Profitability of cultivation of onion interspecific hybrids

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Abstract. Based on interspecific plant crossing of the genus Allium L., with the overcoming of species incompatibility by embryo culture invitro and sterility of F1 hybrids using polyploidy, backcrossing and inbreeding of hybrid forms, cytological analysis, selection evaluation and selection of recombinant forms, highly effective technological processes for creating initial forms of onion interspecific hybrids were developed. The aim of obtaining onion interspecific hybrids is to create resistant forms of onions to false mildew. The paper shows the possibility of growing onion interspecific hybrids that are relatively resistant to false mildew without the use of fungicides to increase the economic efficiency of onion production, as well as to obtain more environmentally friendly and high-quality products.

1. Introduction

Onion (Alliumcepa L.) cultivated since ancient times, due to its nutritional, aromatic and medicinal properties, it is the second most valuable crop in the world after tomato [1]. According to various estimates, there are from 500 to 650 types of onions in the world, about 200 types of onions in Russia, 18 are used in the national economy, and 12 are used in culture [2, 3, 4].

The area of onion crops in the world is 6,148 million hectares, including onions – 4,444 million hectares [1].The largest areas under onions in India – 1,199 million hectares (27% of the world’s area), under garlic – in China 796,609 thousand hectares (54.4% of the world’s area). The gross production of onions in the world is 85.795 million tons. China is on the first place – 23.9 million tons (27.8% of world production). The yield of onions in the world is 19.7 t/ha, in the Republic of Korea – 65.27 t/ha. Onion production per capita: in the world – 11.67 kg, in the Netherlands – 85.6 kg. In Russia 88.563 thousand hectares are occupied with onions (the fifth place in the world), the gross production is 2.131 million tons (the seventh), the yield is 22.84 t/ha, per capita – 13.1 kg.

From populations of onion interspecific hybrids with high genetic diversity, selection forms are effective for creating varieties with popular breeding and valuable signs, for example, with resistance to false mildew [5]. During the transfer of genes of interest from wild relatives, there is a predominance of signs of wild species and the loss of signs of cultivated plants. Therefore, it is necessary to select recombinant forms with a combination of properties of both initial types.

Varieties of onion are strongly affected by false mildew (Peronospora destructor (Casp.) Berk.). Therefore, research on the creation of breeding forms when crossing the culture type Alliumcepa L. with wild-growing species Allium Vavilovii Pop. etVved., A. fistulosum L. and A. altaicum Pall whose plants are resistant to this disease is relevant [6]. After selection and phytopathological evaluation of the obtained forms of interspecific hybrids, the original recombinant forms are selected as the source material for selection. On the basis of recombinant disease-resistant forms of onion interspecific
hybrids, onion varieties with a reduced pesticide load are created, which makes it economically feasible to obtain environmentally friendly onion products.

2. Materials and methods
The research material was plants of onion interspecific hybrids BC₂(F₃.₅(A. cepa×A. fistulosum)), BC₁(F₁.₅(A. cepa×A. vavilovii)), F₃ (A. cepa×A. altaicum). As a standard for biometrics and plant infestation with false mildew, the onion variety Odintsovs was used, as this variety participated in saturating crossings of onion interspecific hybrids.

Field experiments were conducted according to the “Method of field experience” [7]. Biometric assessment was performed according to the “Method of conducting tests for distinctness, uniformity and stability” [8]. Phytopathological assessment was conducted according to the “Guidelines for the selection of onion crops” [9]. Plants of the first year of vegetation were obtained through seedlings grown in the winter glazed greenhouse at a temperature of 18...20°C during the day and 8...10°C at night in the period from March 25 to May 5.

Seeds were sown on March 25, 2-3 seeds in cassettes for seedlings 8x8 (64-F, cell volume 80 cm³), which contained a pre-prepared and moistened peat-soil mixture, supplemented with perlite in a ratio of 4:2:1, and sprinkled with peat. Then the seedling cassettes were additionally moistened and covered with a film to avoid drying out of the peat-soil mixture and to create a microclimate during seed germination. As the germination of seeds (from 7 to 10 days) and the plants entered the “loop” phase, the film was removed from the seedling cassettes and they were cultivated to form 3-4 real leaves using the technology of cultivation of onion seedling culture. After the formation of 3-4 real leaves in onion plants, they were planted in the field [10]. Onion plants were grown in the fields of the FSBSI FSCVG in the Moscow region using the technology of onion cultivation for this soil and climate zone [11].

Cost determination according to technological maps for onion culture was carried out on the basis of prices prevailing in 2018-2019. To identify the economic effect, the cost and profitability were calculated based on the weighted average basic production costs for growing commercial onions, which amounted to 57003 rubles/ha, storage costs - 0.14 rubles/kg, costs for manual bulkhead and disposal of affected bulbs – 0.15 rubles/kg and the average wholesale purchase price – 12 rubles/kg.

3. Results
Obtaining original forms of vegetable plants as a valuable source material for selection based on interspecific hybridization is a complex process that includes the development of methodological processes for creating and evaluating initial forms. When crossing different species, onion was used as a parent component of crossing, perennial species as pollinators.

The use of technologies to overcome the incompatibility of species of different ploidy (in the culture of isolated embryos and through the culture of embryogenic callus) allows obtaining interspecific hybrids from distant crossings and on their basis creating selectively valuable forms of onion interspecific hybrids.

F₁ onion interspecific hybrids have partial or complete sterility of plants, which makes it difficult to obtain hybrid forms of subsequent generations and use them in the breeding process. Only with the use of biotechnology methods – methods of embryo culture invitro and polyplody, it is possible to obtain interspecific hybrids, increase their fertility in diploid forms and overcome the sterility of triploid F₁, BC hybrids, regardless of crossings of species of the same and different ploidy of several combinations of crossing.

Based on the gradual use of incongruent crossings of different species of the genus Allium L., overcoming incompatibility of species by embryo culture invitro and sterility of F₁ hybrids using polyplody, backcrossing and inbreeding of hybrid forms, cytological analysis, selection evaluation and selection of recombinant forms, highly effective technological processes for
creating initial forms of onion interspecific hybrids were developed (table).

**Table 1.** Scheme of technological processes for creating and evaluating the initial forms of onion interspecific hybrids.

| Stage | The process of creating hybrid forms |
|-------|--------------------------------------|
| I.    | Incongruent crossings of selected forms of species of the genus Allium, $P_1$ (2n) × $P_2$ (2n); obtaining F1 hybrids through culture *invitro* by two ways to overcome incompatibility: using embryoculture of poorly developed embryos and culture of embryogenic callus of undifferentiated embryos |
| II.   | Overcoming sterility of F1 hybrids – polyploidization of plants (colchicination of hybrid tissue F1 *invitro*); regeneration of F1 polyploid plants, ploidy analysis, selection of fertile forms (2n, 4n) |
| III.  | Backcrossing: F1.5 (2n) × P1 (2n); obtaining BC1:2 hybrids, including through embryoculture; analysis and selection of diploid and tetraploid fertile forms |
| IV.   | Inbreeding and crossbreeding of forms BC1:2, F4:5 (2n, 4n); selection and cytological assessment of plants of progeny 1 (from BC) and F1 |
| V.    | Selection of recombinant hybrid forms with valuable traits, their testing and selection as a source material |

In the conditions of the Moscow region, the greatest damage to onions is caused by false mildew, caused by the fungus *Peronospora destructor* (Caps.) Berk. In the field experiment, onion plants of the Odintsovet variety were treated with fungicides akrobat MC, VDG; metaxil, SP; metamil, SP and ridomilgold MC, VDG against diseases including false mildew, plants of onion interspecific hybrids were grown without treatments.

The calculation of profitability and economic efficiency of growing onion interspecific hybrids in comparison with varietal onions was carried out using technological maps. The technological map presents agricultural, technical and organizational and economic measures, which consistently indicate the composition, volume of agricultural work on cultivation of crops and their quality characteristics; the used machines; the number and qualification of workers servicing the units; production standards; agricultural, technical and working terms of individual works; the cost of labor and funds per 1 ha of seeding and unit of production. A comparative analysis of costs, capital investments, and performance indicators for onion cultivation technology with and without fungicides shows that growing onion interspecific hybrids, in the absence of treatment with fungicides against onion diseases, reduces the level of direct costs to 53872 rubles per 1 ha of cultivated area (the existing technology – 57003 rubles). This makes it possible to increase the gross output in value terms from 9000 to 13160 rubles, that is, by 35%.

As a result, the cost of 1 C of products will be reduced by 2,940 rubles or 21.4%. This allows increasing the profit volume from 1,590 to 4,000 rubles, or by 2.7 times, and increasing the level of profitability by 30.2%. Indicators that characterize the effectiveness of the introduction of growing onion interspecific hybrids are capital productivity and labor productivity.

With a decrease in capital investment in treatment against diseases, the level of capital return will increase by 15% with an increase in labor productivity by 1.1 times. These indicators are achieved due to the integrated use of technology for growing new selection material of onions and reducing the cost of using means of protection against diseases.

4. Summary

Based on the results of field experiments, treatment of onion interspecific hybrids with drugs against false mildew is excluded from the system of measures to protect onions from diseases during cultivation from seeds through seedlings in an annual culture.
Cultivation of onion interspecific hybrids that are relatively resistant to false mildew allows reducing the fungicide load, preserving the crop and actually increasing the economic efficiency of phytosanitary measures. Growing onion interspecific hybrids allows getting more environmentally friendly and high-quality products, as well as significantly increase the efficiency of onion cultivation.

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