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Article

Seasonal Development (Phenology), Flowering Dynamics, and Seed Productivity of (*Allium Stipitatum* Regel) Regel

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Abstract: This article examines the seasonal development rhythm, flowering dynamics, and seed productivity of *Allium stipitatum* Regel. The study identifies the onset and duration of the plant's primary phenological phases, differences in the timing of generative development between experimental and natural conditions, seasonal and diurnal flowering characteristics, the duration of the overall flowering period, and the relationship between the flowering process and factors such as temperature and relative humidity. Furthermore, data are presented regarding the number of flowers per inflorescence, the quantity of mature seeds, the weight of 1,000 seeds, and overall seed productivity, analyzed in relation to the size of the bulb.

Keywords: Allium Stipitatum Regel, Anzur Onion, Introduction, Phenology, Seasonal Development, Flowering Dynamics, Daily Flowering, Seed Productivity, Bulb Size, Reproductive Biology

Introduction

Anzur onion (*Allium stipitatum* Regel) is a geophyte plant that grows naturally in the mountainous regions of Central Asia and holds significant genetic, ecological, and economic value [1]. Currently, the natural reserves of this species are shrinking considerably due to increasing anthropogenic pressure on wild populations, intensive use of pastures, illegal harvesting, and the impacts of climate change. At the same time, the Anzur onion is of great scientific and practical importance as a promising crop, rich in food, medicinal, and bioactive compounds. The introduction of this species represents a key scientific endeavor aimed at preserving biodiversity, protecting its gene pool, and adapting it to new agro-phytocenoses through cultivation [2].

Globally, the conservation and rational use of biodiversity are considered priority areas of state environmental policy, with special attention being paid to the monitoring of existing natural resources [3].

In particular, the growing demand for natural medicinal remedies, concerns regarding the adverse side effects of synthetic drugs, and requirements for ecological safety are driving increased interest in preparations based on medicinal plants. The Anzur onion is of particular significance; it is a perennial bulbous plant that holds an important place within the flora of Central Asia [4].

Introducing plants into new climatic conditions outside of their natural habitats and conducting an in-depth study of the characteristics of their seasonal developmental cycles holds significant scientific and practical importance. Such research serves to evaluate the degree of the plants' adaptive capacity following introduction and to determine their potential for survival [5].

A key factor in the successful adaptation of a plant to different climatic conditions is its capacity for ontogenetic adjustment to new ecological environments. Variations in developmental processes under diverse climatic and soil conditions make it possible to determine the degree of adaptability of the introduced species. A plant's ability to flower and bear fruit is one of the primary criteria in its evaluative assessment during introduction. Generative organs are highly sensitive to changes in environmental conditions. Various conditions influence factors such as the formation of a plant's generative organs, their developmental dynamics, and the production of fruits and seeds. Changes in the development of these organs serve as an indicator of the plant's acclimatization process [6].

If the onset and duration of a plant's flowering phase show little variation when compared to other species within the same genus and if this consistency remains stable over the years it indicates that the species has achieved stability in its new environment. Phenological observations serve as a vital methodological tool in introduction studies. Through such observations, it is possible to determine the developmental stages of plants, the length of their growing season, the sequence of various phenophases, and the duration of each. These processes allow for the assessment of a plant's adaptability to climatic conditions, as well as its productivity [7].

According to S.N. Kudryashov, conducting systematic observations of the phenological stages related to the seasonal growth and development of plants contributes to a deeper understanding of their ontogeny, which, in turn, facilitates the scientifically-based evaluation of introduced species. The Anzur onion is a perennial bulbous ephemeral, a heliophyte (light-loving plant), which unlike other bulbous plants is distinguished by a relatively short vegetation period [8].

Materials and Methods

The plant can grow in one location for 7–10 years without losing its biological characteristics. In the Anzur onion, the root system spans a range of 3–10 cm, depending on the plant's age and diameter. The bulb itself is spherical in shape. Root buds form on it, which serve the function of absorbing nutrients and moisture from the soil. Currently, it is highly relevant to conduct an in-depth study of the seasonal development patterns of Anzur onion, monitor its vegetative and reproductive stages as well as its phenophases, and determine its overall productivity. Based on the data obtained, it is essential to develop practical recommendations for the acclimatization of the plant and the expansion of its raw material base. Consequently, the seasonal development patterns, phenological phases, and the degree of adaptability to a new environment specifically within the soil and climatic conditions of the Tashkent oasis were investigated through an introduction-based assessment.

Results

During the plant's vegetative period, observations were made regarding the onset of growth, active growth, the emergence of leaves, and their size and number. During the generative phase, the study examined flower formation, flowering, the dynamics of daily and seasonal flowering, as well as the stages of seed formation and maturation. The plant's biomorphological characteristics and stages of ontogeny

were investigated using the methodologies developed by T.A. Rabotnov and I.G. Serebryakov. Analyzing the seasonal development of plants through distinct phenological phases is of significant importance for their evaluation during the introduction process [9]. The seasonal development patterns (phenospectra) of *Allium stipitatum* Regel both in the experimental fields of the Tashkent State Agrarian University (TashDAU) and in its natural habitat are presented in Figure 1.

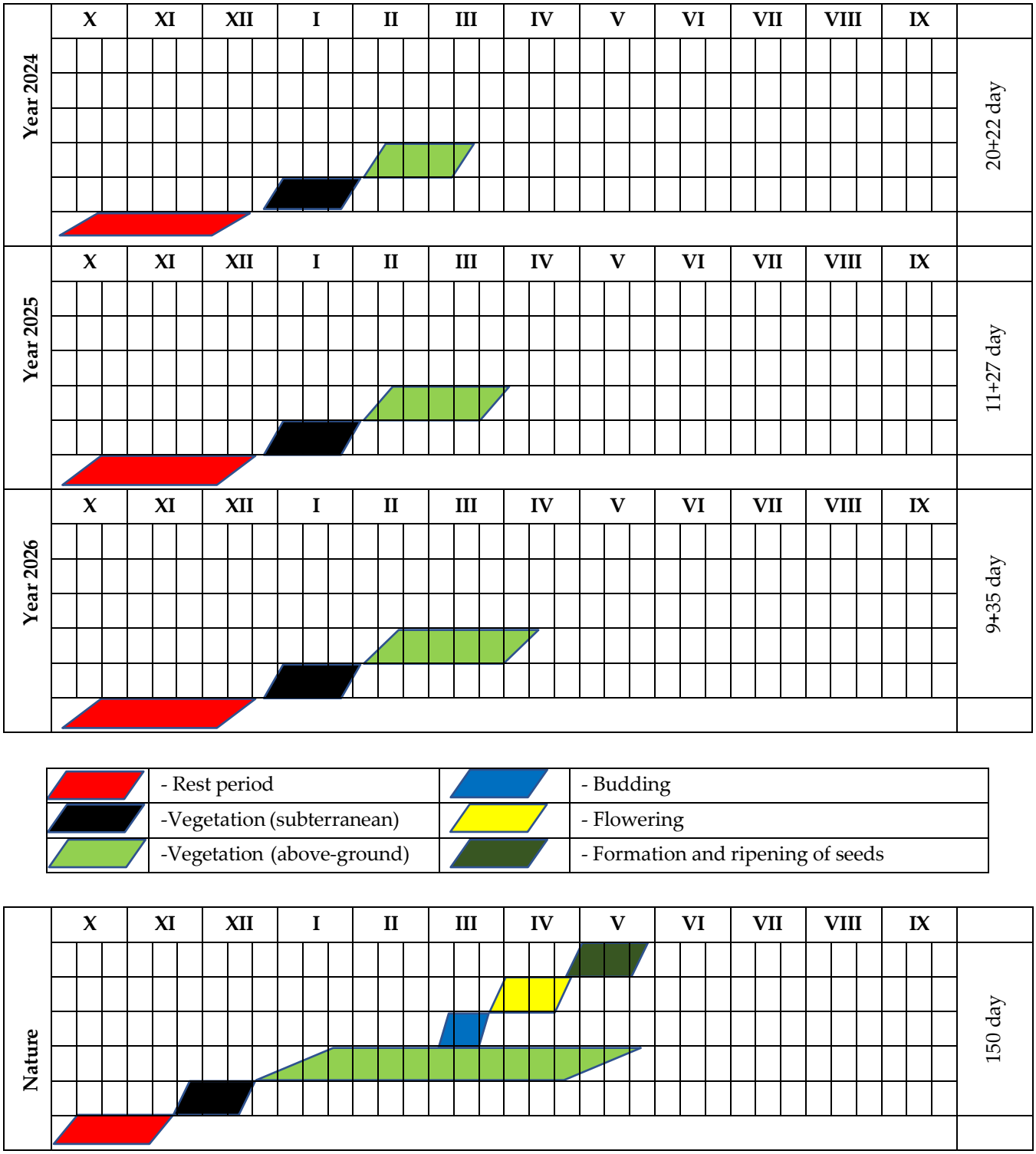

Figure 1. Seasonal development rhythm (phenospectrum) of *Allium stipitatum* Regel at Tashkent State Agrarian University and in its natural habitat.

As can be seen from the phenospectrum, the duration of the plant's above-ground vegetation period was 22 days in the first year, 27 days in the second year, and 35 days in the third year. A five-year-old plant lasts for 150 days; in the experimental plot, the plant's lifespan is 10–15 days longer than it is in its natural environment.

Seasonal and Diurnal Flowering Dynamics

The study of flowering biology a vital component of plant reproductive biology is of particular significance. The flowering period is considered the most critical phenophase in a plant's individual development; it reflects the interrelationships between various phenological stages, as well as the extent to which a plant has adapted to new ecological conditions. In the case of introduced plant species, in particular, monitoring the flowering process serves as a key criterion for evaluating their reproductive success (seed set), the dynamics of their phenological development, and their overall capacity for adaptation [10].

According to the scientific research of many scholars, the biology of flowering the system through which plants carry out their reproductive functions encompasses the maturation of anthers and pistils, as well as the processes of pollination and fertilization. Specifically, research conducted by R. Y. Levina has established that the flowering biology of plants depends on flower types, modes of pollination, and ecological conditions. She posits that the flowering process serves as an indicator of an organism's adaptation to new environments. In the context of plant introduction, the onset of flowering, its peak intensity (mass flowering), and its conclusion are closely linked to a plant's adaptability. Systematic monitoring of this process makes it possible to determine a plant's adaptive capacity; in particular, high seed productivity serves as an indicator that a plant has adapted well to the conditions of its new environment [11].

The flowers of the plant under study are purple, though white-flowered forms are also occasionally found in nature. The flowers are situated at the top of the generative (flowering) stalk, arranged in an umbel-like inflorescence. The generative stalk can reach a length of up to 140 cm, with a single inflorescence located at its apex. The number of individual flowers within an inflorescence depends on the size of the bulb; in nature, there can be up to 210 flowers, while in experimental fields when grown from bulbs the plant produces up to 180 flowers. Prior to the flowering phase, the umbel is enclosed by bracts (tepals/floral leaves). The flowers measure between 15 mm and 2 cm; they are bisexual and actinomorphic (radially symmetrical). There are 6 stamens, arranged in a single whorl. Each flower produces 6 seeds.

Plants growing in their natural habitat have shorter flower stalks but larger flower clusters. In contrast, plants in experimental fields have taller stalks, though the number and density of the flowers are lower. While an individual flower lasts for 15–20 days, the overall flowering period is extended because the flowers within the cluster bloom sequentially. In the conditions of Tashkent, the generative phase of the Anzur onion begins in late March or early April and continues until the second ten-day period of May. In a natural environment, this generative phase occurs about 10 days earlier.

The end of the vegetation period for the Anzur onion is marked by the yellowing and drying of the tips of the lower leaves, the yellowing and drying of the generative organs (starting from the top), the opening of the seed capsules, the ripening of the seeds, and the complete drying of the above-ground parts of the plant [12].

Table 1. Morphogenesis stages of Anzur onion from 2024 to 2026

Year	Planting of onion bulbs	Emerging (sprouting/growing up)	Uniform emergence	Budding	Flowering	Sowing	Completing the vegetation period
2024	05.11	26.01	10.02	20.03	02.04	15.05	16.06
2025	05.11	02.02	15.02	25.03	05.04	17.05	08.06
2026	05.11	28.01	12.02	23.03	03.04	15.05	12.06

In particular, a comparison of the flowering periods of plants in the experimental plot versus those in natural conditions revealed that the processes in natural conditions occurred 10 days earlier, and that there were significant differences in flower diameter.



Figure 2. Appearance of the flowers of *Allium stipitatum* Regel

The generative stage is a critical period in the life cycle of a plant. For the Anzur onion, observations regarding the onset of the generative phase, the number of flowers, the seasonal and diurnal flowering patterns, and the formation of seeds from flowers are essential for assessing the adaptability of the introduced species. During the course of scientific research (2024–2026), the seasonal flowering dynamics of the plant were investigated. These observations were conducted under two different conditions: in an experimental field and in a natural (wild) environment.

Flowering biology was assessed through visual observation and by applying the methods of O. A. Ashurmeto and H. Q. Qarshiboyev. The results indicate that, for Anzur onion, flowering primarily occurs during April and May. In plants with larger bulb diameters, flowering begins earlier, and the number of flowers is greater. Flowering parameters for *Anzur* onion in relation to bulb diameter are presented in Table 2.

Table 2. Flowering indicators when planted from onion bulbs at the TDAU experimental field

Bulb circumference, cm	Onset of flowering	Mass flowering	End of flowering	Number of flowers (average)
12-20	28.03	20.04–28.04	10.05	100-180
6-12	10.04	25.04–02.05	8.05	80-100

3-6	15.04	28.04–05.05	4.05	30-50
<3	-	-	-	0

To establish the dynamics of the seasonal development of flowers, air temperature, relative humidity, and the daily number of blooming flowers were studied, and the dynamics were formulated.

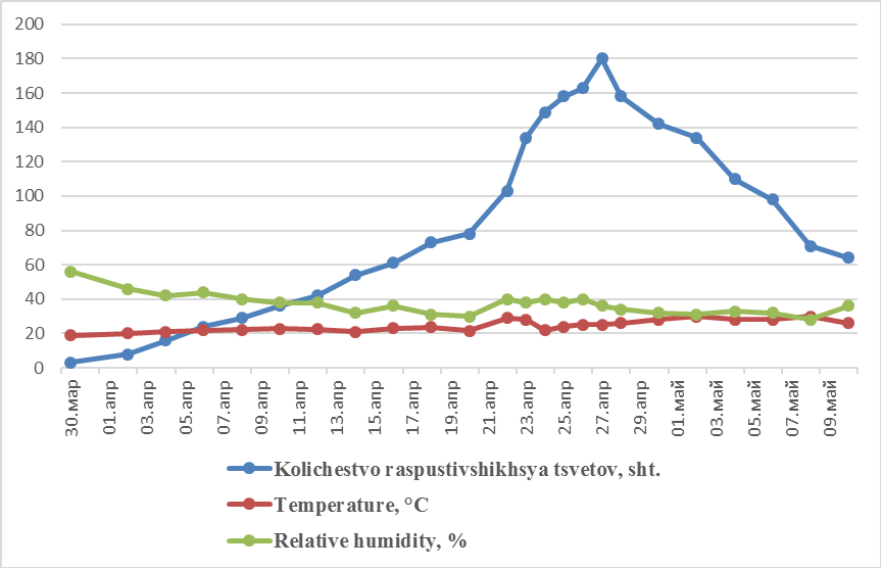

Figure 3. Seasonal flowering dynamics of Anzur onion.

It can be seen that flowering begins in early April and ends in early May. It was observed that the temperature at the beginning of flowering is 200C, the relative humidity is 56%, and at the end of flowering it is 260C, the relative humidity is 38%. The most active flowering occurred on April 25, when the temperature was 300C and the relative humidity was 32%. Daily flowering dynamics were formed based on total flowering days.

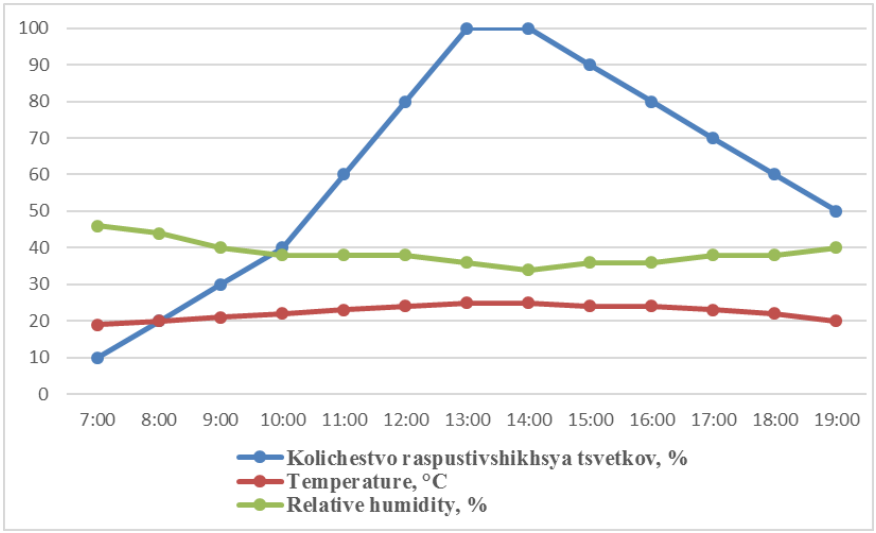

Figure 4. Daily flowering dynamics of Anzur onion.

Mass flowering lasted for 7–10 days. To determine the daily flowering dynamics, observations were conducted over a 5-day period (from April 24 to April 26), spanning the hours of 7:00 to 19:00. The study results indicate that the flowers reached full bloom between 12:00 and 14:00, with 50% of them closing by evening. During these observations, the temperature was 25°C, and the relative humidity was 36% [13].

In conclusion, phenological observations of *Anzur* onion conducted between 2024 and 2026 demonstrate that this species successfully completed all stages of morphogenesis during its introduction into the conditions of the Tashkent oasis. All developmental phases—sprouting, leaf formation, budding, flowering, fruiting, and seed production—were fully expressed. This confirms the species' agro-ecological adaptability and its high capacity for growth and development within the area of introduction.

Seed Productivity

Seeds are living organisms. From the embryo within a seed, a new generation develops that embodies the specific traits of the parent plant. Consequently, in field-based research, it is crucial to study the stages of ontogenesis the development of plants that emerge from these seeds.

When discussing propagation, the primary focus must be on generative (seed-based) reproduction, with particular attention given to seed yield and quality. Regardless of the intended purpose for cultivating a plant, the quality and quantity of the harvest are fundamentally linked to the use of seeds that meet established standards. Naturally, factors such as the selection of suitable land, water availability, fertilization, optimal sowing rates, proper cultivation techniques, and timely planting are all essential for achieving a good yield. However, even if these processes are executed with great skill, the final outcome will fall short of expectations if the seeds themselves do not meet the required standards. There are specific criteria that seeds must satisfy to conform to these standards, including seed purity, fullness (plumpness), health (freedom from disease), the absence of mechanical damage, and other key indicators.

The seed productivity of the Anzur onion plant was evaluated according to the methods of O.A. Ashurmetov and H.Q. Qarshiboyev. In the course of studying and organizing seed production, it was determined that the highest-quality, superior seeds are obtained from healthy plantsthose that received timely irrigation and proper agrotechnical carecharacterized by a bulb diameter exceeding 18–20 cm, a long and thick flower stalk, and an inflorescence (flower head) diameter greater than 38–40 cm. Furthermore, these optimal seeds come from plants that bloom specifically in April and reach maturity during the first ten days of June [14].

Throughout the vegetation period, the following aspects were monitored and recorded: the formation of the generative organ (the flower) and the flower cluster (head), the opening of the petals, the number of individual flowers within a single cluster, the timing of the initial and full (mass) blooming, the formation of seeds, the initial seed maturation, and the final number of fully ripened seeds. Additionally, the number of viable seeds versus empty (non-viable) seeds produced per flower cluster ranging from the minimum to the maximum observed was calculated and tracked.

The seeds of the Anzur onion are black in color with a rough, uneven surface; they consist of a white kernel encased in a black outer coat. The plant blooms profusely in April, and the seeds reach full maturity between late May and early June. The weight of 1,000 seeds ranges from 6.5 to 7 grams. Seed weight is correlated with the size of the onion bulb and the flower cluster (umbel) that is, healthy, large bulbs produce healthy seeds. Data on the seed yield of Anzur onions, in relation to the size of the flower clusters observed in experimental plots, are presented in Table 3.

Table 3. Performance indicators of Anzur onion seeds in the experimental field

Circumference of onion bulbs, cm	Number of flowers in a single bouquet, units	Number of mature seeds in a single inflorescence, count	Ratio of seeds to flowers, %	Weight of 1000 seeds, g
20	186	171	91,9	7,4
12	161	127	78,88	7,2
8,0	110	84,0	76,36	6,8
5,0	85,0	52,0	61,17	6,6

Discussion

In the studies, the seed productivity of Anzur onion was investigated in relation to the size of the onion bulbs (considering the number of flowers per inflorescence, the number of mature seeds, the ratio of seeds to flowers, and seed weights).

As a result, it was determined that when the bulb circumference is 20 cm, the weight of 1,000 seeds is 6.5–7 g (with 186 flowers per umbel, 171 mature seeds, and a seed-to-flower ratio of 91.9%); at 12 cm, the weight of 1,000 seeds is 6–7 g (with 161 flowers per umbel, 127 mature seeds, and a seed-to-flower ratio of 78.88%); at 8 cm, the weight of 1,000 seeds is 6–6.5 g (with 110 flowers per umbel, 84 mature seeds, and a seed-to-flower ratio of 76.36%); and at 5 cm, the weight of 1,000 seeds is 6 g (with 85 flowers per umbel, 52 mature seeds, and a seed-to-flower ratio of 61.17%) [15].

In the conducted studies, the characteristics of Anzur onion seeds under natural conditions and their efficacy were also investigated. The results of the observations are presented in Table 4.

Based on the data presented in the table, the following conclusions were drawn. It was determined that the characteristics of *Anzur* onion seeds under natural conditions depend on the diameter of the onion bulbs. The research examined factors such as the number of flowers per inflorescence, the number of mature seeds, the ratio of seeds to flowers, and seed weight. It was observed that seed productivity was 91.4% for bulbs with a circumference of 20 cm, 84.2% for those with a circumference of 12 cm, 83.3% for those with a circumference of 8 cm, and 73.6% for those with a circumference of 5 cm.

Table 4. Characteristics of Anzur onion seeds under natural conditions

Circumference of onion bulbs, cm	Number of flowers in a single inflorescence, count	Number of mature seeds in a single inflorescence, count	Ratio of seeds to flowers, %	Weight of 1000 seeds, g
20	210	192	91,4	6,9
12	183	154	84,2	6,7
8,0	132	110	83,3	6,5
5,0	91,0	67,0	73,6	6,2

Research has shown that the above-ground parts of the Anzur onion (stems, inflorescences, and seeds) are better developed and more productive than its underground parts (bulbs and root system). This is attributed to the plant's adaptation processes in response to specific climatic and soil conditions.

According to this, in variant 1 (control), the mean (n=10) potential seed productivity (PSP) was 359.86±1.13 kg, actual seed productivity (ASP) was 317.53±1.09 kg, and the productivity coefficient (PC) was 88.15±2.89%.

In the second variant, 10 sample plant clusters were also used as a basis. The average (n=10) potential seed productivity (PSP) was 474.6±1.33 kg, actual seed productivity (ASP) was 432.7±1.1 kg, and the productivity coefficient (PC) was 91.18±2.92%. An analysis of the results showed that the best performance indicators were observed in this variant.

In the third variant, 10 sample plant clusters were also used as a basis. The average (n=10) potential seed productivity (PSP) was 344.8±1.3 kg, actual seed productivity (ASP) was 298.26±1.1 kg, and the productivity coefficient (PC) was 86.36±2.7%.

In the fourth variant, 10 sample plant clusters were also used as a basis. The average (n=10) potential seed productivity (PSP) was 250.16±1.3 kg, actual seed productivity (ASP) was 162.6±3 kg, and the productivity coefficient (PC) was 64.36±3.03%. The lowest performance indicators were recorded for this variant.

Table 5. Seed productivity of Anzur onion across various variants (2024–2026)

Types	No	Variant	Years observed	Seed productivity		Productivity coefficient, Mk%
				PUM	HUM	
Allium stipitatum Regel	1	1-variant	2024	291,44±1,0	257±1,1	88,18±2,91
			2025	335,685±1,1	296±1,2	88±2,80
			2026	452,47±1,3	399,6±0,97	88,27±2,98
			Average	**359,86±1,13**	**317,53±1,09**	**88,15±2,89**
	2	2-variant	2024	384,6±1,2	350,7±0,49	91,18±2,43
			2025	442,2±1,5	403±1,57	91,24±3,23
			2026	597±1,3	544,4±0,96	91,12±3,11
			Average	**474,6±1,33**	**432,7±1,1**	**91,18±2,92**
	3	3-variant	2024	279,5±1,1	241,7±0,67	86,6±2,33
			2025	321,4±1,7	278±1,68	86,6±2,88
			2026	433,5±1,1	375,1±1,1	85,9±2,91
			Average	**344,8±1,3**	**298,26±1,1**	**86,36±2,7**
	4	4-variant	2024	206,4±1,2	133,8±0,55	64,8±2,49
			2025	233±1,5	151,2±1,61	63,9±3,21
			2026	311,1±1,3	202,8±0,87	64,4±3,41
			Average	**250,16±1,3**	**162,6±3**	**64,36±3,03**

The seed productivity of the plants was studied based on experimental data. To determine seed productivity, 10 representative plant specimens were selected from each experimental variant. The research indicates that while propagating Anzur onion (a type of wild onion) from seeds is time-consuming, it yields positive results. Furthermore, seed-based propagation is a cost-effective method for obtaining high-quality, high-yield produce, as well as for preserving and increasing bio-ecological diversity.

During the cultivation of Anzur onion, instances of susceptibility to various diseases may occur. When these plants are cultivated under introduction conditions, they generally do not experience severe infestations by diseases or pests. Nevertheless, certain diseases may develop during the growing season most notably, downy mildew (peronosporosis), a fungal disease. The response of introduced plants to the diseases and pests present in a new floristic region is influenced by factors such as humidity, temperature, and other external environmental conditions.

Downy Mildew (peronosporosis)

Downy mildew is a fungal disease that affects the leaves of Anzur onion. The initial signs of the disease manifest as the appearance of light green or yellowish spots on the leaves. Under cool, damp conditions, a grayish-purple coating forms on the leaf surface. As the disease progresses, the leaves may turn yellow, wilt, and dry out.

Control Measures

To prevent disease, it is recommended to use healthy planting material, avoid overly dense planting, prevent excessive irrigation, and remove infected plant debris from the field. If signs of disease appear, fungicides approved for the specific crop should be applied in accordance with established usage guidelines. When applying these products, it is essential to strictly adhere to the specified application rates, timing, and pre-harvest intervals (waiting periods). Spraying with a 1% Bordeaux mixture or the preparation "Topoz" (at a rate of 100 ml/ha) is effective for disease prevention. This treatment should be carried out once the leaves of the Anzur onion have fully emerged. The application should be performed three times a week specifically, every other day. Following this, the plants should be monitored for 7–10 days. If positive results (recovery) are observed during this period, the treatment is considered sufficient. If, however, symptoms of the disease reappear, the treatment process should be repeated.

To help the plant recover following a disease, a solution of the product (a 15 ml/ha suspension) should be applied once via spraying. Implementing these preventive and curative measures in a timely manner and at the specified application rates reduces the risk of disease spread in Anzur onions, helps maintain a stable vegetative state, and accelerates the recovery process after damage has occurred.

Conclusion

A distinct temporal difference was observed in the phenological development of plants growing in their natural habitat versus those in the experimental plot. In the natural environment, the processes of generative development began, on average, 10 days earlier than in the experimental plot. This discrepancy indicates that the seasonal developmental rhythm of the Anzur onion is sensitive to environmental factors such as temperature, humidity, and other ecological conditions.The seasonal flowering process of the Anzur onion occurred in stages, with the period of peak (mass) flowering lasting 7–10 days. Daily observations revealed that the most active and full opening of the flowers took place between 12:00 and 14:00. The intensity of flowering is linked to fluctuations in air temperature and relative humidity; these parameters serve as significant ecological criteria for characterizing the reproductive biology of the species.

The weight of 1,000 Anzur onion seeds ranged from 6.0 to 7.0 g, a value that varied in relation to the morphometric characteristics of the bulb and the inflorescence. As the size of the bulb increased, there was a corresponding rise in the number of flowers within the inflorescence, the quantity of mature seeds, and the overall efficiency of seed production. The results obtained indicate that it is scientifically appropriate to select large, healthy, and well-developed onion bulbs as mother plants for seed production.

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