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MORPHOLOGY AND BIOLOGICAL PRODUCTIVITY OF *CHENOPODIUM ALBUM* L. PLANTS IN NATURAL AND LABORATORY CONDITIONS

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Abstract

Chenopodium album is a widespread ruderal plant that is used for food and medicinal purposes as a source of protein and valuable biologically active substances. The purpose of our research is to identify how artificial growing conditions affect the growth and development of Chenopodium album plants and the ability to accumulate primary metabolites in leaves. During the studies, a comparative morphometric analysis was carried out, as well as the analysis of ascorbic acid, protein quantitative content and antioxidant activity. The results were processed statistically. The studies have shown that it is necessary to use stratified seeds that have a higher germination capacity in sheltered soil. During their cultivation in sheltered soil under 16-hour lighting and artificial irrigation, Chenopodium album plants go through all stages of ontogenesis, up to flowering and fruiting during 45-50 days. Morphological analysis showed that metric growth parameters in cultivated plants (height, shoot biomass, leaf and generative organs biomass) are lower, and allometric growth parameters (reproductive effort and photosynthetic effort) are comparable to plant parameters from natural growing conditions. Artificial development does not significantly affect the accumulation of protein in the leaves of Chenopodium album and their antioxidant activity. At the same time, the synthesis of ascorbic acid is significantly reduced under artificial growing conditions.

Key words : *Chenopodium album,* seed productivity, seed germination, morphometric analysis, protein content, ascorbic acid.

Introduction

Nowadays weed wild plants are increasingly considered as a possible cheap source of valuable biologically active substances (BAS). The attention of researchers is particularly attracted to the plants containing flavonoids, which can be used to obtain a wide range of capillary-strengthening, antitumor, and immunomodulating drugs.

Frost-blite (*Chenopodium album* L.) is a well-known weed annual plant that has long been used for food (Ivanova, 1988). In addition, it is applied in medicine. Nutritional and medicinal properties are provided by a high content of proteins, vitamins, flavonoids, trace elements that accumulate in the aerial organs of the *Chenopodium album* (Gadano *et al.,* 2007; Jabbar *et al.,* 2007; Vysochina *et al.,* 2009; Baldi & Choudhary, 2013; Pandey & Gupta, 2014; Kaur & Kaur, 2018; Guil Guerrero & Torija Isasa, 1997). The leaves and flowers of frost-blite, growing in different regions of Siberia, demonstrated the presence of flavonoids such as quercetin (the main component) and kempferol by HPLC, and 8 glycosides (quercetin derivatives). At that the content of these substances is associated with the place and timing of plant collection (Vysochina *et al.,* 2009). The analysis of leaf composition among three Chenopodium species (*C. album* L.*, C. murale* L.. *and C. opulifolium Shraeder*) from different places in southeastern Spain (Almeria) showed that the greatest amount of ascorbic acid accumulates in C. album, which is 155 mg/100 g, the participation of carotenoids is also relatively high in C. album and make 12.5 mg/100 g, the content of mineral elements (Na, K, Ca, Mg, P, Fe, Cu, Zn and Mn) was higher than in other green leafy vegetables (Guil Guerrero & Torija Isasa, 1997).

It is known that internal physiological processes, their nature and intensity are closely interconnected with the

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plant morphostructure. Besides, various environmental factors affect the rate of secondary metabolite development in plants (Cook & Samman, 1996).

For *Chenopodium album*, there is no information on the course of growth, metabolic characteristics and the ability to accumulate biologically active substances during artificial cultivation. The purpose of our research is to identify the influence of protected ground conditions on the growth and the development of frost-blite plants and the ability to accumulate various substances. The research tasks included the determination of the germination and the energy of seed germination in laboratory conditions, the conduct of comparative morphological and biochemical analysis of plants growing in natural and artificial conditions.

Materials and Methods

The object of the study - *Chenopodium album* - is the plant that is widely distributed in Tatarstan along weedy places, the banks of water bodies, in settlements, along the roads in all natural areas (Sukhorukov, 1999; Bakin *et al.,* 2000).

The germination and germination energy of unstratified and stratified (at T = -10°C for 6 months) frost-blite seeds were determined in Petri dishes on filter paper and in pots with soil under 16-hour illumination and artificial irrigation. Seeds were germinated in 4-5 replicates of 50 pieces each for 10 (Petri dishes) and 120 days (pots with soil). Germination energy was determined by the ratio of germinated seed number in each repetition and the time during which they germinated.

At the end of the experiment, the plants were dug up from the closed ground and dried to an air-dry state. Frost-blite plants were collected from natural places of growth on 7 meter sites in the Vakhitovsky district of Kazan during September 2018 and then were herbarized. The morphometric studies of collected plants from open and closed ground were carried out in laboratory conditions. Metric indicators were measured in plants, such as height (H, cm), total biomass of above-ground shoots (W, g), leaf biomass (Wl, g), and the biomass of reproductive organs (Wg, g). Besides, allometric indicators were calculated, such as photosynthetic enhancement (W1 / W) - the proportion of leaf biomass relative to the total plant biomass and reproductive gain (Wg/W) - the proportion of reproductive organ biomass relative to the total plant biomass. In total, they measured 12 plants from closed ground conditions and 31 plants from natural growing conditions. The values of metric and allometric indicators were processed statistically.

Plant materials (leaves) from the natural conditions of germination and the closed ground conditions were used to determine the quantitative content of ascorbic acid, protein and antioxidant activity. The concentration of water-soluble ascorbic acid was detected in 6 replicates by high-performance liquid chromatography, the protein content was determined in 8 replicates by the Lowry method, and the antioxidant activity in 5 replicates by the chemical method, which consists in the interaction of the test leaf buffer solution with adrenaline. PE-5300VI spectrophotometer was used in the course of the studies.

Results and Discussion

The studies have shown that non-stratified and stratified *Chenopodium album* seeds germinate evenly in Petri dishes and in protected soil, which is reflected by daily increase of seedling number during the first 6-7 days (Fig. 1).

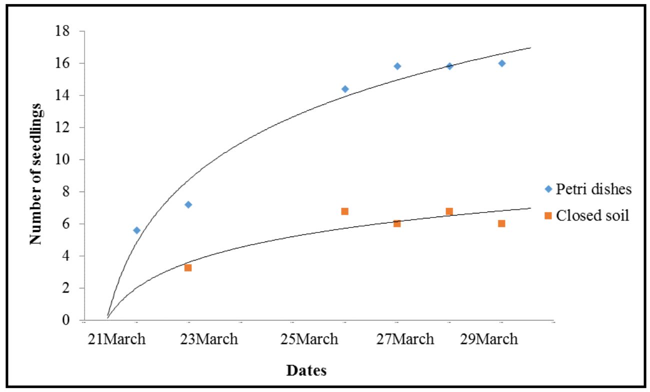

Fig. 1: Germination energy of stratified *Chenopodium album* seeds in laboratory conditions (Petri dishes) and in protected ground.

They showed experimentally that stratified seeds germinate better during the first year after collection, their germination rate is 28-64, while the germination rate of unstratified seeds is 17-34% (Table 1). Therefore, the stratification for 6 months at the temperature of -10°C increases the germination of frost-bite seeds by 1.7-1.9 times. The relatively low germination of *Chenopodium album* seeds during the first year after collection is explained by the high quality of the seeds and their partial immaturity.

The analysis of the morphological parameters of the *Chenopodium album* from the natural conditions of growth showed that the height of plants varies from 16 to 97 cm and reaches 55 cm on average Table 2. The dry biomass of one plant is approximately 2.3 g, while the proportion of leaf biomass (photosynthetic enhancement) is 0.16. At the same time, the contribution of plants to the reproductive organs (reproductive enhancement) is higher and makes 0.42.

Table 1: *Chenopodium album* seed germination.

Experience option		The number of shoots in options, pcs.					Mean	%
		I	II	III	IV	V		
Without stratification	Petri dishes	18	12	8	26	20	16,8	33,6
	Closed soil	4	18	8	4		8,5	17
After stratification	Petri dishes	26	38	28	38	30	32	64
	Closed soil	16	10	12	18		14	28

When *Chenopodium album* plant are grown in protected ground, they go through all stages of ontogenesis, up to flowering and fruiting during the period of 45-50 days. The plants grown in closed ground had relatively low morphometric parameters. So, the average height of plants makes 41 cm, biomass makes 0,66 g, which is 3.5 times lower as compared to the natural conditions of growth. Despite this, the range of photosynthetic amplification values is comparable, and even 1.8 times higher, which indicates the normal development of frost-blite in closed ground and the ability to form the leafy structure of a shoot. The contribution of biomass to the reproductive organs among the plants of protected soil is within 40%, therefore, plant growing under artificial conditions does not significantly affect their reproduction.

Table 2: Morphometric and allometric indicators of *Chenopodium album* under various growing conditions.

Parameters	Natural conditions			Closed soil		
	x	V, %	Min-max	x	V, %	Min-max
H, cm	54,87±3,93	39,83	16-97	41±2,9	24,49	24-54
W, g	2,27±0,35	86,94	0,12-7,02	0,66±0,19	99,94	0,19-2,09
Wl, g	0,34±0,05	87,87	0,02-1,1	0,19±0,05	99,52	0,01-0,54
Wg, g	0,96±0,16	94,66	0,04-3,62	0,21±0,06	99,42	0,02-0,76
LWR, g/g	0,16±0,02	54,55	0,02-0,34	0,28±0,05	56,74	0,04-0,53
RE, g/g	0,42±0,02	30,23	0,18-0,82	0,37±0,06	58,83	0,11-0,83

The high reproductive effort, which in some plants amounts to 80%, indicates an explementary life strategy characteristic of annual plants.

The study of protein content in frost-blite leaves showed that the concentration of this substance makes 35.8 mg/g and 38.1 mg/g on the average under natural conditions of growth and when they are grown in protected ground, respectively (Fig. 2). The obtained values are not statistically different, therefore, under the conditions of stable lighting and watering, the same amount of protein accumulates in plants as in the plants from natural communities.

The content of ascorbic acid in the leaves of *Chenopodium album* plants from natural growing conditions is in the range from 120 to 840 μg/g and makes 420 μg/g on the average Table 3.

The analysis of literature data showed that the accumulation of ascorbic acid among *Chenopodium album* within the research area (Kazan) is 1.5–2 times lower as compared to the plants growing in southeastern Spain (Guil Guerrero & Torija Isasa, 1997). Growing of *Chenopodium album* in protected ground conditions leads to 10-fold decrease of ascorbic acid content in leaves.

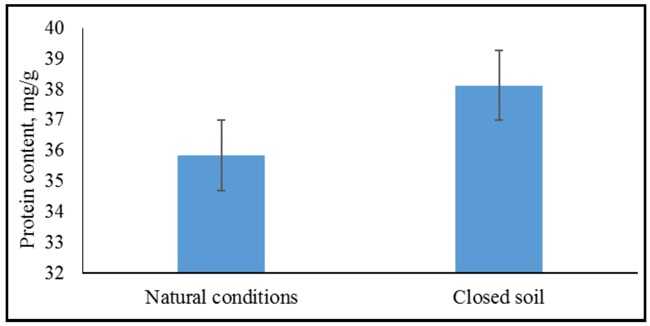

Fig. 2: The concentration of protein in *Chenopodium album* leaves, growing *in vivo* and protected ground.

According to our data, the antioxidant activity of *Chenopodium album* plant materials is high (Fig. 3).

The average values of antioxidant activity *in vivo* and during the growing in sheltered soil do not statistically differ and make up 69% and 79%, respectively.

Summary

During the cultivation in sheltered soil under 16-hour lighting and artificial irrigation, *Chenopodium album* plants go through all stages of ontogenesis, up to flowering and fruiting over the period of 45-50 days. Seed germination makes 17-64% 1 year after collection, while stratification increases germination by 1.7-2 times at T = -10 °C for 6 months. Indoor plants have the morphometric indices 1.3–4.6 times lower as compared with plants under natural habitat conditions. The allometric parameters of RE, LWR in closed soil plants are comparable with the parameters of plants in natural growing conditions. Therefore, plant growing does not violate the normal course of vegetative

Table 3: The concentration of ascorbic acid in the leaves of *Chenopodium album*, growing *in vivo* and greenhouse conditions.

Statistical indicators	Ascorbic acid content, μg/g	
	Natural conditions	Closed soil
x	570±123,7	57±15
V,%	43,4	52,6
min-max	240-840	24-96

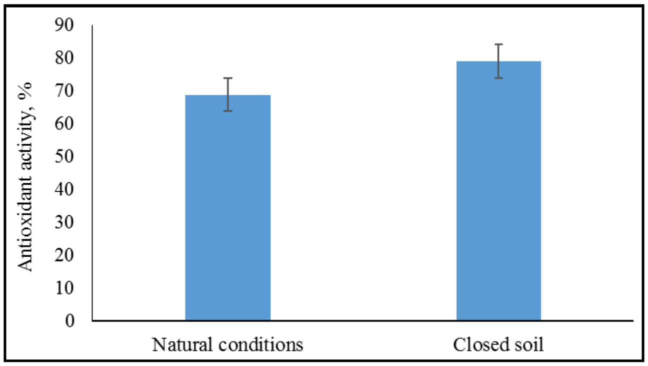

Fig. 3: Antioxidant activity of *Chenopodium album* leaves, growing *in vivo* and protected ground.

and generative organ development. The processes of protein accumulation in the leaves of *Chenopodium album* plants of closed soil with stable growing conditions are comparable to the plants of natural growing conditions. At the same time, the content of ascorbic acid is significantly reduced in closed soil plants (10 times).

Conclusions

Thus, in order to grow *Chenopodium album* in a protected ground, it is necessary to use stratified seeds, the germination of which is higher as compared to non-stratified ones. In artificial conditions of protected ground, *Chenopodium album* plants are developed normally and go through all development stages up to the formation of seeds. The comparative morphological analysis showed that cultivated plants have lower metric growth parameters, and allometric ones are comparable to the plant parameters from natural growing conditions. Artificial development does not significantly affect the accumulation of protein in the leaves of the *Chenopodium album*, however, it affects the synthesis of ascorbic acid negatively.

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References

Ivanova, R.G. (1988). Wild edible plants of Tatarstan. Kazan: Tatar Book Publishing House, 200 p.

Gadano, A., A. Gurni and M.A. Carballo (2007). Herbal medicines: Cytotoxic effects of Chenopodiaceae species used in Argentinian folk medicine. *Pharmaceutical biology*, **45(3):** 217-222.

Jabbar, A., M.A. Zaman, Z. Iqbal, M. Yaseen and A. Shamim (2007). Anthelmintic activity of *Chenopodium album* (L.) and *Caesalpinia crista* (L.) against trichostrongylid nematodes of sheep. *Journal of Ethnopharmacology*, **114(1):** 86-91.

Vysochina, G. I., T.M. Shaldaeva, O.V. Kotsupiy and E.P. Khramova (2009). Flavanoids of frost-blite (*Chenopodium album* L.), growing in Siberia. *Chemistry of plant raw materials,* **4:** 107-112.

Baldi, A. and N.K. Choudhary (2013). In vitro antioxidant and hepatoprotective potential of *Chenopodium album* extract. *International Journal of Green Pharmacy (IJGP)*, **7(1)**.

Pandey, S. and R.K. Gupta (2014). Screening of nutritional, phytochemical, antioxidant and antibacterial activity of *Chenopodium album* (Bathua). *Journal of Pharmacognosy and Phytochemistry*, **3(3):** 1-9.

Kaur, N. and G. Kaur (2018). Effect of processing on nutritional and antinutritional composition of bathua (*Chenopodium album*) leaves. *Journal of Applied and Natural Science*, **10(4):** 1149-1155.

Guil Guerrero, J.L. and M.E. Torija Isasa (1997). Nutritional composition of leaves of Chenopodium species (*C. album* L., *C. murale* L. *and C. opulifolium Shraeder*). *International Journal of Food Sciences and Nutrition (United Kingdom)*.

Cook, N.C. and S. Samman (1996). Flavonoids-chemistry, metabolism, cardioprotective effects, and dietary sources. *The Journal of nutritional biochemistry*, **7(2):** 66-76.

Sukhorukov, A.P. (1999). The pigweeds of Central Russia. M.: Dialog-MSU, 35 p.

Bakin, O.V., T.V. Rogova and A.P. Sitnikov (2000). Vascular plants of Tatarstan. *Kazan: Publishing House of the Kazan University*.