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Bioecological Characteristics of Growth and Development of *Polianthes tuberosa L.* in Soil and Climatic Conditions of the Batumi Botanical Garden

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Lana Kodanovi[1], Aliosha Bakuridze[2], Mariam Metreveli*[3], Malkhaz Jokhadze[2], Dali Berashvili[2], Avtandil Meskhidze[3]

[1] Batumi Botanical Garden, Batumi, Georgia. [2] Tbilisi State Medical University; Tbilisi, Georgia.
[3]Batumi Shota Rustaveli State University, Institute of Phytopathology and Biodiversity, Batumi, Georgia.

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ABSTRACT

Bioecological characteristics of the growth and development of perennial, fragrant species of tuberose or *Polianthes tuberosa L.* representing the genus *Polianthes L.*, asparagus (*Asparagaceae Juss*) family, native to Mexico, was studied based on the said plants introduced to the Batumi Botanical Garden (BBG). The research aimed at introducing tuberose to humid subtropical climatic conditions of the Batumi Botanical Garden with the help of green technologies, as this species is highly decorative, widely accepted in the perfumery industry, and extremely sensitive to environmental conditions. Tuberose was tested in seven different locations with various expositions and soil content. It was identified, that tuberose completes the full cycle of growth and flowering if plenty of sunlight and fertile soil is available in the locations. Moreover, its growth and development processes are significantly improved while using liquid humic bio preparations containing mineral and organic substances. Locations surrounded by hardwood plants with high antimicrobial activities, condition healthy growings free from harmful diseases. Above-ground growth and development cycle of tuberose in the conditions of the Batumi Botanical Garden covers the period from May including December. In winter, frosty weather has no dramatic influence on the tubers left in the soil. Vegetative propagation of locally received plants is possible with the help of multiple child tubers developed during the vegetation process, while generative propagation is impossible due to the absence of fruit-bearing qualities. Based on 4-year research, it can be concluded, that the successful introduction of tuberose using green technologies is possible in the soil and climatic conditions of the Batumi Botanical Garden.

INTRODUCTION

Tuberose or *Polianthes tuberosa L.*, perennial, herbaceous fragrant plant, representative of the genus *Polianthes L*., belongs to asparagus (*Asparagaceae Juss*.) family, the agave (*Agavoideae* Herb.) subfamily. The genus tuberose combines up to 15 species and a few varieties and cultural forms. They are perennial, tuberous plants and the most distinguished taxon in the genus is *Polianthes tuberosa L*., native to Mexico, which is an endemic specimen for the country as well as extremely important from an economic point of view. It is cultivated in many countries, used in perfumery, ornamentations and its flowers are known for the content of valuable essential oils. Tuberose flowers represent valuable materials for perfumery. This plant was introduced to Europe and Asia from Mexico in the 16th century. Tuberose is actively grown especially in India due to ornamental purposes and the perfume industry [1-2; 7;15].

The upright stem of tuberose is about 0-90 cm tall, leaf plates are 0,4 m long, 30mm wide, dark green with trichomes on the surface. Leaf formation starts at the base of the stem. The catkin is a spike containing up to 10-40 tubular buttons (flowers).[7;15.]

Tuberose is a widely recognized aromatic plant for perfumery and plant collections. However, being extremely sensitive to environmental conditions, its introduction is not often successful.

The research goal was to study bioecological peculiarities of the growth and development of tuberose introduced to the BBG with the help of green technologies in local soil and climatic conditions.

METHODOLOGY

Research objects were the plants grown from the tubers of *Polianthes tuberosa L.*, subscribed and received from the Seed Exchange Foundation, introduced to the BBG, and grown in the conditions of open and closed soil of the garden.

Studying morphogenesis and growth and development characteristics of the research object were carried out by the methods by Beideman and Elagin, Lobanov. [4;6.]

RESULTS AND DISCUSSION

Tuberose was introduced to the Batumi Botanical garden in 2016 with the assistance of the Seed Exchange Foundation between the botanical gardens and also, by online subscription of tubers.4 tubers were received from India and planted in the orangery for the collection of exotic plants in May. In June, shoots developed from them (Fig. no.1).

Figure No. 1: Tuberose plants received in the orangery of the collection of aromatic plants of the Batumi Botanical Garden

Based on literature data, tuberose belongs to the plants of dry and warm climate requiring plenty of sunlight, less humidity in the air, and mild winter for its normal growth and development. In the case of warm winter, tubers tend to survive without any damages and sunny autumn is essential for getting a high-quality yield. Being too sensitive to frost, the majority of tubers are frozen in the soil during cold, frosty winter.[15.]

Tuberose is sensitive to the soil too, that should be considered for the regions with high precipitation. Tuberose grows hard in the soil with heavy mechanical content, while normally developed tubers and an abundance of flowers are available only in the sandy soil. If there are dry climatic conditions, tuberose can also be efficient on average clay soil.[7;15.]

Ajara littoral is distinguished by a humid subtropical climate, totally different from the soil and climatic conditions of common spreading areas of tuberose.

Because tuberose is brought in new environmental conditions, it is interesting to compare the natural conditions of Ajara Black Sea littoral to Mexico.

Ajara lies between the latitudes 41° 26' and 41° 51' N and longitudes 41° 32' and 41° 26 E.', while Mexico is located between latitudes 32° 43 ' and 14° 33' N and longitudes 117° 08' and 86° 42' W. Comparable objects are quite different from each other in terms of their latitude locations and reliefs. Mexico lies in tropical and subtropical zones and 50% of its territory, which is mostly populated and used for agriculture, is located 1000m above sea level. However, Ajara Black Sea littoral, in particular, Batumi Botanical garden is located 0-220 m above the sea level, where the plants with different geographical origins are introduced to. Comparing the annual average index of climatic elements of Mexico and the subtropical zone of Ajara reveals a striking contrast between the said zones. For instance, the annual average air temperature of Ajara littoral is 14,4° (Batumi), while in the lowlands and Southern parts of Mexico it reaches 23,8 – 25,7° (La Paz, Mansalo). The temperature falls to 14-15° only in the highlands of the Northern part of Mexico (Namacuina, Capapea) and gets closer to the annual average temperature of Batumi. The annual amplitude of temperature fluctuation is less in central and southern parts of Mexico than in Batumi, but much more in the Northern Mountains. Thus, highlands, lowlands, and southern parts of Mexico are characterized by hotter summer and quite milder winter than Ajara littoral. Regarding mountains and plateaus of northern Mexico, summer is hot here too, although winter is much stricter than in Batumi. There is a specific situation about soils. Most territory of Mexico is covered with deserts and valleys, brown, black earth, and tropical wetland soils, although these types of soils are not available in Ajara subtropical zone at all. They share only red earth soil.[3]

To be more specific, the Batumi Botanical Garden (BBG) is located 0-220 m above the sea level and includes all relief elements typical for Ajara coastal areas facing the front slopes. These zones are characterized by excessively humid and warm subtropical climate. The thermal regime of the coast is determined by its geographical location. In particular, the garden is protected by mountains around its three sides, separated from the Black Sea, etc. Air temperature fluctuation in the BBG is not dramatic, yearly average amplitude is 14-15°C. According to seasons, temperature data is as follows: average autumn temperature is 15,5-16°C, -7-8°C in winter, and 21-22°C in summer. The average multiannual temperature for the coldest month, January is

6,5°C and the hottest months (July-August) - 22,2°C; absolute minimum is -9°C, while absolute maximum reaches 39,9°C.[3]

Average multiannual precipitation approaches 2620 mm. In several years it exceeds 3000 mm. Its seasonal sum is 408 mm. The maximum daily precipitation reaches 200 mm in autumn for certain years; relative humidity of air is 80-82%.79-82% is the maximum for the Autumn and Summer and the minimum for winter approaches 69-73%.[3]

Micro and meso forms of reliefs within the borders of the BBG and in the vicinities are formed on lateritic (rusty-red) weathering crust. However, certain areas of the garden are extremely different in terms of soil and climatic peculiarities. [3]

During the last 5 years, a bit stricter winter was recorded in 2016 and ongoing 2020, not typical for Ajara littoral, in particular, for the Batumi Botanical Garden. The absolute minimum temperature was -1.9^{0}C in January, in 2016, and for the current year, it fell to -4,7-6^{0}C in the 2nd decade of February. Moreover, in certain places of the littoral even -10-14^{0}C was confirmed. The average monthly precipitation was extremely high in March, July, August, September, October, and December, in 2018-2019, fluctuating between 100,9 mm- 388,5mm. Average relative humidity reaching 86-96 %, which is quite a high amount, was revealed in March, May, June-July, August, and October, in 2017-2019, while in the other months it achieved 79-82 %.

For studying the adaptation to new environmental conditions and growth and development peculiarities, three plants from four shoots of tuberose received in the orangery were placed in the open ground. The last one was left in the conditions of closed ground for comparison. The plant flowered in August-September in open as well as closed ground for its first year (Fig. no. 2).

Figure No. 2: Flowering of tuberose in the conditions of closed ground

After the flowering stem got withered in November-December, some tubers with child tubers were extracted and kept in dry conditions, while the others were left in the open ground. Winter frost in 2017 did not damage the tubers, as young shoots appeared again in May and the plant started to develop. Tubers kept in dry conditions were planted in April. The development of the plants from the tubers left in the open ground was more active than the ones from the kept tubers, revealing poor flowering quality too.

Since 2018, for better studying the development of tuberose, tubers, which developed child tubers in the previous two years, have been placed in seven different locations with various expositions and soil conditions of different phytogeographical sections of the garden. These sections are East Asian, Himalayan, Australian, Mediterranean (European), North American sections, central park, and experimental plot.

In all locations, the plant was placed in 15-20 cm deep and 20 cm diameter pits added to substrate peat: perlite: ground with the ratio - 1:1:1. Considering literature data, hardwood plant surroundings and the degree of their phytoncidic activity was carefully observed, as phytoncides are extremely important for improving the air quality and preventing the development of pathogen microorganisms.

Location № 1 lies on the Central Park territory. *Hamamelis mollis, Loropetalum chinense, Myrtus communis, Eucalyptus viminalis, Eucalyptus cinerea*create the habitat around. All of them are plants with high microbial activity.[8-12.]

Location № 2 is situated in the Australian floristic department. *Laurocerasus officinalis, Eucalyptus cinerea*, *Hakea saligna*, *Abelia grandiflora*, *and Aucuba japonica* create the habitat around. Cherry laurel, eucalyptus, and abelia are distinguished by enough high antimicrobial activity.[8-12.]

Location № 3 can be found in the Himalayanfloristic department, in the habitat of pine trees: *Pinus massoniana*, *Pinus pinaster*, *Pinus pallasiana*, *Vaccinium Arctostaphylos*, *Styrax yaponica.* Pine trees are a well-known environment for improving coniferous plants.

Location № 4 is positioned in the East Asian floristic department. The following plants create the habitat: *Parrotiopsis jacquemontii*, *Corylopsis veitchiana*, *Mahonia lomariifolia.* All three species share high antimicrobial activities. [8-12.]

Location № 5 can be found in the North American floristic department. The habitat is created by the group of *Hamamelis Virginians*, also *Pinus taeda*, *Pinus sylvestris*, *Crataegus macrosperma var. Pastorum*, *Crataegus lucorum*, *Crataegus pringlei*, *Catalpa bignonioides*. Hamamelis and pine trees possess strong antimicrobial activities.[8-12.]

Location № 6 lies in European floristic department. *Parrotia persica*, *Cerasus avium* create the habitat around. Iranian ironwood is distinguished by high phytoncidicity. [8-12.]

Confirmed by literature data, bio preparations are considerably beneficial for the growth and development process of tuberose. Therefore, we applied for the bio preparation called GeoHumate. It is 100% natural preparation, special liquid humic fertilizer for active growth and development of the plant, distinguished by high penetrability in the soil without the risk of phytotoxicity. Physical and chemical composition of the biofertilizer is the following: 12% liquid; a fraction of total mass of the organic compound, not less than 12.5% including humic acid, not less than 34%, fulvic and other organic acids reach not less than 25%; a fraction of total mass of a mineral compound is not less than 1.0% including a fraction of total mass of macroelements: $N \geq 1,2\%$, $P_2O_5 \geq 0,55\%$, $K_2O \leq 16,5$, $CaO \geq 0,56\%$, $S < 2,1\%$, $MgO \leq 0,32\%$, $Fe_2O_5 \leq 0,5\%$. Fraction of total mass of microelements: $ZnSO_4 \leq 0,41\%$, $CuSO_4 \leq 0,08\%$, $MnSO_4 \leq 0,08\%$, $CoSO_4 \leq 0,03\%$, $(NH_4)_2MoO_4 \leq 0,7\%$, $H_3BO_4 \leq 0,3\%$, $KIO_3 \leq 0,03\%$.

20 ml bio preparation was diluted in 5 l water; tuberose was watered in the morning hours, in three different locations: experimental plot, phytogeographical departments of East Asia and North America, as the soil of the said locations seemed scantier than the rest of the locations. Watering was done every third day.

Based on phonological observations conducted in 2019, it was identified, that flowering stem was developed only in the locations of the experimental plot and East Asian section, in the second decade of July. The massive flowering period started in the third decade of August. The first decade of September was a period of decreased flowering; the flowering period was finished in the third decade. Flowering stems appeared again in the 1st decade of November, on the territory of the experimental plot. Massive flowering started in the 3rd decade of November and finished in the 3rd decade of December. The flowering stem was 85-93 cm tall. The first blooming period was longer than the second one. Its blooming period was finished earlier in the East Asian section than in the experimental plot; at the end of August, the flowering period was fully finished. The flowering stem was 45-49 cm tall.

Following 2020 observations, tuberose developed multiple child tubers underground in the 2nd decade of January, in the experimental plot and all locations. Its aboveground part appeared in the 2nd decade of May reaching 5-15 cm in the 3rd decade of May. The shoots were best visible in the experimental plot, central park, and East Asian section. The flowering stems were well-developed in the experimental plot, at the end of July –beginning of August. Massive flowering started at the end of August. The main distinguishing points of the flowering period of tuberose compared to the other years were multiple catkins on the flowering stem as well as its typical subtle, sweet, strong aroma that could be smelled for the first time (Fig. no. 3). East Asian phytogeographical section was noted as the location with less flowering quality, while in the other locations, flowering stems appeared difficult to develop.

While blooming, a spike-shaped catkin is developed on the top of a flowering stem of tuberose containing about 10-40 flower buds. Tubular flowers are 50 mm wide and 60 mm long. Pinkish smooth and dense crown petals have sharp tops. Buds are gradually opened, ones located at the bottom of the catkin are first to open. They stay open during 3-4 days, then finish flowering and the other buds start to open; the flowering period continues for a long period, during 2-3 months and more. At the place of the shriveled flower, there are developed box-type oblong, oval-shaped fruit-like formations. However, at this stage, it is impossible to develop the seeds in the conditions of the Batumi Botanical Garden. Therefore, only vegetative propagation is available with the help of fresh child tubers.

We planted the tubers with conical shapes; their surfaces are covered with dense, brown scales, 50-60 mm in diameter. Based on our observations, the lifespan of tubers includes up to 2 years – after the processes of their germination, stem development, leafing, bud development, flowering, end of flowering, and withering of above-ground organs, child tubers start to develop; the same cycle is repeated for the next year and the third year, the lifespan of the main tuber is finished and child tubers are used for planting materials.

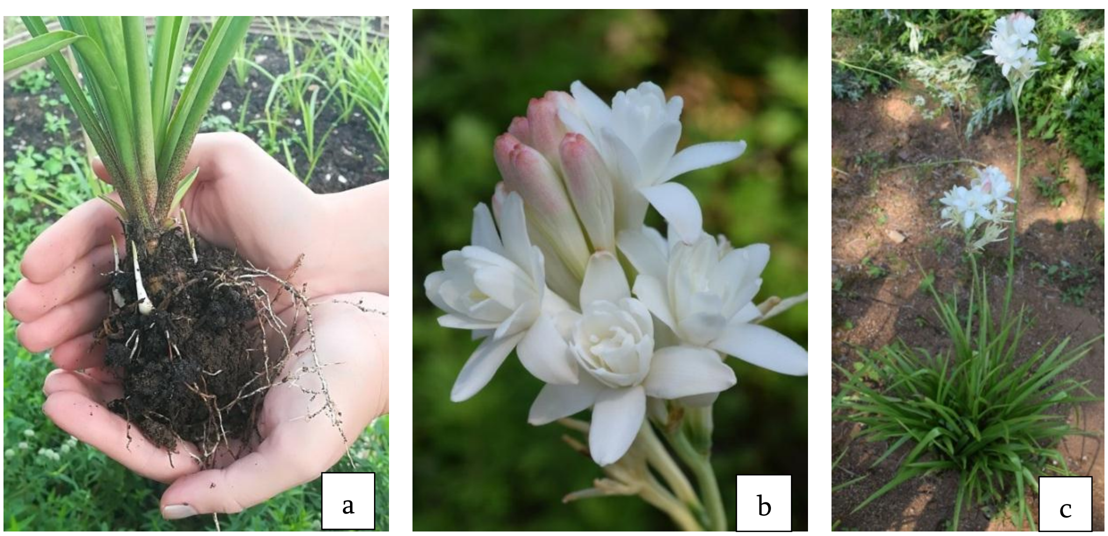

Figure No. 3: Tuberose in the BBG: a) plant with child tubers; b) multiple catkins; c) tuberose flowering on the experimental plot

The best development (flowering) of tuberose was revealed in inclined, dry slopes of East Asian department, on fertile soils and experimental plot, which, in terms of the content of trace elements, does not differ much. We believe that the experimental plot is located in a more open, vaster territory with plenty of sunlight than the other locations. Moreover, no shade from the other plants is one of the crucial factors along with using the bio preparation GeoHumite rich in organic and mineral substances, which appear helpful for plant growth and development. The instruction also mentions that the said bio reparation protects the plant against harmful diseases.

Harmful diseases of tuberose are often mentioned in literature. Some pests are affecting the culture. These pests are *Thysanoptera* and *Red spider – Tetrahychus*, controlling them is possible with insecticides. In recent years, the manufacturers in Mexico have noticed that some damages are caused by *Scyphophorus acupunctures*. *Fusarium oxysporium*is has known among the fungi diseases of tuberose causing considerable loss of yield.[15] Any pests or diseases were not detected on our research objects that might be conditioned by the surrounding of phytoncidic plants and the positive effect of bio preparations.

CONCLUSION

Based on the studies of bioecological characteristics of growth and development as well as the introduction of *Polianthes tuberosa* L. in the conditions of an open and closed ground of the Batumi Botanical Garden, it can be concluded, that tuberose gets on quite well with soil and climatic conditions of Batumi Botanical Garden. It was identified, that tuberose completes the full cycle of growth and flowering if plenty of sunlight and fertile soil is available in the locations. Moreover, its growth and development processes are significantly improved while using liquid humic bio preparations containing mineral and organic substances. Locations surrounded by hardwood plants with high antimicrobial activities, condition healthy growings free from harmful diseases.

Above-ground growth and development cycle of tuberose in the conditions of the Batumi Botanical Garden covers the period from May including December. In winter, frosty weather has no dramatic influence on the tubers left in the soil. Vegetative propagation of locally received plants is possible with the help of multiple child tubers developed during the vegetation process, while generative propagation is impossible due to poor development quality of seeds. Based on 4-year research on the growth and development of tuberose, carried out in humid subtropical climatic conditions of the Batumi Botanical Garden, it can be concluded, that successful introduction of tuberose using green technologies is possible in the soil and climatic conditions of the BBG. According to further researches, it will be possible to develop recommendations on growing Polianthestuberosa L. for industrial purposes in the humid subtropical conditions of Ajara.

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