Antecology and seed productivity of Artichoke varieties (in the example of medium salinity soils of Uzbekistan)

Eldor Erxonovich Isomov, Guljan Madrinbayevna Duschanova, Gulnoza Rizoyevna Djumayeva, Iroda Saydullayevna Saydullayeva, and Zebuni S Baxr Nomozova

Abstract. The antecology, fertilization and seed maturation processes of Green Gold, Imperial Star and Violetto (Cynara scolymus L) varieties were studied in medium saline soils of Bukhara region under conditions of moderately saline soils of Uzbekistan. The following adaptation features were identified: The beginning of the flowering phase and the duration of flowering (2-5 days) of artichoke varieties do not differ significantly from each other. The opening of flowers continued from 600 to 2000 hours during the day, the maximum opening was at 800-1100 hours, when the air temperature was +29+35°C and the relative air humidity was 50-55%.

1 Introduction

In order to solve the taxonomic and phylogenetic issues of each introduced plant, in addition to selection and seed production, it is necessary to study its flowering biology and seed productivity. About the importance of this issue, A.N. Ponomarev [1], V.F. Shamurin [2], and several other scientists expressed their opinions. Z.B. Nomozova, Z.H. Nasimova [3] studied flowering biology, flowering dynamics and seed productivity of C. scolymus in irrigated and non-irrigated fields in Samarkand region. Accordingly, the antecology, germination and seed maturation processes of Green Gold, Imperial Star and Violetto artichoke varieties were studied in medium saline soils of Bukhara region.

2 Materials and methods

The experiments were conducted mainly in medium salinity soils of Vobkent district of Bukhara region. Morphological structure of vegetative and generative organs I.G. Serebryakov [4], as well as "Atlas of descriptive morphology of higher plants" by A.N. Ponomarev [5], R.Ye. Levina [6]. Seed productivity in perennial plants O.A. Ashurmetov *Corresponding author:
boboqandov@gmail.com
3 The results and discussion

The morphological description of inflorescences of artichoke varieties. The morphological structure of an artichoke basket flower is as follows: it consists of a large, multi-flowered, homogamous, homochromic cluster of flowers, spherical or slightly elongated at the tip.

The analysis of the results obtained during our research showed that the basket flowers of the artichoke varieties did not differ from each other in terms of their morphological structure, but in terms of size, size and the shape of the tips of the folded leaves is different. These characteristics showed different indicators in the section of varieties.

According to the morphological structure, the basket ball of the Green Gold variety is large, 32-46 cm in diameter, 12-19 cm in length, spherical in shape. There are 80-100 leaves that cover the flower from the outside, and they surround the flower in a basket forming 8-12 circles. 8-12 rolled leaves are placed in each ring of the circle. Wrapping leaves of each circle are placed one on top of the other. The side of the lower part of the folded leaves is slightly narrowed, the shape is almost straight, the upper part is elongated, the tip is divided into three lobes, the middle part of the lobe is strongly prickly, sometimes the edges are slightly barbed. Convex 8-9 rows of folded leaves on the outer side of the basket are large, fleshy, and 3-4 rows of folded leaves on the inner side are narrow, delicate and thin.

The length of the wrapping leaves (Fig. 1, v 1, 2, 3) surrounding the baskets on the outer layer is 2.4-2.9 cm, the width is 0.6-0.9 cm, and the tip is conical. Part much thinned and in some with short spines; the color of the outer surface of the coiled leaf is dark red, covered with silvery flowing hairs, slightly bent to the surface. The folded leaves in the middle part of the basket are 3.5-4.3 cm long and 1.5-2.0 cm wide. is located (Fig. 1).

The scroll leaves located in the innermost circle of the basket are 3.1-3.9 cm long and...
1.2 cm wide, light green in color, the middle part is white, the third part is pink, the top of the scroll leaves is that is, the inner part of those located near the flower is colorless, smooth and shiny, and the outer part is rough, that is, uneven (Fig. 1).

It can be seen that Imperial Star is slightly different from Green Gold in the smallness (size) of the basket and wrapper leaves. The basket-ball flower of the Imperial Star variety has a diameter of 30–38 cm, a length of 10–17 cm, and a spherical shape (Fig. 2). The rolled leaves located on the outside of the basket are 2.2–2.5 cm long, 0.4–0.8 cm wide, oval in shape, flowing green in color, some have a thinner tip, and the color is more reddish, almost smooth, hairy and partially curved outwards (Fig. 2).

The length of the wrapping leaves located in the middle part is 3.2–3.9 cm, the width is up to 1.2–1.8 cm, they are cylindrical in shape, green in color, the length of the tip is 0.5–0.9 cm. lacquered in appearance, some with a slightly tapered tip, most with a smooth pinkish edge (Fig. 2).

It can be seen that the basket and bracts of Violetta differ from those of Green Gold and Imperial Star in the smallness (size) of the basket and bracts. The basket-ball flower of the Violetta variety has a diameter of 28–33 cm, a length of 8–15 cm, and a spherical shape (Fig. 3).

The rolled leaves located on the outer side of the basket are 1.9–2.3 cm long, 0.3–0.6 cm wide, oval in shape, green in color, some have a thinner tip, and the color is more reddish, almost smooth, hairy and partially curved outwards (Fig. 3).

The length of the wrapping leaves located in the middle part is 3.0–3.1 cm, the width is up to 1.0–1.3 cm, they are cylindrical in shape, the color is green, the length of the tip is 0.4–0.7 cm. lacquered in appearance, and in some, the tip is thinned, the edge of the leaflets is smooth and purple in color (Fig. 3).
Fig. 3. The appearance of the basket-ball flower of the Violetto variety: a) general appearance of a bud; b) general view of the flower (the process of bursting of pollen grains in a flower); c) sequence of winding leaves.

In general, Violetta's basket color is more purple than Green Gold's and Imperial Star's. In addition, it was observed that the basket and the wrapping leaves that surround it from the outside are smaller. The basket inflorescence of artichoke varieties is flat, the surface is wide and hairy.

The diameter of the inflorescence of the Green Gold variety is 30–43 cm, the width is 6–10 cm, the thickness is 1.4–2.5 cm in the central part, and 0.6–0.8 cm at the edges. In the Imperial Star variety, these indicators were slightly smaller, that is, the circumference of the inflorescence is 28–33 cm, the width is 6–8 cm, the thickness is 1.3–2.0 cm in the central part, and 0.6–0.7 cm (Fig. 4, a, b).
Fig. 4. Basket—longitudinal section of a flower (the fleshy edible flower): a – Green Gold; b – Imperial Star; c – Violetto

The flower of artichoke varieties has five sepals, joined together to form a straight tube, the lower part of the tube is thinner than the top, and the tip of the sepals is not joined. The tube is straight, long, hairless, smooth, and the tip is widened. More than half of the tube is colorless or oozing, and the upper part is purple. Chanchisi five, equal to each other; erect, upright anthers are joined. Ski thread is cylindrical in shape, thin, smooth. Changchi thread grew together with a tube of rosy leaves. The anther is attached to a long anther thread and is connected by its sides, forming an anther tube.

The node of the seed is lower, the shape is ovoid, the column is upright, cylindrical, the beak is bifurcated or lipped, the lips are whole, convex. The flower of artichoke varieties is typical of the proterandria type, and the anther bursts at the same time. Accordingly, the structure of dust grains has its own characteristics. Its peculiarity is that the upper part of the seed column is partially thickened and has short hairs, which act as pollen grains.

The pollen grains in the flower tightly surround the hairy column of the seed, mainly the upper part, from the outside. The hairs on the outer layer of the column catch the dust particles falling from the tubular anther. As a result of the growth of pollen grains, the tube-shaped stamen rises above the petals. Then the hairy column of the seed grows, and as a result, the column pulls the pollen grains up and out of the tubular anther. In this process, the anther grows through the anther tube and pushes the pollen grains out of the anther.

The development period of the seed begins with the separation of the tip into two parts, but the surface that catches the dust grains sticks to each other. The opening of the seed pod begins 3–5 hours after it emerges from the pollen tube. Since the pollen grains are removed from the anther, they are spilled or transported by pollinating insects, so pollination takes place with the help of other flower pollen grains, i.e., external pollination.

When the petals open in the basket, they are initially light purple, and towards the end of the opening process, the flowers have a purple color. After the flowers have opened, 5–6 mm long sepals grow from the basket. At this time, the folded leaves become denser with each other and the basket becomes egg-shaped. After the flowering process is over, the pollinator thread and seed column begin to shorten. Tubular anthers and seed pods are drawn into the petals. After that, the gułtójibarg teeth are attached.

The diameter of the basket flower of the artichoke grown in the conditions of the Samarkand region is 17–30 cm, the length is 8–12 cm, it is spherical or slightly elongated at the tip. The flower is surrounded by 8–10 circular leaves. The rolled leaves located on the outside of the basket are 1.6–2.8 cm long, 1.0–1.6 cm wide, oval in shape, light green in color, some have a thinner tip, and the color is more reddish, almost smooth, few hairs and sparse partially bent outward.
It can be seen that the artichoke varieties grown in moderately saline soils are slightly different from the plants grown in Samarkand region according to the structure of the basket flower. That is, it is explained by the fact that the tip of the flower is relatively large, the rolled leaves are of different shapes.

Diurnal flowering dynamics of artichoke cultivars Green Gold, Imperial Star and Violetto grown in medium salinity soil conditions. All features such as the implementation of processes in closed-seeded plants, other phenological stages, the opening of flowers during the day, and the occurrence of the pollination process are the individual characteristics of each species that have been formed and strengthened during the evolution.

It is known that the opening and pollination of the flowers of various plants takes place according to a specific daily rhythm, one of the main factors affecting this is humidity, and the other is temperature and light, a certain time of the day.

Artichoke is a plant belonging to the group of polycarpic plants. Its flowers are diurnal. The dynamics of the opening of flowers of Cynara scolymus Z.B. Nomozova, [10] studied in gray soils of Samarkand region.

According to the experiments, the dynamics of flower opening of artichokes Green Gold, Imperial Star and Violetto were studied. According to him, it was observed that there is no sharp difference in the opening dynamics of flowers of artichoke varieties. It was observed that the beginning of the opening of the flowers of the Green Gold, Imperial Star and Violetto varieties of artichoke in the experimental field differed from each other by 2-3 days.

When we observed the opening order of the flowers of the artichoke varieties in the basket in the experimental field, the flowers located at the edge of the basket opened first and the flowering continued in the direction towards the center. The opening process of the flowers in the baskets of one plant started from the first order branch, and after that the flowers of the second and third order baskets opened sequentially. This regularity in the opening of flowers was also realized in the Green Gold, Imperial Star and Violetto artichoke varieties. On the first day of flowering, the number of flowers opened on the first branch was very small. The maximum opening of flowers in one basket corresponds to the 2-3 days of flowering. The opening of the baskets on the lateral branches begins with the opening of the flowers of the baskets located at the bottom of the first branch. After that, the next baskets were opened in the same way. This process is carried out according to the conditions of high air temperature and average salinity of the soil.

Artichoke varieties Green Gold, Imperial Star and Violetto bloom mainly in the second year of vegetation. It can be seen that 10-15% of artichoke varieties sprouted from seeds sown in the fall formed generative organs in the first year. The height of plants formed by generative organs was 30-40 cm.

The flowers of the Green Gold, Imperial Star and Violetto varieties of artichoke grown in conditions of moderately saline soils began to open during the day, at 600 in the morning. In this case, the number of opened flowers is very small, it is 0.6% of the total number of flowers opened during one day. From 800 to 1100 hours, the flowers opened the most, and it corresponds to 70% of the flowers that open during the day. At this time, the air temperature was +29-35°C, and the relative air humidity was 50-55%. Individual flowers opened between 1600 and 2000 hours, after which flowering stopped (Fig. 5). When determining the duration of flowering of one basket, the period from the first petals emerging from the basket to the last petals rising from the basket and turning completely black was taken. Because, after the pollination of the flowers, the petals turned black and then began to dry.
The opening of flowers during the day was studied in the months of the general flowering season (May, June). The beginning of flowering was observed in the second decade of May. The initial opening of the flowers in the central baskets was observed on May 18-20, when the air temperature was +29+35°C, the relative humidity was 50-55%, and the flowers opened the most, and it corresponded to June 1-5 (Fig. 5).

According to our experience, the opening of flowers usually begins in the morning. A large number of flowers open mainly between 8:00 and 11:00 hours, and almost the same number of flowers open between 11:00 and 12:00 hours. Then the number of opened flowers begins to decrease and at 20:00 hours it stops completely.

There are some changes in diurnal opening in June, that is, during the general opening period of flowers. In this case, the opening of flowers started from 6:00 in the morning, but the opening of the largest number of flowers corresponded to 8:00–11:00 hours. The rapid opening of flowers coincided with the time when the air temperature was +29+35°C and the relative humidity was equal to 50-55%.

Fig. 5. Artichoke Green Gold, Imperial Star, Violetto, varieties of flowers open during the day.
Seasonal flowering dynamics of artichoke varieties Green Gold, Imperial Star and Violetto grown in moderately saline soils. When we observed the seasonal opening of flowers of artichoke varieties, this process was much shorter, that is, it lasted 30-32 days starting from May 18 for Green Gold variety, 29-30 days starting from May 20 for Imperial Star variety, and 27-28 days starting from May 19 for Violetto variety. In the budding phase of artichoke varieties, up to 30-35 baskets are formed on each plant. The flowers in the baskets also begin to open one by one, and until the second decade of June, individual flowers open. According to observations, the opening of one flower takes 2-3 days, the opening of flowers in one basket takes 5-6 days, one plant takes 12-15 days, and all plants in the plantation do not open at the same time. Therefore, seasonal opening of flowers of artichoke varieties lasts 28-32 days (Table 1).

The nighttime rhythm of flower opening of artichoke cultivars grown in moderately saline soil conditions is closely related to the nighttime flight activity of insects participating in pollination of entomophilous plants. According to our research, the Green Gold, Imperial Star and Violetto varieties of artichokes are pollinated by honey bees, bumble bees and green golden beetles, which allows for better germination. The fact that the artichoke grown in the conditions of the Samarkand region does not differ from the insects involved in the pollination process confirms our opinion.

Table 1. Seasonal flowering technology of artichoke varieties

<table>
<thead>
<tr>
<th>Varieties</th>
<th>The beginning of vegetation</th>
<th>Flowering process</th>
<th>Duration of flowering, days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Beginning</td>
<td>Beginning</td>
</tr>
<tr>
<td>Green Gold</td>
<td>10.02</td>
<td>23.05</td>
<td>5.06</td>
</tr>
<tr>
<td>Imperial Star</td>
<td>15.02</td>
<td>20.05</td>
<td>5.06</td>
</tr>
<tr>
<td>Violetto</td>
<td>12.02</td>
<td>18.05</td>
<td>5.06</td>
</tr>
</tbody>
</table>

Seed productivity of artichoke varieties

Experiments devoted to the study of flowering biology, seed formation and seed productivity of artichoke varieties Green Gold, Imperial Star and Violetto were conducted in the field experiment area in Vobkent district of Bukhara region during 2020-2022. The formation process (budding) of flower elements of artichoke varieties was observed in the second decade of April. The flowering process lasted from the second decade of May to the second decade of June. Our experiments confirm that the formation of buds of artichoke grown in Samarkand region varies between the third decade of May and the first decade of June, and the flowering process continues from the second decade of June to the third decade of July [12].

The analysis of the results obtained during our research showed that the number of flowers and seeds in the baskets of artichoke varieties is proportional to the seed productivity of all studied varieties. These characteristics showed different indicators in the section of varieties.

It was found that in one bush of the Green Gold variety, there were 638.9 ± 8.7 flowers and 161.8 ± 6.1 seeds per basket, and the seed productivity was 25.32%. It was determined that the number of flowers of the baskets of branches of the 2nd order is 497.9 ± 8.8, the seeds formed are 188.6 ± 6.4, and the seed productivity is 37.87%. The average number of flowers in baskets of branches of the 3rd order was 337.0 ± 8.7, the number of seeds was 102.1 ± 6.5, and the seed productivity was 30.29% (Fig. 6 b).
It was found that one bush of the Violetto variety had an average of 547.4±11.2 flowers and 300.0±40.8 seeds per basket in the 1st branch, and the seed productivity was 54.87%. It was determined that the number of flowers of the baskets of branches of the 2nd order was 545.1±14.6, the seeds formed were 247.3±12.6, and the seed productivity was 45.36%. The average number of flowers of the 3rd order branch baskets was 336.2±11.1, the number of seeds was 109.3±9.8, and the seed productivity was 32.44% (Fig. 6).

![Image of a plant with numbered branches]

It was found that in one bush of the Imperial Star variety, there were 676.0±28.4 flowers and 360.4±12.1 seeds per basket, and the seed productivity was 53.6%. It was found that the number of flowers of the baskets of branches of the 2nd order is 471.3±11.5, the seeds formed are 262.6±9.1, and the seed productivity is 55.71%. The average number of flowers of branch baskets of the 3rd order was 339.3±35, the number of seeds was 112.8±6.9, and the seed productivity was 33.24% (Fig. 6).

**Fig. 6.** Bar charts showing seed productivity for different varieties: Green Gold, Violetto, and Imperial Star. The charts depict the number of flowers and seeds per branch order, with error bars indicating variability.
The analysis of the results of the dependence of the number of flowers, seeds and seed productivity on the branches of the artichoke varieties showed that the number of baskets in the branches of the 2nd order of all studied varieties was more than that of the 1st and 3rd orders. (Table 2). The given numbers are the data of the first year of the introduced artichoke varieties in the conditions of moderately saline soils of the Bukhara region. According to the analysis of the literature data, it is known that the productivity of this seed increases by 15-22% from 2-3 years of vegetation. In all studied varieties, the baskets on the 1st-order branches are formed and ripen before the 2nd-3rd-order baskets, but because their number is 1, the productivity is much lower than the 2nd-order baskets.

4 Conclusions

In summary, indicators such as the beginning of the opening of the flowers during the day, the total flowering and the end of flowering of the flowers of the Green Gold, Imperial Star and Violetto varieties of artichoke grown in the conditions of moderately saline soils of the Bukhara region are different from each other in the section of the varieties and it was almost no different from the plants grown in the conditions of Samarkand region. However, the seasonal flowering process is explained by the fact that, compared to the plants grown in the conditions of Samarkand region, the air temperature is hot and dry, and the average salinity of the soil causes acceleration of the flowering processes in plants. It was found that the duration of seasonal flowering of artichoke Violetto is better than other varieties in medium saline soils of Bukhara region.

The analysis of the obtained results showed that all studied varieties of artichoke grow normally and produce seeds in the conditions of moderately saline soils of the Bukhara region. According to the information provided in the literature, it was mentioned that in the

<table>
<thead>
<tr>
<th>Order of branching</th>
<th>number of flowers in baskets, pieces</th>
<th>number of seeds in baskets, units</th>
<th>Seed productivity coefficient in 1 plant, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Gold</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>638,9±8,7</td>
<td>161,8±6,1</td>
<td>25,32</td>
</tr>
<tr>
<td>II</td>
<td>1493,7±8,8</td>
<td>563,8±6,4</td>
<td>37,87</td>
</tr>
<tr>
<td>III</td>
<td>674,2±8,7</td>
<td>204,2±6,5</td>
<td>30,29</td>
</tr>
<tr>
<td>Violetto</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>547,4±11,2</td>
<td>300,4±40,8</td>
<td>54,87</td>
</tr>
<tr>
<td>II</td>
<td>1635,3±14,6</td>
<td>741,9±12,6</td>
<td>45,36</td>
</tr>
<tr>
<td>III</td>
<td>672,4±11,1</td>
<td>218,6±9,8</td>
<td>32,44</td>
</tr>
<tr>
<td>Imperial Star</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>676±28,4</td>
<td>362,4±12,1</td>
<td>53,6</td>
</tr>
<tr>
<td>II</td>
<td>471,3±11,5</td>
<td>262,6±9,1</td>
<td>55,71</td>
</tr>
<tr>
<td>III</td>
<td>339,3±35</td>
<td>112,8±6,9</td>
<td>33,24</td>
</tr>
</tbody>
</table>
Almost all artichoke varieties bloomed and produced seeds in the moderately saline soils of the Bukhara region, where we conducted research. This is explained by the fact that the air temperature is hot and dry compared to other regions, and the high level of soil salinity accelerates the processes of ontogenesis in the plant. It was found that the Imperial Star variety of artichoke is superior to other varieties in terms of seed productivity in the conditions of moderately saline soils of the Bukhara region.

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