Ecological methods of protecting bearded irises in the urban environment

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Abstract. The article presents data from a long-term phytopathological survey of a collection of varieties Iris x hybrida Hort. Main Botanical Garden named after N.V. Tsitsin RAS (Moscow). Data on diseases of bearded irises in the urban environment were obtained, changes in the composition of the fungal complex in the rhizo- and phyllosphere were studied. Low soil fertility during the adaptation period of bearded irises worsens the formation and development of the root system of plants, increases the likelihood of increased disease damage and premature leaf fall. The experience of successful establishment of cultivators Iris x hybrida with the use of complex preventive and health-improving measures to improve fertility and reduce stress factors has been obtained. It was found that the introduction of NPK-complex, etching with a biofungicide based on phytobacteriomycin, and spraying vegetative plants with a microbiological preparation based on saprophytic antagonist fungi and bacteria within two years from the moment of transplanting varieties of garden bearded irises have a positive effect on their survival rate and decorative effect. The use of biological fungicides in combination with a complex of fertilizers is mandatory in a pesticide-free protection system for garden iris varieties sensitive to mycoses.

1. Introduction

In the composition of the modern assortment of cultivated representatives of the genus Iris L., a significant part of the varieties belongs to the garden class Bearded Irises, which are distinguished by increased requirements for cultivation conditions. Minimal violations of agricultural technology, adverse weather conditions can lead to the development of non-infectious and infectious diseases. The most harmful and widespread are fungal and bacterial infections, which are often found in mixed form and have similar symptoms of damage on leaves, stems, buds, flowers, and rhizomes [1]. More often than other diseases, one can find lesions of irises by heterosporiosis, gray mold, ascochitosis, alternaria, fusarium and verticillosis, as well as bacterial pathogens from the genera Pseudomonas and Erwinia [1, 2].

In urban conditions, taking into account the restrictions of chemical treatments and recommended pesticides, officially permitted methods of plant protection are mainly reduced to a complex of agrotechnical measures. In the urban environment, they influence the passage of the development cycles of living organisms, and, consequently, the course of infectious processes, the formation of the
level of resistance in the host plant system [3]. A promising direction in this situation is the use of microbiological preparations with different mechanisms of action. But in the conditions of a rather aggressive urban environment, the question of the interaction of microorganisms that are part of biological preparations and aboriginal microorganisms requires a comprehensive study.

The article aims to evaluate the effectiveness of preventive and health-improving measures of Iris x hybridae Hort varieties from microbiological lesions in collection plantings in an urban environment.

2. Materials and methods

Phytomonitoring of the collection of garden irises was carried out in the period 2018-2020 on the territory of the laboratory of ornamental plants of the Main Botanical Garden named after N.V. Tsitsin under conditions of a rather aggressive urban environment, the question of the interaction of microorganisms that are part of biological preparations and aboriginal microorganisms requires a comprehensive study.

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different objects (N) were carried out; the effectiveness of the measures taken for the reaction of plants was determined, incl. decorativeness (foliage, length of leaves) and the abundance of phytopathogens in the rhizosphere and phyllosphere.

3. Study of mycoses of garden irises and changes in the composition of the mushroom complex

According to the data of long-term phytomonitoring, the main factors were identified that worsen the growth conditions, affecting metabolic disorders in the cells and organs, and most importantly, on the decorativeness and viability of irises: non-infectious diseases of the plant caused by adverse effects of temperature, air or soil moisture, mineral nutrition, mechanical damage (rodents, molluscs, etc.); infectious diseases - damage by phytopathogens (fungi, bacteria, etc.).

Irices are mesophytic, grow successfully in dry habitats, but after planting during the rooting period, they are demanding moisture. We found that among non-communicable diseases, moisture deficit accounts for 16%, which is associated with the increased frequency of prolonged summer periods of drought in the Moscow agglomeration. The maximum risk is in the phenophase of flowering when irises have a high water requirement.

Light sandy soils with a neutral or slightly acidic reaction of the medium (pH = 5.5-6.8) are considered optimal for cultivating Iris x hybrida varieties. Light loamy soils are also acceptable [8-10]. According to the results of the physicochemical analysis of the soil, the collection site is characterized by a soil reaction (pH$_{water}$) in the range of 7.2, -7.5, i.e. higher than optimal level. The plot is of low fertility content of nitrate nitrogen less than 130 mg/kg, medium and high content of phosphorus (over 200 mg/kg); high and high potassium content (above 200 mg/kg); calcium deficiency (less than 30 mg/kg) and excess magnesium (above 350 mg/kg). These conditions during the survival period impair the growth of plants, for example, an excessive potassium content inhibits the formation of the root system, causing the weakening of the plant and the danger of premature leaf fall. The results of analysis of variance showed the significance of fertility in the infectious disease of iris plants (the contribution is 51±24% at p-level = 0.05 and Pearson’s factor - Pr=0.016).

By visual symptoms, infectious diseases were identified: heterosporiasis of irises (variety Honey Glazed, Yubileiny) - rounded-elongated spots were formed on the leaves, at first yellowish, then drying out light brown with a brown border, further drying, browning of the ends of the leaves and sporulation of the fungus, which was confirmed by mycological analysis of leaves and identified the causative agent Cladosporium iridis (Fautrey & Roum.) GA de Vries [= Helminthosporium gracile Wallr., Heterosporium iridis (Fautrey & Roum.) J.E. Jacques] with NW less than 10%.

Signs of gray rot (causative agent Botrytis cinerea Pers.) Were recorded - peduncles and leaf tips were affected, which first discolored, then turned brown, rotted, covered with a gray bloom of fungus sporulation. Symptoms of bacteriosis were noted - the ends of the leaves turned yellow and began to dry out; the browning spread to the central, growing leaves of the leaf bundle. Rot developed at the base of the leaf bundles and adjacent rhizome areas; accompanied by an unpleasant odor. Bacteria Erwinia Winslow et. al. and Pseudomonas Migula.

We have also identified dry rot on the roots and shoots that develops under the influence of the phytopathogen of the genera of Rhizopus Ehrenb (NW = 20-100%) and vascular wilting (genera of Verticillium Nees with NW = 10-40 %), red-brown spots on the roots and dark brown spots on the root collar (genera of Pythium Pringsh with NW = 20-40 %).

Differences in the composition of the mushroom complex of different varieties of Iris x hybrida were established, taking into account the place of selection:

- soil from the root zone - Acremonium, Actinomucor Schostak., Alternaria. Arthographis, Aspergillus, Botrytis, Chaetomium, Clonostachys, Colletotrichum, Cunninghamella, Curvularia, Fusarium, Geotrichium, Heterosporium, Humicola, Macrosporium, Mucor, Nigrospora, Penicillium, Pestalotiopsis, Phellinus, Pellicillum, Pestalotiopsis, Phellomona, Pusarium
- the rhizosphere (roots) - Acremonium, Actinomucor, Alternaria, Aspergillus, Chaetomium, Clonostachys, Colletotrichum, Cunninghamella, Fusarium, Heterosporium, Humicola, Penicillium, Plectosporium, Pythium, Rhizoctonia, Rhizopus,
Russian Winter, and Henry Shaw), fungi of the phylloplan (leaves, flowers) - Alternaria, Aspergillus, Cladosporium, Colletotrichum, Fusarium, Heterosporium, Penicillium, Rhizopus.

In different years of observation, the diversity of micromycetes varied within 13-20 genera in the soil, 4-12 genera in the rhizosphere, and 2-7 genera in the phylloplan. The results of the correlation analysis confirmed the significant effect of the temperature factor on the growth of the number of fungi in the soil and on the elements of iris plants: in the rhizosphere ($r = 0.81$, $Pr = 0.007$) and in the phylloplan ($r = -0.83$, $Pr = 0.013$). In recent decades, there has been an increase in the recurrence of conditions - extreme high air temperatures and a shortage of soil moisture. The results obtained allow us to conclude about the manifestation of dangerous hydrometeorological phenomena - atmospheric drought, turning into soil drought.

A mycological effect was observed from the use of biological products based on a suspension of active strains of saprophytic fungi and super-parasites in the plantings of garden bearded irises. In samples from variant_B (iris varieties Red Zinger, Russian Winter, and Henry Shaw), fungi of the genera of Aspergillus, Clonostachys, Fusarium, Humicola, Pythium, Rhizopus were identified; variant_C (varieties of irises Honey Glazed, Yubileiny) - Clonostachys, Colletotrichum, Cunninghamella, Fusarium, Humicola, Rhizopus; variant_E (iris varieties Well Suited, Smitten Kitten, Ranger) - Acremonium, Actinomucor, Chaetomium, Fusarium, Humicola, Rhizopus.

Phytopathogens of the genera of Fusarium were distinguished by the highest species diversity in the structure of the fungal complex: F. section Discolor (NW less than 37%), F. solani (Mart.) Sacc. (32-55%), F.sambucinum Fuckel (24-30%), F.graminearum Schwabe (16-20%), F. dimerum Penz. (less than 30%), F. sporotrichioides Sherb. (less than 20%), Fusarium sp. (20-26%). According to the degree of infestation by mycosis, iris varieties that are highly sensitive to mycoses - Henry Shaw, Ranger and Honey Glazed and moderately sensitive - Smitten Kitten, Well Suited, were distinguished. Micromycetes of the genera of Fusarium differ in reaction in different experimental schemes (Figure 1).

The effect of the application of fertilizers and microbiological preparation (variant_E) reduced the abundance of fungi of the genera of Fusarium, including due to the complete suppression of the growth of some species, for example, the micromycete F. sporotrichioides. The maximum effect of inhibition in growth was observed for F. section Discolor and F. dimerum (NW less than 30%). Etching and spraying with biological fungicides well protected highly and medium sensitive varieties. For the resistant variety Yubileiny, there was no significant decrease in the abundance of phytopathogens.

Fungi of the genera of Alternaria, Aspergillus, Cladosporium, Fusarium, Heterosporium, Penicillium, Rhizopus were identified on the leaves in the control (variant_C); Heterosporium, Alternaria, Cladosporium, Fusarium, Colletotrichum - variant_E. Changes in the composition of the fungal complex on the leaves of irises of different varieties are statistically insignificant ($Pr > P$).

The response of plants to measures of ecologized plant protection was assessed by changes in the morphometric parameters of irises (table 1). In the first year of trials, the application of mineral fertilizer and etching with biofungicide had a positive effect on the growth and visual characteristics of the aboveground plant mass (decorativeness) in Iris x hybrida varieties at the stage of survival. An increase in foliage (the number of leaves per plant) of irises from the intake of:
- mineral fertilization and pickling - in 2018, on average, 97 % relative to the background (range 21-167 %, depending on varietal characteristics and belonging of cultivars to one or another garden group), in 2019 - 49 % (range 2-123 % depending on the biology of the variety and the garden class);
- mineral fertilization, dressing, and microbiological fertilization - in 2018 by an average of 76 % (range 34-133 % depending on varietal characteristics and belonging of cultivars to a particular garden group) and in 2019 - 72 % (range 17-178 % depending on varietal characteristics and belonging of cultivars to one or another garden group).

These results confirmed the data on the maximum length of leaves: variant_C - in the first year 99 (16-181) % and in the second - 76 (21-159) %; variant_E - in the first year 76 (58-119) % and in the second - 97 (62-145) %.

4
Figure 1. Representation genera of *Fusarium* in different systems of cultivation of garden irises (average over the years of observation).

A comparative analysis of the research results, taking into account the varietal characteristics, was carried out according to the proposed plant vegetation index ($I_v$) equal to the ratio of the length of leaves to the number of leaves per plant. High values of the $I_v$ index characterize plants with good decorative qualities and resistance to mycoses (Table 1).

Table 1. Ornamental parameters of iris plants in different years of observation

| Iris variety (group)   | Variant | $I_v$, 2018 | $I_v$, 2019 | $I_v$, 2020 | $I_v$, average±ST | Coefficient var., % |
|-----------------------|---------|------------|------------|------------|-------------------|-------------------|
| Well Suited (SDB)     | C       | 2.90       | 3.05       | 2.66       | 2.87±0.16         | 5.5               |
|                       | E       | 3.46       | 3.48       | 3.07       | 3.34±0.19         | 5.7               |
| Smitten Kitten (IB)   | C       | 5.10       | 5.04       | 7.65       | 5.93±1.21         | 20.5              |
|                       | E       | 4.94       | 4.92       | 7.44       | 5.76±1.18         | 20.5              |
| Honey Glazed (IB)     | C       | 4.47       | 4.59       | 5.29       | 4.79±0.36         | 7.6                |
|                       | E       | 4.54       | 4.27       | 6.13       | 4.98±0.82         | 16.5              |
| Yubeleyniy (TB)       | C       | 5.09       | 5.01       | 5.41       | 5.17±0.18         | 3.4               |
|                       | E       | 5.76       | 5.99       | 6.76       | 6.17±0.43         | 6.9               |
| Ranger(TB)            | C       | 4.76       | 4.55       | 7.16       | 5.51±1.18         | 21.6              |
|                       | E       | 5.59       | 5.89       | 6.78       | 6.08±0.50         | 8.3               |

Note: variant_C – control, variant_E – experiment, ST - standard deviation

The range of $I_v$ index values equal to 2.66-6.78 for iris plants in different years of observation was obtained. We conventionally accepted that if the value of the $I_v$ index is higher than 5.0, then the plant has a good decorative effect (a set of external signs: size, color of leaves, size of flowers, resistance to mycoses). A stable result was obtained using the variant_E for irises of the Ranger variety (medium sensitive), which confirms the low values of the coefficient of variation in different years of observation (8.3%), compared with the variant_C.
4. Conclusion
Phytomonitoring surveys of the collection of the genera Iris in the Main Botanical Garden of the Russian Academy of Sciences, which is represented by 8 species of iris, 3 garden forms, and 199 varieties, were carried out. We have accumulated long-term material on the spread of diseases on iris plants in an urban environment. According to phytomonitoring data, factors that reduce the decorativeness of plants are identified. These are biological agents (phytopathogens) - mycoses (up to 60%) and bacterioses (up to 30%), as well as non-infectious causes - lack of nutrients or soil trophicity (from 10 to 50% in different years of observation).

The composition of the mushroom complex on garden irises grown in urban conditions (in different years of observation - from 22 to 34 genera): Acremonium, Alternaria, Arthrographis, Aspergillus, Botrytis, Chaetomium Kunze, Cladosporium, Colonostachys Corda, Colletotrichum Corda, Cunninghamamella, Curvular Fusarium, Geotrichum, Heterosporium, Humicola, Macrosporium, Mucor, Nigrospora, Penicillium, Pestalotiopsis, Phoma, Plectosporium, Pythium, Rhizoctonia, Rhizopus, Stibella, Trichoderma, Verticillium.

It has been experimentally shown that good decorativeness of garden irises, especially cultivars sensitive to mycoses, is achieved by a set of techniques: the use of mineral fertilizers, dressing of rhizomes and the use of biological preparations within two years from the moment of transplanting Iris x hybrida varieties. The results obtained are important for plants when they enter the generative phase of development, especially in an aggressive urban environment.

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