

The Current State and Prospects of Perennial and Annual Flower Plants Selective Breeding and Introduction Development

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ABSTRACT

The main features of hybridization and selection of perennial and annual flower plants on the example of a *Gladiolus hybridus hort.* and annual asters (*Callistephus chinensis (L.) Nees*) are presented. The sources of valuable decorative, economic, and biological qualities recommended for further selection are described. The main directions of gladiolus and annual aster selective breeding are specified.

Key words: Selection, Hybridization, Gladiolus, Aster, Source.

INTRODUCTION

The selection and introduction of ornamental plants are the main ways to expand the existing varieties and enrichment of their genotypes owing to the new sources of valuable economic and biological properties. Since the ancient times, people have tried to enrich the existing flora of a particular region by the introduction and acclimatization of imported plants. Thus, a huge flow of introduced plants, including ornamental ones, rushing to Europe after the discovery of the Americas by Christopher Columbus could be a good example. The selection of flower plants was carried out in Europe long before the disclosure of its scientific bases. Particularly active breeding experiments were conducted in the Netherlands. In the XIX century numerous varieties of hyacinths and tulips were already obtained there. A great success in breeding have been achieved in the world as well as in our country during the second half of the XX century, due to the development of the science based on a growing desire of humans for aesthetical enrichment of the environment.

The necessary initial stages of breeding are hybridization and selection. The particularities

of these stages for perennial ornamental plants will be studied on an example of gladiolus hybrid and annual aster as an example of annual plants.

The preparatory stage of hybridization is a selection of parental pairs with a detailed study and evaluation of individual parental features. At the same time it is important to remember that the source of valuable economic and biological characteristics could be the existing varieties or hybrids with a complex of following qualities:

- High coefficient of vegetative propagation (for perennials) or high seed production (for annuals);
- Early and continuous flowering;
- Valuable decorative qualities (a large number of flowers or inflorescences per plant; a beautiful corrugation of flowers (gladiolus); an interesting form of a flower or inflorescence, etc.);
- Resistance to pests and diseases as well as many other qualities.

In 2007 the breeders of gladiolus and annual asters from Michurinsk (Kuzichev B.A., Kuzicheva O.A., and Kuzichev O.B.) clearly

identified the main sources of valuable economic and biological qualities of these plants. Their decision was based on a long-term study of variety samples collection conducted since 1962 at the Michurin Research Institute of Horticulture. The research was initiated by Kireyeva M.F. and continued by Ustinskova L.B. and the Kuzichevs. The sources of valuable economic and biological properties recommended for further gladiolus and annual asters breeding are presented in Tables 1 and 2.

While selecting the parental pairs, it is important to consider not only decorative and economically valuable qualities, but also the particular biological features of the plant. For example, it is necessary to know the time of ripening the stigma and readiness of pollen to fertilization. The ease of pollination is determined by the size of flowers, stamens and pistils, and the degree of openness of the flower. Single large flowers are convenient for pollination due to their well-defined stamens and pistils (gladiolus, lilies, iris, etc.).

In order to study the peculiarities of perennial flowering plants hybridization and selection, the gladiolus hybrid was chosen as an example.

Hybridization of gladiolus

A breeder must define in advance the varieties which will be used as the parent plants. The anthers used for pollination should be gently pulled out of the filaments of the parental plant with tweezers. Afterwards they either could be used directly or placed in any kind of package (the box of matches) until pollination, seeing that the maturation of anthers and stigma pistils of majority of varieties occurs at different time. After removing the anthers (castration) the flowers or even the whole inflorescences are getting covered by the linen bags that prevent natural pollination of flowers by insects. The date of the castration should be written on the label placed inside the bag or fasten by string fixed to its base. This date will be an important indication of pollination period.

In order to initiate the pollination the anthers should be picked with tweezers, dissecting needle or fingers and placed towards the stigma

carefully avoiding any damages. However, the pollen must be applied abundantly to achieve a successful result of hybridization. The pollen can also be applied to the stigma with a dry finger. The movements should be gentle: from the match box towards the stigma of gladiolus. Before the next pollination the tweezers or the finger should be carefully wiped with a dry cloth in order to illuminate the pollen of the previous hybrid combination.

Usually only 3-5 lower gladiolus flowers in the inflorescence are getting pollinated. The upper flowers should be either removed or left for later pollination, when the stigma will be able to catch the pollen. After the end of pollination the flowers should be isolated from insects by linen bags of the correct length and width. The bag should be spacious, not to damage the generative organs of flowers. The isolation bags might be fixed by the labels containing the information about the hybrid combination, the date of pollination, the number of pollinated flowers (inflorescence). The name of maternal species should be placed first, and then the paternal one combined by the symbol of breeding (X). For example: "City of Kitezh X Laura, 21.08.07, 4 flowers". Moreover, the records are done to a special journal of hybridization, indicating the crossing combinations, castration and pollination date, time of pollination, air temperature and weather conditions, as well as the other necessary information.

In case of successful pistil's fertilization, the germ of gladiolus increases significantly in size to form the fruits (bolls).

There are the other features indirectly indicating the pollination. For example, the gladiolus flower petals do not dry up longer if the pistil's pollination did not occur; while the petals of pollinated flower wither and fall off within a short time.

The selection and evaluation of promising gladiolus seedlings

In order to provide the breeding and the selection of examples of vegetatively propagated (perennial) plants with the best decorative and agronomic qualities, the seed propagation is used. While the vegetative propagation (rhizomes, bulbs,

tubers, and etc.) is used in order to maintain certain varietal qualities. For example, the maintaining of gladiolus varietal purity and reproduction is implemented by the cormlets reproduction.

The selection of gladiolus hybrid seedlings for decorative qualities is usually carried out during the period of mass flowering of the hybrid family. It is also important that the selective hybrid seedling is resistant to pests and diseases, as well as to adverse weather conditions. The selection

based on the coefficient of vegetative propagation is done during the digging by counting the number of cormlets per corm. It is very important to take into account the fact that the hybrid should also have decorative qualities. The accessions marked by a good multiplication factor level can be used as a source of this trait for further gladiolus selection.

The selected gladiolus seedling should be marked with the label, fixed to the stem. The label should contain the following information: the

Table. 1: The sources for further gladiolus breeding

Feature desired for transition	Name of the variety, hybrid
Complex of decorative features	Blue Jam, Queen Estrada, Russian woman, Sudarushka, Tatiana's Day, High style, Yuri Nikulin, 19-07
High growth	Scarlet Dawn, Blue Jam, Queen Estrada, Raspberry Powerful, Tenderness, beacon lights, Olympic Fire, Roman, Spartan, Sudarushka, Tatiana's Day, High style, 56-07, Snow Fantasy
Moderate growth and a small ear	Iceland, Divinity, New Gold, Blue Bird, 23-07, 57-07, 58-07
Early flowering	Iceland, Scarlet Dawn, Velvet, White Sail, Volga Dali, Galina, Izaura, Carnival, Mary, Tenderness, Commander, Blue Bird, Fun Time, 30-93, 169-0, 209-2, 6-07, 10-07, 14-07, 15-07, 16-07, 17-07, 18-07, 22-07, 23-07, 28-07
Giant flower	Volga Dali, Izaura, Raspberry Powerful, Roman, Typhoon (selection of Michurin Research Institute of Horticulture), High style, 32-06, Lyudmila
Feature desired for transition	Name of the variety, hybrid
Miniature flower	Early morning (selection of Michurin Research Institute of Horticulture), Mountain Glade, Maria, Olympic Fire, Blue Bird, Fan Time, Heritage, Purple Dwarf
A large number of buds in the ear	Izaura, Tenderness, Spartan, Sudarushka, High style, 19-07, 22-07, 28-07
A large number of simultaneously open flowers and buds	Velvet, girlish tears, Divinity, Izaura Queen Estrada, Russian woman, Sudarushka, High style, Yuri Nikulin
The original color of the flower and color purity	Iceland, Arkasha, Ballet on Ice, Velvet, White Bear, City of Kitez, Divinity, Izaura, Winter Cherry, Kashtanka Queen Estrada, Raspberry Tent, New Gold, Lights Lighthouse, Olympic Fire, Roman, Blue Bird, Sudarushka, Fun Time, Crane, The Little Mermaid, The Cherry Orchard
Super corrugating flower petals	City of Kitez, Divinity, Golden Beehive, Starfish, Tenderness, Ruby Spike, 52-07, 55-07, 75-07, 92-07, Bambino, Coral Reef, Die Hard
Large multiplication factor	Blue Gem, Burnt by the Sun, Lyudmila, Beacon Lights, Snow Fantasy, Candy, 7-06, 70-07, 100-07
Resistance to adverse factors	Ballet on Ice, a great temptation, Volga Dali Golden Hive, Purple Dwarf, Laura, beauty, Dewdrop
Shape, color of corms	White Splendor, Jungle Flower, Laura, Lyudmila, Firstborn, Commander, Romance, Ruby Ear, Blue Bird, Lilac Evening

number and the year of selected seedlings release, the name of a hybrid family in parentheses, for example, "5-012 (23 x 15)." This record means: the selected hybrid seedling was the fifth; it was selected in 2012 from a family 23 x 15. The numbers 23 and 15 correspond to the notes written in the journal of hybridization, indicating maternal and paternal plants. Then the breeder indicates in another special register the number of seedlings, its detailed description, its location on the plot, and the name of the hybrid family. If the inflorescence of the selective seedling was cut, the label should be tied close to the soil in order to avoid losing it while digging. When digging corms and cormlets of selected seedlings all of them should be collected including the smallest ones, because they also are the valuable breeding material. It is important not to commingle the corms and cormlets of other gladiolus cultivar.

During the first years of selected hybrid seedlings growing the detailed study should be realized. The phenological observation data, the measurements of biometric indicators as well as the decorative qualities of the selected hybrid seedlings should be written in the descriptive

register. Annually, the testing of selected plants concordance to the particular variety characteristic features is organized. All the atypical and diseased plants must be removed. The impurities should be labeled and placed in separate containers. The diseased plants should be removed out of the plot; usually they are burn down.

The evaluation process of the best decorative and agronomic qualities of selected gladiolus hybrid seedlings lasts during 3-5 years. When it is finished it is possible to start the determination of the elite ones. To provide the further studies of these elite seedlings they are transmitted to the system of State Variety Testing. There the certificates of authorship and patents are issued.

Current state and prospects of gladiolus breeding

The significant success in gladiolus hybrid breeding is achieved worldwide during the last 3-4 decades. Despite the fact that breeders have already obtained numerous varieties, the selection work does not decay; it is conducted with great interest and enthusiasm in many countries around the world.

Table. 2: The sources for further annual aster breeding

Feature desired for transition	Name of the variety, hybrid
Complex of decorative features	Gray-haired lady, the Blue Lady, Thumbelina, morning mist, Cleopatra, the Marmara Sea, Night Star, Memory
High growth (peduncle length > 50 cm)	Elegy, Alina, Fire Pearl, Cloud, Suliko
Fillets form	Petito Rubinrot, Petite Raspberry, Baby, Oktyabrina, White Stork
Early flowering	Star Magic, Yabluneva, Oktiabrina, Princess yellow, Omega
Giant inflorescence size (diameter inflorescence > 10 cm)	Elegy, Blue Magnet, Alina, Assol, Arisha, Apple blooming
Miniature inflorescence (bush form, inflorescence diameter < 6 cm)	Golden Autumn, Alenka, Anastasia, Granddaughter, Othello, White Balloon, Red Beads
Great number of inflorescences (5 inflorescences per bush)	Svetlana, Alina, The cloud, Nata, Isadora, Star Magic, Snow White, Fire Pearl
Original coloring of inflorescence	Gray-haired lady, the Blue Lady, Arish, Anastasia, Naina, Morning Freshness (39-04)
Fuzziness of inflorescence	Elegy, Cleopatra, Alina, Blue Magnet, Assol, Olenka
High seed production (more than 2 g of seeds from bush)	Star Magic, Ruby Star, Assol, Baby, Alenka
Feature desired for transition	Name of the variety, hybrid
Resistance to adverse conditions	Gray-haired lady, Pink pearl, Blue-eyed, Alina, Svetlana, Yesenia

Nowadays the most important gladiolus breeding directions are:

1. Creation of early flowering period varieties;
2. Determination the plants with a long flowering;
3. Identification of the plants with high grades gracious ear, consisting of a large number of simultaneously open flowers (10-12 or more);
4. Selection of the gladiolus variety with bright clean color of flowers;
5. Creation of original color varieties, with beautiful, elegant spots, strokes, circles, diamond shapes on the lower lobes of the perianth.
6. Determination of the varieties with large flowers for cutting; at the same time the small flowers varieties are also popular in the compositions or the flower beds;
7. Reception of the cultivars with fine corrugation and folding of perianth segments;
8. Selection of the varieties of the high vegetative propagation;
9. Creation of the varieties resistant to abiotic and biotic stress factors (adverse weather conditions, pests, diseases, etc.);
10. Identification of the gladiolus varieties with a pleasant aroma.

The research work of gladiolus introduction in the Michurin Research Institute of Horticulture was launched by famous scientists: M.F. Kireyeva and L.B. Ustinskova. Afterwards it was continued and currently (since 1992) it is being implemented in collaboration with the selection research in Michurinsk by Kuzichev B.A., Kuzicheva O.A., and Kuzichev O.B.

Based on a complex study of introduced new varieties of gladiolus, the gladiolus breeders from Michurinsk have identified the sources for the further breeding based on 13 desirable features (Table 1).

Among mentioned varieties and hybrids, varieties with a high multiplication factor, such as Lyudmila, Beacon Lights and Snow Fantasy are recommended for further breeding. Good

vegetative productivity of these varieties is also combined with high decorative properties. This fact could be used when providing the new level of features selection.

The seed production of gladiolus depends on the weather conditions during pollination and seed formation periods. During the breeding research years the relatively high air temperature (above + 25 ... + 27 ° C) had the negative impact to the yield of seeds. The success of hybridization also depends on the selection of partners and their genotypes.

In addition to the study of seed production, the breeders also conduct the research about the influence of maternal or paternal genotypes on the results of crosses.

Comparative study of new Michurinsk varieties and introduced accessions on the decorative qualities, resistance to stress factors in the soil and during storage, proved the domination of the local ones.

The selection of hybrid seedlings with valuable economic and biological characteristics out of variety samples collections is annually provided. The best hybrid seedlings are selected to the elite if they satisfy all the requirements. Elite seedlings are regularly transmitted to the system of State Variety Testing with further issuing of the certificates of authorship and patents.

Hybridization and selection of the annual flower plants (the example is Aster annual)

The main difference in between Aster annual and Gladioli is significantly smaller size of their inflorescences. This peculiarity makes artificial pollination as well as directed hybridization impossible. Aster flowers are pollinated only by natural means, by insects. The breeder only selects the best specimens in the collection and stores them in subsequent generations. Despite this, it is possible to increase the probability of desired hybridization, by planting the sourcing varieties plants at the same area (plot).

Elite seed production is the basis for the cultivation of varieties of annual crops using a seed-

propagated way.

The first step is the selection of super-elite. The aster super-elite are the seed obtained from the best plants specimens with typicality high complex of biological and agronomic features, specific for the certain variety.

The seed propagation of super-elite ensures the production of elite seeds. Elite seeds are characterized by the complex of qualities, such as: a great varietal purity and germination; a well matured; an equal size.

The maintain and enhance of the aster elite seeds varietal characteristics are achieved in the following ways:

- Selection of the best plants;
- Compliance of the spatial isolation (not less than 5-6 m) between adjacent plants of different varieties (to prevent intravarietal hybridization);
- Growing of seed on good quality agricultural background;
- Realization of systematic cleanings (on the level of species and variety; as well as for sanitary purposes);
- High quality seeds cleaning and sorting from the impurities;
- Use of seeds with high varietal and sowing characteristics for further propagation.

Elite seeds are used for the future seed sowing, respecting annually the basic rules of varietal purity.

Current state and prospects of annual aster breeding

Nowadays the active selection research about annual aster is organized in the following countries: Russia, Denmark, the Netherlands, France, Germany, Poland, Sweden, the Czech Republic, the USA, Japan and some other countries.

In our country the selection of annual aster is carried out starting from the 20s of XX century. The acceleration of the research was observed in the 60s. In the 60-80s, until the collapse of the

USSR, the aster seeding selection research was actively conducted in Russia, Ukraine, and Moldova.

Currently the leading research center of annual aster selection and elite seeding is Voronezh Vegetable Growing Experimental Station of Russian Research Institute of vegetable growing. And one of the most known annual aster breeders is G.V. Ostryakova working there since 1963. During the years of her professional life G.V. Ostryakova and her students have created more than 50 varieties of annual aster. For example, the most outstanding aster varieties created by G.V. Ostryakova are: Zephyr, Galina, Bride, Glow, Havsky Bouquet, Havskaya Serebristaya, Eurasia, Blue Rime, and etc. Ostryakova G.V. has also elaborated the schemes of annual aster breeding process and its elite seeding.

The research of introduction, selection, and species identification of annual aster are also conducted in the Michurin Research Institute of Horticulture since 1964. The research was initiated by M.F. Kireyeva and continued by L.B. Ustinskova and O.A. Kuzicheva. Michurinsk breeders have created numerous varieties, for example: Lada, Snow White, Katyusha, Nata, and many others. The asters created in Michurinsk are full, their inflorescences have the original colors and shapes, and they are resistant to various diseases.

The most important directions of annual aster breeding, according to Voronezh and Michurinsk breeders, are the following ones:

1. Creation of the varieties adapted to mechanized cultivation or those which productivity would not change while decreasing manual labor efforts. These varieties should have a strong compact bush and should bloom simultaneously;
2. Breeding new early flowering varieties of annual aster based on the Voronezh and Michurinsk cultivars;
3. Obtaining the new varieties adapted for cutting down with strong, almost leafless peduncles;
4. Determined selection of the cultivars having new colors and more compact shrub of

- columnar shape, such as the Star Magic cultivar;
5. Creation of the varieties with blue and salmon-pink inflorescences;
 6. Selection of the varieties with bright, clean, saturated colors of inflorescence;
 7. Breeding the varieties with an unusual shape and coloring of tubular flowers;
 8. Selection of the varieties with two-tone colors and previously unknown or rare form of ray flowers (such as: Cleopatra and Michurinsk Krujeva, the varieties of Michurinsk selection);
 9. Creating the varieties with large inflorescence (such as cultivar Michurinsk Claws - 20 cm and more).
 10. Obtaining new fuzzy annual aster varieties resistant to fusarium, the one of the most damaging diseases;
 11. Breeding new varieties of bouquet shape with buds located in the same platitude (for example, Michurinsk selection variety Pauline).
- Michurinsk breeders have determined the most important sources of economic and biological characteristics for further annual aster breeding. The sources are presented in the Table 2.

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