighter. Other studies [Jerzy et al. 2005] showed that red light and especially blue light retarded the flowering of narcissuses forced from bulbs cooled at the temperature of +5°C. The colour of light did not exert any effect on the rigidity of flower shoots in the cultivars 'Ice Follies' and 'Johann Strauss'. Blue light had a favourable effect on the rigidity of shoots in the cultivars 'Yellow Sun' and 'Unsurpassable'. Fluorescent daylight accelerated the flowering of narcissuses [Woźny and Jerzy 2007]. In blue light, narcissuses produced shorter and more rigid flower shoots.

Table 3. Leaf elongation of three hyacinth cultivars forced in pots under fluorescent lamps with different colours of light

Tabela 3. Elongacja najdłuższego liścia u trzech odmian hiacyntów pędzonych w doniczkach pod lampami fluorescencyjnymi o różnej barwie

	The longest leaf Najdłuższy liść	Light colour – Barwa światła				
		white biała	blue niebieska	green zielona	yellow żółta	red czerwona
'Anna Marie'	Length increase (cm) Przyrost długości (cm)	8.7 b	7.0 a	9.1 b	9.0 b	8.4 b
	Final length (cm) Długość końcowa (cm)	34.3 *b*	29.6 *a*	35.9 *b*	34.9 *b*	34.1 *b*
	Stiffness (1-4) Sztywność (1-4)	(3)	(3)	(3)	(2)	(2)
'Fondant'	Length increase (cm) Przyrost długości (cm)	10.7 b	9.0 a	11.7 b	9.5 a	13.6 c
	Final length (cm) Długość końcowa (cm)	32.8 *b*	29.6 *a*	32.9 *b*	32.8 *b*	32.4 *b*
	Stiffness (1-4) Sztywność (1-4)	(3)	(3)	(3)	(2)	(1)
'White Pearl'	Length increase (cm) Przyrost długości (cm)	8.0 a	7.5 a	9.3 b	9.7 b	8.0 a
	Final length (cm) Długość końcowa (cm)	28.0 *a*	27.5 *a*	31.9 *b*	31.6 *b*	30.0 *b*
	Stiffness (1-4) Sztywność (1-4)	(3)	(3)	(2)	(2)	(2)

Leaf stiffness scale: (1) very flabby, (2) flabby, (3) stiff, (4) very stiff
Skala sztywności liści: (1) bardzo wiotkie, (2) wiotkie, (3) sztywne, (4) bardzo sztywne

Flowering potted bulbs may be transported over long distance prior to being sold in retail florist's shops and mass market outlets. They are then maintained in offices and homes under varying temperature and light conditions. Hyacinth stem topple occurs at 18, 22 and 26°C temperatures but is greatest at the lowest temperature. Post-harvest longevity of flowering hyacinths is 3 days higher at the 14 $\mu mol \cdot m^{-2} \cdot s^{-1}$ than in 7 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of quantum irradiance from white fluorescent lamps [Nell at al. 1992].

No studies have been conducted so far to evaluate the influence of light colour on postharvest life of hyacinths flowering in pots. However, the effect of light quality on hyacinth growth and development *in vitro* in long-term cultures is well known. Blue light stimulates formation of adventitious shoots and buds in organogenesis of *Hyacinthus orientalis* L. [Bach and Świderski 2000].

Red and yellow light promotes embryogenic callus formation. Blue light and ultraviolet radiation stimulate development of somatic embryos. The number of adventitious bulbs is the highest when explants are irradiated with red light or cultured in darkness. As far as the level of pigments is concerned, it was observed that blue light enhanced the total amount of anthocyanins while both blue light and UV irradiation promoted the production of chlorophyll a and b. Red light reduced the amount of chlorophylls and carotenoids [Bach et al. 2000, Bach and Król 2001].

CONCLUSIONS

1. Studies carried out so far, indicate that the post-harvest longevity of hyacinths depends, among others, on the length of the flowering period and it is the longest after the application of white and blue light colour.

2. Red light decreased flower life and deteriorated the ornamental value.

3. The rigidity of inflorescence shoots depended on the cultivar, but in all flowers, it was significantly lower than it is recommended in market turnover for flowering plants grown in pots. It also refers to leaves, whose elongation is the greatest under lamps with red colour. In the 'Fondant' cultivar, elongation caused a maximal flabbiness of inflorescence shoots and leaves.

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TRWAŁOŚĆ POZBIORCZA HIACYNTÓW PĘDZONYCH W DONICZKACH PRZY ŚWIETLE SZTUCZNYM O RÓŻNEJ BARWIE

Streszczenie. Cebule trzech odmian hiacyntów pędzono przy sztucznym świetle, pod lampami fluorescencyjnymi typu TLD 36W, emitującymi światło białe, niebieskie, zielone, żółte i czerwone. Dobowa ilość światła wynosiła 0.54 mol·m^{-2} (25 µmol·m^{-2}·s^{-1} × 6 h). Trwałość pozbiorcza hiacyntów zależała m.in. od długości okresu kwitnienia, a ten był najdłuższy po zastosowaniu białej i niebieskiej barwy światła. Światło czerwone obniżało trwałość kwiatów i pogarszało wartość ozdobną roślin. Sztywność pędów kwiatostanowych zależała od odmiany, ale u wszystkich była niższa od pożądanej. Dotyczy to również liści, których elongacja była największa pod lampami o barwie czerwonej. U odmiany 'Fondant' liście były bardzo wiotkie.

Słowa kluczowe: *Hyacinthus orientalis* L., lampy fluorescencyjne, trwałość pozbiorcza, elongacja kwiatostanu i liści, sztywność pędów i liści

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