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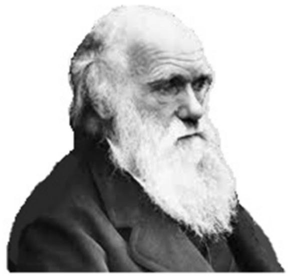

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Comparison of nutrient content in bulbs of Japanese red spider lily (*Lycoris radiata*) and golden spider lily (*Lycoris aurea)*, ornamental and medicinal plants

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ABSTRACT

Plants of the genus *Lycoris* in Japan are of importance in culture and religion; they are used as ornamental and medicinal plants. Two species are particularly attractive: *Lycoris aurea* with yellow flowers and *Lycoris radiata* with red flowers. Both species show a wide biological activity mainly due to the high content of alkaloids. The aim of the study was to compare the mineral composition of *Lycoris aurea* and *Lycoris radiata* bulbs. The analyses were carried out on bulbs obtained after the end of flowering. There were significant differences between the tested species in the content of both macronutrients and micronutrients. The bulbs of *Lycoris radiata* contained significantly more nitrogen, potassium, magnesium, zinc, manganese and iron compared to *Lycoris aurea* bulbs. In turn, more boron was found in *Lycoris aurea* bulbs. There were no differences between species in terms of phosphorus, calcium and copper contents in the bulbs. In summary, both species have different nutritional requirements. *Lycoris aurea* bulbs have the highest nitrogen and magnesium content, while *Lycoris radiata* bulbs contain the highest amounts of nitrogen and potassium. Bulbs of both species are a rich source of iron and zinc.

Keywords**:** components, geophytes, *Lycoris*, medicinal plants, minerals

1. INTRODUCTION

Species of the genus *Lycoris* Herb. (Amaryllidaceae) are bulbous plants in the natural state occurring in Japan, Taiwan, as well as in China, Korea, Laos, Thailand and Vietnam. They

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can be grown for cut flowers or as garden and pot plants for interior decoration [1, 2]. The following two species are the most popular as ornamental plants: *Lycoris aurea* (L'Hér.) Herb. (**Figure 1)** with yellow flowers and *Lycoris radiata* (L'Hér.) Herb. with red flowers (**Figure 2**). Many Lycoris species are not only ornamental, but also a natural source of therapeutic alkaloids [3, 4]. *Lycoris aurea* is characterized by the content of 10 different alkaloids, which include lycorine, galanthamine and lycoramine. It can be used to treat poliomyelitis sequel, Alzheimer's disease and myasthenia gravis [5, 6].

Lycoris radiata bulbs with anticancer/cytotoxic, anti-inflammatory, antibacterial and antiretroviral properties are also used for pharmacological purposes [3, 7-10].

The amount and quality of secondary metabolites in plants depends on the adequate supply of macro- and micronutrients to them. Each of the components plays a specific role in metabolism. Insufficient number of individual components can cause significant changes in the composition of metabolites [11, 12].

The literature lacks information on the content of minerals in *Lycoris aurea* and *Lycoris radiata* bulbs, therefore, the aim of the study was to compare the content of macro- (N, P, K, Ca, Mg) and micronutrients (B, Cu, Zn, Mn, Fe) in both species.

Figure 1. Golden spider lily (*Lycoris aurea*). Photo by P. Salachna.

Figure 2. Japanese red spider lily (*Lycoris radiata*). Photo by P. Salachna).

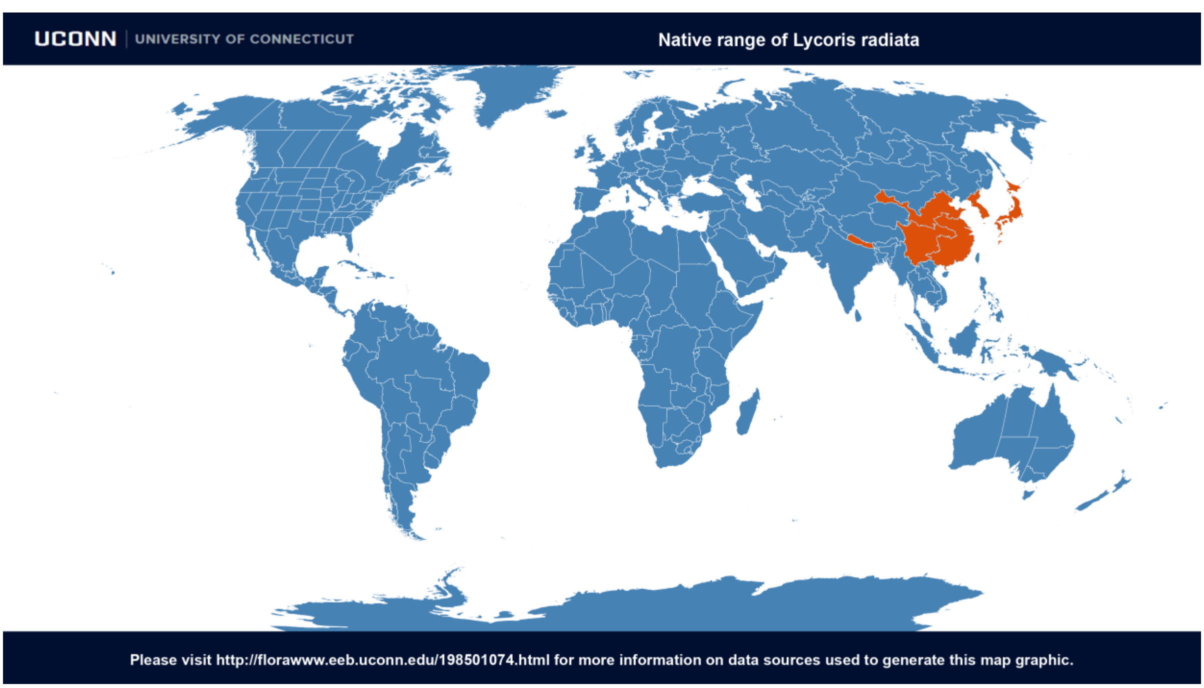

Figure 3. The distribution of *Lycoris radiata*
(source: http://florawww.eeb.uconn.edu/images/maps/tdwg/198501074.png)

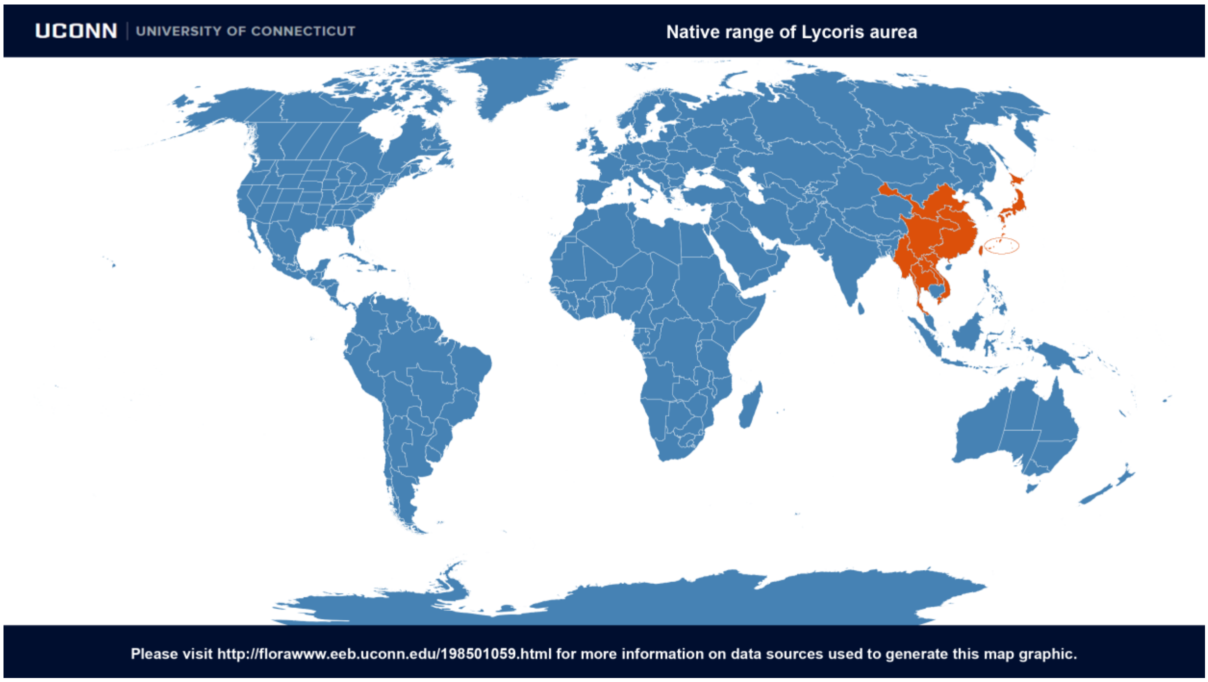

Figure 4. The distribution of *Lycoris aurea*
(source: http://florawww.eeb.uconn.edu/images/maps/tdwg/198501074.png)

2. MATERIALS AND METHODS

The study used 20 *Lycoris aurea* and *Lycoris radiata* bulbs with a weight of 32.2-41.1 g and 23.9-28.9 g, respectively, imported from the Netherlands (importer: Ogrodnictwo Wiśniewski Jacek Junior). The bulbs were treated for 30 minutes before planting with a suspension of 0.7% (w/v) preparations of Topsin M 500 SC (Nippon Soda, Tokyo, Japan, active ingredient: thiophanate-methyl) and 1% (w/v) Kaptan 50 WP (Organika-Azot Chemical Company, Jaworzno, Poland, active ingredient: Captan). The bulbs were planted in May individually in black PVC pots with a capacity of 2.5 dm^3. The medium was a peat substrate with pH 6.5 mixed at a dose of 3 g dm^{-3} with the Yara Mila Complex fertilizer (Yara International ASA, Norway) containing 2% N, 11% P_2O_5, 18% K_2O, 2.7% MgO, 8% S, 0.015% B, 0.2% Fe, 0.02% Mn and 0.02% Zn.

The plants were grown under natural photoperiod in an unheated plastic tunnel belonging to the Department of Horticulture at the West Pomeranian University of Technology in Szczecin (53°25'N, 14°32'E). The temperature was controlled using vents opened automatically above 25 °C. The plants were watered twice a week, and the average concentration of ions (mg dm^{-3}) in the water used for watering was: as follows: 1.53 N-NO_3, 1.5 P, 6.2 K, 97.4 Ca, 16.6 Mg, 24.0 Na, 24.0 Cl, 0.62 Cu, 0.42 Zn, 1.3 Fe, 194 HCO_3 and EC – 6.5. After the completion of the cultivation in November, all the plants were removed from the pots, after which the leaves and roots were cut off from mother bulbs.

After washing the bulbs in distilled water, they were cut into fragments and dried at 105 °C. Chemical analyses were carried out in an accredited laboratory. After sample mineralization in 96% H_2SO_4, the content of: total nitrogen (Klejdahl method), phosphorus (colorimetric method), potassium, and calcium (flame photometry method), magnesium (ATA atomic absorption flame spectrophotometry method) was determined. Boron, copper, zinc, manganese and iron were determined after dry matter mineralization in a mixture of HNO_3 and $HClO_4$ in the 1:4 ratio.

The results of analyses from 4 replicates were verified statistically using the analysis of variance and the TIBCO Statistica™ program. The significance of the differentiation of means was assessed according to the Tukey multiple comparison test at the significance level of $p \leq 0.05$.

3. RESULTS AND DISCUSSION

Analyzing the macronutrient composition, it was found that *Lycoris aurea* bulbs contained the highest quantities of nitrogen, followed by magnesium, potassium, phosphorus, and the lowest amount of calcium (**Table 1**). In the case of *Lycoris radiata* bulbs, it was found that nitrogen and potassium were present in tissues in the highest amounts, followed by magnesium, phosphorus and calcium. Liu et al. [13] found that the yield of *Lycoris radiata* bulbs was most influenced by potassium, followed by nitrogen and phosphorus. In our study, analyzing the N:P:K nutrient ratio in the bulbs, it was shown that this coefficient in *Lycoris aurea* was 1:0.3:0.6 and in *Lycoris radiata* 1:0.2:1. Chunsong et al. [14] demonstrated that the N:P:K nutrient ratio in *Lycorsi longituba* bulbs was 4:1:2.

When assessing the content of micronutrients, it was noted that the bulbs of both species contained the most iron and zinc, and the least boron and copper. The high content of zinc in *Lycoris radiata* bulbs was also shown by Xiaoyong [15], who evaluated the mineral composition of bulbs using atomic absorption spectrophotometry. The quoted author also found a relatively low content of potassium, calcium, magnesium, iron, manganese and copper in *Lycoris* bulbs (**Table 2**).

Table 1. Macronutrients content in the bulbs of two *Lycoris* species grown in a greenhouse. Mean values (4 n) in the same row followed by the same lower-case letter were not significantly different at $p \leq 0.05$ according to Tukey's multiple range test.

Macronutrients (% dry weight)	Species	
	Lycoris aurea	*Lycoris radiata*
Nitrogen	1.12 b	1.92 a
Phosphorus	0.29 a	0.42 a
Potassium	0.68 b	1.96 a
Magnesium	0.83 b	1.19 a
Calcium	0.21 a	0.32 a

Lycoris aurea and *Lycoris radiata* species differed significantly in nitrogen, potassium, magnesium, boron, zinc, manganese and iron contents in the bulbs. There were no statistically confirmed differences in the content of other analyzed mineral components, i.e. phosphorus, calcium and copper. The bulbs of the species *Lycoris radiata* contained more nitrogen, potassium, magnesium, zinc, manganese and iron than *Lycoris aurea* bulbs by 71.4%; 188%; 43.4%; 69.2%; 118% and 101%, respectively. An inverse relationship was noted for boron – *Lycoris aurea* bulbs had 31.7% more of this micronutrient compared to *Lycoris radiate* (**Table 1** and **Table 2**).

Table 2. Micronutrients content in the bulbs of two *Lycoris* species grown in a greenhouse. Mean values (4 n) in the same row followed by the same lower-case letter were not significantly different at $p \leq 0.05$ according to Tukey's multiple range test.

Micronutrients (mg kg^{-1} dry weight)	Species	
	Lycoris aurea	*Lycoris radiata*
Boron	27.4 a	20.8 b
Copper	18.6 a	20.9 a
Zinc	78.5 b	132.9 a
Manganese	27.5 b	60.1 a
Iron	85.5 b	172.4 a

Macronutrients are used by plants mainly for tissue formation. Nitrogen determines plant growth and is the most important nutrient affecting yielding, determining plant's demand for other components. Phosphorus is one of high-energy substances that serve the plant as an essential energy storage and is a component of nucleic acids. Potassium increases plant resistance to stress, regulates plant water balance and photosynthesis. Magnesium as the central chlorophyll component conditions many enzymatic processes in the plant [16].

Micronutrients are elements that take part in many important biological processes of plants. They are involved in numerous metabolic processes and fulfill very important physiological functions. Their deficiency leads to a reduction in plant stress ressitance. Copper affects the processes of respiration and photosynthesis, takes part in iron and nitrogen metabolism, biosynthesis of proteins and chlorophyll. In addition, copper increases resistance to diseases as well as low temperature. Zinc is an essential component of RNA polymerase (ribonucleic acid), catalyzing its formation. Deficiency or excess of zinc affects the level of indole-acetic acid, which is the growth hormone in plants. In addition, zinc is part of some enzymes regulating respiration; it enables the transformation of carbohydrates and affects plant supply with proteins and sugars. Manganese is involved in photosynthesis and respiration as well as in sugar, protein and vitamin C production. Iron is involved in many processes occurring in the plant (photosynthesis, respiration, nitrate reduction), therefore, it is an essential element for proper development and yielding. It is an element necessary for chlorophyll synthesis, it affects tissue respiration and is a component of many enzyme groups. Boron participates, *inter alia*, in the process of carbohydrate metabolism, stimulates cell growth and differentiation processes [17, 18].

The results on the content of minerals in the *Lycoris aurea* and *Lycoris radiata* bulbs can be used to assess the content of indicator minerals. Thus far, there has been no such indicator content for *Lycorsi*, and the obtained data will be very useful for assessing the nutritional status of plants in production cultivations.

4. CONCLUSION

In conclusion, the genotypes of *Lycoris aurea* and *Lycoris radiata* differed in the content of individual macro- and micronutrients in the bulbs. Both species contained particularly high amounts of nitrogen, iron and zinc in the bulbs. In addition, *Lycoris aurea* was characterized by an increased content of magnesium, while *Lycoris radiata* of potassium. Calcium, boron and copper were present in the lowest amounts in both *Lycoris aurea* and *Lycoris radiata* bulbs.

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