Winter hardiness of *Iris barbatus* L. in the climatic conditions of the nonchernozem zone of Russia

G D Levko\(^1\)\(^*,\) V A Kharchenko\(^1\) and I T Ushakova\(^1\)

\(^1\) Federal Scientific Center for Vegetable Growing, 14 Seleksionnaya str., VNIISSOK Village 143080 Russia

E-mail: gennadylevko@yandex.ru

Abstract. The article presents a comparative analysis of such an important trait that is economically valuable for vegetative reproduction in the bearded iris as the degree of winter hardiness of rhizomes. Economic efficiency for the industrial production of planting material is also calculated. The degree of winter-hardness was determined by the ratio of the number of plants left before winter to the number of plants that grew up in early spring. As a result of research, 84 varieties of domestic and foreign selection were assessed, among which a total of four groups were identified with varying degrees of winter hardiness. Observations have shown that the irises of domestic breeding and time-tested foreign varieties, which have been cultivated for a long time in central Russia, are most resistant to overwintering. The economic efficiency of growing planting material was 144% per unit area (1 ha).

1. Introduction

Winter hardiness in rhizomatous perennial plants is an important sign of resistance to the complex of adverse wintering factors. Winter hardiness is the ability of plants to withstand the complex effects of the environment during the winter and early spring periods. This includes the following: an ability to resist spring burns, low temperatures, decay, soaking, an ability to withstand frequent temperature extremes. Bearded irises are ephemerals and xerophytes. They are the hybrids of frost-resistant irises of diploids, for example, *Iris Pallida*, and thermophilic tetraploids – these are Cypriot irises, from which they inherited genes and modifications that contribute to their frost resistance at low temperatures in the winter dormancy period. These are the dysmutase enzyme production genes that support lipid membrane fatty acids in an unsaturated state, which enables them to maintain their resistance to frost [1], [2], [3], [4].

Currently, the global range is more than 80,000 species, varieties and hybrids. Irises of domestic breeding and time-tested foreign varieties that have long been grown in the middle lane are the most winter hardy. For most irises, 30 cm of snow is sufficient protection from frost. The most vulnerable are the novelties of the world selection of high irises. The potential of their winter hardiness and methods of shelter have to be established empirically [5], [6]. Earlier experiments have found that varieties of bearded iris with a higher total content of antioxidants (overproduction) are winter hardy by 100%, and varieties of bearded iris with a reduced total content of antioxidants (deficient) have a decreased winter hardiness. Thus, the total content of antioxidants in rhizomes can serve as a potential marker of resistance to stress [7]. The purpose of the study is to assess the winter hardiness of the rhizomes of...
bearded iris during the first to third years of vegetation and to calculate the economic efficiency of growing.

2. Research Methodology
The degree of winter hardiness was determined by the ratio of the number of plants left before winter to the number of plants grown up in early spring (expressed as a percentage). All studied varieties were distributed in the following four groups with varying degrees of winter hardness: (1) not winter-hardy (0%), (2) poorly winter-hardy (up to 25% and from 26 to 50%), (3) moderately winter-hardy (51-75%) and (4) winter-hardy (from 75 to 95%, and more). Phenological observations were carried out according to the methodological recommendations [8]. Profitability was calculated as the ratio of costs to profit.

3. Results and Discussion
During the spring inspection, observations of the manifestation of such an important trait that is economically valuable for vegetative propagation in bearded iris as the degree of rhizomes' winter-hardiness were followed by plants planted in 2015, annually. As a rule, the regrowth of variety samples began at the end of April (from April 20 to April 30). So, 80 varieties (out of 84 varieties) that went through the winter in 2017 survived (i.e. 95%).

Of the varieties of foreign selection, 7% of them were not winter-resistant, 20% were poorly winter-resistant, 19% were moderately winter-resistant, and 34% were winter-resistant. In varieties of domestic breeding, in the four groups listed, the highest indicator was recorded in the group of winter-hardy varieties, constituting 56% (Fig. 1). On average, the overwintering percentage of domestic varieties was 72.9%, and 73.1% of foreign varieties (Table 1). Poorly winter-resistant plants among the Russian varieties turned out to be “K Yubileyu Ilicha” (22%), “Mehta” (40%), “Udacha” (33%). Not winter-resistant varieties of the foreign breeding were “Bay Fog,” “Cinnamon Girl,” “Satin Satan,” “Pink Romance,” “Royal Intrigue” (0% overwintering), and the “Henry Shaw” variety was poorly winter resistant (25%).

![Fig. 1. Distribution of variety samples of bearded domestic and foreign iris breed by winter-resistance groups.](image)

The variability of the “plants’ overwintering” characteristic for the entire set was significant (Cv = 42.7%), and it was 1.5 higher for foreign varieties than in domestic ones (Cv = 41.1% and 28.5%, respectively).
Table 1. The level of “overwintering” in bearded iris (2015-2018).

| No | Variety                        | Rhizomes wintered, % |
|----|--------------------------------|----------------------|
|    | **Domestic varieties**         |                      |
| 1  | Amethyst of VNISSOK            | 70                   |
| 2  | Belosnezhka                    | 80                   |
| 3  | Belyy of VNISSOK               | 50                   |
| 4  | Belyy Karlik                   | 70                   |
| 5  | Belyanchik                     | 100                  |
| 6  | Bordyurnyy Belyy               | 67                   |
| 7  | Bordyurnyy Siniy               | 90                   |
| 8  | Bordyurnyy Chernyy             | 80                   |
| 9  | Viktor Dryagin                 | 90                   |
| 10 | Gvardeyskiy                    | 78                   |
| 11 | Graf Tolstoy                   | 90                   |
| 12 | Drevniy Rim                    | 80                   |
| 13 | Zharok                         | 80                   |
| 14 | Irley                          | 89                   |
| 15 | K Yubileyu Ilica               | 22                   |
| 16 | Lunnaya Sonata                 | 100                  |
| 17 | Marshal Pokryshkin             | 100                  |
| 18 | Mehta                          | 40                   |
| 19 | Nadezhdy                       | 72                   |
| 20 | Olimpiyiskiy                   | 80                   |
| 21 | Pervenets                      | 50                   |
| 22 | Ryzhik                         | 64                   |
| 23 | Sirenevyy Venocheck            | 90                   |
| 24 | Udacha                         | 33                   |
| 25 | Fioletovyy Nizkoroslyy         | 63                   |
|    | **Foreign varieties**          |                      |
| 26 | Batik                          | 100                  |
| 27 | Arpege                         | 90                   |
| 28 | Back in Black                  | 70                   |
| 29 | Bay Fog                        | 0                    |
| 30 | Black tie Affair               | 80                   |
| 31 | Blushing Pink                  | 70                   |
| 32 | Brook Flowers                  | 100                  |
| 33 | Cascade Springs                | 80                   |
| 34 | Celebration Song               | 50                   |
| 35 | Champagne Music                | 50                   |
| 36 | Charm City Choice              | 86                   |
| 37 | Cinnamon Girl                  | 0                    |
| 38 | Cosmic Dance                   | 86                   |
| 39 | Cracker                        | 100                  |
| 40 | Crinoline                      | 100                  |
| 41 | Dark Side                      | 63                   |
| 42 | Christmas Angel                | 50                   |
| 43 | Dusky Challenger               | 63                   |
| 44 | Edith Wolford                  | 100                  |
| 45 | Everything Plus                | 100                  |
| 46 | Fiesta Time                    | 100                  |
| 47 | Five Star Admiral              | 100                  |
| 48 | Flash Fire                     | 100                  |
Calculating the economic efficiency of growing planting material of bearded iris for industrial reproduction (2015-2018) is presented in Table 2. From this table it is clear that profitability is 144% with a high degree of recoupment when growing planting material of iris bearded commercially.

**Table 2.** Calculation of the economic efficiency of growing planting material bearded iris for industrial reproduction (2015-2018).

| No | Costs                        | Amount, rub. |
|----|------------------------------|--------------|
| 1  | Wages                        | 41,898       |
| 2  | Taxes (30.2%)                | 12,653       |
| 3  | Fuels and lubricants         | 6,039        |
| 4  | Spare parts                  | 72           |
| 5  | Depreciation                 | 8,748        |
| 6  | Auto insurance               | 176          |
| 7  | Utilities                    | 2,921        |
| 8  | Overhead                     | 41,898       |
|    | Total:                       | 114,405      |
|   |   |   |
|---|---|---|
| 9 | Planting material | 8,925 |
| 10 | Fertilizers, pesticides | 472 |
| 11 | Peat | 590 |
| 12 | Water | 571 |
|   | Total: | 124,963 |
| 13 | Storing | 13823 |
|   | Total: cost | 138,786 |
| 14 | Cost of 1 tuber bud | 4,09 |
| 15 | Realization (revenue) | 339,150 |
| 16 | Profit | 200,364 |
| 17 | Profitability | 144% |

4. **Conclusion**

As a result of research, 84 varieties of domestic and foreign breeding were assessed, among which four groups with different degrees of winter hardiness were identified. Irises of domestic breeding and time-tested foreign varieties, which have been grown for a long time in central Russia, are the most resistant to overwintering. The economic efficiency of the growing planting material was 144% per unit area (1 ha).

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