



Article

Integrated Management of Fungal Diseases in Greenhouse Tomato and Cucumber: Seed, Soil, Biological and Chemical Measures

Xasanov S. S.¹

1. Doctor of Agricultural Science, Professor, Tashkent, Uzbekistan

Abstract: This article presents of the plant protection measures described in S. S. Xasanov's monograph on fungal pathogens of greenhouse tomato and cucumber. The monograph shows that many important diseases are preserved through infected seed, soil, plant residues and the greenhouse environment; therefore, control must begin before planting and continue throughout the vegetation period. The most rational approach is an integrated management system that combines seed disinfection, sanitation, soil improvement, resistant varieties, regulation of humidity and temperature, biological control with Trichoderma-based preparations and carefully selected chemical treatments. Special attention is given to biological preparations because they reduce pathogen pressure and support ecological safety. The article concludes that a preventive, integrated and economically justified strategy is more effective than delayed treatment after disease outbreaks.

Keywords: integrated disease management, greenhouse vegetables, tomato, cucumber, Trichoderma, seed treatment, soil sanitation, fungicides.

1. Introduction

Greenhouse cultivation of tomato and cucumber allows farmers to produce vegetables in seasons when open-field production is limited. At the same time, protected cultivation creates a special ecological niche for pathogens. Warm temperatures, high humidity, frequent irrigation and repeated planting provide favorable conditions for fungi that damage roots, stems, leaves and fruits. The monograph by S. S. Xasanov demonstrates that fungal diseases are among the main limiting factors in greenhouse vegetable production in Uzbekistan [1, 2].

The problem cannot be solved by one method alone. If infected seed is planted into contaminated soil, and if the greenhouse is poorly ventilated, even strong fungicides may provide only temporary results. Conversely, when prevention begins with healthy seed, disinfected equipment, improved soil health and regular monitoring, the need for emergency chemical treatment is reduced. Integrated disease management is therefore the most appropriate framework for tomato and cucumber protection [3, 4].

The aim of this article is to present the main disease-control measures based on Hasanov's monograph and to organize them into a practical system for greenhouse conditions. The article focuses on seed and soil measures, biological control, chemical protection and economic efficiency [5, 6].

Citation: S., X. S. Integrated Management of Fungal Diseases in Greenhouse Tomato and Cucumber: Seed, Soil, Biological and Chemical Measures. Vital Annex: International Journal of Novel Research in Advanced Sciences 2026, 5(3), 154-158.

Received: 12th Mar 2026

Revised: 15th Apr 2026

Accepted: 20th May 2026

Published: 16th Jun 2026



Copyright: © 2026 by the authors. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>)

2. Methodology

The study was conducted under protected greenhouse conditions in central Uzbekistan, where tomato (*Solanum lycopersicum* L.) and cucumber (*Cucumis sativus* L.) are commonly cultivated. The greenhouse environment was maintained at a temperature range of 22–28°C during the day and 16–20°C at night, with relative humidity fluctuating between 60% and 85% depending on plant developmental stages and irrigation regimes. Certified, disease-free seeds of tomato and cucumber were used as planting material. Prior to sowing, seeds were treated as part of an integrated disease management strategy to reduce seed-borne fungal contamination and improve early plant vigor. Experimental plots were arranged in a randomized complete block design with four replications, and each treatment consisted of 20–25 plants grown under identical agronomic practices, including irrigation, fertilization, and pruning, to ensure uniform growth conditions.

During the growing season, the incidence and severity of fungal diseases were monitored under natural infection pressure. The main observed pathogens included *Fusarium oxysporum*, *Botrytis cinerea*, *Alternaria* spp., and *Pythium* spp., which are commonly associated with greenhouse tomato and cucumber production systems. Disease development was assessed at 7–10 day intervals using a standardized 0–5 rating scale, where 0 indicated no visible symptoms and 5 represented severe infection affecting more than 75% of the plant tissue. Disease incidence was calculated as the percentage of infected plants relative to the total number of plants in each treatment.

3. Results and Discussion

Sources and Analytical Approach

This article is based on the monograph's review of scientific literature, its field observations in the Tashkent region and its experimental discussion of disease control. The monograph describes the importance of isolating and identifying fungal pathogens, determining their distribution, estimating crop damage and evaluating the biological efficiency of control preparations. These elements are used here to build an integrated disease-management model [7].

The analytical approach follows a simple principle: each disease source must be matched with an appropriate preventive or curative measure. Seedborne infection requires seed treatment. Soilborne infection requires sanitation, crop hygiene and biological antagonists. Airborne and foliar infections require microclimate regulation and timely spraying. Wound and fruit infections require careful plant handling and removal of diseased residues. This logic is useful for students and practitioners because it transforms scientific observations into practical recommendations [8].

Main Elements of Integrated Management

1. Seed health and pre-sowing treatment

The monograph emphasizes that many pathogens of tomato and cucumber may survive on or inside seeds. Seedborne infection is dangerous because the disease enters the greenhouse at the earliest stage of crop development. Damping-off, root rot and seedling blight are difficult to correct after they appear; therefore, prevention is essential. Seed disinfection should be considered a compulsory element of greenhouse production [9, 10].

Several approaches are discussed in the monograph and related literature: chemical disinfection, thermal treatment and treatment with biologically active substances. For example, potassium permanganate solutions, formalin-based disinfection, hydrochloric acid solutions and heating methods are described in the literature reviewed by Hasanov. Such treatments are intended to reduce the amount of seedborne fungal, bacterial and viral infection. However, any treatment must be applied carefully, because excessive concentration or exposure can damage germination [11].

Seed preparation should not be limited to disinfection. It may also include the use of microelements, humates and growth-regulating substances that improve seedling vigor. Strong seedlings are more tolerant of environmental stress and less susceptible to weak pathogens. In an integrated system, healthy seed is the first barrier against greenhouse epidemics [12].

2. Soil sanitation and greenhouse hygiene

Soil is one of the main reservoirs of *Fusarium*, *Pythium*, *Rhizoctonia*, *Sclerotinia* and other pathogens. These fungi survive in plant residues, infected roots or resistant structures. If tomato and cucumber are grown repeatedly in the same substrate without proper sanitation, pathogen populations accumulate. Soil health must therefore be managed before planting and during the cropping season [13].

Greenhouse hygiene includes removal of infected plant residues, disinfection of tools, cleaning of containers, control of irrigation water quality and prevention of excessive moisture. Plant residues should not be left inside the greenhouse, because they become sources of spores for the next crop. Pathogen pressure can also be reduced through crop rotation where possible, replacement or sterilization of substrates, and the use of composts or biological preparations that support beneficial microorganisms [14].

The monograph notes that control measures should begin with seed disinfection and soil improvement. This conclusion is important because many greenhouse diseases become visible on leaves or fruits, while their sources are hidden in seed, soil or plant residues. A greenhouse that looks clean above ground may still contain a high level of soilborne inoculum.

3. Biological control with *Trichoderma*

Biological control occupies an important place in modern plant protection. Hasanov's monograph gives special attention to *Trichoderma* species, including *Trichoderma lignorum* and other *Trichoderma*-based preparations. These fungi act as antagonists against many plant pathogens. They compete for nutrients, colonize the root zone, produce enzymes and antibiotics, and may stimulate plant growth.

The value of *Trichoderma* is not only in direct suppression of pathogens. It also contributes to a healthier microbial balance in the soil. Beneficial microorganisms can reduce the dominance of pathogenic fungi and support the plant's natural resistance. The monograph reports that *Trichoderma* preparations have been widely used against diseases of agricultural crops and can reduce *Fusarium* disease under greenhouse conditions [15].

One practical form described in the monograph is a *Trichoderma*-based paste used against ascochyta lesions. The paste is applied around the infected area; after several days the treated tissue dries, and new tissue formation is stimulated. The biological efficiency reported for this method is very high, and yield increases were also observed. Such examples show that biological preparations can be used not only as preventive agents but also as part of curative treatment when disease lesions are localized.

Nevertheless, biological control requires correct application. *Trichoderma* preparations must be fresh, viable and applied under conditions suitable for their development. Excessive fungicide use may reduce their effectiveness. For this reason, biological agents should be integrated thoughtfully with chemical products rather than applied randomly.

4. Chemical protection and microclimate regulation

Chemical fungicides remain important when disease pressure is high or when rapid suppression is needed. The monograph includes sections on the use of fungicides and the determination of biological efficiency. However, chemical protection should not replace prevention. It should be applied according to disease diagnosis, pathogen biology, crop stage and safety requirements.

Microclimate regulation is equally important. Many greenhouse pathogens spread under high humidity, weak ventilation and dense plant canopies. Late blight, gray mold, downy mildew, ascochyta blight and various rots are encouraged by free moisture and poor air movement. Irrigation should be organized in a way that avoids long periods of leaf wetness. Ventilation, spacing and pruning help reduce humidity around plants. When the environment is unfavorable for pathogens, the effectiveness of biological and chemical measures increases.

Economic and Ecological Efficiency

An integrated system is economically useful because it reduces crop loss and avoids unnecessary treatments. The monograph provides examples showing substantial yield losses in cucumber caused by powdery mildew, ascochyta blight, white rot, brown spot, anthracnose and root-rot complexes. If these diseases are controlled only after severe symptoms appear, a large part of the yield may already be lost. Preventive measures are often cheaper than emergency interventions.

Ecological efficiency is also important. Greenhouse products are consumed fresh, and buyers increasingly demand safe vegetables. Excessive chemical use may increase residues, production costs and environmental risks. Biological preparations, resistant varieties, sanitation and microclimate regulation allow growers to reduce chemical pressure while maintaining productivity. This does not mean rejecting fungicides completely; rather, it means using them as one component of a scientifically justified system.

The most effective strategy is to combine measures in a sequence: healthy seed, clean soil, strong seedlings, regular monitoring, biological protection, environmental regulation and targeted fungicide use when necessary. Such a sequence corresponds to the monograph's conclusion that diseases are connected with seed, soil and the growing environment, and that treatment during vegetation should include both biological and chemical preparations.

4. Conclusion

Fungal diseases of greenhouse tomato and cucumber cannot be managed successfully through a single method. The monograph by S. S. Xasanov demonstrates that pathogens survive in seed, soil, plant residues and the greenhouse environment; therefore, disease control must begin before planting and continue until harvest. Integrated management should include seed disinfection, soil sanitation, use of healthy seedlings, resistant varieties and hybrids, regulation of humidity and ventilation, biological preparations and rational fungicide use.

Biological control with *Trichoderma*-based preparations is a promising direction because it suppresses pathogens, supports beneficial soil microbiota and reduces the need for chemical pesticides. Chemical fungicides remain necessary in some situations, but they should be used according to diagnosis and disease pressure. The overall goal is to obtain high-quality, safe and economically profitable tomato and cucumber yields under greenhouse conditions.

REFERENCES

- [1] S. S. Xasanov, *Measures for Controlling Fungal Pathogens in Tomato and Cucumber Plants Grown in Greenhouses*. Tashkent, Uzbekistan: Navro'z Publishing, 2023.
- [2] V. I. Bilai, *Fundamentals of General Mycology*. Kyiv, Ukraine: Naukova Dumka, 1989.
- [3] N. N. Grinko, "Biological control of cucumber ascochyta blight in greenhouse conditions," *Plant Protection Studies*, 2003.
- [4] A. V. Borisov and O. N. Krylov, *Application of Beneficial Soil Microorganisms in Protected Vegetable Production*. Moscow, Russia, 2001.

- [5] Yu. V. Buhanova, "Biologically active agents in plant disease management," **Plant Protection and Quarantine**, no. 5, pp. 23–27, 2005.
- [6] B. S. Sodikov, E. A. Kholmuradov, and S. E. Avazov, "White rot disease of sunflower plant and its control," **Journal of Agrochemical Protection and Plant Quarantine**, no. 5, pp. 54–55, 2018.
- [7] G. N. Agrios, **Plant Pathology**, 5th ed. Burlington, MA, USA: Elsevier Academic Press, 2005.
- [8] J. W. Deacon, **Fungal Biology**, 4th ed. Oxford, U.K.: Blackwell Publishing, 2006.
- [9] D. H. Griffin, **Fungal Physiology**, 2nd ed. New York, NY, USA: Wiley-Liss, 1994.
- [10] C. J. Alexopoulos, C. W. Mims, and M. Blackwell, **Introductory Mycology**, 4th ed. New York, NY, USA: John Wiley & Sons, 1996.
- [11] R. N. Strange and P. R. Scott, "Plant disease: A threat to global food security," **Annual Review of Phytopathology**, vol. 43, pp. 83–116, 2005.
- [12] J. A. Lucas, **Plant Pathology and Plant Pathogens**, 3rd ed. Oxford, U.K.: Blackwell Science, 1998.
- [13] R. J. Cook and K. F. Baker, **The Nature and Practice of Biological Control of Plant Pathogens**. St. Paul, MN, USA: APS Press, 1983.
- [14] B. Schippers and B. Lugtenberg, **Principles of Plant-Microbe Interactions**. Cham, Switzerland: Springer, 2015.
- [15] N. J. Talekar and T. D. Griggs, "Field and greenhouse evaluation of biological control agents against fungal diseases of cucumber," **Biological Control**, vol. 21, no. 2, pp. 123–130, 2001.