

Flowering biology of *Salvia officinalis* L. introduced in different climatic conditions of Uzbekistan

Dusmuratova F.M.

Department of Pharmacognosy, Tashkent Pharmaceutical Institute, Tashkent-100190, Uzbekistan

Fakhriddinova D.K.

Tashkent Botanical Garden Named after Acad. F.N. Rusanova at the Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan

Berdiboeva D.B.

Department of Medicinal plant, Tashkent State Agrarian University, Tashkent-100190, Uzbekistan

Yulchieva M.T.

Department of Pharmacognosy, Tashkent Pharmaceutical Institute, Tashkent-100190, Uzbekistan

Abstract

Flowering biology in the conditions of introduction of medicinal *Salvia officinalis* L. grown in Tashkent Botanical Garden and Jizzakh region, the dynamics of daily and seasonal flowering and the duration of phases in the generative period of the plant (budding, flowering, fertilization), the development of generative branches formed by inflorescences, the maturation of buds and the duration of flowering of the opened flower were studied. The increase in the number of generative branches of the medicinal plant during the growing season affects the duration of the flowering phase, the generative period of the plant in the first and second growing years was found to be 30-35 days, and in subsequent (3-5) growing years this period lasted 25-30 days longer.

The beginning of the generative period of medicinal *Salvia officinalis* L. grown in the conditions of Jizzakh region began 12-15 days later than the beginning of the generative period of plants grown in the Tashkent Botanical Garden. However, the duration of the phases of growth, development, and generative period (budding, flowering, and fertilization) of the medicinal *Salvia officinalis* L. grown in different climatic conditions were almost the same, and no significant differences were observed between the number of generative branches per plant and the number of flowers per plant. Medicinal *Salvia officinalis* L. grown in different climatic conditions, is a factor that confirms its flexibility, fully passing the developmental stages during the growing season.

Keywords: *Salvia officinalis*, generative period, budding, flowering biology, flowering phase, diurnal flowering dynamics, seasonal flowering dynamics.

INTRODUCTION

Salvia officinalis L. - one of the most valuable species of the family Lamiaceae, a well-known medicinal and spice plant [1,4]. Medicinal *Salvia officinalis* L. is a shrub up to 40-60 cm tall, an evergreen plant that grows in subtropical climates with hot summers, dry summers and rainy winters. Naturally distributed in the western part of the Balkan Peninsula, mainly in the flora of the northern Mediterranean countries bordering on Italy [5,6]. The medicinal *Salvia officinalis* L. was brought to Europe by the Romans (monks) in the Middle Ages. The plant is now cultivated in many southern European countries and is grown in Yugoslavia, Greece, Italy, France, Czechoslovakia, Krasnodar and Altai regions of Russia, the Autonomous Republic of Crimea, Moldova and Ukraine [15,19]. The plant is strongly branched, in 6-8 growing years its diameter is on average 60-70 cm. 15–18, sometimes up to 20 years, can be harvested from areas planted with medicinal *Salvia officinalis* L. Essential oils accumulate in the leaves of plants and are harvested 2-3 times a year as a raw material [6,20].

The Latin term *Salvia* is derived from the English word "salvare", which means "to save" and means that the plant has medicinal properties [11]. The *Salvia* L. family includes 900 species and 17 species in Uzbekistan [2,12]. One of the most important species in the category is the medicinal *Salvia officinalis* L., introduced in the Tashkent Botanical Garden named after Academician F.N. Rusanov at the Institute of Botany of the Uzbek Academy of Sciences of the Republic of Uzbekistan. The fact that medicinal *Salvia officinalis* L. is widely used in medicine is well known to the people and scientists of many nations. Of the beneficial properties of the plant, it has gained great attention in traditional medicine with its application in the treatment of all types of diseases. Especially *Salvia officinalis* L. tea is very popular and has been used in infections of

the oral cavity, rapid healing of gums, leaving sore throats. The scientific literature states that the Romans called the medicinal *Salvia officinalis* L. a "sacred plant" and spread it throughout Europe [4,7].

Today, medicinal raw materials are used not only in medicine, but also in other sectors of the national economy: perfumes, food industry; It is widely used as an insecticide in confectionery, beverage production, and in the control of agricultural pests. In Western cuisine, medicinal *Salvia officinalis* L. is used in the preparation of meat, fish products, chicken as the main spice that gives a fragrant aroma and improves the taste of food. The green and dried leaves of the medicinal *Salvia officinalis* L. are used in medicine and folk medicine as an anti-viral and anti-inflammatory agent. Depression, hemispheres have a sedative effect in ischemic diseases, antimicrobial of the oral cavity, antiseptic in washing wounds. The essential oils of the plant have disinfectant, bactericidal, antiseptic, anti-inflammatory properties [7].

There are 30 types of components in the raw material of medicinal *Salvia officinalis* L., the dominant organic substances of which include essential oils (α - β -tuyon, 1,8-tsineol, camphor, humilen), phenolic substances (luteolin and apigenin), glycosides. It also contains biologically active substances such as flavonoids, saponins, coumarins, alkaloids, rosemary acid, sclareol. During the developmental stages of the plant, the composition and amount of these biologically active substances are observed to vary [7,20]. In scientific sources, the peculiarity of essential oils derived from medicinal *Salvia officinalis* L. is explained by the high content of oxygen-containing monoterpenes. During the generative period of the plant there was an increase in the amount of dominant components (monoterpenoids) in the essential oil, at the end of the growing season there was a slight decrease in the content of

monoterpenes and monoterpenoids in the plant and an increase in sesquiterpenes[13].

To study the phytoremediation potential of the medicinal *Salvia officinalis* L., seedlings grown in soil containing heavy metals (Cu, Cd, Pb, and Zn) near the nonferrous metal smelting plant were biochemically and physiologically evaluated. Heavy metals in the soil accumulate in different amounts in plant organs and a 10% -15% decrease in the dry biomass of the surface and subsoil has been observed. The combination of Cu, Cd, Pb occurs in the roots of the plant, and copper (Cu) accumulates in the same amount in the surface and underground of the *Salvia officinalis* L., and heavy metal ions affect the quantity and quality of medicinal essential oils. The increase in the content of heavy metals in the plant led to a decrease in the content of the main components of essential oils α -tuyon, β -tuyon, β -karyophyllene and viridoflorol, and an increase in the amount of camphor, borneol, 1,8-tsineol and bornilacetate. Such imbalances in the components of essential oils are reported in scientific sources as dependent on the chemicals in the soil [4,13].

The value of medicinal *Salvia officinalis* L. raw materials is the fact that it contains valuable essential oils, which is why the plant is introduced in many countries. [3,12,19].

The maximum accumulation of essential oils in the plant during the flowering phase of the development period is given in scientific sources [8,11]. Therefore, it is important to study the flowering biology of the medicinal *Salvia officinalis* L..

The flowering biology of plants is part of their reproductive biology and its study is important for the science of botany [14]. The flowering period of plants is the most important phase, which is a system that combines the interdependence of all phenophases and the adaptation of the plant to the new environment[14].

In order to study the flowering biology of the medicinal *Salvia officinalis* L., introduced in the Tashkent Botanical Garden, scientific research was conducted in 2021.

Research methods.

The flowering biology of the medicinal *Salvia officinalis* L. was studied on the experimental plot of the laboratory of medicinal plants of the Tashkent Botanical Garden and 3-year-old seedlings planted on small plots in Zafarabad district of Jizzakh region. The research was conducted in April and May 2021. The methods of A.N. Ponomarev (1960) and R.E. Levina (1981) were used in the study of seasonal and diurnal flowering dynamics of the medicinal *Salvia officinalis* L.. The order of opening of the plant flowers and the duration of the opening of the inflorescence were observed during the seasonal flowering period. In the study of the dynamics of diurnal flowering, the maturation of flowers was observed during the day. For the study of flowering biology, 10 model plants were identified in the budding phase of the plant and labels were hung on them. The dynamics of seasonal and daily flowering of the medicinal *Salvia officinalis* L. was studied in 1 stem of perennial seedlings. The following stages of opening of flowers were observed: from bud formation to flower opening, duration of flowering of opened flower, cases of withered flower.

To study the seasonal flowering dynamics of medicinal *Salvia officinalis* L. flowers, the flowers opened in the model plants were counted every 2 days and cut from the plant. To determine the number of flowers opened per day on the plant (daily flowering dynamics), the opening of the flowers was observed every two hours from 8:00 in the morning to 20:00 in the evening, the number of opened flowers was determined, cut from the plant and recorded. Meteorological indicators (such as air temperature and relative humidity, sunlight) of the surveyed areas were also determined every two hours. The study also used data from the

Bozsuv meteorological station to determine the microclimate conditions of the area during the flowering period (air temperature (°C), relative humidity (%), precipitation (mmX), wind speed (m / s), sunlight (lux)) observed.

At the same time the activity of insects landing on the flowers of the plant was determined.

The anatomy of the medicinal *Salvia officinalis* L. flower was studied using the method of D.A. Transkovsky (1979). The plant flowers were fixed in 70% ethanol, the incisions were cut by hand and stained with saffron. Tissue is measured under a MOTIC BI-220 F-4 binocular microscope. The photos were taken with a RA-6 digital microphotograph.

Research results.

The duration of the developmental phases of plants depends on the environmental factors of the region. Studies have shown that in the conditions of the Tashkent Botanical Garden, the transition to the generative period in the first growing year, both when propagated from seed and seedlings of *Salvia officinalis* L. is carried out [10,16]. The generative period of the plant begins in the third decade of August in the first growing year (when propagated by seed) and lasts until the end of September, and in the second, third and remaining growing years this period begins in the second decade of April and lasts until early June. In years with good environmental factors, the average spring temperature is + 22-25°C, the annual rainfall is 380-400 mm, the generative period of the plant begins in the first decade of April [9]

The generative period of the medicinal *Salvia officinalis* L. introduced in the CIS countries

begins in late May and lasts until the end of June [3,20].

In the first growing year of seedlings prepared from plant cuttings placed in greenhouses in November-February, the generative period began in early July and lasted until mid-August. The average duration of the generative period in the first growing year of seedlings grown from seed and cuttings was 25-35 days. In the remaining vegetation years, the generative period lasts longer [9]. Medicinal *Salvia officinalis* L. flowering biology was observed in 3-year-old seedlings.

Medicinal *Salvia officinalis* L. flower begins to form in generative branches, which are bisexual, zygomorphic, short-flowered, formed in the third part of the annual branches. The flower band is covered with hairs and is 0.2-0.3 cm long. The flower parts are acyclic in place of the flower, the petals do not fall off and are stored until the fruit ripens. The petals are 5-toothed, fused, the flowers turn green when they are newly opened, and the petals turn pink when they fall. The petals are 5, 2 of which combine to form the upper lip, 3 of which combine to form the lower lip. The pollen grains are 4 to 2 short 2 of which have a long dusty stalk and are attached to the flower tube. Seed 2, fruit leafy, nodule upper [5].

Inflorescence spiked, the flowers are arranged in a ring on the generative branch. 1 generative branch has an average of $8,0 \pm 1,2$ rings, with an average of $6,9 \pm 1,9$ flowers per ring. Each generative branch contained an average of $55,2 \pm 2,2$ flowers (Fig. 1, Table 1).

Figure 1. Generative branches in 3-year seedlings of medicinal *Salvia officinalis* L

The life form of the medicinal *Salvia officinalis* L. is a semi-shrub, and the number of generative branches increases during the growing season. When the plant is sown from seed, the average is $1,2 \pm 0,8$ per bush in the first

growing year, an average of $10,8 \pm 1,6$ in the second growing year, $48,5 \pm 2,3$ in the third growing year, $84,5 \pm 2,8$ in the fourth growing year, and $92,8 \pm 2,8$ in the following growing years branches were identified (Table 1).

Table-1 Formation of vegetative and generative organs in seedlings of *Salvia officinalis* L. different ages grown from seed

Vegetation years	The number of vegetative branches in 1 bush		The number of generative branches formed in 1 bush plant	The number of generative branches formed in 1 vegetative branch	The number of inflorescence rings formed in 1 generative branch	The Number of flowers opened in 1 inflorescence ring
	may	August				
1 year vegetation	$1,0 \pm 0,8$	$1,6 \pm 1,1$	$1,2 \pm 1,8$	$1,2 \pm 0,4$	$5,3 \pm 1,2$	$6,0 \pm 1,2$
2-year vegetation	$3,2 \pm 1,0$	$5,2 \pm 1,8$	$10,8 \pm 1,6$	$3,4 \pm 1,2$	$8,3 \pm 1,5$	$6,8 \pm 2,3$
3-year vegetation	$6,3 \pm 2,3$	$10,1 \pm 2,3$	$48,5 \pm 2,3$	$7,7 \pm 2,1$	$8,9 \pm 2,0$	$7,3 \pm 2,1$
4-year vegetation	$9,6 \pm 3,2$	$13,8 \pm 3,6$	$84,5 \pm 2,8$	$8,8 \pm 2,6$	$9,0 \pm 2,1$	$7,4 \pm 2,4$
5-year vegetation	$10,2 \pm 3,0$	$14,3 \pm 3,2$	$92,8 \pm 3,2$	$9,1 \pm 2,8$	$8,8 \pm 2,1$	$7,2 \pm 2,1$

When propagated by cuttings, the average number of plants per plant in the first growing year was $4,6 \pm 1,3$; in the second growing year $16,3 \pm 2,0$; in the third growing year $33,8 \pm 2,6$; in the fourth growing year formed $68,5 \pm 2,6$ generative branches.

The flowering phase of the medicinal *Salvia officinalis* L. lasts from the third decade of April to the end of May, and the total generative period is found to average 60-65 days. When the plant buds are formed, they are very small (0,1-0,2 mm) and grow to 1,0-1,2 cm in 4-6 days (Fig. 2).

Figure 2. Medicinal *Salvia officinalis* L. flower structure, flower parts and flower ripening



Air temperature, relative humidity affect the maturation of plant buds and the duration of flowering. It was found that the newly formed buds mature in 5-6 days at an average temperature of $+20-25^{\circ}\text{C}$, and when the air temperature averages $+30-33^{\circ}\text{C}$, the newly formed buds mature and flower in an average of 2,5-3 days. It was found that 1 flower on a plant with an average air temperature of $+29-30^{\circ}\text{C}$ blooms for an average of 1,5-2 days, and 3-3,5 days when the weather is cloudy.

In order to study the dynamics of daily flowering in 3-year-old seedlings of medicinal *Salvia officinalis* L. sown from seed in the conditions of the Tashkent Botanical Garden, observations were made on April 28 (beginning of flowering), May 3, May 11 (end of flowering), May 20 (end of flowering). On April 28, 2021, the average air temperature was $24-26^{\circ}\text{C}$, and the average humidity was 38-

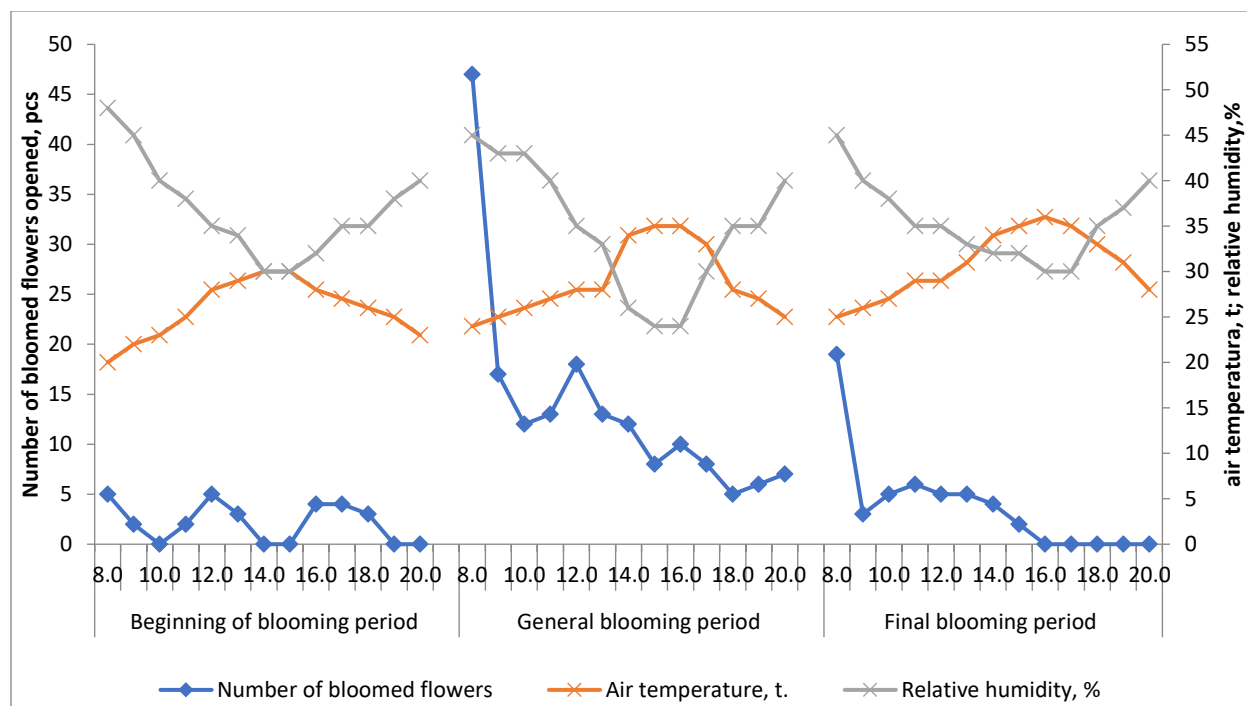
45%. At the beginning of flowering of medicinal *Salvia officinalis* L. (28.IV.) in the morning (8-9) the air temperature is $+20-22^{\circ}\text{C}$, relative humidity is 48%, illumination is 10000 lux at the designated stems of the model plants at 800 hours $4,9 \pm 1,3$ at 900 hours $2,2 \pm 0,8$ flowers opened. At 10-11 o'clock the air temperature is $+23-25^{\circ}\text{C}$, the relative humidity is 38-40%, when the illumination is 15000 lux per 1 stem (1 stem contains an average of 6-8 generative branches) at 1000 hours the average is $2,0 \pm 0,7$; $2,7 \pm 0,9$ 1100 flowers were opened. $5,3 \pm 1,4$ at 1200 h, $3,1 \pm 1,1$ at 1300, flowers opened, no flower opening was observed in the plants at 1400 and 1500 h. At 16-18 o'clock the air temperature is $+26-28^{\circ}\text{C}$, humidity 32-35% in the marked stems of the medicinal *Salvia officinalis* L. at 1600 hours $4,5 \pm 1,4$ hours 1700 average $4,2 \pm 1,6$ hours, 1800 hours $3,1 \pm 1,2$ flower openings were observed. At 19-20 o'clock, no opening of flowers was observed in

the plants. During the day, an average of $30,4 \pm 3,3$ flower openings were detected in the generative branches of the marked stem of the medicinal *Salvia officinalis* L. (Fig. 3).

After 3-4 days, the number of flowers opening in the medicinal *Salvia officinalis* L. seedlings began to increase, and the plants entered the period of mass flowering. On May 3, the daily flowering dynamics of this period of the medicinal season was observed. The flowers that had opened the day before were removed from the designated plant seedlings. On May 3, the average air temperature was $+28-30^{\circ}\text{C}$, the relative humidity averaged 28-45%, and the illumination level was in the range of 12000-90000 lux. At 800 h, an average of $15,3 \pm 1,8$ flowers bloomed on the plants, at which time the air temperature was $+22^{\circ}\text{C}$ and the relative humidity was 45%. At 900 hours, an average of $10,8 \pm 1,2$ flowers bloomed and the temperature was $+23^{\circ}\text{C}$ and the humidity was 42%. $12,1 \pm 1,6$ flowers bloomed at 1000 hours and the temperature was $+25^{\circ}\text{C}$, relative humidity was 40%, $10,3 \pm 2,1$ flowers bloomed at 1100 hours, temperature was $+27^{\circ}\text{C}$, humidity was 35%, 1200 hours $16,5 \pm 2,4$ flowers in marked plants, air temperature $+28^{\circ}\text{C}$, relative humidity 33%, $7,8 \pm 0,8$ flowers on stems marked at 1300, air temperature $+29^{\circ}\text{C}$, relative humidity 30% , at 1400 hours the air temperature readings were $+30^{\circ}\text{C}$ and the relative humidity was 28%, at which time it was found that an average of $4,5 \pm 1,9$ flowers were opened on the stems of the plant. During the remaining hours of the day (up to 15–20) flowering was not observed on the celebrated stems of medicinal *Salvia officinalis* L.. On

May 3, a total of $76,7 \pm 2,7$ flowers bloomed on the designated stems of plant seedlings.

To once again study the effect of temperature on the daily flowering dynamics during the overall flowering period of the plant, the flowering dynamics of medicinal *Salvia officinalis* L. seedlings were observed on 11 May. On this day, the average temperature was $+24-32^{\circ}\text{C}$, relative humidity was 30-45%. At 8:00 a.m., when the average air temperature was $+24^{\circ}\text{C}$ and the relative humidity was 47%, $46,6 \pm 3,2$ flowers were found on bloomed. At 9:00 a.m., $17,0 \pm 1,3$ flowers bloomed, with an air temperature of 25°C and a relative humidity of 43%. At 10-11 a.m. the air temperature was $+26-27^{\circ}\text{C}$, the relative humidity was 40-43%, and at 10:00 a.m. the marked stems of the medicinal *Salvia officinalis* L. were $1,2 \pm 0,6$; at 11:00 a.m., $13,1 \pm 1,8$ flower bloom were observed. At 12:00, $18,1 \pm 1,6$ flowers bloomed, at which time the air temperature was $+28^{\circ}\text{C}$ and the relative humidity was 35%. At noon, the opening of flowers on the plant slightly decreased, and at 13:00 $8,4 \pm 1,8$ flowers opened on the set stems, and the temperature readings remained the same as in previous hours. During the hours from 14:00 to 20:00 the air temperature varied in the range of $+25-34^{\circ}\text{C}$, relative humidity 24-40%. At these times, $12,1 \pm 1,8$ per hour (14:00-20:00) per hour on the celebrated stems of the medicinal plant; $8,3 \pm 1,3$; $10,1 \pm 1,0$; $8,4 \pm 1,1$; $5,4 \pm 1,3$; $6,2 \pm 1,8$; $6,8 \pm 1,3$ flowers bloom were detected (Fig. 3). For 12 hours on 11 May, $150,3 \pm 3,3$ flower buds were observed on the designated stems of the plant's seedlings.

Figure 3. Dynamics of daily flowering of medicinal *Salvia officinalis* L. grown in Tashkent Botanical Garden

In the second half of May, a decrease in the number of flowers bloomed in the medicinal *Salvia officinalis* L. seedlings was observed, and the final flowering period of the plants began. Scientific research was conducted on May 20 to determine the dynamics of daily flowering in the final flowering period of the medicinal *Salvia officinalis* L.. The indicator of environmental factors today is as follows, the air temperature averaged +25-36°C, relative humidity 30-45%, illumination varied in the range of 15000-95000 lux. At 8:00 in the morning, the air temperature was +25°C and the relative humidity was 45%, at which time $18,7 \pm 1,9$ flowers bloomed on the marked stems of the medicinal *Salvia officinalis* L. At 9:00-11:00 the air temperature was +26-29°C, the relative humidity was in the range of 35-40%, and in the marked stems of the plants it was $3,2 \pm 1,3$; $4,6 \pm 1,4$; $6,1 \pm 1,5$ flowers bloomed. From 12:00 to 14:00 were the hottest times of the day, the air temperature was +29-34°C, the relative humidity was 32-35%, and in plants at 12:00 it was $5,3 \pm 1,7$; at 13:00 $4,9 \pm 1,3$

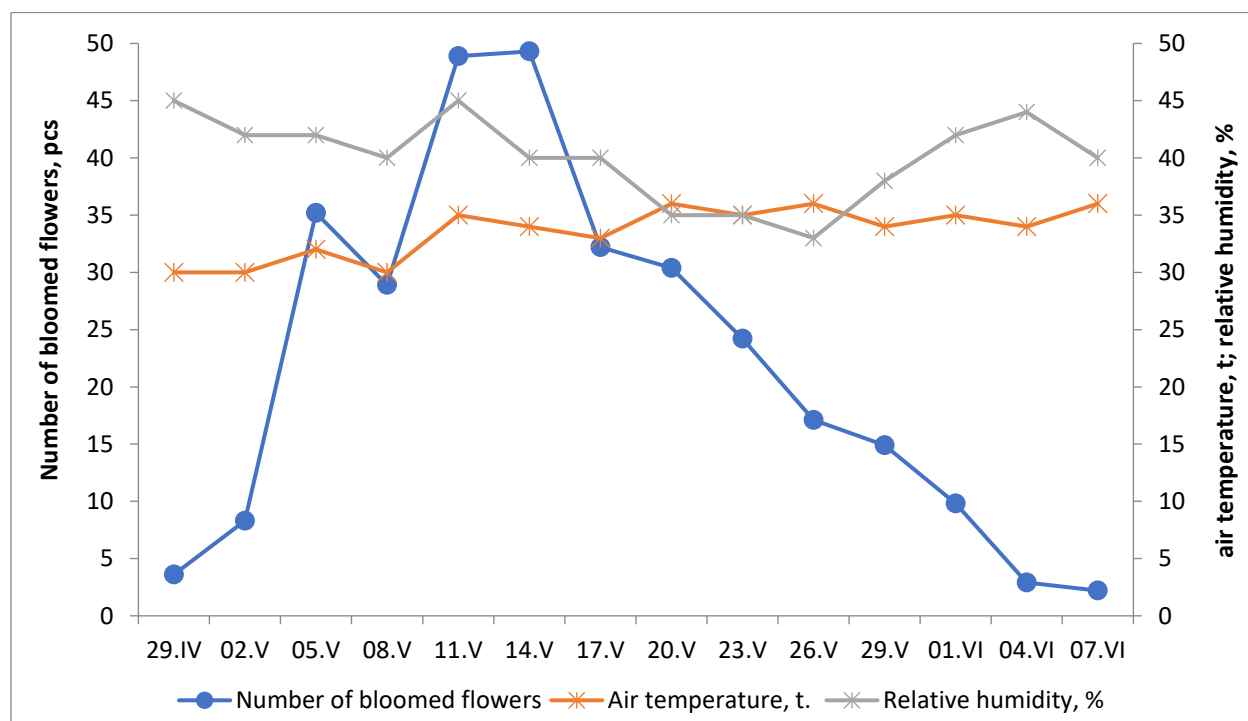
and at 14:00 $4,1 \pm 1,4$ flowers were bloomed. At 15:00, $1,7 \pm 0,7$ flowers bloomed on the plant stems. During the rest of the day (16:00-20:00) no flowering of the plants was observed. From 15:00 to 20:00, the indicators of environmental factors were as follows: air temperature +28-35°C, relative humidity in the range of 30-40%. During the final flowering period of the plant, a total of $49,2 \pm 2,3$ flowers were bloomed on the marked stems for 12 hours. (Figure 3). In the conditions of the Tashkent Botanical Garden, the beginning of flowering of the medicinal plant is 10-14 days, the average flowering period is 16-18 days on average, the final flowering period is 18-20 days.

The seasonal flowering process of the medicinal *Salvia officinalis* L. was regularly monitored from the beginning of flowering to the end of flowering in the model plants, the flowers bloomed every 2 days were counted, air temperature and relative humidity were measured. Every 3 days from the beginning of the flowering period of the medicinal *Salvia officinalis* L., the flowers bloomed on the

designated stems were counted and cut from the plant. The study of seasonal flowering in plants began to be observed from the third (26.IV.) decade of April. 29.IV. the average number of flowers bloomed at was $3,6 \pm 1,6$, and at 02.V. it was $8,3 \pm 0,8$. The number of flowers bloomed at this time is the deficit and is the beginning period of flowering. In 05.V. $35,2 \pm 2,2$, in 08.V. $28,9 \pm 1,8$, in 11.V. $48,9 \pm 2,5$; in 14.V. $49,3 \pm 2,8$, in 17.V. to $32,2 \pm 2,3$; in 20.V. $30,4 \pm 2,1$ flowers bloomed. From 05.V. to 23.V. the number of flowers bloomed in the medicinal season increased, and this time interval indicates that the *Salvia officinalis* L. is in a period of general flowering. $14,9 \pm 1,4$ flowers were opened at 29.V. $9,8 \pm 1,5$ at 01.VI. and $2,9 \pm 1,2$ at 04.VI. (Fig. 4). A decrease in the number of flowers opened from 29.V. to 05.IV.

was observed in the designated stems of the plants, and it was determined that this time was the final flowering period depending on the number of flowers bloomed. An average of $264,4 \pm 3,8$ flower blooms were detected in the designated stems of the medicinal *Salvia officinalis* L. from the beginning of the flowering period to the final flowering period. In the Tashkent Botanical Garden, the budding phase of the medicinal *Salvia officinalis* L. began in the second decade of April 2021, the flowering phase in the third decade of this month, the fertilization phase in the second decade of May. The seeds of the plant were fully ripened and harvested in early July. An average of $37,2 \pm 2,7$ g of ripe seeds was collected from 1 plant.

Figure 4. Dynamics of seasonal flowering of medicinal *Salvia officinalis* L. grown in Tashkent Botanical Garden.



In the first decade of April 2021 (03.IV.2021) 3-year-old seedlings of medicinal *Salvia officinalis* L. planted from seed were planted in Zafarabad district of Jizzakh region. It was found that the generative period of seedlings began in late April (26.IV.) and 10-12 days

later than the generative period of plants grown in the Tashkent Botanical Garden. In order to study the dynamics of daily and seasonal flowering of medicinal *Salvia officinalis* L. grown in Jizzakh region, observations were made on May 10 (beginning of flowering

period), May 24 (general flowering period), May 24 (end of flowering period) and June 5. On May 10, 2021, the average temperature in Zafarabad district of Jizzakh region was $+25-27^{\circ}\text{C}$, the average humidity was 40-48%. At the beginning of the flowering phase of medicinal *Salvia officinalis* L. seedlings (10.V.) in the morning (8:00) from the indicators of environmental factors air temperature $+23-25^{\circ}\text{C}$, relative humidity 46%, illumination 20000 lux at the designated stems of plants $5,1\pm 0,8$, the next hour $2,0\pm 1,0$ flowers bloomed. At 10:00 the air temperature was $+26-28^{\circ}\text{C}$, the relative humidity was 45%, with an average of $4,9\pm 1,7$; at 11:00 a.m. $2,2\pm 1,3$ flowers were bloomed. An average of $2,0\pm 0,8$ in 3 repetitive plants at 12:00; at 13:00, $1,6\pm 0,8$ flower bloomings were observed. In the afternoon, the flowering of the plants slowed down and no flower blooming was observed on the stems observed from 14:00 to 17:00. At this time, the air temperature was the highest during the day, $+32-35^{\circ}\text{C}$, relative humidity was low, 30-35%. At 18:00, an average of $2,2\pm 0,4$ flower bloomings were observed in the designated stems of the medicinal *Salvia officinalis* L. At 19:00 and 20:00 the air temperature was $+25-27^{\circ}\text{C}$ and the relative humidity was 40-45%, no buds were observed on the marked stems of the medicinal *Salvia officinalis* L.. During the flowering phase of the plant, $18,2\pm 1,6$ flower blooms were detected on generative branches on a single stem (1 stem contains an average of 5-8 generative branches per day) (Fig. 5).

The period of total flowering of medicinal *Salvia officinalis* L. seedlings grown in Jizzakh region coincided with the third decade of May, and on May 24 the dynamics of daily flowering of this period of the plant was observed. On this day, the indicators of environmental factors (1 day) were as follows: air temperature averages $+25-30^{\circ}\text{C}$, relative humidity averages 30-50%, illumination level 12000-110000 lux. At 8:00 a.m., an average of $32,1\pm 2,4$ in the marked stems of the medicinal *Salvia officinalis* L.; at 9:00 a.m. the flowers bloomed to $7,2\pm 1,9$ and

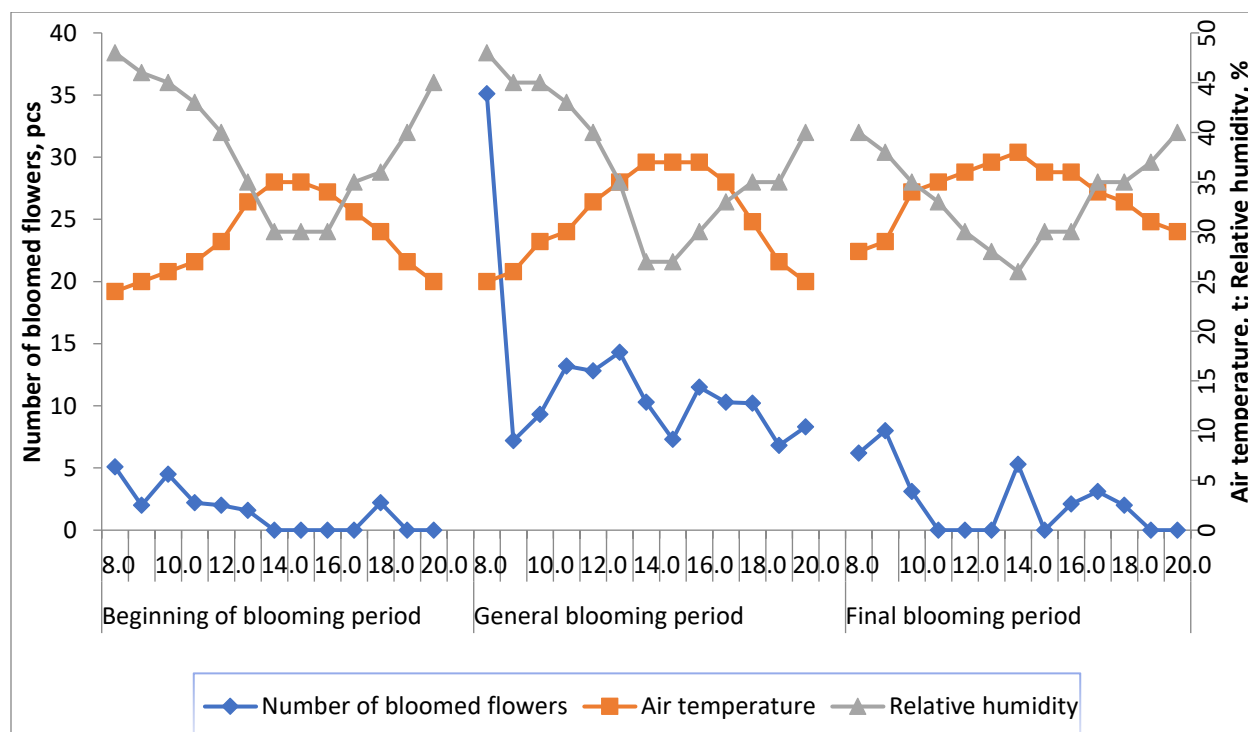
the air temperature was $+25-26^{\circ}\text{C}$, the relative humidity was 45-48%. To determine the number of flowers bloomed by the plant at 10:00, the average number of flowers bloomed on the stems marked in 3 repetitions was $9,3\pm 1,7$; at 11:00 was $13,2\pm 1,6$. At this time the air temperature was $+30^{\circ}\text{C}$ and the relative humidity was 43%. At 12:00, $12,8\pm 2,2$ in model plants; $1,3\pm 2,2$ flowers bloomed at 13:00 and temperature $+33-35^{\circ}\text{C}$, relative humidity 35-40%, $10,3\pm 1,3$ at 14:00; at 3 p.m., $7,3\pm 1,2$ flowers bloomed, temperature $+37^{\circ}\text{C}$, humidity 27%. At 16:00, $11,5\pm 1,6$ in plants; at 17:00 $10,3\pm 1,8$ flowers bloomed, air temperature $+35-37^{\circ}\text{C}$, relative humidity 30%. During the rest of the day, the blooming of flowers was observed in the medicinal *Salvia officinalis* L. seedlings, $10,2\pm 1,7$ at 18:00 and $6,8\pm 1,5$ at 19:00; at 20:00 $8,3\pm 1,6$ flowers bloomed. In the evening of the day from the indicators of environmental factors (from 18:00 to 20:00) the air temperature was $+25-31^{\circ}\text{C}$, relative humidity was 35-40%, and despite a slight decrease in air temperature, the plant continued to bloom at the same rate. In the general flowering phase (24.V.) of the medicinal *Salvia officinalis* L. grown in Jizzakh region, a total of $140,6\pm 3,8$ flowers were detected on the established stems.

By early June, there was a decline in flowering in the medicinal *Salvia officinalis* L. and the plants entered the final flowering phase. The daily flowering dynamics of plants in this phase was observed on 05.VI. from 8:00 am to 20:00 pm. On this day, the daytime air temperature averaged $+34-36^{\circ}\text{C}$, and the relative humidity averaged 35-45%. The open flowers of the plants were observed at 8:00 a.m. at $6,2\pm 1,2$ on the bloomed stems; at 9:00 a.m. $9,0\pm 1,3$ flowers bloomed, with an average air temperature of $+28-29^{\circ}\text{C}$ and a relative humidity of 38-40%. At 10:00, $3,1\pm 0,3$ flowers bloomed on the plants, the air temperature was $+34^{\circ}\text{C}$, and the relative humidity was 35%. From 11:00 to 13:00 no opening of flowers was observed on the marked stems of the medicinal

Salvia officinalis L.. In the afternoon, the flowers continued to bloom on the generative branches of the marked stems of the medicinal *Salvia officinalis* L., and at 14:00 $5,3 \pm 1,0$ flowers bloomed, the air temperature was $+38^\circ\text{C}$, the relative humidity was 26%. At 16:00 $2,1 \pm 0,7$ flowers were bloomed and at this time the air temperature was $+36^\circ\text{C}$ and the relative humidity was 30%, at 17:00 $3,1 \pm 1,2$; At 18:00; $2,0 \pm 0,9$ flowers were bloomed on the

designated stems of the plant and the temperature was $33-34^\circ\text{C}$ and the relative humidity was maintained at 35%. At 19:00 and 20:00 no flowers were observed to bloom on the marked stems of the medicinal *Salvia officinalis* L. Indicators of environmental factors were $+30-31^\circ\text{C}$, 37–40%. (Figure 5). During this day, a total of $30,8 \pm 2,4$ flowers bloomed on the designated stems of the plant.

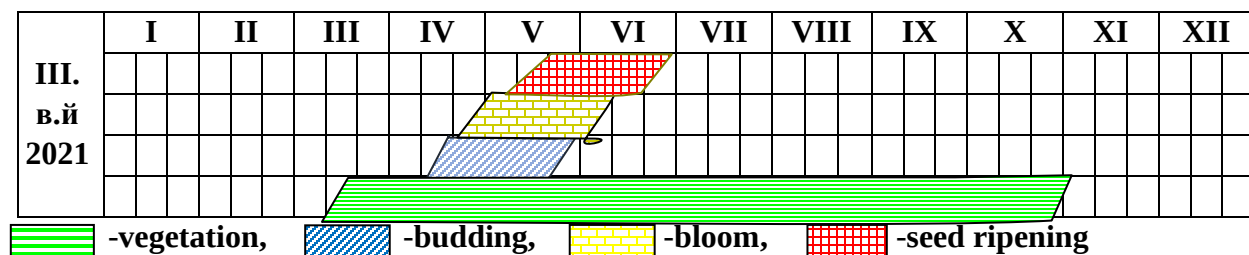
Figure 5. Dynamics of daily flowering of medicinal *Salvia officinalis* L. grown in Jizzakh region



At the beginning of flowering of medicinal *Salvia officinalis* L. grown in the conditions of Jizzakh region, on average $68,6 \pm 3,2$ per 1 plant per day, on average during the general flowering period up to $562,4 \pm 3,8$, in the final flowering phase up to $123,2 \pm 3,6$ the blooming of the flowers was detected. The generative period of medicinal *Salvia officinalis* L. seedlings grown in Jizzakh region lasts 50-55 days, the budding phase averages 40-42 days, the flowering phase 35-40 days and the

fertilization phase 28-30 days it was found to be 3-5 days shorter than the duration of the phases (Fig. 6).

In the study of medicinal *Salvia officinalis* L. flowering biology, it was found from the daily flowering dynamics that most flower blooms at the beginning of flowering, gross flowering, and final flowering were often observed between noon (8:00 to 13:00) and fewer at other times.

Figure 6. Phenosphere of the medicinal *Salvia officinalis* L. in the Tashkent Botanical Garden.

The seasonal flowering of the medicinal *Salvia officinalis* L. grown in Jizzakh region was also observed by counting the flowers that bloomed every 3 days. The flowering phase in plants (11.V.2021) began in the second decade of May and continued until mid-June, lasting 35-40 days. At this time, the average air temperature in the growing area of the plants was +33-35°C, the average humidity was 32-40%. The number of flowers bloomed at the beginning of the flowering phase (at fixed stems) was $6,3 \pm 1,1$ at 12.V. This figure reached $10,8 \pm 2,3$ at 15.V. an increase in the number of flowers bloomed from the second decade of May. $18,1 \pm 2,8$ flowers were bloomed at 18.V. and $26,2 \pm 3,1$ at 21.V. In Jizzakh region, the average air temperature at 21.V. was + 32-33°C, relative humidity was 35-40%. The mass flowering of the medicinal *Salvia officinalis* L. which is grown in the conditions of Jizzakh region, began in the second decade of May, and the number of flowers on the plants was the highest. $36,2 \pm 2,6$ in fixed stems of plants at 24.V; $38,3 \pm 2,4$ flowers were bloomed at 27.V. and $41,2 \pm 2,8$ at 30.V. At the end of May, the air temperature averaged +35-37°C, relative humidity was 30-35%. The overall flowering phase of the medicinal *Salvia officinalis* L.

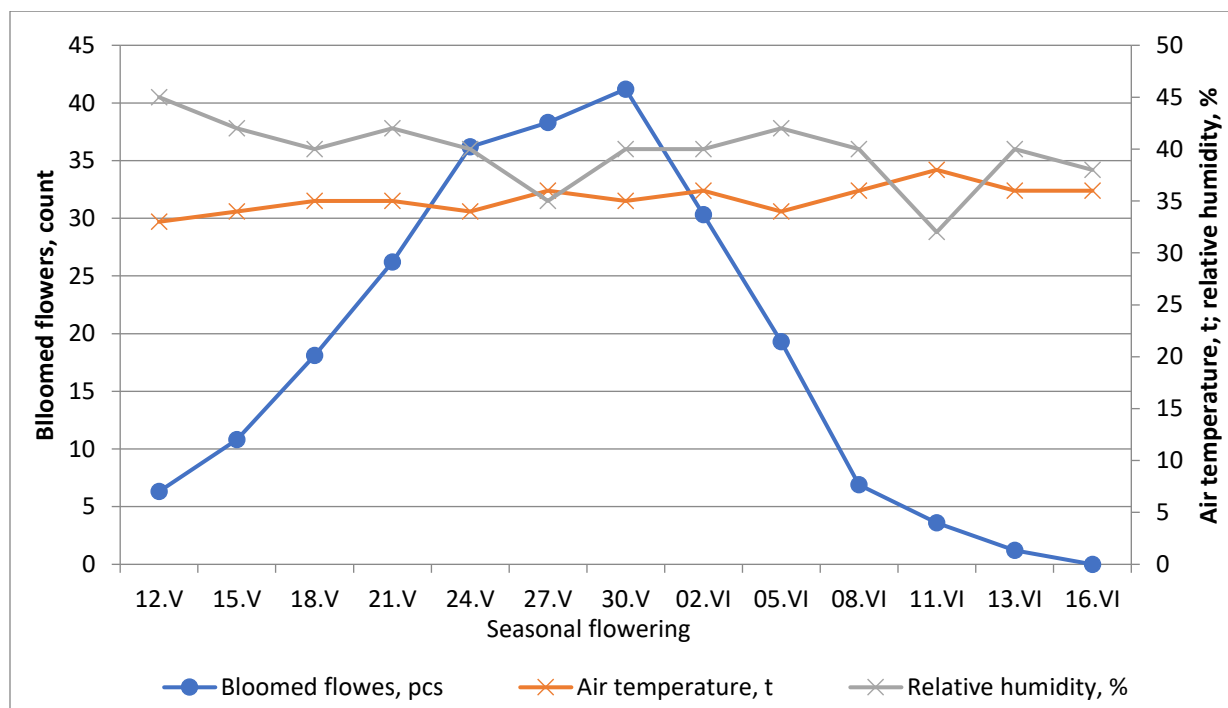
lasted an average of 8-10 days (24.V.-30.V.). On the days from 02.VI to 08.VI the number of flowers bloomed on the marked stems of the medicinal *Salvia officinalis* L. decreased to $30,3 \pm 1,3$ at 02.VI; $19,3 \pm 2,8$; At 08.VI $6,9 \pm 1,2$ flowers were bloomed. The number of flowers bloomed from 11.VI. to 13.VI. continued to decrease, and $3,6 \pm 1,3$ flowers were bloomed in 11.VI. and $1,2 \pm 0,7$ in 13.VI. (Fig. 7).

The final flowering period of the plant was a total of 10-14 days (02.VI-13.VI.). From the beginning of the flowering period to the end of the flowering period, an average of $238 \pm 3,8$ flowers were detected in the marked stems of the medicinal *Salvia officinalis* L. (Fig. 7).

In the conditions of Jizzakh region, the budding phase of the medicinal *Salvia officinalis* L. began in late April 2021 (24.IV.), the flowering phase in the first decade of May (08.V), the fertilization phase in the third decade of May (29.VI.). The seeds of the plant were fully ripened and harvested in late July.

An average of $34,3 \pm 2,1$ g of mature seeds were obtained from 1 plant, and the average weight of 1000 medicinal seeds was $6,8 \pm 1,3$ g.

Figure 7. Dynamics of seasonal flowering of medicinal *Salvia officinalis* L. grown in Jizzakh region.



Microscopic examination of medicinal *Salvia officinalis* L. flowers grown in the Tashkent Botanical Garden revealed the presence of essential oil sacs in the tissue cells of the cup and petals. Glandular hairs (or trichomes) form in the cells of the upper epidermis of the scalp, and the essential oils produced by these glandular hairs accumulate under the cuticle of the epidermis. This cuticle is in the form of a blister, located on one or more cells of the epidermis. In the spaces between the parenchyma of the underlying tissue when the longitudinal and transverse sections of the cortex are seen, there are multicellular schizogenous pathways that collect the secreted essential oil. Schizogenous pathways are long and branched.

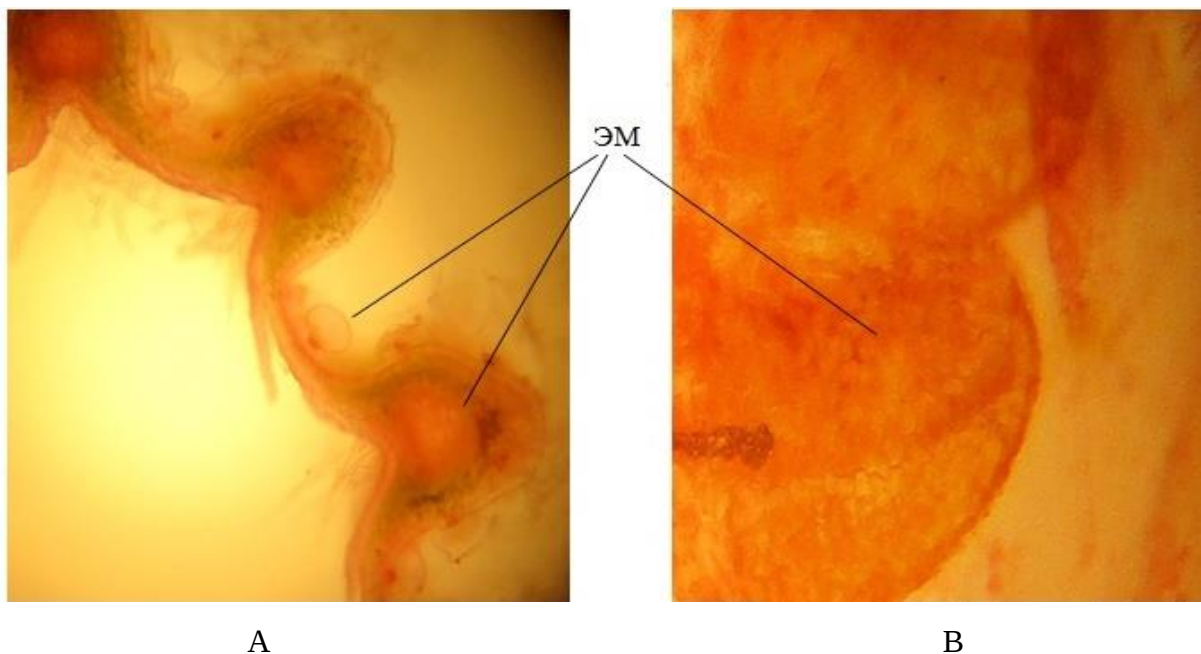
The sacs of essential oil in the petals of the medicinal *Salvia officinalis* L. flower are schizogenically formed as a result of enlargement of the primary tissue parenchyma cells. The anatomical structure of plant organs

clearly shows that the amount of essential oil sacs in the crown leaves of the plant is less than the amount of essential oil glands in the leaf mesophylic stem cells (Fig. 8).

Microscopic cuts of vegetative organs during the generative period of the medicinal *Salvia officinalis* L. revealed the presence of many essential oil glands in the epidermis of the annual branch, in the cavities of the main parenchyma cells and in the leaf epidermis, in the cavities of the leaf mesophylic parenchyma (Fig. 9). The amount of essential oil glands and vesicles is greater in the mesophylic and epidermis of the leaves of the plant, and sparsely located in other vegetative organs.

The leaves are 4-7 cm long and 1-1,5 cm wide, pointed, oblong or oval. The leaf blade is reticulate, the upper and lower epidermis of the leaf is strongly hairy. The edges of the leaves are flat, the bands are short, sparsely pubescent. The leaves are located opposite the stem.

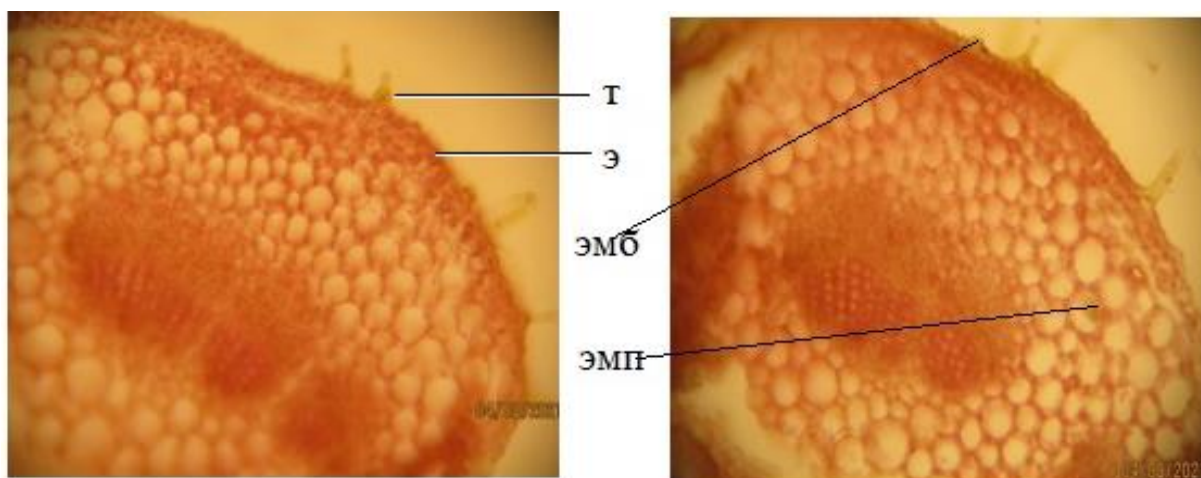
Figure 8. A-general appearance of enlarged parenchymal cells with essential oil in the petals of medicinal *Salvia officinalis* L. flowers, appearance of B-essential oils



The leaf is covered with epidermis from the top and bottom of the mesophyll, the epidermis is located in one layer. In the outer layer of the epidermis are short trichomes and mouthparts, epithelial glands. The thickness of the leaf

blade was $130,3 \pm 5,50 \mu\text{m}$, and that of the mesophyll was $100,7 \pm 4,93 \mu\text{m}$. It is composed of mesophylic parenchymal cells, thin-walled, densely packed.

Figure 9: Placement of bags of essential oils on the leaves of medicinal *Salvia officinalis* L. T-trichoma, E-epidermis, EMB-essential oil glands, EMP-essential oil parenchyma.



The essential oils contained in the leaves of the medicinal *Salvia officinalis* L. are located in the upper and lower epidermal hairs of the leaf, in the form of blisters or glands under the epidermis. The main tissue that forms the leaf

mesophyll consists of cloudy parenchyma, between which schysogenic cavities are formed, in which essential oils accumulate.

Conclusions.

The flowering biology of the medicinal *Salvia officinalis* L. introduced in the conditions of Tashkent oasis and Jizzakh region was studied.

Flowering of seedlings grown in the conditions of the Tashkent oasis began 15-20 days earlier than flowering of medicinal *Salvia officinalis* L. seedlings grown in Jizzakh region. It was found that the maturation and blooming of plant buds are affected by temperature changes. Newly formed buds ripen in 5-6 days at an average temperature of +20-25°C, and when the air temperature is +30-33°C, the buds mature and bloom in 2,5-3 days. The average temperature was +29-30°C, 1 flower on the plant was open for 1,5-2 days when there was enough sunlight, and 3-3,5 days when the weather was cloudy.

When observing the daily flowering dynamics of medicinal *Salvia officinalis* L. grown in the conditions of the Tashkent oasis and Jizzakh region, the flowering of plants was observed during the day.

The blooming of the medicinal *Salvia officinalis* L. flowers coincided with different times of the day during the flowering phase. During the flowering phase, the beginning and end of the flowering period, the opening of the flowers was more during the daylight hours, and during the general flowering period, the opening of the flowers was observed at the same pace throughout the day.

When observing the dynamics of seasonal flowering of medicinal *Salvia officinalis* L. grown in the conditions of the Tashkent oasis, the phase of gross flowering in seedlings began in the first decade of May, in the third decade of May in seedlings grown in Jizzakh region.

Differences were observed in the generative period, the beginning of the phases of the medicinal *Salvia officinalis* L., grown in different climatic conditions. The duration of the phases (budding, flowering, fertilization)

was the same in both conditions, with budding 30-35 days, flowering 40-45 days and fertilization 45-50 days, the total generative period being 60-65 days.

References

- Avato P., Fortunato I., Ruta C.D., Elia R. Glandular hairs and essential oils in micro propagated plants of *Salvia officinalis* L. *Plant Sci* 2005. 169: 29-36 p.
- Arabova N.Z., Arabova Z.Z., Akhmedov Kh.A. Narrow-range species of the family Lamiaceae Lindl. in the flora of Uzbekistan. *Bulletin of Science and Education* No. 23 (101). Part 2. 2020. p. 11-15.
- Bazhova E.V. Results of the introduction of species of the genus *Salvia* L. in Novosibirsk // Materials of the scientific conference "Biological diversity. Plant introduction". St. Petersburg, 1995 p. 232-233
- Bulusheva M.K., Lasskaya O.F., Savina A.A. Study of the chemical composition of the roots of *salvia officinalis* (*Salvia officinalis* L.) -Young scientists and pharmacy of the XXI century - a collection of scientific papers of the third scientific and practical conference with international participation. M., 2015, 208-213.
- Gorlacheva Z.S. Morphological analysis of damage to the generative organs of *Salvia officinalis* L. during introduction in the conditions of Donbass / Z.S. Gorlacheva // *Industrial botany*. - 2009. - Issue. 9. - P. 132-13
- Dzhambetova M.U. Agrobiological substantiation of the cultivation of medicinal sage (*Salvia officinalis* L.) in the Chechen Republic: Abstract of the thesis. dis ... candidate of agricultural sciences. -

- M. 2013 .-- 23 p.
- Dolya V.S., Trzhetsinsky S.D., Mozul V.I., Tretyak N.I. Features of the chemical composition of species of the genus *Salvia* L. - Actual nutrition of pharmaceutical and medical science and practice 2013, 3 (13), 083-085.
- Drahić, S., Thivanovicz, T., and Brankovicz, D., Variability and phenotypic divergence of sage populations (*Salvia officinalis* L.) on conditions of ex situ conservation, in Book of Abstracts of the fifth scientific-research symposium on breeding and seed production. Vrnjaka Banja – Serbia, May 25–28, 2008.
- Dusmuratova F., Faxriddinova D., Allaberdiev R. Study of the biology of some species of the family Yasnotkaguldosh in the Tashkent Botanical Garden. News of the National University of Uzbekistan. Tashkent. 2019. 3/2.
- Dusmuratova F.M., Rakhimova T., Fakhriddinova D.K., Uralov A.I. Seed forgiveness of some species of the family Lamiaceae introduced in Tashkent Botanical garden. European Journal of Molecular & Clinical Medicine Volume 7, Issue 11, 2020. P.324-351.
- Dweck A. C. Introduction the folklore and cosmetic use of various *Salvia* species. In: Medicinal and Aromatic Plants Industrial Profiles; Vol. 14, Sage, the genus *Salvia*; (Kintzios SE, ed), Harwood Academic, United Kingdom. 2000. 10-11.
- Zhidkova A.E., Dimitriev A.V. Introduction of spicy-aromatic species of family Lamiaceae Lindl. in the Chuvash Republic. Collection of scientific works of GNBS. 2018. Vol. 146, p. 39-44
- Kovalenko N.A. Accumulation dynamics and component composition of essential oils of some species of the genus *Salvia* L. / N.A. Kovalenko, G.N. Supnichenko, V.N. Leontiev, A.G. Shutova, E.V. Spiridovich, L.V. Kukhareva // Proceedings of BSU. - 2010. - T. 5. - S. 27–33.
- Levina R.E. Reproductive biology of seed plants. M., 1981. 96 p
- Leonova N.A., Miroshnichenko T.E., Kuznetsova A.V. Features of biology and introduction of economically valuable species of the genus *Salvia* in the Penza region. Proceedings of higher educational institutions. Volga region. Natural Sciences. Biology. No. 3 (19), 2017. p. 40-48.
- Liu, L., Guo, Q., Wang, Y., and Zhao, R., Study on characteristics of seed germination of *Salvia officinalis*, 2006 PubMed – indexed for MEDLINE. <http://www.ncbi.nlm.nih.gov/pubmed/17165580>.
- Ponomarev A.N. Study of flowering and pollination of plants // Field Geobotany. M.; Leningrad, 1960. T. 2. P. 9–18.
- Trankovsky D.A. Workshop on plant anatomy. - M.: Higher school, 1979 .-- 221 p.
- Tkacheva E.N. Spicy-aromatic plants of the Yaroslavl family as a source of polyphenols - New and unconventional plants and prospects for their use 2017, P3, 115-117.
- Shklyarov A. P. Results of the introduction of medicinal sage (*Salvia officinalis* L. ssp. Major Gams.) / A. P. Shklyarov // Vegetable growing: collection of scientific papers. National Academy of Sciences of Belarus, RUE "Institute of Vegetable Growing". - Minsk, 2010. - Issue. 17. - P. 396-402.