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Introduction of rare species of the genus Allium L. of the Kazakhstan Altai in the Altai Botanical Garden

The aim of this work was to study the biological characteristics of three introduced rare onion species of the Kazakh Altai flora, to assess the sustainability and prospects of their cultivation in the Altai Botanical Garden. The article presents the results of a long-term study of the seasonal rhythm of development, biometric parameters and seed productivity of *Allium ivasczenkoae* Kotuch., *A. ledebourianum* Schult. et Schult., *A. schoenoprasum* L. in the exposition of natural flora of the Altai Botanical Garden. These onions are combined into the subgenus *Rhizirideum* (Koch) Wendelbo and combined into the section *Schoenoprasum* Dumort. It was found that all three species in the introduction have a stable phenological rhythm, during the growing season they annually undergo a full cycle of shoot development and form seeds. According to the phenorhythmotype, they belong to spring-early summer-green with an average flowering period. They grow in April, bloom mainly in early June, seeds ripen in July, vegetation ends naturally in late August — early September. Vegetation lasts from 128.33 ± 2.58 days (*A. ledebourianum*) to 146.8 ± 7.24 days (*A. schoenoprasum*). The studied onion species differ in biometric parameters: height, number of flowers in inflorescence, inflorescence diameter. In culture, biometric parameters vary in the studied species mainly at a low level, which indicates the stability of these indicators in culture. High reproductive rates were established in culture for all three species, the productivity coefficient varies at the level of 56.75–69.26 %. At the same time, a low coefficient of variation in the weight of seeds and flowers in inflorescence was recorded for all three species, which indicates an insignificant degree of data dispersion in the introduction.

Keywords: Allium, introduction, seasonal rhythm of development, seed productivity.

Introduction

Genus *Allium* L. (Amaryllidaceae), which includes from 650 to 920 species according to various sources, is one of the most diverse and largest genera of monocotyledonous plants in the Northern Hemisphere [1]. Almost a third of the species grow in mountainous Central Asia, the world's largest center of onion diversity [2–4]. According to the latest data, the genus includes at least 127 species in Kazakhstan [5], found almost everywhere, but with greater species diversity in the steppe and semi-desert regions of the lowlands and mountains. Five new endemic onion species for the flora of Kazakhstan have already been described in 2021 [6–8]. Yu.A. Kotuhov [9] For the Kazakh Altai, 41 species are found. At the present stage, the introduction of representatives of the genus *Allium,* known for its many useful properties — food, medicinal, decorative and fodder, as well as rare ones that require protection, is also relevant in connection with the fact that the species of this genus belong to the wild relatives of cultivated plants [10–12].

An analysis of the introduction studies in phenological journals for 1983–2023 showed that out of 41 species of wild onions of the Kazakh Altai, 26 (or 63.4 %) were tested in the culture of the Altai Botanical Garden, including 9 (or 34.6 %) rare species (*Allium altaicum* Pall., *A. caespitosum* Siev. ex Bong. & C.A. Mey., *A. ivasczenkoae* Kotuch., *A. ledebourianum* Schult. et Schult., *A. microdictyum* Prokh., *A.schoenoprasum* L., *A. pskemense* B. Fedtsch. *A.polyrhizome* Turcz. ex Regel, *A. robustum* Kar. &Kir.).

The aim of the research conducted in the exposition of natural flora of the Altai Botanical Garden on the introduction of species of the genus *Allium* is to study the biological characteristics and identify their resistance to new growing conditions.

Currently, the collection fund of the genus *Allium* from the flora of the Kazakh Altai in the Altai Botanical Garden is formed from 68 species and form taxa, of which 10 are rare species in need of protection. This article provides information on the study of the seasonal rhythm of development, morphometry, reproductive biology and reproduction features in culture, the definition of three rare onion species of the flora of the Kazakh Altai that are resistant to the conditions of the introduction area: *Allium ivasczenkoae* Kotuch., *A. ledebourianum* Schult. et Schult., *A. schoenoprasum* L. These onions are biologically close to each other, belong to the Subgenus *Rhizirideum* (Koch) Wendelbo) and are united in the section *Schoenoprasum* Dumort [13].

Allium ivasczenkoae is a narrow-local endemic of the southwestern periphery of Western Altai, a relict. A new species for the flora of Kazakhstan, described by Yu.A. Kotukhov, from the Ubinsky Ridge (Kazakhstan Altai). In the nature of the Kazakh Altai, the species was discovered by the author in the south-eastern foothills of the Ubinsky ridge, in the vicinity of the village of Butakovo and the south-eastern foothills of Listvyazhnaya Mountain, as well as on the south-western slope of the Koksinsky ridge. It grows in open, well-lit, excessively moist meadows [14, 15].

Allium ledebourianum is a narrow-local endemic, indicated for the Kazakhstan Altai on the ridges of the southwestern and southeastern periphery of the Western Altai (Ivanovsky, Ulbinsky, Ubinsky, Lineisky, Kholzun, Koksinsky ridges), the mountain-forest part of the Southern Altai ridge (Kurchumsky, Southern Altai, Sarym-Sakty, Southern Altai Tarbagatai ridges). It grows in well-lit, moist meadows [16].

Allium schoenoprasum is boreal holarctic, polymorphic species, its range is wide, found in Japan, Korea, Siberia, Europe. It grows in damp meadows, river floodplains, forest edges, except for swamps. Morphologically, this plant can easily adapt to dry and sunny habitats [17–19]. In the territory of the Kazakhstan Altai, the species is widespread on the ridges of the Southern and Western Altai. Within the Kalbinsky Highlands, one location has been noted, where the species is apparently a relic of the Ice Age [13]. Since *A. schoenoprasum* has medicinal and edible functions, it is widely cultivated throughout the world [20].

Experimental

The Altai Botanical Garden is located in the city of Ridder in the East Kazakhstan region, in the mountain-forest zone between the Ubinsky (1967 m) and Ivanovsky (2776 m) ridges, with absolute heights from 700 to 900 meters. The distance from the oceans and the mountainous relief determine the degree of continentality, humidity and temperature conditions. According to the humidity coefficient, the Altai Botanical Garden is located in the GTK -1.2 indicators, which indicates humid conditions of existence [21].

The climate is sharply continental. According to the Ridder meteorological station, the winter period begins in the third ten days of October and lasts until the beginning of April. The average height of snow cover in open spaces reaches 50–60 cm with a soil freezing depth of 40 to 119 cm. The average winter temperature is -12.6 °C with short-term frosts of -35–45 °C. According to the characteristics of the winter period, the length of forced dormancy of plants reaches from 5.9 to 6.4 months per year. Spring is late and long. Summer is short and humid. The air temperature of the warmest month of July is 16.6 °C. The average annual precipitation ranges from 432 to 937 mm with a summer maximum, which ensures good hydration throughout the growing season [22].

The garden soils are mountain chernozems. Humus content fluctuates between 6 and 8 (10 %) with a high percentage of nitrogen and potassium. In the upper horizons the soil reaction is neutral or slightly acidic; in the lower tiers it acquires an alkaline reaction. The soil-forming rocks are loess-like loams of various genesis [23].

The limiting factors of introduction into the Altai Botanical Garden are large amplitudes of daily and annual temperatures, humidity, limited frost-free and vegetation periods. Hence, the leading indicators for the selection of introduced species are high winter- and frost-resistance, shortened growth and development rhythm, which allows them to pass the main phases of seasonal development. Introduction site of the genus *Allium.* The natural flora exposition is located in the southwestern part of the garden. The floral material is placed in a free landscape style, taking into account the biology and ecology of the species.

Objects of study: *A. ivasczenkoae, A. ledebourianum, A. schoenoprasum* were introduced as live plants from natural habitats of the Kazakh Altai in 2015. Thus, samples *of A. ivasczenkoae* were collected in the foothills of the ridge. Ubinsky, Kozlushka, location coordinates of the natural population: 50.27639 N, 83.28917 E, 625 m above sea level; sample *A.ledebourianum* — foothills of the ridge. Ivanovsky, northwestern slope, coordinates: 50.3201 N, 84.19694 E, 980 m above sea level; sample *A.schoenoprasum* — foothills of the ridge. Kalbinsky (Sibinskaya depression), coordinates: 49.43417 N, 82.56194 E, 911 m above sea level (Fig. 1–3).

The following methods were used in the introduction experiments: when studying the seasonal rhythm of growth and development, the method of phenological observations of I.N. Beideman was used [24], classification of phenorhythmotypes — according to the method of E.S. Fomin et al. [25]. Winter hardiness, resistance to unfavorable environmental factors and seed productivity were determined using generally accepted methods [26, 27]. The names of species were adopted according to Plants of the World Online (POWO, 2024) [28]. Statistical analysis was performed using the Excel software application. The mean values of the indicators, the coefficient of variation, and the accuracy of the experiment were determined.

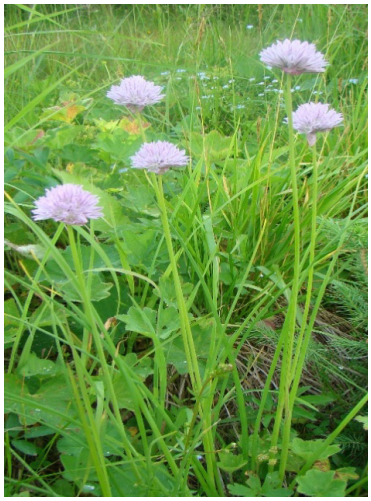

Figure 1. Allium ivasczenkoae

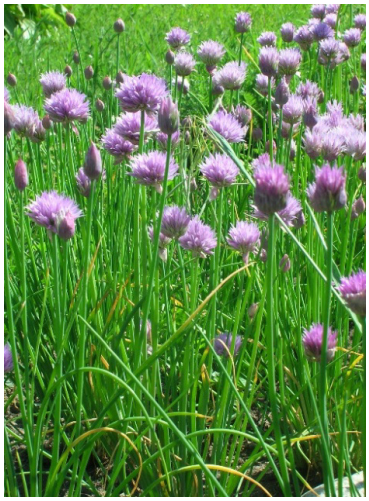

Figure 2. Allium ledebourianum

Figure 3. Allium schoenoprasum

Results and Discussion

One of the visually recorded indicators of plant adaptation to new growing conditions is their seasonal rhythm of growth and development. Many years of cultivation experience have shown that from under the snow *A. ledebourianum* and *A.schoenoprasum* always emerge without signs of sub snow growth, *A. ivasczenkoae* has a regrowth phase in some years. No losses were observed during the winter period and *they* are not damaged by spring frosts. The results of phenometry observations revealed that during the growing season the plants go through a full shoot development cycle and form seeds. The phenological rhythm is stable. Based on the analysis of the obtained phenodata data, phenorhythmotypes were determined, according to which all three species are classified as spring- early summer green with an average flowering period. Table 1 presents the average annual calendar dates of the main phenophases of the studied onions for an 8-year observation period (2016–2023).

Table 1

Average annual phenodates *Allium ivasczenkoae, A.ledebourianum* and *A.schoenoprasum* in the exposition of the Altai Botanical Garden

Name of phenodate	Statistical indicators	Phenodates of the studied onions		
		Allium ivasczenkoae	*Allium ledebourianum*	*Allium schoenoprasum*
Beginning of spring regrowth	(M± m) P %	17.04±4.34 4.33	16.04 ±4.06 4.10	18.04±4.84 4.72
Beginning of budding	(M± m) P %	22.05±3.94 2.16	28.05±4.45 2.16	04.06±5.62 2.79
Beginning of flowering	(M± m) P %	05.06±5.12 2.53	10.06±2.47 1.16	12.06±3.97 1.82
Mass flowering	(M± m) P %	16.06±3.00 1.33	15.06±2.78 1.24	19.06±3.96 1.43
End of flowering	(M± m) P %	02.07±5.99 4.24	01.07±3.68 1.43	02.07±4.21 1.62
Beginning of seed maturation	(M± m) P %	25.07±12.21 3.96	18.07±12.30 4.19	08.07±5.06 1.86
End of seed maturation	(M± m) P %	02.08±6.46 1.99	02.08±6.46 1.99	22.07±4.35 1.44
End of the growing season	(M± m) P %	05.09±10.28 2.6	21.08±8.61 2.36	22.09±10.86 2.52
Note – M — average value of the indicator; P% — accuracy of the experiment				

As practice has shown, in the spring after the snow melts from the site, all three species under observation begin to grow in the second half of April. The flowering phase begins in late May–early June. The seeds ripen in July. Vegetation ends naturally in late August–early September for *Allium ledebourianum* and *A. ivasczenkoae,* in September — *Allium schoenoprasum.*

During the introduction, the duration of the seasonal development phases was determined (Table 2). It was experimentally revealed that the duration of the seasonal development phase in all three species fluctuates depending on the weather conditions of the growing season. The duration of the interphase "beginning of spring regrowth — beginning of flowering" was set at 52–55 days with minor fluctuations from the average long-term. Comparison of the flowering start date in the experimental onion species over several years, at least 5 of which were atypically hot years with a dry growing season, moderately warm and humid, and also atypically cool, showed that one of the main factors determining the timing of flowering is the air temperature. Deviation of air temperature in the first half of the growing season from the average long-term upwards by 1-2° accelerates the onset of the flowering date. 3–5 days before the average perennial date. Duration of flowering in *A. ivasczenkoae* individuals is 24.4±1.77 days, *A.ledebourianum* and *A.schoenoprasum* almost the same, respectively 20.90±2.63 and 20.40±2.44 days. The seeds of all three species ripen simultaneously within 14–18 days with minor deviations from the average long-term indicator. The seeds fall out of the capsules as they ripen, but single self-seeding was noted only in *A. ledebourianum.* The vegetation period varies from 128.33±2.58 days (*A. ledebourianum*) up to 146.8±7.24 days (*A. schoenoprasum*). The studied species are characterized as winter-hardy, since no losses during the wintering period were noted during the observation period. No damage to plants from spring frosts was found, which indicates their frost resistance. In some years, in late August–early September, a single repeated flowering of *A. schoenoprasum.*

Table 2

Duration of seasonal development phases *Allium ivasczenkoae, A.ledebourianum* and *A.schoenoprasum* in the exposition of the Altai Botanical Garden

Name of the period of seasonal development	Statistical indicators	Duration of the seasonal development period, in days		
		Allium ivasczenkoae	*A.ledebourianum*	*A. schoenoprasum*
The beginning of spring growth, the beginning of flowering	(M± m) C% P %	52.30 ± 4.60 13.31 4.21	55.33 ±1.89 5.68 1.64	53.80 ±3.14 8.84 2.79
Beginning of flowering — end of flowering	(M± m) C% P %	24.40 ±1.77 10.96 3.47	20.90 ±2.63 19.07 6.03	20.40 ±2.44 18.08 5.72
Beginning of seed maturation — end of seed maturation	(M± m) C% P %	18.70 ±3.50 28.30 8.95	14.92 ±2.08 23.13 6.67	14.83 ±1.91 21.29 6.14
Beginning of vegetation — end of vegetation	(M± m) C% P %	130.40 ±6.54 7.58 2.39	128.33 ±2.58 3.33 0.96	146.80 ±7.24 7.46 2.36
Note – M — average value of the indicator; C% — coefficient of variation; P% — accuracy of the experiment				

In statistics, if the variation coefficient is less than 12 %, the degree of variability of the trait is considered low; from 13 % to 20 % — average; from 21 % to 40 % — high; more than 40 % — very high [29]. In our studies, the level of variability of the studied indicators of average annual phenodates established in all 3 species mainly at a low level of variability, rarely at an average level in *A. ivasczenkoae* and *A.ledebourianum,* single in *A. schoenoprasum.* High degree of variation in the seasonal rhythm of development is the fruiting phase, where this indicator varies at a high level in all three species. Such indicators of variability Phenodate confirms the good adaptation of the three studied species in culture.

Table 3 presents the results of morphometric parameters of experimental onion samples. According to the obtained parameters*, A. ledebourianum* distinguished by the height of generative shoots and leaves. The shortest is *A.schoenoprasum,* in which the height of the generative shoot and leaf are 37.46 ±1.79 and 30.85 ±1.74, respectively. At the same time, a high coefficient of variation of the leaf width was established in *A. schoenoprasum,* medium-*A. ivasczenkoae* and *Allium ledebourianum.* The remaining parameters vary

at a low level, which indicates the stability of these indicators in the culture over a long period of introduction.

Table 3

Morphometric parameters *Allium ivasczenkoae, Allium ledebourianum, Allium schoenoprasum* in the exposition of the Altai Botanical Garden

Parameters	Statistical indicators	Name of the species		
		Allium ivasczenkoae	*Allium ledebourianum*	*Allium schoenoprasum*
Height of generative shoot, cm	(M± m) C% P %	58.9±1.81 10.05 2.79	91.85±2.54 4.76 1.32	37.46±1.79 8.27 2.29
Length, cm	(M± m) C% P %	45.3±2.03 11.71 3.25	78.77±3.18 12.24 3.39	30.85±1.74 9.71 2.69
Sheet width, cm	(M± m) C% P %	1.2±0.06 17.71 4.91	1.2±0.06 19.44 5.39	0.67±0.06 27.94 7.75
Inflorescence height, cm	(M± m) C% P %	3.08±0.14 7.92 2.19	3.43±0.18 9.01 2.50	3.58±0.17 8.28 2.29
Inflorescence width, cm	(M± m) C% P %	3.06±0.16 9.09 2.52	3.01±0.12 6.71 1.86	3.43±0.17 8.36 2.32
Note – M — average value of the indicator; C% — coefficient of variation; P% — accuracy of the experiment				

The ability of a species to produce full-fledged seeds when transferred from natural habitats to culture is considered one of the most important criteria for its adaptation to changed living conditions. At the same time, as R.E. Levina notes [30], seed productivity indicators are difficult to predict, since their formation is influenced by many biological and abiotic external factors in addition to internal causes. The more favorable the growing conditions, the smaller the difference between potential and actual seed productivity [30]. For all species *Allium* box three-celled, each cell contains exactly 2 ovules, the ovary contains 6 ovules. Determination of potential seed productivity and the degree of its implementation characterizes the reproductive capabilities of the species, its ability to self-reproduce in the introduction and can serve as a test for assessing the degree of acclimatization [31]. In the course of the study, high reproductive rates were established in culture for all three species (Table 4).

Table 4

Reproductive indices *of Allium ivasczenkoae, A.ledebourianum, A.schoenoprasum* in the exposition of the Altai Botanical Garden

Indicators	Name of the species		
	Allium ivasczenkoae	*Allium ledebourianum*	*Allium schoenoprasum*
Number of flowers in inflorescence, pcs.	48.31±1.69	84.77±5.45	97.08±4.96
Number of fruits with seeds in inflorescence, pcs.	41.2±1.36	79.29±6.15	88.05±6.26
Number of seeds in fruit, pcs.	4.0±0.71	4.16±0.62	4.23±0.63
Potential seed productivity of inflorescence, pcs.	289.86±22.64	508.62±26.62	582.48±35.43
Actual seed productivity of inflorescence, pcs.	164.8±8.98	329.85±31.24	372.45±36.32
Productivity coefficient, %	56.75±8.39	64.76±10.24	63.92±12.52
Weight of 1000 seeds, g.	1.60±0.08	1.54±0.08	1.74±0.07
Laboratory germination of freshly collected seeds,%	42.88±6.49	69.26±10.34	67.82±9.35
Ground germination of freshly collected seeds,%	29.76±4.31	38.5 ±8.39	43.64±8.48

At *A.ivasczenkoae* on one inflorescence 48.31 ±1.69 pieces are formed, of which 41.2 fruits ±1.36 are set with the number *of* seeds in each being 4.0±0.71, in *A. ledebourianum* number of flowers in florescences — 84.77±5.45 pcs., seeds in a capsule — 4.1 ±0.62 pcs., *A. schoenoprasum* — 97.08±4.96 and 4.23, respectively. From these indicators it follows that the real seed productivity of the inflorescence in *A.ivasczenkoae* is on average 164.8±8.98, and potential — 289.86±22.64, in *A. ledebourianum*– 329.85±31.24 and 508.62±26.62 respectively. The productivity coefficient characterizes the actual implementation *of* the reproductive potential of introduced species. This indicator was recorded for *A. ivasczenkoae* — 56.75±8.39, *A. ledebourianum* — 64.76±10.24, *A. schoenoprasum* — 63.92±12.52 depending on the year of study.

In studies for all three species, a low coefficient of variation in the mass of seeds and flowers in an inflorescence was established, which indicates an insignificant degree of data dispersion (Fig. 4).

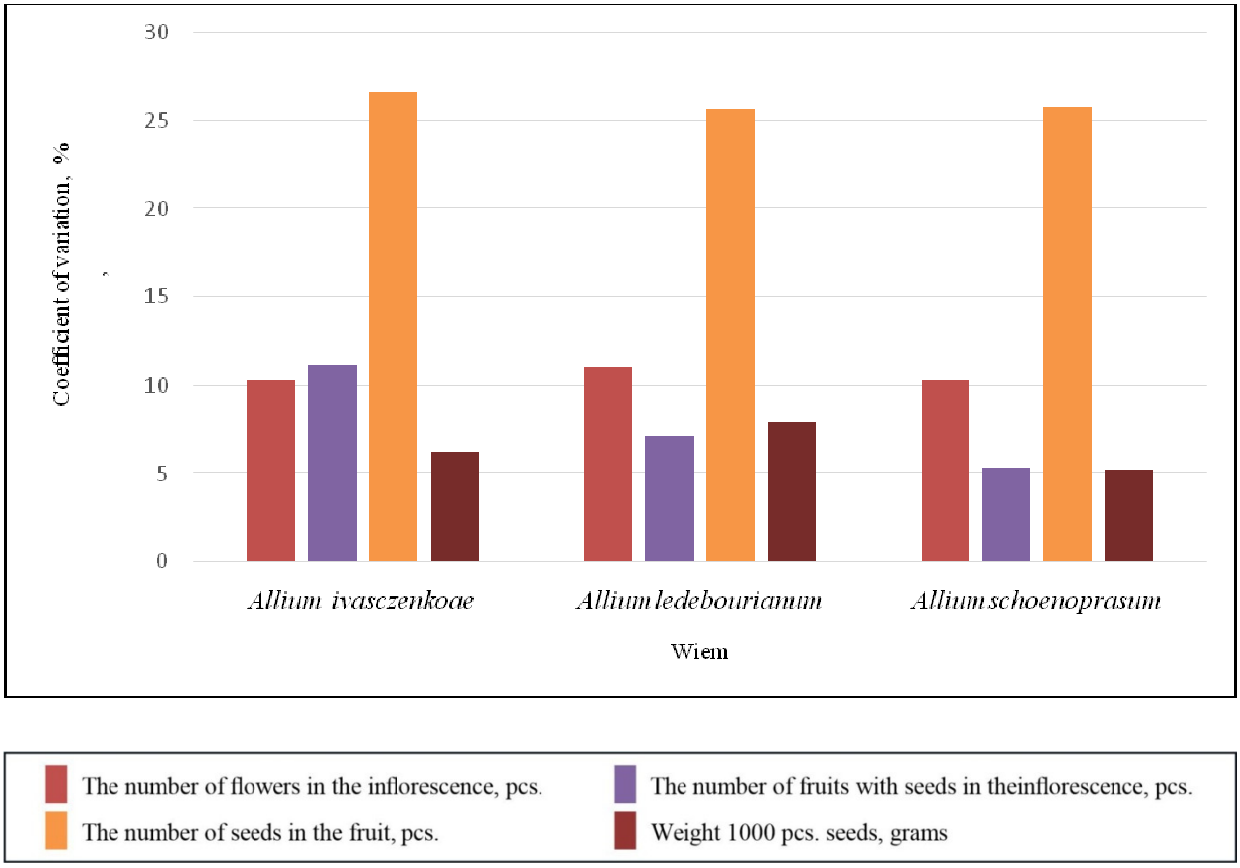

Figure 4. Coefficient of variation of some indicators of seed productivity *of Allium ivasczenkoae*, *A.ledebourianum, A.schoenoprasum* in the introduction

A high range of variability is established for the number of seeds in the fruit, where the coefficient of variation of the trait for all three species is recorded above 25 %.

The seeds are small, black, triangular, matte, without pubescence, oblong. In terms of weight of 1000 seeds, *A. schoenoprasum* is in the lead, the weight of which is 1.74±0.07 g. at *A. ledebourianum* and *A.ivasczenkoae* this indicator is 1.54±0.08 g and 1.6±0.08 g, respectively. The seeds do not have a dormant period. The germination of freshly collected seeds in laboratory conditions was recorded from 42.88±6.49 % to 69.26±10.34 %, in the ground — from 29.76±4.31 % to 43.64±8.48 % depending on the species and year of recording.

It has been established experimentally that with dry room storage in a dark room with daily temperature fluctuations in the mode from 18 °to 24, °the seeds retain their germination for 2 years. In the first two years of storage, the germination of seeds remains high, changes are insignificant. In the third year of storage, the laboratory germination of seeds drops sharply and remains, on average, at the level of *A. ivasczenkoae*– 8.7 %, *A. ledebourianum*–13.7, *A. schoenoprasum*–14.6 %.

In all three studied species, under laboratory conditions at room temperature of 15–17, water absorption by freshly collected seeds continues for 16–18 hours. At the same time, the length of the seed increases by 6 %–10 %, the width — by 10 %–14 %. Water enters the seeds most intensively during the first 2–4 hours. Good water permeability of the seed covers of the experimental onions eliminates the need for scarification.

Conclusions

Studied types of onions *A.ivasczenkoae, A.ledebourianum*, *A. schoenoprasum*in the Altai Botanical Garden have successfully adapted to new growing conditions, proving themselves in culture as winter-frost-resistant with a stable rhythm of seasonal development, according to the phenorhythmotype — spring-early summer-green with an average flowering period. Over a long period of introduction, they maintain stability of morphometric parameters with high reproductive rates, which made it possible *to classify A. ivasczenkoae, A. ledebourianum*, *A. schoenoprasum*to promising introduced species and include them in the landscaping assortment.

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Алтай ботаникалық бағына қазақстандық Алтайдың *Allium* L. тұқымдасының сирек кездесетін түрлерін енгізу

Жұмыстың мақсаты қазақстандық Алтай флорасының интродукцияланған, яғни 3 сирек кездесетін пияз түрінің биологиялық ерекшеліктерін зерделеу, оларды Алтай ботаникалық бағында өсірудің тұрақтылығы мен келешегін бағалау. Мақалада Алтай ботаникалық бағының табиғи флорасының экспозициясындағы *Allium ivasczenkoae* Kotuch., *A. ledebourianum* Schult. et Schult., *A. schoenoprasum* L. түрлерінің маусымдық даму ырғағын, биометриялық параметрлерін және тұқым өнімділігін көпжылдық зерттеудің нәтижелері келтірілген. Биологиялық жағынан бір-біріне жақын аталған пияздар *Rhizirideum* (Koch)Wendelbo) тұқым тармағына және *Schoenoprasum Dumort* секциясына біріктірілген. Интродукциядағы барлық үш түрдің де тұрақты фенологиялық ырғағы бар екені анықталды, вегетациялық кезеңде жыл сайын өркендер дамуының толық циклінен өтіп, тұқымдар түзіледі. Фенортмотип бойынша олар орташа гүлдену кезеңі бар көктемгі-ерте жазғы-жасыл түрлер болып саналады. Олар сәуірде өсіп шығады, негізінен маусымның басында гүлдейді, тұқымдары шілдеде піседі, вегетация тамыздың аяғында, қыркүйектің басында табиғи түрде аяқталады. Вегетация 128,33±2,58 күннен (*A. ledebourianum*) 146.8±7.24 күнге (*A. schoenoprasum*) дейін жүреді. Зерттелген пияз түрлері биіктігі, гүлшоғырындағы гүлдер саны, гүлшоғырының диаметрі сияқты биометриялық параметрлері арқылы ерекшеленеді. Дақылдың зерттелген түрлерінде биометриялық параметрлер негізінен төмен деңгейде өзгереді, бұл дақылдағы осы көрсеткіштердің тұрақтылығын көрсетеді. Дақылдың барлық үш түрінің репродуктивті көрсеткіштері жоғары, өнімділік коэффициенті 56,75–69,26 % деңгейінде өзгереді. Сонымен қатар барлық үш түр үшін тұқым массасының, гүлшоғырдағы гүлдердің төмен вариация коэффициенті тіркелді, бұл интродукциядағы деректердің таралуының шамалы дәрежесін көрсетеді.

Кілт сөздер: *Allium,* енгізу, маусымдық даму ырғағы, тұқым өнімділігі.

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Интродукция редких видов рода *Allium* L. Казахстанского Алтая в Алтайском ботаническом саду

Целью данной работы явилось изучение биологических особенностей интродуцированных 3 редких видов луков флоры Казахстанского Алтая, оценка устойчивости и перспективности их культивирования в Алтайском ботаническом саду. В статье приведены результаты многолетнего изучения сезонного ритма развития, биометрических параметров и семенной продуктивности *Allium ivasczenkoae* Kotuch., *A. ledebourianum* Schult. et Schult., *A. schoenoprasum* L. в экспозиции природной флоры Алтайского ботанического сада. Данные луки, биологически близкие между собой, объединены в подрод *Rhizirideum* (Koch) Wendelbo) и объединены в секции *Schoenoprasum* Dumort. Установлено, что все три вида в интродукции имеют устойчивый фенологический ритм, в период вегетации ежегодно проходят полный цикл развития побегов и формируют семена. По феноритмотипу относятся к весенне-раннелетне-зеленым со средним сроком цветения. Отрастают в апреле, цветут в основном в начале июня, семена созревают в июле, вегетацию заканчивают естественно в конце августа–начале сентября. Вегетация продолжается от 128,33±2,58 дней (*A. ledebourianum*) до 146,8±7,24 дней (*A. schoenoprasum*). Изученные виды лука отличаются по биометрическим параметрам: высоте, количеству цветков в соцветии, диаметру соцветия. В культуре биометрические параметры варьируют у изученных видов в основном на низком уровне, что свидетельствует о стабильности этих показателей в культуре. Установлены в культуре у всех трех видов высокие репродуктивные показатели, коэффициент продуктивности варьирует на уровне 56,75–69,26 %. При этом зафиксирован для всех трех видов низкий коэффициент вариации массы семян, цветков в соцветии, что свидетельствует о незначительной степени рассеивания данных в интродукции.

Ключевые слова: Allium, интродукция, сезонный ритм развития, семенная продуктивность.

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