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Flowering biology of Acorus calamus L. growing in Tashkent

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Abstract: This article describes the flowering biology of Acorus calamus L. grown in Tashkent. The research was conducted on plants planted on the experimental plot of Tashkent State Agrarian University in 2017-2019. Object of study - Acorus calamus L. – is hygrophytic plant, growing along streams and rivers, on the edges of rice fields and other wetlands. During the study of the flowering process of the plant Acorus calamus, it was found that the opening of the buds of the plant took place mainly from 8^{oo} to 12lab in the morning. In Tashkent conditions, the flowering of Acorus calamus began earlier than in its natural range. The onset of flowering coincided with different times, depending on climatic conditions of each year. The generative organs of the plant are formed in the leaf axils of the rhizomes, and each plant produces up to 1-3 Spadix. Spadix grow up to 6.2-12 cm in length and 0.9-1.2 cm in diameter. The flowers are densely arranged in a cylindrical Spadix, the opened buds are small, inconspicuous, greenish-yellow, bisexual. The opening of the flowers begins at the bottom of the inflorescence. The duration of flowering inflorescences depends on the number of flowers in them. Inflorescences with more flowers (500-585) bloom longer (18-26 days), inflorescences with fewer flowers (390-480) bloom shorter (12-15 days). The opening of the flowers is of the acropetal type. On the first day, 1 or 2 flowers bloom in conditions of low temperature (9-10℃). As the temperature begins to rise (13-17℃), the opening of the flowers also increases. During a three-year study, it was noted that Acorus calamus does not produce seeds in Tashkent. During our subsequent experiments, it was found that the dust grains developed in the plants were sterile. The results of many years of observations have shown that Acorus calamus does not produce seeds mainly due to the influence of biotic and abiotic factors.

Keywords: Acorus calamus, biology of flowering, ecological factors.

1. INTRODUCTION

As a result of the growing population of the world, it is necessary to increase the diversity of raw materials for a wide range of medicinal, food and fragrant plants, as well as the development of new types of products.

It follows that the selection of export-oriented medicinal plants for such characteristics, meeting the needs for their raw materials at the expense of existing plants belonging to the local flora or belonging to the flora of other regions, the development of effective methods of ignition is one of the current challenges. There are more than 1154 species with medicinal features in the territory of our country. More than 110 medicinal plants, or 2.5%, are widely

used in medicine in the natural flora of the southern regions of Uzbekistan. Law of the Republic of Uzbekistan No. 409 of September 21, 2016 "On protection and use of flora", resolution of the President of the Republic of Uzbekistan No. 2911 of April 2017 "On measures to create favorable conditions for the rapid development of the pharmaceutical industry", Decree No. 5229 of November 7, 2017 "On measures to radically improve the management system of the pharmaceutical industry" has made it one of the urgent tasks to conduct targeted research on the development of technologies for the cultivation of medicinal plants introduced into medical practice.

At the present time, i.e. in this period of rapid development, the study of bioecological features of plants that are endemic, introductive and naturally growing, but containing valuable drugs, which need to be cultured, the development of mass reproduction agrotechnics are one of the current problems.

As noted in the Resolution of the Cabinet of Ministers of the Republic "On state protection of medical and pharmaceutical industries of the Republic of Uzbekistan" (1996), it is necessary to preserve medicinal plants belonging to the local flora, to propagate them culturally. Furthermore, the implementation of the introduction of medicinal plants belonging to the foreign flora to local conditions is a pressing issue. This, in turn, will solve the problem of the Republic's pharmaceutical industry to purchase raw materials from abroad, as well as create opportunities for the export of raw materials, if necessary. Introduction and cultivation of medicinal plants The pharmaceutical industry of the Republic to some extent meets the demand for raw materials of medicinal plants.

Medicinal plants of such importance include the *Acorus calamus* L.

Acorus calamus contains bitter acorine glycoside, 25% starch, resin, alkaloids and tannins, tannins, up to 150% vitamin C and vitamin B.

Abu Ali ibn Sino (1966) a famous physician of his time from Bukhara, also used ointments made from this unique plant in the treatment of liver, spleen and gastrointestinal diseases, as well as as a diuretic. From time immemorial, people living in China and India have used the plant *Acorus calamus* to treat diseases such as bronchitis, bronchial asthma, pneumonia, rheumatism, rickets, blurred vision, ear heaviness and neurosis.

According to Kh.X. Kholmatov and A.I. Kasimov (1994), the rhizome of *Acorus calamus* contains up to 5% of essential oil, acorine glycoside, additives, resin, glue, up to 25% of starch and other substances. There are also terpenes such as azarone, proazulene, pinene, calamine and camphene. The leaves contain up to 150 mg% of vitamin C, essential oil and nutrients.

In modern medicine, the action of acorin glycoside in the rhizomes of *Acorus calamus* has been shown to increase the secretion of gastric juice by reflex, increase the excretory function of the liver and diuresis by increasing the gallbladder. An extract from this plant - causes loss of pain sensation and lowers blood pressure. *Acorus calamus* drugs are used to treat gastric and duodenal ulcers (gastritis, enteritis, colitis). The tincture has the properties of speeding up digestion and opening the appetite. It also emits a fragrant odor, improves the composition of the air and cleanses it of various germs.

Acorus calamus (Acoraceae Agardh) is native to tropical countries - China, Burma, India and Japan, and is widely used there (Taubaev, 1970).

Bioecological features of *Acorus calamus* grown in Tashkent have not been fully studied. Therefore, to study of the biology of flowering of ornamental, rare and medicinal plants such as *Acorus calamus* for determination of seed yield, develop methods of mass propagation, study their chemical composition and their widespread cultivation and use remains one of the current problems.

2. MATERIAL AND METHODS

Object of study - *Acorus calamus* L. - is hygrophytic plants and grow in streams and riverbanks, on the edges of rice fields and other wetlands.

Acorus calamus L. is a perennial herbaceous plant of the family Acoraceae. The rhizome is creeping, slightly flattened and covered with small roots. From the rhizome grows clusters of leaves, the leaves are linear or sword-shaped, up to 60-120 cm in length. Stems grow upright, unbranched and leafless, sloping on one side, with a sharp edge on the opposite side. Plant produces thick spadix. The stem is 4-12 cm long, yellow, covered with small flowers of both sexes. The perianth is simple, six-leafed, blooms from May to June. The fruit is a multi-seeded berry with a red color (Takhtadzhyan, 1966; 1972).

In 2016-2017, samples of *Acorus calamus* rhizomes grown in Tashkent Botanical Garden named after academic F.N. Rusanov were planted on the experimental plot of the Tashkent State Agrarian University. As *Acorus calamus* is a hygrophytic plant, it was planted around swampy ponds.

The experimental areas are geographically located in the north-eastern and southern part of Tashkent, and the soil is culturally irrigated gray soil.

The method of I.N. Beydeman (1960; 1974) was used to study the seasonal development of the plant. The study of the morphology of the flower was carried out by the method of Al.A. Fedorov and others (1962), and the biology of flowering - by A.N. Ponomarev (1960). In determining the saturation of pollen, drugs prepared by the method of acetocarmine were studied using microscopes MBI-1, MBS-3. Micrographs were prepared on microscopes MBI-1, MBS-3 using MFN-5 and MFN-12 microphotons. The relative humidity and temperature of the air were determined using an Assman psychrometer. A luxmeter was used to determine the amount of light. Statistical processing of the results collected during scientific research was conducted by G.N. Zaytsev (1984).

3. RESULTS AND DISCUSSION

As a result of scientific research conducted on the experimental plot of Tashkent State Agrarian University in 2017-2019, the development of the generative organs of *Acorus calamus,* the biology of flowering was studied in depth.

It is known from the analysis of literature sources that *Acorus calamus* blooms in June-July in its natural habitats (Akopov, 1981). According to the book "Atlas of Areas and Resources of Medicinal Plants of the USSR" (1976; 1980), *Acorus calamus* blooms from late May to July. The generative organs of the plant are formed in the leaf axils of the rhizomes, and each plant produces up to 1-3 spadixes. The spadixes grow to 6.2–12 cm in length and 0.9–1.2 cm in diameter (Figure 1, 2). The flowers are densely arranged in a cylindrical spadix, the open buds are small, inconspicuous, greenish-yellow, bisexual. The opening of the flowers begins at the bottom of the inflorescence. The duration of flowering inflorescences depends on the number of flowers in them. Inflorescences with more flowers (500-585) bloom longer (18-26 days), inflorescences with fewer flowers (390-480) bloom shorter (12-15 days). The opening of the flowers is of acropetal type. On the first day, 1 or 2 flowers bloom in low temperatures (9-10℃). As the air temperature begins to rise (13-17℃), the opening of the flowers also increases.

During the study of the flowering process of the *Acorus calamus*, it was found that the opening of the plant buds occurred mainly between 8:00 and 12:00 in the morning. In our conditions, the flowering of *Acorus calamus* was observed to start earlier than the naturally

distributed area. The onset of flowering coincided with different times, depending on the annual climatic conditions.

In 2017, the first flowering of the plant took place in the second decade of April, and the end of flowering coincided with mid-May. Gross flowering was observed on April 23-29. The number of buds in the observed plant spadix ranged from 390 to 481, or an average of 426 ± 10.6. The number of open flowers in the spadixes ranged from 380 to 469, i.e. an average of 413 ± 10.8, of which an average of 400 ± 12.5 nodes were formed. Buds were 21-24 days, flowering 13-16 days (Table 1; Figure 1, 2). When the flowering phase was over, the spadix stopped growing and the plant began to bear fruit. But the nodes in the spadix fell off before they ripened, and the spadixes turned red.

In 2018, the flowering of *Acorus calamus* was observed to last from the second half of April to the end of May. The number of flowers in the spadix varies, the spadix is 7-11 cm long, 0.9-1.2 cm in diameter, the number of buds is on average 525 ± 13.4, the number of flowers formed from them is 514 ± 13.1, the nodes are the number averaged 504 ± 13.2 units. The buds developed for 21–26 days, and their flowering occurred for 19–26 days (Table 2).

In 2019, it was observed that *Acorus calamus* started flowering on April 24th. The spadixes are 7-12 cm long, 0.9-1.2 cm in diameter, the number of buds is on average 562 ± 7.6, the number of flowers formed from them is 552 ± 7.4, and the number of nodes is 541 ± 7.7 pieces. The development of buds took 22-26 days, their flowering occurred 14-16 days (Table 3). It was observed that the growth and development of plants grown in the experimental fields are closely related to external environmental factors. The flowering of the plants was negatively affected by the presence of rainy days, on such days the opening of the buds was reduced. *Acorus calamus* plants require moderate amounts of heat and light. When a plant grows in specific conditions and climates, it synthesizes a lot of biologically active substances in its composition. It follows that the growth and development of the plant: the development of inflorescences and buds, the beginning and end of flowering, seed and fruit formation and the synthesis of biologically active substances or their accumulation are hugely impacted by the external environment (humidity, heat, light, air temperature, wind speed, soil composition, location of growth, etc.)

FIGURE 1. Plant inflorescence during flowering.

Pollination biology. The axis of the A*corus calamus* inflorescence is triangular, in which small, inconspicuous flowers are closely spaced. The flower is bisexual, actinomorphic. The leaves of the perianth are placed opposite to each other with six pollinators. The stamens have short cylindrical filament and are loosely located. Ginetsey is a cenocarp pistil, consisting of three seed petals. The node is upper, three-chambered, in the rooms developed one seed bud. The pollen path of the seminal vesicle is located perpendicular to the funiculus — orthotropic. The stigma is sedentary and the column is underdeveloped. According to our observations, the opening of the flower took place mainly in the morning. Perianth petals spread. During this period, the stigma of pistil first matured, then pollens in the anther matured.

FIGURE 2. The *Acorus calamus* spadix.

TABLE 1. Developmental morphobiology of the generative organ (data taken in 2017)

Plants that generate inflorescences	**Spadix**		**Number**			**Days**	
	length, sm	**Diameter, sm**	**Number of buds, piece**	**Number of flowers, piece**	**Number of nodes, piece**	**The day of budding**	**The day of flowering**
1	8,2	1,2	460	449	439	1	16
2	7,0	1,1	480	468	460	19	15
3	6,2	1,0	400	385	374	19	13
4	6,8	1,0	464	450	441	21	15
5	6,0	1,0	400	387	378	19	12
6	6,4	0,9	390	375	360	19	12

7	7,4	1,1	440	428	420	20	15
8	7,4	1,0	403	390	380	19	13
9	7,8	1,1	433	419	410	20	16
10	7,3	1,0	391	379	340	19	12

TABLE 2. Developmental morphobiology of the generative organ (data taken in 2018)

Plants that generate inflores-cences	**Spadix**		**Number**			**Days**	
	Length, sm	**Diametr, sm**	**Number of buds, piece**	**Number of flowers, piece**	**Number of nodes, piece**	**The day of budding**	**The day of flowering**
1	9	1,1	562	552	540	25	25
2	11	1,2	585	570	558	26	26
3	10	1,1	572	560	550	25	25
4	8	1,0	558	547	539	24	24
5	7,4	1,0	540	531	522	23	26
6	7,2	1,0	500	491	482	22	18
7	7,0	0,9	490	481	471	22	19
8	7,2	0,9	485	473	460	21	18
9	7,0	0,9	480	470	460	21	18
10	7,0	0,9	477	468	455	20	19

TABLE 3. Developmental morphobiology of the generative organ (data taken in 2019)

Plants that generate inflores-cences	**Spadix**		**Number**			**Days**	
	Length, sm	**Diameter, sm**	**Number of buds, piece**	**Number of flowers, piece**	**Number of nodes, piece**	**The day of budding**	**The day of flowering**
1	12	1,2	580	571	563	26	15
2	12	1,2	578	568	557	26	16
3	11	1,2	577	572	560	25	16
4	10	1,1	575	560	550	25	15
5	10	1,1	572	561	552	24	16
6	9	1,0	566	558	547	24	15

7	9	1,1	568	555	543	24	14
8	8	1,0	550	542	530	24	16
9	8	0,9	554	541	530	24	15
10	7	0,9	500	493	480	22	15

It was observed that the ripe pollen was spilled on the surface of the stigma. The pollen grains were very fine, round to ovoid in shape, and were not stained with acetocarmine in experiments.

According to the literature, members of the family Acoraceae Agardh (Araceae) are pollinated by insects such as bees, flies. The pollen grains are sticky, heavy, and if part of the mature pollen is stored in the anther, a certain part will stick to the seed. Heavy and sticky pollen grains indicate entomophilous pollination of the *Acorus calamus* plant. Pollination can take the form of xenogamy and sometimes geytenogamy. During the flowering phase, pollinators retain pollen for a long time. During our observations, we encountered pollen mites that dried without shedding their anther.

The opening of the bud begins in the middle of the inflorescence. Within 2–3 weeks, the buds on the inflorescence open in acropetal type. The buds on the tip of the inflorescence remain unopened.

Fruit is multi-seeded, green or red, dried fruit. The biology of flowering of the plant has been studied in Lithuania, and it has been noted that the pollen grains formed under these conditions are sterile (Yuknevichene, 1999).

According to the analysis of literary sources, the pollen grains in *Acorus calamus* anther were found to be sterile. The number of chromosomes in the species of poplar plant populations distributed in Armenia is 2n-33.34, and the pollen grains in the flowers are found to be 60-70% sterile. This disruption in the reduction division led to the formation of abnormal gametes. One of the main reasons why a plant almost does not produce seeds has been identified as aneuploidy (Barsegyan and Sweet, 1998; Oganezova and Barseghyan, 1999). *Acorus calamus* does not produce seeds even in naturally distributed areas (Obukhov, 1962; Obukhov, 1965). From the scientific point of view of K. Fegri and L. van der Pail (1982), species in European populations were created as ‘incompatible clones’. The *Acorus* places serve as a habitat for aquatic birds. Muskrats feed on rhizomes, while wild ducks feed on seeds (where seeds are formed and ripen). Fruits are multi-seeded, green or red, dried fruits.

During a three-year study, it was noted that *Acorus calamus* does not produce seeds in Tashkent. During our subsequent experiments, it was found that the pollen grains developed in the plants were sterile. The results of many years of observations have shown that *Acorus calamus* does not produce seeds mainly due to the influence of biotic and abiotic factors.

4. CONCLUSION

1. The vegetation of *Acorus calamus* is average 290 days, of which the budding period is 24-27 days and the flowering period is 16-24 days. According to perennial phenological observations, *Acorus calamus* begins to form buds in the summer and enters a dormant state in late November.

2. In Uzbekistan, *Acorus calamus* does not produce seeds due to sterile pollen grains. The flowers were discovered to open in the second week of April. It was observed that 8-12 flowers were left unopened.

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