Variability of morphometric traits of seeds of different genotypes of *Lycium* spp.

M. Yu. Zhurba¹, S. V. Klymenko¹, I. Szot²

¹M. M. Hryshko National Botanical Garden of NAS of Ukraine, 1 Tymiriazevska St., Kyiv, 01014, Ukraine, *e-mail: zhurbamikhail@gmail.com*
²University of Life Sciences in Lublin, Faculty of Horticulture and Landscape Architecture, 13 Akademicka, Lublin, 20-033, Poland

**Purpose.** The objective of this study was to evaluate the morphological parameters of *Lycium* spp. seeds from the collections in M. M. Hryshko National Botanical Garden (NBS) NAS of Ukraine. **Methods.** Cultivars and varieties of three *Lycium* species (*Lycium barbarum*, *L. chinense*, *L. truncatum*) were studied in the period from 2016 till 2019. The following morphometric measurements were conducted: seeds weight, seeds length, seeds width and index of seeds shape. Basic statistical analyses were performed using PAST 2.17. Hierarchical cluster analyses of similarity between genotypes were computed on the basis of the Bray-Curtis similarity index. Correlation between traits was determined using the Pearson correlation coefficient. **Results.** Cultivars and varieties of different species of *Lycium* varied in weight, shape, and size of seeds. Seed weight varied from 0.54 to 3.54 mg, seed length from 1.90 to 3.06 mm, seed width from 1.43 to 2.53 mm. The shape indexes of seeds were found ranging from 0.73 to 0.80. The analysis of coefficient of variation showed the difference of variability in morphometric characteristics between some *Lycium* spp. cultivars and varieties. The most variable features: seeds weight (8.51–28.22%) and seeds length (5.07–24.81%) are important parameters for selection.

**Conclusions.** Diagnostic signs by seed morphometry for differentiation of *Lycium* species were revealed. The analysis of coefficient of variation showed the difference of variability in morphometric characteristics between some *Lycium* cultivars and varieties. The most variable characteristics of the studied genotypes were seed weight and length, which are important parameters for selection because they determine the pulp content and number of seeds, as well as the ratio of these parameters between them. It is through variability that promising varieties with low seed weight and length can be selected. Due to securing them later vegetatively.

**Keywords:** goji berry; cultivars; varieties; seeds; parameters; cluster hierarchical analysis.

---

**Introduction**

For the successful cultivation of neglected and underutilized species and the production of new valuable varieties, a comprehensive study of their plant morphology and anatomy is necessary [1–6]. It is especially important to study the biological characteristics of seeds, since they characterize the most successful varieties, especially those propagating by seed.

The morphological characteristics of the seeds of different plant species serve as taxonomical markings and also in deducing phylogenetic relationships [7] that would be a great help in academic as well as in applied ventures [8, 9].

The genus *Lycium* L. (Solanaceae Juss.) includes about 92 (97) species, of which 35 species are used as food and medicinal [10–12]. The two most common species are *L. barbarum L.* and *L. chinense* Mill., which have been used in Chinese medicine for over 2000 years [12, 13] because of content of valuable bioactive substances [14–18] that have many pharmacological effects, namely anti-cancer, anti-hyperglycemic, antioxidant, anti-inflammatory, and anti-aging properties [19–23]. Not only fruits, but also other plant parts, especially leaves contain valuable biologically active substances [24–26].

*Lycium* fruits are used to prepare juices, wine, canned food, used in soups, as porridge with rice, and added to various types of meat and vegetable dishes [12–18].
The unique biochemical characteristics of *Lycium* are well documented. However, information about the morphological variability of *Lycium* seeds is insufficient. It is important to study the genetic variability of seeds for improving selected characteristics in the future.

The purpose of this study was to determine the variability of morphological characteristics of *Lycium* spp. seeds. The obtained results will help to select promising genotypes for further breeding work.

**Material and methods**

**Collection of plant material**

Plants growing in M. M. Hryshko National Botanical Garden of NAS of Ukraine (Kyiv) from seeds or cuttings obtained from China, France, Slovak Republic and other Botanical Gardens of Ukraine. The research was conducted during 2016–2019. The following genotypes of the three *Lycium* species were studied in this work: *L. barbarum* (var. LB01, LB02 and LB03); *L. chinense* (var. LC01, LC02, LC03, LC04, LC05, and cv. Amber Sweet, Big Lifeberry, Delikat, Q1, Sweet Lifeberry, Tybet); *Lycium truncatum* (var. LT01 and cv. Super Sweet, Korean Big, N1 Lifeberry, New Big, Princess Tao). The ripened fruits were harvested in the maturity stage (August).

**Morphometric analysis**

Immediately after the harvest, 30 fruits of each genotype were taken and 30 seeds were randomly selected. The following morphometric parameters were measured: seeds weight (50 seeds), in g; seeds length, in mm; seeds width, in mm. Seeds weight was measured by using a digital balance with a sensitivity of 0.01 g (PS6000/C/1). Linear dimensions of seeds as length and width were measured by using a digital calliper gauge with a sensitivity of 0.01 mm than shape index was calculated for or indicate only length. This does not reveal the morphometric parameters fully.

**Statistical analysis**

Basic statistical analyses – the minimal and maximal values of the traits, arithmetic means, and coefficient of variation (V %) were performed using PAST 2.17 (Norway, 2001). Results of the morphometric analysis were determined by mean ± standard deviation (SD) and statistical significance was estimated. Hierarchical cluster analyses of similarity between phenotypes were computed by the Bray-Curtis similarity index and were performed using PAST 2.17.

**Results and discussions**

For the first time since 2016 in Ukraine in the M. M. Hryshko National Botanical Garden (Department of Acclimatization of Fruit Plants) work on the collection of different species of *Lycium* L. has begun. Until this time, *Lycium* spp. was not studied in Ukraine at all. The collection consists of 45 genotypes (from seeds or cuttings) received from China, France, Slovakia and other botanical gardens in Ukraine, 9 of which were selected for cultivars.

There is limited information on morphometric parameters of *Lycium* seeds. Descriptions of species in the flora of countries indicate rough parameters of seed length and width indicators, which are usually 2–3 and 1.5–2.0 mm, or indicate only length. This does not reveal the morphometric parameters fully.

Cultivars and varieties of different species of *Lycium* plants varied in weight, shape, and size of seeds (Fig. 1).

The seeds color of the currently studied *Lycium* ranges from pale yellow, grayish yellow, and light brown.

The minimum and maximum values for the seeds weight, seeds length, seed width and shape index of seeds in the twenty-one cultivars and varieties are shown in Table 1.

Variation limits for seed length varied from 1.38 mm for LT01 (*Lycium truncatum*) to 2.20 mm for cv. Princess Tao (*L. truncatum*) (Table 1). The value of width varied within the interval from 1.01 mm (*L. barbarum* LB03) to 3.03 mm (*L. chinense* cv. Delikat). Seed weight ranged of 0.37 mg (*L. truncatum* cv. Princess Tao) to 4.43 mg (*L. chinense* LC03).

The average weight of the seed was determined in the range of 0.54 (*L. truncatum* cv. Princess Tao) to 3.54 (*L. chinense* LC03) mg, length of seed from 1.90 (*L. truncatum* LT01 and cv. New Big) to 3.06 (*L. chinense* cv. Delikat) mm, width of seed from 1.43 (*L. truncatum* LT01) to 2.53 (*L. chinense* LC03) mm (Fig. 2, 3).

Kazbekovna et al. [27] established a seed width range in *L. barbarum* from 2.50 to 3.0 mm and in *L. ruthenicum* from 1.5 to 2.0 mm. According to Zhang et al. [28], the seeds width of *L. ruthenicum* was also determined from 1.5 to 2.0 mm. The seeds width of *L. chinense* was determined to be between 2.5 and 3.0 mm and *L. shawii* between 1.5 and 2.0 mm [29].

The shape index (Fig. 4) of seeds which is ranged from 0.73 (*L. barbarum* LB04 and *L. chinense* LC01) to 0.80 (*L. chinense* LC03).
Variety studying and variety science

Fig. 1. Seeds of different *Lycium* species

| Cultivars, varieties | Weight of 1000 seeds, g | Seeds length, mm | Seed width, mm | Shape index |
|----------------------|-------------------------|------------------|----------------|-------------|
|                      | min  | max  | min  | max  | min  | max  | min  | max  |       |       |
| *Lycium barbarum*    |      |      |      |      |      |      |      |      |       |       |
| LB01                 | 1.81 | 2.87 | 2.19 | 2.97 | 1.58 | 2.46 | 0.64 | 1.02 |       |       |
| LB02                 | 2.30 | 3.37 | 1.90 | 3.65 | 1.45 | 2.75 | 0.64 | 0.93 |       |       |
| LB03                 | 0.75 | 2.14 | 2.00 | 3.03 | 1.01 | 2.57 | 0.39 | 1.12 |       |       |
| LB04                 | 1.33 | 2.04 | 2.36 | 3.04 | 1.69 | 2.63 | 0.58 | 0.88 |       |       |
| *Lycium chinense*    |      |      |      |      |      |      |      |      |       |       |
| LC01                 | 1.75 | 2.77 | 2.54 | 3.23 | 1.67 | 2.63 | 0.60 | 0.95 |       |       |
| LC02                 | 2.18 | 3.32 | 2.50 | 3.44 | 1.87 | 2.70 | 0.60 | 0.92 |       |       |
| LC03                 | 2.80 | 4.43 | 2.02 | 3.33 | 2.08 | 2.91 | 0.71 | 1.12 |       |       |
| LC04                 | 2.30 | 3.23 | 2.43 | 3.38 | 1.88 | 2.88 | 0.68 | 0.96 |       |       |
| LC05                 | 2.29 | 4.11 | 2.60 | 3.48 | 1.64 | 2.69 | 0.50 | 0.91 |       |       |
| Amber Sweet          | 2.26 | 3.73 | 2.13 | 3.28 | 1.62 | 2.48 | 0.62 | 1.03 |       |       |
| Big Lifeberry        | 1.86 | 2.99 | 2.46 | 3.06 | 1.64 | 2.50 | 0.60 | 0.96 |       |       |
| Delikat              | 2.29 | 3.66 | 2.74 | 3.48 | 1.99 | 3.03 | 0.61 | 0.97 |       |       |
| Q1                   | 2.46 | 3.54 | 2.33 | 3.27 | 1.85 | 2.71 | 0.68 | 0.98 |       |       |
| Sweet Lifeberry      | 1.49 | 2.37 | 2.32 | 3.31 | 1.77 | 2.76 | 0.62 | 0.99 |       |       |
| Tybet                | 2.22 | 3.25 | 2.40 | 3.10 | 1.76 | 2.60 | 0.67 | 0.98 |       |       |
| *Lycium truncatum*   |      |      |      |      |      |      |      |      |       |       |
| LT01                 | 0.75 | 1.31 | 1.38 | 2.32 | 1.14 | 1.68 | 0.58 | 1.01 |       |       |
| Super Sweet          | 0.72 | 1.42 | 1.69 | 2.46 | 1.12 | 1.96 | 0.53 | 1.05 |       |       |
| Korean Big           | 0.52 | 1.10 | 1.45 | 2.38 | 1.09 | 1.80 | 0.47 | 1.00 |       |       |
| N1 Lifeberry         | 0.69 | 1.02 | 1.57 | 2.40 | 1.19 | 1.78 | 0.63 | 0.93 |       |       |
| New Big              | 0.45 | 0.78 | 1.59 | 2.26 | 1.15 | 1.81 | 0.57 | 0.98 |       |       |
| Princess Tao         | 0.37 | 0.78 | 1.44 | 2.20 | 1.12 | 1.92 | 0.54 | 1.12 |       |       |

**Note.** min – minimum values; max – maximum values.
The analysis of coefficient of variation showed the significant variability of morphological signs between cultivars and varieties (Fig. 5). The variation coefficients (%) ranged between 8.51 (L. chinense cv. Amber Sweet) and 28.22 (L. truncatum cv. Super Sweet) for seeds weight, between 5.07 (L. chinense cv. Big Lifeberry) and 24.81 (L. barbarum LB02) for seeds length, between 8.51 (L. chinense cv. Amber Sweet) and 15.22 (L. truncatum cv. Super Sweet) for the shape index.

The most variable characteristics in the studied genotypes were seed weight and length,
Variety studying and variety science

Variety studying and variety science are important parameters for selection. They determine the pulp content and number of seeds in the fruit and the ratio of these parameters to each other. The smaller the seed in weight and length, the greater the pulp content of the fruit. It is through variability that promising varieties with small weight and lengths can be selected, securing them afterwards, as in other cultivars, vegetatively.

Determination of the complex of relationships of morphological characteristics of seeds of cultivars and varieties of *Lycium* spp. showed a strong correlation between the main morphological features (Fig. 6).

![Figure 4. Comparison of shape index of seeds of cultivars and varieties of *Lycium* spp.](image)

[means in each column followed by different letters are not significantly different (P < 0.05)]

![Figure 5. Variability of morphological characters of *Lycium* spp. cultivars and varieties (%)](image)

![Figure 6. Correlation of morphological parameters of seeds of cultivars and varieties of *Lycium* spp.](image)

\[
\begin{align*}
\text{Seed width (r = 0.964)} & \quad \text{Seeds weight (r = 0.894)} \\
\text{y = 2.042x - 3.166} & \quad \text{y = 0.799x - 0.070} \\
\text{RI = 0.799} & \quad \text{RI = 0.930}
\end{align*}
\]
Thus, the correlation coefficient between seed length and width was 0.964 and is reliable at all accuracy levels. The strength of the relationship between the length and seed weight was characterized by the coefficient of 0.894, and between the width and seed weight by 0.934.

Cluster analysis is very widely used to assess the genetic diversity of many plant species [1, 6, 30, 31].

The above data (Figure 2–5) confirms cluster analysis. In clustering, all studying parameters of seeds for 21 cultivars and varieties of the *Lycium* spp. were used, and the resulting clusters are shown in Figure 7.

Based on the data presented in Figure 7, we can say that cluster analysis divides the collection into two main clusters. The largest number of samples (15 cultivars and varieties) were included in Cluster I. Cluster II consisted of 5 cultivars and 1 variety of *L. truncatum*, which were the most distant from all other samples of Cluster I, and differed from the others by the smallest morphometric characteristics of seeds. Cluster analysis demonstrates the integrated character of the variability in seeds of the studied species, cultivars and indicates possible ways to artificially improve the genetic material.

Varieties of *Lycium* with big seeds weight and size not be seen as a practical unusable. The seeds of different *Lycium* species contain rich biologically active substances, mainly fatty acids. Oil from these seeds can be used in the pharmaceutical and food industries [32–34].

**Conclusions**

Diagnostic signs by seed morphometry for differentiation of *Lycium* species were revealed. The analysis of coefficient of variation showed the difference of variability in morphometric characteristics between some *Lycium* cultivars and varieties. The use of cluster analysis allowed us to establish a clear limitation of *L. truncatum* on a complex of diagnostic characters. Seeds of *L. truncatum* differed from other plant species by the lowest morphometric indices. The most variable characteristics in the studied genotypes were seed weight and length, which are important parameters for selection. They determine the pulp content and number of seeds in the fruit and the ratio of these parameters to each other. The smaller the seed in weight and length, the more pulp the fruit contains. It is through variability that promising varieties with small weight and lengths can be selected, securing them afterwards, as in other cultivars, vegetatively.

**Acknowledgments**

The publication was prepared with the active participation of researchers in International Network AgroBioNet within the project ITMS 25110320104 «Innovation of Test Methods and Procedures for the Detection of Sources of Bioactive Substances for the Improvement of Health and Quality of Life». The authors are grateful to Visegrad Fund (52011113).
References

1. Ivanišová, E., Grygorieva, O., Abramavá, V., Schubertová, Z., Terentjeva, M., & Brindza, J. (2017). Characterization of morphological parameters and biological activity of jujube fruit (Ziziphus jujuba Mill.). J. Berry Res., 7, 249–260. doi: 10.3233/JBR-170162
2. Vinogradova, Y., Grygorieva, O., Vergun, O., & Brindza, J. (2017). Morphological characteristics for fruits of Aronia mitschurinii A.K.Skvorost & Maitul. Potr. S. J. F. Sci., 11(1), 754–760. doi: 10.5219/845
3. Grygorieva, O., Klymenko, S., Ilinska, A., & Brindza, J. (2018). Variation of fruits morphometric parameters of Elaeagnus multiflora Thumb, germplasm collection. Potr. S. J. F. Sci., 12(1), 527–532. doi: 10.5219/92
4. Grygorieva, O., Klymenko, S., Vinogradova, Y., Motyleva, S., Gurenko, I., Plorecki, N., & Brindza, J. (2018). Study of morphological characteristics of pollen grains of Aronia Mitsu−chinii A.K.Skvorost & Maitul. Agrobiodivers. Improv. Nutr., Health Life Qual., 2, 49–56. doi: 10.15414/agrobiodiversy.2018.2855−8246.049−056
5. Grygorieva, O., Klymenko, S., Vinogradova, Y., Vergun, O., & Brindza, J. (2018). Variation in morphometric traits of fruits of Mespilus germanica L. Potr. S. J. F. Sci., 12(2), 782–788. doi: 10.5219/999
6. Hořčinová Sediaľková, V., Grygorieva, O., Vergun, O. M., Vinogradova, Ju. K., & Brindza, J. (2019). Comparison of selected characteristics of cultivars and wild-growing genotypes of Sambucus nigra in Slovakia. Biosyst. Divers., 27, 56–61. doi: 10.15421/011909
7. Barthlott, W., & Ziegler, B. (1981). Seed coat morphology as a systematic characteristic in orchids. Ber. Deutsch. Bot. Ges., 94, 267–273. doi: 10.1111/j.1438-8677.1981.tb03402.x
8. Rani, U., Singh, S. G., Gupta, S., & Garg, V. (1993). Morphometry of orchid seeds in Epidendroideae as revealed by SEM. Adv. Plant Sci., 6, 128–133.
9. Augustine, J., Yogendra, K., & Sharma, J. (2001). Orchids of India—II. Biodiversity and status of Bulbophyllum Thou Daya publishing house. New Delhi: Trinagar.
10. Levin, R. A., Bernardello, G., Whiting, C., & Miller, J. S. (2011). A new generic circumscription in tribe Lycieae (Solanaceae). Taxon, 60(3), 681–690. doi: 10.1207/s12030005
11. Barboza, G. E., Hunziker, A. T., Bernardello, G., Cocucci, A. A., Carrizo Garcia, C., … Anton, A. (2016). Lycium and carotenoid profile of new goji cultivars and their anti-hyperglycemic, anti-aging and antioxidant properties. J. Funct. Foods, 48, 632–642. doi: 10.1016/j.jff.2018.07.061
12. Protti, M., Gualandi, I., Mandrioli, R., Zappoli, S., Tonelli, D., & Bubecelvicek, P. (2018). Phenolic and carotenoid profile of new goji cultivars and their anti-inflammatory, anti-aging and antioxidant properties. J. Funct. Foods, 48, 632–642. doi: 10.1016/j.jff.2018.07.061
13. Qian, D., Yang, J., Kang, L., Ji, R., & Huang, L. (2017). Variation of sweet chemicals in different ripening stages of wolfberry fruit. Chin. Herb. Med., 9(4), 329–334. doi: 10.1016/j.chmed.2017.08.005
14. Poterat, O. (2010). Goji (Lycium barbarum and L. chinense): Phytochemistry, pharmacology and safety in the perspective of traditional uses and recent popularity. Planta Med., 76(1), 7–19. doi: 10.1055/s-0029-1186218
15. Protti, M., Gualandi, I., Mandrioli, R., Zappoli, S., Tonelli, D., & Merconin, L. (2017). Analytical profiling of selected antioxidants and total antioxidant capacity of goji (Lycium spp.) berries. J. Pharm. Biomed. Anal., 143, 252–260. doi: 10.1016/j.jpba.2017.05.048
16. Wang, S., Suh, J. H., Zheng, X., Wang, Y., & Ho, C. T. (2017). Identification and quantification of potential anti-inflammatory hydroxy-cinnamic acid amides from wolfberry. J. Agric. Food Chem., 65(2), 364–372. doi: 10.1021/acs.jafc.6b05136
17. Cumaoglu, A., Bekci, H., Ozturk, E., Yerer, M. B., Baldemir, A., & Bishayee, A. (2018). Goji berry fruit extracts suppress proliferation of triple-negative breast cancer cells by inhibiting EGFR-Mediated ERK/MAPK and PI3K/Akt signaling pathways. Nat. Prod. Commun., 13(6), 701–706. doi: 10.1177/1934578x180300619
18. Wang, S., Suh, J. H., Zheng, X., Wang, Y., & Ho, C. T. (2017). Isolation of carotenoids, flavonoids and polysaccharides from Lycium barbarum fruit (Goji). Food Chem., 200, 95–105. doi: 10.1016/j.foodchem.2016.02.029
19. Protti, M., Gualandi, I., Mandrioli, R., Zappoli, S., Tonelli, D., & Bubecelvicek, P. (2018). Phenolic and carotenoid profile of new goji cultivars and their anti-hyperglycemic, anti-aging and antioxidant properties. J. Funct. Foods, 48, 632–642. doi: 10.1016/j.jff.2018.07.061
20. Ma, Z. F., Zhang, H., Teh, S. S., Wang, C. W., Zhang, Y., Hayford, F. … Zhu, Y. (2019). Goji berries as a potential natural antioxidant medicine: An insight into their molecular mechanisms of action. Food Chem., 2019, 2437397. doi: 10.1016/j.foodchem.2019.2437397
21. Kazbekovna, S. F., Sekinaeva, M. A., & Denisenko, O. N. (2018). Comparative micromorphological investigations of red gojiberries (Lycium ruthenicum Murt.) Pharmacogn. J., 10(5), 911–915. doi: 10.5530/pj.2018.5.153
22. Zhang, Z. Y., Lu, A. M., & D’Arcy, W. G. (1994). Solanaceae. In Z. Y. Wu & P. H. Raven (Eds.), Flora of China (Vol. 17, pp. 330–332). Beijing: Science Press; Saint Louis; Missouri Botanical Garden Press.
23. Yao, R., Heinrich, M., & Weckerle, C. (2018). The genus Lycium as food and medicine: a botanical, ethnomedical and historical review. J. Ethnopharmacol., 212, 50–66. doi: 10.1016/j.eph.2017.10.010
24. Amagase, H., & Farnsworth, N. R. (2011). A review of botanical characteristics, phytochemistry, clinical relevance in efficacy and safety of Lycium barbarum fruit (Goji). Food Res. Int., 44(7), 1702–1717. doi: 10.1016/j.foodres.2011.03.027
25. Wang, C. C., Chang, S. C., Inbaraj, B. S., & Chen, B. H. (2010). Isolation of carotenoids, flavonoids and polysaccharides from Lycium barbarum L. and evaluation of antioxidant activity. Food Chem., 120(1), 184–192. doi: 10.1016/j.foodchem.2009.10.005
26. Niro, S., Fratianne, A., Panfigli, G., Falasca, L., Cinquanta, L., & Alam, M. R. (2017). Nutritional evaluation of fresh and dried goji berries cultivated in Italy. Ital. J. Food Saf., 29(3), 398–408. doi: 10.14674/1120−1770.ijfs.v649
1. Ivanisová E., Grygorieva O., Abramavich V. et al. Characterization of morphological parameters and biological activity of jujube fruit (Ziziphus jujuba Mill.). J. Berry Res. 2017. Vol. 7. P. 249–260. doi: 10.3233/JBR-170162

2. Vinogradova Yu., Grygorieva O., Vergun O., Brindza J. Comparison of selected characteristics of cultivars and wild-growing genotypes of Ziziphus jujuba M. in Slovakia. Potr. S. J. F. Sci. 2018. Vol. 12. Iss. 1. P. 527–532. doi: 10.5219/92

3. Grygorieva O., Klymenko S., Ilinska A., Brindza J. Variation of morphological characteristics for fruits of Lycium barbarum L. Chin. Herb. 2017. Vol. 65, Iss. 2. P. 364–372. doi: 10.1016/j.china.2017.05.048

4. Wang C.C., Chang S.C., Inbaraj B.S., Chen B.H. Isolation and characterization of pro-health and functional properties of goji berries as a potential natural antioxidant medicine: An insight into their molecular mechanisms of action. Oxid. Med. Cell. Longev. 2019. Vol. 2019. Art. 2437397. doi: 10.1155/2019/2437397

5. Chen P.Y., Shih H.H., Chang K.C. Potential of galled leaves of Goji (Lycium chinense) as functional food. BMC Nutrition. 2020. Vol. 6. Art. 26. doi: 10.1186/s40795-020-00351-w

6. Grygorieva O., Vergun O., Klymenko S. et al. Estimation of phenolic compounds content and antioxidant activity of leaves extracts of some selected non-traditional plants. Potravinarstvo Slovak Journal of Food Sciences 2020. Vol. 14. P. 501–509. doi: 10.5219/1314

7. Potr. S. J. F. Sci. 2020. Vol. 14. P. 134–145. doi: 10.15414/5001_2020_14-135

8. Kazbekovna S. F., Sekinaeva M. A., Denisenko O. N. Comparative micromorphological investigations of red goji berries (Lycium barbarum L.) and black goji berries (Lycium ruthenicum Murr.). Pharmacogn. J. 2018. Vol. 10, Iss. 5. P. 911–915. doi: 10.5530/ pj.2018.5.153

9. Zhang Z.Y., Lu A.M., D’Arcy W.G. Solanaceae. 2010. Vol. 76, iss. 2. P. 672–677. doi: 10.1007/s10341-015-0238-6

10. Zhang Z.Y., Lu A.M., D’Arcy W.G. Solanaceae. Adv. Plant Sci. 2020. Vol. 60, No. 3. P. 681–690. doi: 10.1002/tax.603005

11. Wang S., Suh J.H., Zheng X. et al. Identification and quantification of potential anti-inflammatory hydroxycinnamic acids amides from wolfberry. J. Agric. Food. Chem. 2017. Vol. 65, Iss. 2. P. 364–372. doi: 10.1021/acs.jafc.6b05136

12. adap a developed pre-column derivatization method for the determination of free fatty acids in edible oils by reversed-phase HPLC with fluorescence detection and its application to Lycium barbarum seed oil. Food. Chem., 2012. Vol. 135, Iss. 3172. doi: 10.1016/j.foodchem.2010.10.007

13. Liu J., Zou Z., Wang H.-P. et al. An evidence-based update on the pharmacological activities and possible molecular targets of Lycium barbarum polysaccharides. Drug Des. Dev. Ther. 2015. Vol. 9. P. 33–78. doi: 10.2147/DDDT.S72892

14. Qi D., Yang J., Kang L. et al. Variation of sweet chemicals in different ripening stages of wolfberry fruits. Chin. Herb. Med. 2017. Vol. 9, Iss. 4. P. 329–334. doi: 10.11674/8348(17)60112-6

15. Amagase H., Farnsworth N. R. A review of botanical characteristics, phytochemistry, pharmacology and safety in the perspective of traditional uses and recent popularity. Planta Med. 2010. Vol. 76, Iss. 1. P. 7–19. doi: 10.1055/s-0029-1186218

16. Li G., You J., Suo Y., Song C., Sun Z., Xia L., … Shi J. (2011). A developed pre-column derivatization method for the determination of free fatty acids in edible oils by reversed-phase HPLC with fluorescence detection and its application to Lycium barbarum seed oil. Food. Chem., 2012. Vol. 135, Iss. 3172. doi: 10.1016/j.foodchem.2010.10.007
Variety studying and variety science

Variety studying and variety science

ÓÄÊ 582.951.4:581.48
Anna Ñ. Ñ., Shol Ñ.2
íëèâ³ñòü ìîðôîìåòðè÷íèõ ïàðàìåòð³â íàñ³ííÿ ð³çíèõ ãåíîòèï³â Lycium spp.
Plant Varieties Studying and Protection. 2021. T. 17, № 1. C. 5–13. https://doi.org/10.21498/2518-1017.17.1.2021.228198
1Íàö³îíàëüíèé áîòàí³÷íèé ñàä ³ìåí³ Ì. Ì. à ðèøêà ÍÀÍ Óêðà¿íè, âóë. Òèì³ðÿçºâñüêà, 1, ì. Êè¿â, 01014, Óêðà¿íà, *e-mail: zhurbamikhail@gmail.com
2Óí³âåðñèòåò íàóêè ïðî æèòòÿ â Ëþáë³í³, ôàêóëüòåò ñàä³âíèöòâà ³ ëàíäøàôòíî¿ àðõ³òåêòóðè, âóë. Àêàäåì³÷íà, 13, ì. Ëþáë³í, 20-033, Ïîëüùà, e-mail: szoti@autograf.pl

Ìåòà. Îö³íèòè ìîðôîìåòðè÷í³ ïîêàçíèêè íàñ³ííÿ Lycium spp. êîëåêö³¿ Íàö³îíàëüíîãî áîòàí³÷íîãî ñàäó ³ìåí³ Ì. Ì. à ðèøêà (ÍÁÑ) ÍÀÍ Óêðà¿íè.

Ìåòîäè. Óïðîäæ 2016–2019 ðð. äîñë³äæåíî 21 ãåíîòèï (10 ñîðò³â ³ 11 ôîðì) òðüîõ âèä³â (Lycium barbarum, L. chinense, L. truncatum).

Óñòàíîâëåíî ìîðôîìåòðè÷í³ ïîêàçíèêè íàñ³ííÿ (ìàñà, äîâæèíà, øèðèíà òà ³íäåêñ ôîðìè). Ñòàòèñòè÷íèé àíàë³ç âèêîíóâàëè çà äîïîìîãîþ PAST 2.17. Êëàñòåðíèé àíàë³ç ïîä³áíîñò³ ãåíîòèï³â çä³éñíåíî çà ³íäåêñîì ïîä³áíîñò³ Áðåé-Êåðò³ñà. Íàÿâí³òü çâ'ÿçê³â í³æ ïàðàìåòðàìè âñòàíîâëþâàëè çà êîåô³ö³ºíòîì êîðåëÿö³¿ јðñîíà.

Ðåçóëüòàòè. Ñîðòè òà ôîðìè ð³çíèõ âèä³â ðîñëèí Lycium âàð³þâàëè çà í³æ, ðîçì³ðîì òà ôîðìîþ íàñ³ííÿ.

Ìîðôîìåòðè÷í³ ïàðàìåòðè íàñ³ííÿ áóëè òàêèìè: ìàñà – â³ä 0,54 äî 3,54 ìã, äîâæèíà – â³ä 1,90 äî 3,06 ìì, øèðèíà – â³ä 1,43 äî 2,53 ìì. Âåëè÷èíà ³íäåêñó ôîðìè íàñ³ííÿ ñòàíîâèëà â³ä 0,73 äî 0,80. Àíàë³ç êîåô³ö³ºíòà âàð³àö³¿ ïîêàçàâ ð³çíó í³æ íàñ³ííÿ (8,51–28,22%) òà éîãî äîâæèíà (5,07–24,81%), ÿê³ º âàæëèâèìè ïàðàìåòðàìè äëÿ ñåëåêö³¿. Âèêîðèñòàííÿ êëàñòåðíîãî àíàë³çó äàëî çìîãó âñòàíîâèòè ãåíåòè÷í³ çâ'ÿçêè í³æ ñîðòàìè é ôîðìàìè Lycium òà ðîçïîä³ëèòè ¿õ îáëàñòèõ êëàñòåðè.

Âèñíîâêè. Âèÿâëåíî ä³àãíîñòè÷í³ îçíàêè ìîðôîìåòðè÷íèõ ïàðàìåòð³â íàñ³ííÿ äëÿ ³äåíòèô³êàö³¿ âèä³â Lycium. Àíàë³ç êîåô³ö³ºíòà âàð³àö³¿ ïîêàçàâ í³æ íàñ³ííÿ. Íàéì³íëèâ³øèìè ïàðàìåòðàìè äîñë³äæóâàíèõ ãåíîòèï³â áóëè ìàñè òà äîâæèíà íàñ³ííÿ. Îñòàíí³ º âàæëèâèìè äëÿ ñåëåêö³¿, îñê³ëüêè â³ä íèõ çàëåæèòü òì³ñò ì'ÿêóøó òà ê³ëüê³ñòü íàñ³ííÿ, à òàêîæ ñï³ââ³äíîøåííÿ öèõ ïàðàìåòð³â í³æ íèìè. Çàâäÿêè í³æ íàñ³ííÿ ìîæíà ä³áðàòè ïåðñïåêòèâí³ ñîðòè ç íåâåëèêèìè ìàñîþ òà äîâæèíîþ íàñ³ííÿ, çàêð³ïèâøè ¿õ ïîò³ì âåãåòàòèâíî.

Êëþ÷îâ³ ñëîâà: ãîäæ³; âèäè; ñîðòè; ôîðìè; íàñ³ííÿ; ìîðôîìåòðè÷í³ ïàðàìåòðè; êëàñòåðíèé ³ºðàðõ³÷íèé àíàë³ç.

Íàä³éøëà / Received 09.02.2021
Ïîãîäæåíî äî äðóêó / Accepted 22.03.2021

application to Lycium barbarum seed oil. Food Chem. 2011. Vol. 125. P. 1365–1372. doi: 10.1016/j.foodchem.2010.10.007
34. Liu Z., Liu B., Kang H. et al. Subcritical fluid extraction of Lycium ruthenicum seeds oil and its antioxidant activity. J. Food Sci. Technol. 2019. Vol. 54, Iss. 1. P. 161–169. doi: 10.1111/jfsts.13920