

ANNOTATION

**of the dissertation work of Alima Shoibekova
on the topic “Selection of Domestic Pumpkin Rootstocks Resistant to the
Fusarium Pathogen for Grafting Cucumber Hybrids in greenhouses”
submitted for the degree of Doctor of Philosophy (PhD)
specialty 6D080900 – « Horticulture»**

Relevance of the research topic

The agro-industrial complex of the Republic of Kazakhstan is regarded as a strategic important sector ensuring national food security. Greenhouse vegetable growing is a highly profitable branch that provides year-round production of valuable produce. Cucumber (*Cucumis sativus L.*) is one of the leading crops of protected ground, occupying a dominant share of the areas in the greenhouse farms of the republic. However, yield levels remain substantially below the world technological benchmarks.

A particular problem for greenhouse production is Fusarium wilt caused by the soil-borne pathogen *Fusarium oxysporum f. sp. cucumerinum*. This disease is characterized by high persistence of the pathogen in the soil and the ability to accumulate in greenhouse substrates, and it causes yield losses of up to 25–30%. Traditional control measures – crop rotation and chemical disinfection – are ineffective under protected-ground conditions, while chemical fungicides increase the residual toxicity of the produce and promote the formation of resistant pathogen populations.

In world practice, grafting cucumber onto resistant rootstocks of the Cucurbitaceae family is widely used as an effective bioprotective method. In Japan and South Korea, more than 95% of greenhouse cucumbers are grown on grafted plants, which ensures protection against soil pathogens and a yield increase of 30–50%. The world area of grafted vegetable crops exceeds 800 thousand ha, with cucumber accounting for about 40%.

Kazakhstan possesses a rich genetic resource of domestically bred cucurbit crops; however, their suitability as rootstocks for cucumber has not previously been studied. The lack of systematic research creates dependence of greenhouse farms on imported rootstock material and hinders the development of domestic protected-ground vegetable growing. The relevance of this direction is confirmed by published studies demonstrating the positive effect of using pumpkin rootstocks on the productivity of cucumber hybrids.

Aim of the dissertation research

Identification and agrobiological selection of domestic pumpkin cultivars resistant to *Fusarium oxysporum f. sp. cucumerinum* for grafting cucumber hybrids, with analysis of the efficiency of rootstock–scion combinations in protected-ground technologies.

Objectives of the research

1. Creation and analysis of a rootstock collection comprising samples from various genera of the family *Cucurbitaceae*.

2. Isolation and obtaining of a pure culture of the pathogen *Fusarium oxysporum* from infected cucumber plants.
3. Determination of the resistance of *Cucurbitaceae* samples to *Fusarium* under an artificial infectious background.
4. Identification of optimal methods of grafting cucumber onto pumpkin rootstocks.
5. Evaluation of rootstock–scion combinations by economically valuable traits in protected ground.
6. Evaluation of the effect of the rootstock on the quality of the scion fruits.
7. Economic assessment of the efficiency of rootstock–scion combinations.

Research Methods

Field studies were carried out in 2018–2022 in two production greenhouses of the Kazakh Research Institute of Fruit and Vegetable Growing (KazRIFVG). Field experiments were established and conducted in accordance with the «Methodology of State Variety Testing of Agricultural Crops» and the «Methodology of Field Experiment» by B.A. Dospekhov. The comprehensive evaluation of rootstock–scion combinations included phenological observations, biometric measurements (plant height, stem thickness, number of leaves), yield accounting by the continuous-harvesting method, and tasting assessment of fruit quality on a 9-point scale.

Isolation and identification of the pathogen *Fusarium oxysporum* were carried out by classical mycological methods using a moist chamber and cultivation on potato-sucrose agar. The resistance of pumpkin accessions was assessed under an artificial infectious background by inoculating the root system with a conidial suspension of the pathogen at a concentration of 1×10^6 spores/ml. The degree of damage was assessed on a 4-point scale with calculation of disease incidence.

The study of grafting methods included a comparative evaluation of tongue-approach grafting (method «X») and hole-insertion grafting (method «Y») by survival rate, content of phytohormones and amino acids, and yield. After grafting, the plants were placed in a climatic chamber (Vindon Scientific Ltd., UK) under controlled conditions for adaptation and fusion of the components.

Biochemical analyses were performed by high-performance liquid chromatography (HPLC) to determine the content of indole-3-acetic acid (IAA), amino acids (L-valine, L-threonine, L-alanine, L-tyrosine), and sugars. Statistical processing of the data was performed by analysis of variance using MS Excel and Statistica 10.0. The data were processed using cluster and discriminant analysis, which made it possible to identify groups of genotypes with a high degree of resistance and compatibility.

Main provisions submitted for defense

Proven scientific hypotheses and other conclusions constituting new knowledge:

1. Isolation and identification of the pathogen *Fusarium oxysporum* from infected cucumber plants under the protected-ground conditions of south-eastern Kazakhstan.

2. Results of the evaluation of 5 pumpkin accessions of three species for resistance to *Fusarium* wilt, with the identification of highly resistant forms – Karina and Stofuntovaya (*C. maxima*) and Mozoleevskaya 10 (*C. pepo*) – for use as rootstocks.

3. Comparative evaluation of cucumber grafting methods onto pumpkin rootstocks by biochemical indicators (IAA, amino acids) and productivity, with justification of the most effective method – tongue-approach grafting (survival rate 96%).

4. Comprehensive characterization of cucumber rootstock–scion combinations on resistant pumpkin rootstocks by economically valuable traits: a yield increase of up to 42.38%, improved fruit quality, and increased resistance to root rots.

5. Economic efficiency of using domestic pumpkin rootstocks (profitability of additional costs 1197%, cost reduction of 25%).

Main Research Results

1. The pathogen *Fusarium oxysporum* was successfully isolated and identified from cucumber plants infected with *Fusarium* wilt under protected-ground conditions. The use of the moist-chamber method and cultivation on potato-sucrose agar ensured a pure culture of the pathogen with high viability for creating an artificial infectious background.

2. A comprehensive assessment of the resistance of 5 pumpkin cultivars of three species (*C. maxima*, *C. moschata*, *C. pepo*) to *Fusarium oxysporum* was carried out. Three highly resistant cultivars were identified – Karina and Stofuntovaya (*C. maxima*) and Mozoleevskaya 10 (*C. pepo*) – with a damage score of 0–1, versus 2–4 points (50–70% damage) in the susceptible own-rooted cucumber. By inoculating the root system with a pathogen suspension (1×10^6 spores/ml), it was established that the cultivars Karina and Stofuntovaya exhibit an immune type of reaction (absence of symptoms after 30 days), whereas susceptible cultivars are characterized by root necrosis, leaf chlorosis, and death of 70–90% of plants.

3. A comparative study of two grafting methods showed the advantage of tongue-approach grafting (method «X»): a survival rate of 96% versus 43% for hole-insertion grafting. Plants grafted by method «X» exceeded the control in height by 9.2% and in stem thickness by 9.0% ($p < 0.05$). The IAA content by the 6th week was 40% higher than the control (288.0 vs. 205.7 $\mu\text{g/g}$, $p < 0.01$). An increase in the content of amino acids (L-valine, L-threonine, L-alanine, L-tyrosine) by 28.8–98.1% by 4–6 weeks after grafting was revealed.

4. Cucumber plants grafted onto the Karina rootstock provided the maximum yield of 27.56 kg/m^2 , which was 42.38% higher than the control (19.45 kg/m^2 , $p < 0.01$). The Stofuntovaya rootstock showed an increase of 36.68% (26.65 kg/m^2). In terms of early yield, Karina and Stofuntovaya exceeded the control by 36.7% and 33.9%. The increase in productivity was achieved by increasing the number of fruits: on the Karina rootstock – 165 fruits/plant (+37.5%), on the Stofuntovaya rootstock – 156 fruits/plant (+30.0%), while maintaining the fruit weight within the standard.

5. Under the natural infectious background of a production greenhouse, the grafted plants showed high resistance to root rots. Disease incidence in own-rooted plants was 45%, whereas in plants grafted onto Mozoleevskaya 10 it was 5% (a 9-fold reduction), onto Karina – 8.5% (a 5.3-fold reduction), and onto Stofuntovaya – 12% (a 3.75-fold reduction).

6. Grafting onto pumpkin rootstocks has no negative effect on fruit quality. The tasting score was 8.3–8.7 points on a 9-point scale, and marketability was 98.1–99.3%. The best indicators were for the Karina (8.7 points) and Stofuntovaya (8.6 points) rootstocks. The vitamin C content increased by 15.3% and carotene by 37.5% ($p < 0.05$).

7. An economic analysis of the efficiency of the grafting technology was carried out. The additional costs of grafting amount to 28,038 tenge per 100 m² of greenhouse (6.2% of total costs), while the net additional income from grafting onto the Karina rootstock is 335,562 tenge per 100 m² (3,356 thousand tenge per 1 ha). The profitability of additional costs is 1197%, corresponding to a 12-fold payback. The cost of production decreases by 25.0% (from 231.4 to 173.5 tenge per kg), and production profitability increases from 91.2% to 156.1%.

Justification of the novelty and importance of the results obtained

The scientific novelty of the research lies in the fact that, for the first time for the conditions of Kazakhstan, a comprehensive assessment of the resistance of 5 domestic pumpkin cultivars of three species to the causative agent of cucumber Fusarium wilt was carried out, and highly resistant genotypes – Karina and Stofuntovaya (*C. maxima*) and Mozoleevskaya 10 (*C. pepo*) – suitable for use as rootstocks were identified. For the first time for the region, a comparative study of grafting methods in combination with biochemical justifications of their effectiveness was conducted. By HPLC, the effect of rootstocks on the hormonal status of the scion was established: an increase in IAA content by 40% and in key amino acids (L-valine, L-threonine, L-alanine, L-tyrosine) by 28.8–98.1% by 4–6 weeks after grafting. A technology for grafting cucumber onto pumpkin rootstocks for the protected-ground conditions of Kazakhstan was developed and scientifically substantiated. The economic efficiency was determined: profitability of additional costs of 1197% with a 12-fold payback of investments.

Practical significance of the work lies in the fact that highly Fusarium-resistant pumpkin cultivars of Kazakh selection (Mozoleevskaya 10, Karina, Stofuntovaya) suitable for use as rootstocks under protected-ground conditions were identified. An effective grafting method – tongue-approach grafting, ensuring a survival rate of 96% – was substantiated and recommended for production. The best rootstock–scion combinations were determined, allowing an increase in cucumber yield by 36.7–42.4% and a reduction in root rot damage by 3.75–9 times without the use of chemical protection. The results have been introduced into production: seeds of the cultivars Karina and Aphrodite were transferred to farms of Kazakhstan (farm «Aben», IE «Golub», IE «Brilkova»), which is confirmed by certificates (Appendix B).

Compliance with state programs

The dissertation research was carried out within the framework of the grant scientific project No. AG19679681 «Creation of high-yielding, pathogen-resistant tetraploid pumpkin rootstocks with evaluation of rootstock–scion combinations with cucumber and melon» at KazNARU. The work corresponds to the priority directions «Food security» and «Agrobiotechnologies» and is aimed at developing domestic rootstock material and reducing yield losses from root pathogens.

Description of the doctoral candidate's contribution to the preparation of each publication

On the topic of the dissertation, 21 scientific works have been published, of which: 4 articles in journals indexed in the Scopus database (quartiles Q1–Q2); 4 articles in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the MSHE RK; 2 articles in publications recommended by the NAS RK; 6 articles in proceedings of international conferences; 1 article in an international scientific-methodological journal; 1 article in proceedings of an international conference of the near abroad (Ukraine) and 1 article in proceedings of an international conference of the far abroad (USA); 2 presentations with reports at international scientific-practical conferences – Uzbekistan, 2020 (speaker–presenter, working language: English) and a poster presentation, Russia, SMIT 2021 (working language: English). In the articles published in international journals, the applicant performed the collection and analysis of experimental data, statistical processing of the results, and preparation of the manuscripts for publication. The personal contribution of the author to the publications is 70–85%.

Volume and Structure of the Dissertation

The dissertation is presented on 125 pages of computer text and consists of an introduction, a literature review, research methodology, research results, and a conclusion. The list of references includes 123 titles. The text of the dissertation is illustrated with 22 tables and 18 figures and contains 6 appendices.