IMPACT OF DIFFERENT LIGHT INTENSITY ON THE PRODUCTION OF THE PLANT NARCISSUS L. AND ITS FINANCIAL EFFECTS

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ABSTRACT

Plant production monitoring should be conducted taking into consideration agrarian, economic and other factors. The authors of the paper point out the importance of the intensity of light on plant growing in predominantly urban growing conditions. The authors conducted an experimental research on Narcissus L. The focus was on 8 physical parameters of cultivated plants that are compared to average actual prices on the market of the Republic of Serbia. The contribution of authors is in pointing out an individual physical plant parameter with a decisive impact on its price. Narcissus L. growing under lower natural light intensity indicates that the biggest impact on plant price is that of the flower diameter (β = .555, $\pi \leq .001$). Plant growing under higher light intensity has an impact on its price predominantly on the basis of the flower diameter (β=2.947, $p \leq .001$) and stalk diameter (β = 2.947, $\pi \leq .001$).

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Introduction

Numerous authors refer to blooming of *Narcissus* L. as a sign of arrival of spring (Kandeler and Ullrich 2009; Tooke and Battey 2010; Boanca et al. 2014). Grown in urban conditions, it is exposed to natural light of different intensity (Popović et al. 2014).

The genus *Narcissus* L. includes approximately 50 species (Simón-Porcar 2015) growing in vast habitats (Arroyo and Barrett 2000). Increase in daily temperatures triggers growth processes in *Narcissus* L., (Rudnicki and Nowak 1976; Hobson and Davies 1977; Horton and Ruban 2005).

The study conducted supplements the research on the impact of light on the plant (*Narcissus* L.), (Chen 1969; Briggs and Christie 2002; Sun et al. 2005; Devlin et al. 2007; Folta and Maruhnich 2007; Loreto et al. 2009; Albert et al. 2009). A visible result of growing plant *Narcissus* L. is its flower, although there are other measurable properties (Rønsted et al. 2008).

The principal aim of this paper is to present the impact of light of different intensity on the plant (*Narcissus* L.) growing. The other aim of the authors is to compare the effects of 8 chosen parameters of the plants under observation on their market price. The parameters chosen by the authors are those corresponding to visual requirements of customers.

The authors tested morphological plant properties by selecting 8 parameters (flower diameter, stem length, stem diameter, leaf length, leaf width, above-ground plant mass, bulb diameter and bulb mass). More productive plants have higher price, which is in line with the paper published by the authors (Popović et al. 2017a), stating the importance of real valuation. The expectations of the authors were that plants grown in area exposed to higher intensity light (2000 lx) would be more competitive than those grown under lower intensity light (1000 lx) in open-air urban areas.

The authors' principal expectations were that in both cases of plant growing, out of the 8 selected parameters, the size of flower would be prevailing in determining the marketability of the plants grown. The authors expected that, out of the selected parameters measured, a big effect would be of those that could be visually evaluated by customers. When plants grown in the shade were concerned, the expectations were that plants would be less competitive, with smaller flowers and lower values of the 7 tested parameters.

The experiment was conducted in the open, on two land plots, with the distance of 30-50 m between them, continuously exposed to different light intensity. Measurements showed that light intensity differed 100%, as the first plot was in the shade of park trees and urban furniture. *Narcissus* L. bulbs, 12/14 cm in circumference, were planted in soil of the following properties: pH in KCl = 6.98 in H_2O = 7.46, $CaCO_3$ in percentage terms was 3, while humus in percentage terms was 3.86. 100 bulbs were planted in each plot, plus 20% reserve bulbs in two parallel rows, in 15 cm deep holes, with 7.5 cm distance between two bulbs, and the distance between two rows of bulbs of 10 cm.

The results are analyzed by applying the arithmetic mean method with standard deviation, using the one-way variance analysis (ANOVA) and regression analysis. The results of the first regression analysis show that for plants grown in the shade (1000 lx), out of 8 selected parameters, the biggest effect is that of flower diameter (β=.555, $p \leq .001$), whereas a lesser contribution is that of stem diameter (β=.274, $p \leq .001$) and length (β=.250, $p \leq .05$). The results of the second regression analysis show that for plants grown under higher light intensity (2000 lx) the biggest effect is that of stem diameter (β=2.947, $p \leq .001$) and flower diameter (β=-2.664, $p \leq .001$), and the smallest is of bulb mass (β=.286, $p \leq .01$).

On the basis of the above stated, we developed three hypotheses **H1-3. H: 1** Plant (*Narcissus* L.) growing under conditions of different natural light intensity results in plants of different output values. **H: 2** growing the plant (*Narcissus* L.) under conditions of different natural light intensity and comparison to average retail prices show significant differences. **H: 3** Plants (*Narcissus* L.) grown under conditions of higher light intensity have greater values of the tested parameters and therefore a higher price.

Finally, we focused our activities on determining an individual contribution of each of the 8 selected parameters of plants grown under different light intensity, as by a different organization of plant production it is possible to improve parameter values in the future.

Material and methods

The experiment was conducted in the City of Novi Sad area (latitude 45° 20', longitude 19° 51'), more precisely, approximately 1000 meters from the entrance to Novi Sad plant nursery (north of Serbia). The average annual air temperature at the site is 10.9° C, with average precipitation of approximately 578 mm and altitude of 86 m. The activities were carried out in the period from 1 November 2013 to 3 March 2016, when values of the 8 chosen parameters were measured.

The experiment commenced by planting bulbs of 6-7 cm in diameter in the soil from which weed was mechanically removed and which was not fertilized or chemically treated since 1963. The two plots were close to each other (approx. 35 m distance), and they were continuously exposed to different sunlight intensity during the day. The first plot received 100% less sunlight (due to trees and urban furniture of up to 0.5 m height) than the second. That was confirmed by measurements of light intensity in the part of day with the most intensive sunlight on both plots. Measurements of light intensity were made by a manual device along both plots on every 0.5 to 0.8 m, and the device tolerance was 3%.

Light intensity measurements were made at 12, 14 and 16 hours on 30 March 2014, 30 March 2015 and 30 March 2016. Control measurements were made 30 days before and 30 days after the period under consideration in the same time intervals. At each measurement the natural light intensity on the first plot was 1000 lx, and on the second 2000 lx.

The first aim of the study was to determine the impact of different natural light intensity on cultivated plants on the basis of their morphological changes, by monitoring 8 physical values of the selected parameters. The second aim was to disclose the significance of changes in 8 selected parameters in terms of retail prices in the Republic of Serbia on the three selected days in the three years under observation (2014-2016). The third aim was to determine which of the 8 selected parameters had the biggest impact on retail price.

Data obtained in the experiment were processed using the arithmetic mean analysis. The authors also used the variance analysis (ANOVA) to compare the groups. In addition to that, two regression analyses were made to test the relationships.

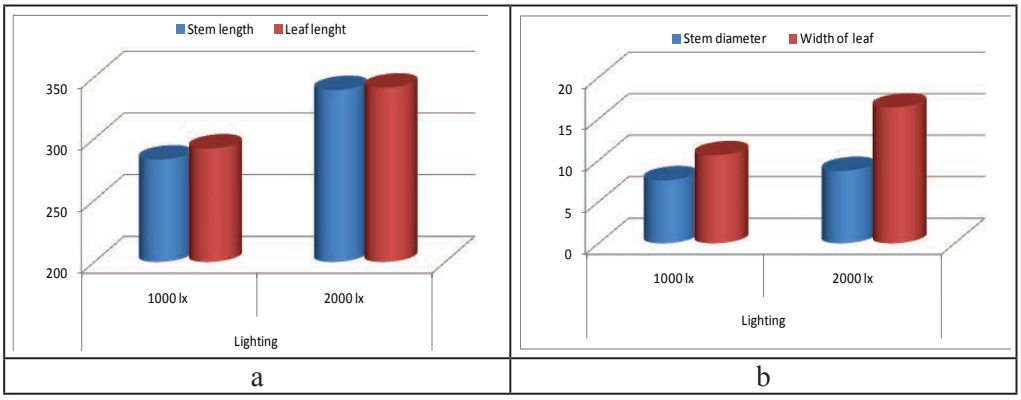
Results

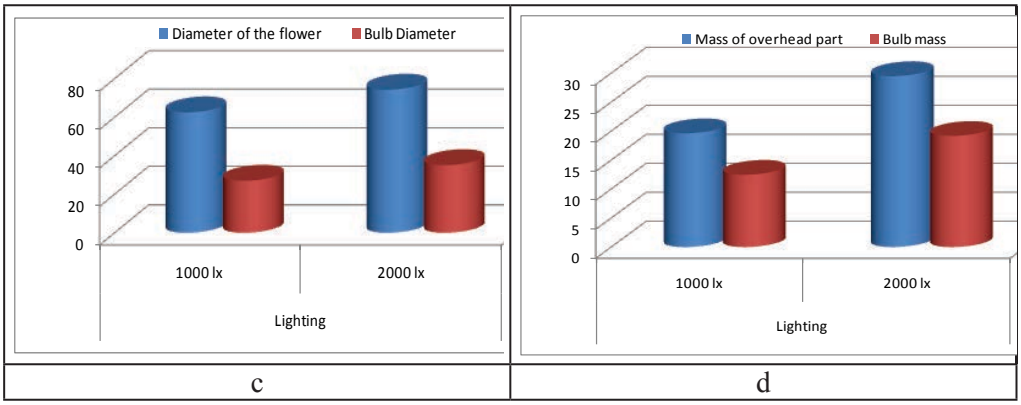
Impact of light on morphological properties of plants

Following the published three-year experiment (from 1 November 2013 until 30 March 2016) conducted in an open-air urban area under conditions of significantly different natural light intensity; the obtained results on the grown plants indicate significant changes in plant appearance.

The results of the described physical measurements of the selected parameters of the grown plants are presented using the arithmetic mean of the 8 plant parameters in question as follows:

Figure 1. Average values of stem length and leaf length (mm)





c d

Note: (a), stem diameter and leaf width, mm, (b), diameter of the flower and bulb diameter, mm, (c), mass of overhead part and bulb mass, g, (d), grown under different intensities of light intensity

Source: author's own research.

Further research conducted by the authors on the impact of light on plant morphological properties (Table 1) is shown through 8 parameters of the arithmetic mean and standard deviation. The results of arithmetic means have greater values, i.e. plants have greater physically measured values in all 8 parameters in conditions of being grown under higher intensity light (2000 lx compared to 1000 lx in the shade). We applied the one-way analysis of variance to compare the arithmetic means of the parameters. Value p = .000 is obtained with all 8 parameters, indicating significant differences in the plants grown. The biggest value, F = 530.174 is obtained for flower diameter parameter and F = 519.877 for stalk length parameter which indicates that these two parameters are the most pronounced of all parameters involved.

Table 1. Results obtained by comparing physical values of parameters (ANOVA)

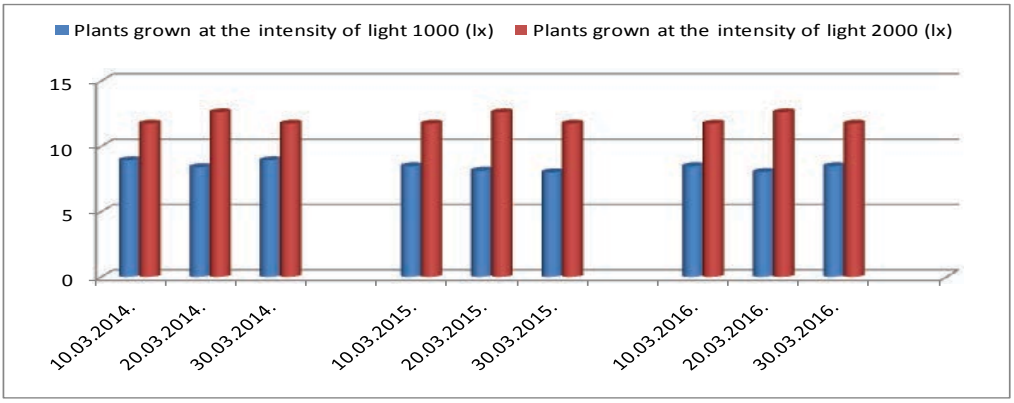
Parameters	Arithmetic mean		Standard deviation		F	p
	Light intensity					
	1000 lx	2000 lx	1000 lx	2000 lx		
Flower diameter	62.50	74.30	4.24	7.80	530.174	.000
Stalk length	282.93	339.33	20.41	37.67	519.877	.000
Stalk diameter	7.60	8.73	.89	1.65	109.659	.000
Leaf length	291.93	341.27	35.32	55.47	168.809	.000
Leaf width	10.62	16.37	2.20	5.71	264.238	.000
Plant above-soil part mass	19.63	29.49	8.26	9.35	187.238	.000
Bulb diameter	26.98	35.10	3.80	7.30	292.023	.000
Bulb mass	12.47	19.17	2.71	5.21	389.786	.000

Source: author's own research.

Plant pricing

The impact of the selected parameters of plants grown under different light intensity on their pricing in the tree days of measurement in March in the 2014-2016 interval, is shown in Fig. 2

Figure 2. Average prices realized on the retail market for plants grown at different light intensity.



Source: author's own research.

Results of relations of prices and plants grown are presented in Table 2. The obtained plant parameter measurement results are p = .000. Throughout the research period the results of the one-way analysis of variance (ANOVA) indicate that prices of plants grown in shade are lower.

Table 2. Results obtained by comparing prices and parameters (ANOVA)

Prices at day/year	Arithmetic mean		Standard deviation		F	p
	Light intensity					
	1000 lx	2000 lx	1000 lx	2000 lx		
10 March 2014	8.93	11.73	.99	1.69	607.645	.000
20 March 2014	8.40	12.60	1.50	2.54	607.645	.000
30 March 2014	8.93	11.73	.99	1.69	607.645	.000
10 March 2015	8.47	11.73	.99	1.46	1.025.570	.000
20 March 2015	8.13	12.60	1.50	2.11	891.835	.000
30 March 2015	8.00	11.73	.99	1.95	869.012	.000
10 March 2016	8.47	11.73	.99	1.46	1.025.570	.000
20 march 2016	8.03	12.60	1.49	2.58	702.809	.000
30 March 2016	8.47	11.73	.99	1.46	1.025.570	.000

Source: author's own research.

First regression analysis

We went further in our research to determine which of the 8 selected parameters of plants grown in the shade (1000 lx) prevails individually in retail price setting (Tab.3 and Tab.4).

Table 3. First regression analysis of relations between the average retail price and physical values of the selected parameters of plants grown under light intensity of 1000 lx

	Sum of squares	Degree of freedom	Average square	F	Significance level	R	R^2	Adjusted R^2
Regression	497.708	8	61.46	34.549	.000	.698	.487	.473

Source: author's own research.

Table 4. Values of selected parameters as predictors of average retail price of plants grown at light intensity of 1000 lx

Predictors	Non-standardized ratios		Standardized ratios	t	Significance level
	B	Standard error	Beta		
Constant	-2.398	.889		-2.698	.007
Stalk length	.012	.005	.250	2.241	.026
Flower diameter	.131	.018	.555	7.338	.000
Stalk diameter	.305	.091	.274	3.365	.001
Leaf length	-.008	.005	-.234	-1.719	.087
Leaf width	-.093	.061	-.112	-1.543	.124
Above-ground part mass	-.013	.017	-.059	-.773	.440
Bulb diameter	.029	.023	.115	1.246	.214
Bulb mass	-.031	.038	-.087	-.812	.417

Source: author's own research.

The first regression analysis of the plant grown at 1000 lx indicates the biggest effect of flower diameter on the flower retail price (β=.555, p≤.001), whereas somewhat lesser effect is that of stalk diameter (β=.274, p≤.001) and length (β=.250, p≤.05).

Second regression analysis

The research continued in order to determine which of the 8 selected parameters of the plant grown under 2000 lx light intensity has the biggest individual effect on retail price setting (Tab. 5 and Tab. 6).

Table 5. Second regression analysis on relationship between the average retail price and selected parameters of plants grown at 2000 lx light intensity

	Square sum	Degrees of freedom	Average square	F	Significance level	R	R^2	Adjusted R^2
Regression	245.944	8	30.743	55.713	.000	.778	.605	.594

Source: author's own research.

Table 6. Values of the selected parameters as predictors of the average retail price of plants grown under 2000 lx light intensity

Predictors	Non-standardized ratios		Standardized ratios	t	Significance level
	B	Standard error	Beta		
Constant	-7.905	2.072		-3.815	.000
Stalk length	.047	.005	.825	10.404	.000
Flower diameter	-.727	.140	-2.644	-5.192	.000
Stalk diameter	3.846	.580	2.947	6.635	.000
Leaf length	.023	.006	.703	3.714	.000
Leaf width	-.331	.061	-1.620	-5.383	.000
Above-ground part mass	.242	.031	1.943	7.875	.000
Bulb diameter	.351	.046	1.144	7.642	.000
Bulb mass	.123	.045	.286	2.727	.007

Source: author's own research.

The second regression analysis of the plants grown under 2000 lx indicates that the biggest effect is that of stalk diameter (β=2.947, $p \leq .001$) and flower diameter (β=-2.664, $p \leq .001$), followed by the above-ground part (β=1.943, $p \leq .001$), leaf width (β=-1.620, $p \leq .001$) and bulb diameter (β=1.144, $p \leq .001$). Somewhat smaller is the effect of stalk length (β=.825, $p \leq .001$) and leaf length (β=.703, $p \leq .001$) and the smallest effect is that of bulb mass (β=.286, $p \leq .01$).

Discussion

Our initial expectations were that there was a significant impact of light intensity on morphological features of plants grown under different natural light intensity, and we were focused on two analyses relating to the plant growing.

First, physical values of plant parameters obtained on the basis of experiment results were analyzed. The results indicate that there is a significant difference among all 8 physical parameters (p = .000) measured on the plants grown under different natural light intensity, which corresponds to the views of Kinoshita and Wada 2000; Kinoshita et al. 2001; Okazawa and Nishijima 2017; Tan et al. 2017. Plant growing under higher intensity light results in higher values of the 8 plant parameters, with the biggest difference in flower diameter (F = 530.174) compared to the plants grown in the shade.

The second observation relates to the price of plants grown under different light intensity. The obtained values of 8 parameters (p = .000) compared to their retail prices indicate a significant difference. Plants grown in the shade have lower retail prices. The prices were steady in the entire period in which the experiment was conducted, as illustrated in Fig. 2.

The complex observation of plant growing under different natural light intensity is made using two regression analyses, one for the plants grown at light intensity of 1000 lx, and the other for plants grown at light intensity of 2000 lx. We went further in our research by determining individual effects of the 8 physical parameters of the plants grown under different light intensity on retail price setting (Tab. 3 through 6). Plants grown under 1000 lx, i.e. in the shade, have lower price, with the biggest effect of flower diameter (β=.555, p≤.001), whereas stalk diameter (β=.274, p≤.001) and length (β=.250, p≤.05) have a smaller effect. Other physical properties measured through the selected parameters do not prove to be good predictors in retail price setting. Plants grown under 100% higher natural light intensity, which is 2000 lx, have higher prices, with the biggest effect of stalk diameter (β=2.947, p≤.001) and flower diameter (β=-2.664, p≤.001) on the flower price, followed by above-ground plant part (β=1.943, p≤.001), leaf width (β=-1.620, p≤.001) and bulb diameter (β=1.144, p≤.001), then, to a somewhat lesser extent, stalk length (β=.825, p≤.001) and leaf length (β=.703, p≤.001) and bulb mass (β=.286, p≤.01) having the smallest effect.

We point out that, on the basis of obtained results, H: 1 is fully accepted, as the plants grown under different light intensity have different product-related values. H:2 is fully accepted as the results of the experiment of plant growing under different natural light intensity are obtained and the comparison of light intensity to average retail prices resulted in significant deviations. H: 3 proved to be correct, as the plants (*Narcissuss* L.) grown under conditions of higher intensity light have significantly bigger values of the tested parameters and therefore a higher retail price.

Our final activities were aimed at determining an individual effect of each of the 8 parameters of selected plants grown under different light intensity, as it is possible to improve parameter results in the future with different organization of plant growing. This corresponds to the other research (Williams 2010; Popović, 2014; Popović et al. 2017b). The results of the study could serve for future research activities with other plants attractive in appearance, on the basis of the survey of customer needs, the demand for which is continuously growing.

Conclusion

There is an impact of conditions of urban plant production on their actual market price. The research results show that plants grown under different natural light intensity are priced differently on the market. Plants grown under higher natural light intensity have higher retail prices. The study indicates that in case of Narcissus L. grown under lower natural light intensity, out of 8 parameters under consideration, the biggest impact on its

price is that of flower diameter. Plant growing under higher light intensity has an impact on its price predominantly on the basis of flower diameter and stalk diameter. These conclusions can be used as a guideline to researchers in selecting the required plant properties that impact its price. The authors point out the innovation and importance of results they obtained in the study. They also emphasize that the research could be expanded to other plant species.

Conflict of interests

The authors declare no conflict of interest.

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