Abstract: Plants extracts have been used, especially in natural medicine since antiquity. In many studies various properties of essential oils (EO) are proven. A volatile oil obtained from *Pelargonium graveolens* is considered to be one of the most valuable substance for different industries, such as: cosmetics, soaps, perfumes, aromatherapy products, food and beverages industry, as well as for medicine. *P. graveolens* belongs to *Geraniaceae* family and include around 280 species that vary in floral morphologies and life forms. *P. graveolens* is an aromatic, perennial shrub that can reach up to 1.3 m in height and a spread of 1m. This species is native to Cape Province, South Africa and is widely cultivated in many other regions, including Reunion Island, Algeria, southern France, Egypt, Spain, Morocco and others, mainly for essential oil production. Pelargonium essential oil has been found to have use in for example: treating variety of skin diseases, reducing pain, treating dysentery, hemorrhoids, heavy menstrual flows, and even cancer. This EO is characterized by presence of citronellol, geraniol, isomenthone, linalool and a wide range of esters. This research was carried out to determine how small changes in abiotic conditions effect pelargonium growth. Two cultivations of *P. graveolens* were set. In the first part of this study, the access to sunlight and humidity were different in each group. It turned out that plant with higher access to light and lower humidity were smaller, but had much more leaves than plants growing under lower intensity of light and higher humidity. Also two cultivations were set, in which two kinds of light were implemented - the sun light and the blue light. Plants that have grown under the blue light, were 58.3 % higher than the other under the sunlight, but as in previous part, leaves of these plants, even though they were much bigger, were present in smaller amount. This data proves that implementing minor changes in abiotic environmental factors, it is possible to control the process of plants growth.

Keywords: *Pelargonium graveolens*, blue light, abiotic environmental factors

Introduction

Plants have been used as medicinal agents for thousands of years. Their extracts were used for many different purposes, but mainly in treatments of inflammatory conditions [1]. Extracts that have been especially valued are essential oils (EOs). They are also called volatile odoriferous oils, that can be extracted from several plants with use of various extraction methods, and a method choice depends on used botanical material. The one of the most widely used techniques are steam distillation and hydrodistillation (for materials such as wood or flowers). Aromatic oily extracts can be derived from different parts of the plant, such as: barks, peels, seeds, leaves, flowers and so on. The choice of material affect essential oil content [%] and yield [cm$^3$ plant$^{-1}$]. EOs differ also in odour and flavour, as well as in colour of final substance. They are known to posses antimicrobial activity, that is why they are yet used as natural additives in food and food packaging materials [2].

“Essential oil derived from aromatic plants (...) have been reported as exceptionally good therapeutic agents for chemoprevention, cancer suppression, antidiabetic activity and
lowering serum cholesterol and triglycerides“ [3]. The ability of plant extracts to reduce inflammation and inhibit various microbes growth has been widely examined and proven by different means. That shows the importance of even further studying natural products which are potentially able to be used as disease treatment [1]. Composition of essential oils is influenced by variety of factors, for example age of the plant, and part of the plant the material was derived form, geographical location of plantation, light intensity, temperature, fertility conditions, method and time of material distillation, as well as storage of obtained oil [4, 5].

One of the plant that is very valued due to its divers properties is *P. graveolens*. *Pelargonium* is one of the seven genus (*Geranium, Pelargonium, Erodium, Monsonia, Hypseocharis, Rhynchotheca* i *Sarcocaulon*) that belong to Geraniaceae family. This genus contains around 280 species, including herbaccous, shrub and subshrub species species that vary in floral morphologies and life forms [6].

*P. graveolens* is an aromatic, perennial shrub that can reach up to 1.3 m in height and a spread of 1 m. It has hairy herbaceous stems when young and become woody with age. Leaves are prickly, carved, light green, velvety, soft to the touch and is strongly citrusy scented (Fig. 1). Flowers are small, usually pink [6-8]. This species is native to Cape Province, South Africa and is widely cultivated in many regions, including Reunion Island, Algeria, southern France, Egypt, Spain, Morocco, Madagascar and Russia, mainly for essential oil production. This volatile oil is a component of cosmetics, soaps, perfumes, aromatherapy products, food and beverages industry, as well as in medicine [6, 8, 9]. The pelargonium oil that is considered to be of the highest quality is known as a Bourbon oil and comes from plant growing on Reunion Island [10].

Due to antiasthmatic, antiallergic, antioxidant, antidiarrhoeic, antidiabetic, haemostatic and antiasthmatic activity [7], this oil has been found to have use in for example: treating variety of skin diseases, reducing pain, treating dysentery, hemorrhoids, heavy menstrual flows, and even cancer. With pelargonium extract French community is treating diabetes, diarrhea, gastric ulcers, liver problems and even urinary stones [3, 9, 11]. Moreover, medicinal use to treat inflammatory conditions has been claimed in other areas, such as Iran, India, Turkey, and European countries. The hydroalcoholic extract of *P. graveolens* flowers has shown wound healing properties in a rat model [1]. What is more, in Chinese homeopathy this oil is thought to help to achieve balanced body by promoting the toxins removal [9]. It is also proven that pelargonium essential oil is active against *Candida* species that may predispose the oral cavity to lesions [12]. What is even more, this volatile oil is also exploited as topical repellents to reduce the incidence of mosquito bites [13].

Discussed substance is characterized by presence of citronellol, geraniol, isomenthone, linalool, a wide range of esters, such as geranyl formate, citronellyl formate, geranyl acetate, geranyl propionate, citronellyl and geranyl tiglates and others, as well as many sesquiterpenes [4, 10]. The main constituents of the essential oil responsible for the biological activity are known to be citronellol, geraniol, linalool, isomenthone, nerol and citronellyl formate [3]. The most often method used for determination of chemical composition of essential oils is a gas chromatography mass spectroscopy (GC-MS) analysis.
The production of essential oil in plants may be altered by biotic and abiotic environmental factors. Abiotic aspects include physical-chemical soil parameters, moisture, temperature, humidity, access to the light, developmental stage and phenology. Soil composition is very important for crop establishment and can be altered due to the plant’s needs. Changing soil conditions may be done by, for example, inputting of chemical or organic fertilizers, which by decomposition, causes a production of organic matter, and therefore is an important source of nutrients [6]. This research was conducted to determine how minor change in abiotic conditions, such as access to light, different types of light and humidity effect pelargonium growth.

Fig. 1. The leaf of *P. graveolens* (on the left) and its petiole (on the right)

**Materials and methods**

The research consisted of two parts. In the first one, two indoor *P. graveolens* cultivations were set. In both cases soil pH for the planting were between 5.5 and 6.5 which is the right pH value for *Pelargonium* growth. The temperature was sustained at 23-24 °C. First cultivation were growing under the high light intensity (1800 Lx), while the second one had limited access to the sunlight (1450 Lx). Both of them were watered twice a week with the same amount of water. Humidity were also controlled. Higher humidity (60 %) was implemented into the second cultivation while lower humidity (35 %) into the first plantation (Table 1). The humidity was obtained by placing plates with water around the cultivated plants. The light intensity was measured with the use of lux meter L-02 type with the measuring range of 5-150000 Lx.

<table>
<thead>
<tr>
<th>Environmental factors/ Cultivation</th>
<th>Cultivation I</th>
<th>Cultivation II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>23-24°C</td>
<td>23-24°C</td>
</tr>
<tr>
<td>Illuminance</td>
<td>1800 Lx*</td>
<td>1450 Lx*</td>
</tr>
<tr>
<td>Humidity</td>
<td>35 %</td>
<td>60 %</td>
</tr>
<tr>
<td>Soil pH</td>
<td>5.5-6.5</td>
<td>5.5-6.5</td>
</tr>
</tbody>
</table>

* Lx - lux

Table 1

Environmental factors influencing growth of *P. graveolens*
In the picture (Fig. 2) there are representatives of each plantation presented. The difference in appearance of the plants from two cultivations is apparent. On the left, there is a representative of first plantation, where the access to sunlight were high and the humidity was lower. The one on the right were growing under smaller amount of sunlight and higher humidity. As it is shown, the first plant is smaller than the second one, but it is also bigger in volume. In the second case, pelargonium has longer stems, but not much leaves. As the leaves are the most reach in volatile oil among the other part of the plant, the first cultivation is more preferred for obtaining essential oil.

Fig. 2. Representatives of two different cultivation; the cultivation with higher intensity of sunlight (on the left) and the plantation with lower intensity of sunlight but higher humidity (on the right)

Light is a major factor that allows plants to live and growth. Plants use light as a source of energy that is necessary for photosynthesis which affects plant development. Thanks to photoreceptors, such as phytochromes, cryptochromes and phototropins, plants generate
a wide range of specific physiological responses. In order to carry out photosynthesis, sufficient quantity of different light spectrums are required. The best known are blue, red and green lights. Blue light is known to be involved in many plant processes, for instance: phototropism, photo-morphogenesis, stomatal opening, and also leaf photosynthetic functioning. It suppresses hypocotyl elongation and induces cotyledon (the primary leaf in the embryo) expansion. Blue light also induces the accumulation of flavonoids and anthocyanins, which are responsible for antioxidant activity. What is more, chlorogenic acid, which has higher antioxidant activities than vitamins C and E activity can be also increased in this case. The quality of seedlings affects their growth and yield of a mature plant. That is why specific light spectrums are being implemented in the early stages of plant growth.

Emitted red light is close to the maximum absorbance for chlorophyll as well as phytochromes and has a great potential for use as a source of photosynthesis. Studies shows that blue light separately or a mix of blue and red light affect a production higher plant biomass.

On the other hand, green light is known to reduce the process of photosynthesis. Implementation of fluorescent lamps that give specific light spectrum to the plant plantations can be than use to control plant growth and its development in different aspects [14, 15].

In the second part of the research, also a growth of two indoor cultivation of Pelargonium graveolens under different types of the light were studied. First cultivation has grown under the sun light, while for the second one, a source of illumination was fluorescent bulb, emitting blue spectrum of the light. As the literature above has documented, the blue light is responsible for the process of cells elongation, that is why it was assumed, that implementing this kind of light would be able to speed up the process of plants growth. Two cultivations of pelargonium of 20 cm were set, and then, after one month and three months, the height was measured. As it is presented in the table below (Table 2), there is a significant difference in height of plants from each cultivation. In the first one that was treated with the sunlight, the average pelargonium height was 36 cm (Fig. 3), while in the second plantation, plants have grown more than 20 cm higher (the average height 57 cm). It was not only the stems and petioles that were longer, but also in the second cultivation the leaves were much bigger than the once in the first plantation (Fig. 4). However, the smaller leaves had deeper, darker green colour. Even though the leaves were bigger, they were much less numerous. And that means that there is less material to obtain the volatile oil from.

<table>
<thead>
<tr>
<th>Time/Type of light</th>
<th>Sunlight</th>
<th>Blue light</th>
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<tbody>
<tr>
<td>1 day</td>
<td>20 cm</td>
<td>20 cm</td>
</tr>
<tr>
<td>After 30 days</td>
<td>30 cm</td>
<td>43 cm</td>
</tr>
<tr>
<td>After 90 days</td>
<td>36 cm</td>
<td>57 cm</td>
</tr>
</tbody>
</table>
Fig. 3. Representatives of two different cultivation; the cultivation growing under the blue light (on the left) and the cultivation growing under the sunlight (on the right)

Also the size of the leaves in both cultivation was very significant (Fig. 4). Also leaves in the second cultivation (blue light) had slightly lighter green colour.

Fig. 4. The difference in leaves size in cultivation growing under the sunlight (on the left) and the cultivation growing under the blue light (on the right)
Influence of abiotic environmental factors on Pelargonium graveolens growth

Conclusions

As it was proven in the above studies, changing the abiotic environmental factors, such as temperature, humidity, access to the light or the light spectrum, it is possible to manipulate P. graveolens growth. Especially the plant height can be easily control. Unfortunately, with the elongation of pelargonium cells, the quantity of leaves decrease. As it was determined in previous research, pelargonium leaves are the most efficient in terms of obtaining essential oil. Thus, smaller amount of leaves equals smaller amount of volatile oil. That is why it is important to establishes in further studies environmental factors that will cause improvement of P. graveolens leaves growth.

References


WPŁYW ABIOTYCZNYCH CZYNNIKÓW ŚRODOWISKOWYCH NA WZROST Pelargonium graveolens

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**Abstrakt:** Ekstrakty pozyskiwane z roślin były używane, zwłaszcza w medycynie naturalnej, już od czasów antycznych. Przeprowadzono wiele badań, które dowodzą różnokierunkowych właściwości olejków eterycznych. Ten pozyskiwany z Pelargonium graveolens jest jedną z najbardziej cenionych substancji dla różnorodnych gałęzi przemysłu, takich jak: kosmetyczna, mydlarska, perfumeryjna, aromaterapeutyczna, spożywcza czy medyczna. P. graveolens należy do rodziny Geraniaceae i zawiera około 280 gatunków różniących się morfologią i wyglądem zewnętrznym. Bylina ta jest krzewem sięgającym 1,3 m wysokości i ok. 1 m szerokości. Jest rodzima dla regionu Cape w południowej Afryce, natomiast została rozpowszechniona na większość obszaru całego świata i obecnie, głównie ze względu na pozyskiwanie oleju eterycznego, uprawiana jest na wyspie Reunion, w Algierii, południowej Francji, Egipcie, Hiszpanii czy Maroku. Pelargoniowy olejek znany jest z wszechstronnego zastosowania. Używany się go m.in. do: leczenia chorób skinnych, czerwonoć, hemoroidów, podczas obfitych miesiączek, jest wykorzystywany jako substancja przeciwbiológica, a nawet podczas leczenia nowotworów. Najważniejszymi związkami chemicznymi znajdującymi się w omawianym oleju są: cytronelol, geraniol, izomenton, linalol i szeroki wachlarz estrów. Przedstawione badania zostały przeprowadzone, aby sprawdzić, jak niewielkie zmiany środowiskowych czynników abiotycznych wpływają na wzrost pelargonii. Załóżono dwie uprawy wewnętrzne, gdzie w pierwszej części rośliny miały różny dostęp do światła słonecznego oraz różną wilgotność. Okazało się, że plantacja z większym dostępem do światła i mniejszą wilgotnością miała mniejszą wysokość, natomiast znacznie więcej liści niż rośliny o mniejszym dostępie do światła słonecznego, a wyższej wilgotności. W drugiej części badania sprawdzono, jak rośliny zareagują na dwa różne rodzaje światła - światło słoneczne oraz światło niebieskie. Pelargonie rosnące pod światłem niebieskim były o 58,3 % wyższe od tych, na które działało światło słoneczne. Wpłynęło to również na wykształcenie znacznie większych liści, natomiast występowały one w bardzo małej ilości. Te wyniki dowodzą, że poprzez wprowadzenie nawet niewielkich zmian w czynnikach abiotycznych możliwe jest kontrolowanie wzrostu rośliny.

**Słowa kluczowe:** Pelargonium graveolens, niebieskie światło, abiotyczne czynniki środowiskowe