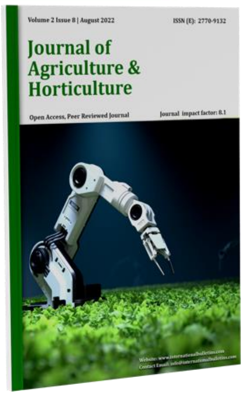

BIOLOGICAL EFFICACY OF FUNGICIDES APPLIED AGAINST GRAY MOLD DISEASE IN STRAWBERRY PLANTS

Abdurakhman Allayarov
Yuldoshov Shavkat
Scientific Research Institute of Horticulture, Viticulture and Winemaking named after Academician M. Mirzayev. ORCID ID 0000-0001-9776-4979
Doctoral candidate at the Scientific Research Institute of Horticulture, Viticulture and Winemaking named after Academician M. Mirzayev. ORCID ID 0009-0007-49703-1368
+998 90 956-01-87 allayarovabduraxmon1986@gmail.com
https://doi.org/10.5281/zenodo.15687209

Abstract: This article presents the results of control measures against Botrytis cinerea fungi, which cause significant damage to the fruits of strawberry crops. In greenhouse conditions, the application of the fungicide Flusil 40 e.c. at a rate of 0.1 l/ha against gray mold disease in strawberries manifested 90.4% biological effectiveness. The disease prevalence was 2.8%, its severity was 1.3%, and the disease index registered at 2.05%. An average yield of 280 centners per hectare was achieved in the greenhouse. When the fungicide Flusil 40 e.c. was applied at a rate of 0.1 l/ha before flowering in open field areas against these diseases, the prevalence rate of the disease was 3.7% and its severity was 1.3%. Additionally, a biological effectiveness of 87.2% was achieved. This treatment created the potential to obtain an average yield of 124.6 centners per hectare.

Key words: greenhouse, *Botrytis cinere*a, fungi, diseases, prevalence, harmful, fungicide, Flusil, control measures.

Introduction

The increase in the world's population and its food needs requires the search for additional sources to increase agricultural production, the efficient use of agricultural land, and the development and implementation of new innovative technologies. Globally, the volume of strawberry production is 9.5 million tons. Of the total strawberry crop, 47.9% is produced in Asia and 24.5% in the Americas. China leads global strawberry production with a harvest of 3.35 million tons. The United States produces 1.26 million tons, followed by Turkey with 728 thousand tons and Egypt with 638 thousand tons (FAOstat, 2022. http://www.fao.org/faostat/en/#data/QC1).

Today, 70% of all berries grown in the world are strawberries. Globally, the average strawberry yield is 12.8 tons per hectare [2]. Among the berries grown in our country, strawberries rank first in terms of cultivated area and yield. For the 2022 harvest, strawberries were cultivated on 1,400 hectares of open fields, which is 117 percent more compared to the same period last year. A total of 28,200 tons of strawberries were harvested from open fields, while modern greenhouses covered 41.5 hectares, producing 660 tons of strawberries. As of May 20, 2022, Uzbekistan exported 126 tons of strawberries worth 118

JAH | Volume 5, Issue 06, June

thousand USD, primarily to countries such as Russia, Kazakhstan, Kyrgyzstan, Tajikistan, and the United Arab Emirates (Ministry of Agriculture https://www.agro.uz[3]).

Many factors contribute to the decline in strawberry yields. Among them, fungal diseases have a particularly significant impact. These diseases can cause a 15–92% reduction in yield, and in years with favorable conditions for disease development, losses of up to 100% have been recorded [7],[19].

Among the widespread diseases affecting strawberries, fungal diseases have been extensively studied by numerous scientists around the world. Among these, the most thoroughly researched are leaf spot (white spot) and angular leaf spot diseases [12],[19],[13].[8].

Verticillium wilt is one of the most harmful diseases of strawberries, significantly reducing yields, causing plant wilting, reduced runner formation, and in some cases, resulting in 40–70% yield loss. Plant death caused by this disease largely depends on the strawberry variety and the level of soil infestation with the pathogenic organism. Cases of complete plant loss in strawberry plantations due to Verticillium wilt have been observed. The causative agent of this disease has been identified as the fungal species *Verticillium dahliae*. [10].

Powdery mildew is a common disease found in all areas where strawberries are cultivated, and it has been studied by a number of researchers [15], [17]. The pathogens responsible for powdery mildew include the conidia-producing *Oidium orysiphoides* Fr. and the ascocarp-forming *Sphaerotheca maculopis* var. *fradachiae*. The primary source of infection is the conidia of these fungi [6].

Gray mold is one of the most widespread diseases affecting strawberries and is found almost everywhere [14]. Under its influence, yield losses of up to 10–18% have been recorded in the northwestern and northern regions of Russia. In the northwestern and central parts of European Russia, this figure has reached as high as 60%. The causal agent of this disease is *Botrytis cinerea*, a fungal species known to infect many agricultural crops. Although several races of this pathogen have been identified, a race specific solely to strawberries has not yet been confirmed.

Botrytis cinerea fungus, in addition to being a parasite, is also well adapted to a saprophytic lifestyle. As a result, this fungus can grow and develop on plant residues, producing large quantities of spores, and it is capable of surviving in the soil in a saprophytic state [11].

During the strawberry cultivation period, the growth of fungal pathogen *Botrytis cinerea* was studied. For this, pure cultures of the pathogen were isolated under laboratory conditions, and the effect of temperature on its growth was studied. Observations showed that colony formation began on the second day. At 20 °C, the diameter of fungal colonies reached 3 mm, whereas at 25 °C, it increased to 5 mm. On the ninth day, the fungus grown at 20 °C had completely covered the Petri dishes. *B. cinerea* was able to grow starting from 5 °C, while its growth ceased at 35 °C [5].

Strawberry white spot disease is recognized worldwide and is among the most commonly encountered diseases [10]. The conidial stage of the causative fungal pathogen is

JAH | Volume 5, Issue 06, June

known as *Ramularia tulasnei* Sacc., while ascocarp -forming stage is referred to as *Mycosphaerella fragariae* (Tul.) Lind [4].

Strawberry white spot disease was first studied under the conditions of Tashkent region by Z.I. Kolesnik in 1969. The researcher conducted the study at the Research Institute of Horticulture, Viticulture, and Winemaking named after Academician M. Mirzaev, where 77 different strawberry cultivars were planted. Vegetative experiments were carried out to test chemical treatments against the disease. Under these conditions, the spread of white spot disease among strawberry cultivars varied depending on their resistance, with infection rates ranging from 8.3% to 29.8%. [1].

Brown spot is also one of the most widespread diseases affecting strawberries, as identified by several researchers [10]. Depending on local conditions, yield losses caused by this disease have been observed to range from 7% to 30%. The ascus-forming stage of the fungal pathogen responsible for the disease is known as *Mycosphaerella potentillae*. The incubation period of the fungus ranges from 8 to 11 days, and in some cases, may extend up to 20 days [6],[3],[18].

Materials and methods

In the experiments, the prevalence and impact of diseases on strawberry crops grown in greenhouses and open-field conditions were studied. Research on the species composition of diseases affecting strawberries was conducted during 2023–2024 in the Qibray, Urtachirchiq, and Tashkent districts of Tashkent region. Additionally, the species composition of gray mold on strawberries cultivated in greenhouses covering 0.6 hectares located in contour 7 of the Tashkent Scientific Experimental Station was examined. Laboratory studies were carried out at the Plant Protection Laboratory of the Scientific Research Institute of Horticulture, Viticulture, and Winemaking named after Academician M. Mirzayev.

To identify the fungal species causing the diseases, microscopes such as MIKMED-5, Optika B-292PLI, and NiB-100 were used [5].

Identification of fungal species [16],[9].

Prevalence and severity of the diseases of strawberry crops [20] were identified by using the commonly accepted methods.

Recording methods for gray mold disease [10]. The recording of gray mold disease in strawberries is conducted during fruit harvesting and is carried out based on the following scale:

0 point – healthy fruits;
1 point – fruits show partial signs of disease;
2 points – up to 10% of the fruit has rotted;
3 points – 10-20% of the fruit has rotted;
4 points – more than 20% of the fruit has rotted;

Methods [20] for determining the damage caused by diseases. To assess the decrease in yield, the weight of fruits was taken into account. The number of plants in each tested sample was 10. The number of healthy and diseased strawberry plants in the samples was calculated, and the difference between the number of diseased and healthy plants was expressed as a percentage. The damage caused by the disease was then determined using the following formula:

$V=((A-a) \times 100)/A$ where,

V – yield loss, %;
A – healthy plant yield;
A – diseased plant yield.

Results and discussions

Among the fungal diseases affecting strawberry plants, gray mold is considered the most dangerous. Small-scale field experiments to determine the effectiveness of fungicides against the disease were conducted in greenhouses belonging to the Tashkent Research and Experimental Station. Such conditions serve as the most crucial factor in conducting experiments to accurately assess the impact of fungicides on gray rot disease and to ensure positive results.

In 2023, fungicides that showed effective results against the fungus causing gray mold disease in strawberries during laboratory experiments were tested in small-scale field trials. The vegetation experiments were conducted with five replications. Each replication consisted of 10 running meters.

In the experiments, fungicides Skor 25% e.c. (0.1 l/ha, 0.12 l/ha, 0.15 l/ha) and Flusil 40 e.c. (0.05 l/ha, 0.07 l/ha, 0.1 l/ha) were tested at various application rates against strawberry gray mold disease (as shown in Table 1).

According to the test results, all application rates of fungicides demonstrated effective outcomes. Among them, the best performance was observed in all variants treated with the fungicide Flusil 40 e.c., with its biological efficacy ranging from 84.7% to 87.1%. In the variants where the fungicide Skor 25% e.c. was applied, the biological efficacy ranged from 75.0% to 83.9%.

In the control variant where fungicide was not used, the spread of gray mold disease was 25.6%, and its severity was 1.4%.

Large-scale experiments in greenhouse conditions. In 2024, fungicides Flusil 40 e.c. (0.1 l/ha) and Skor 25% e.c. (0.15 l/ha), which showed high effectiveness in small-scale experiments in 2023, were also tested in large-scale trials against gray mold disease in Seolhyan variety strawberries. These trials were conducted in a 1.0 ha greenhouse belonging to "Fauna" LLC in the Qibray district of Tashkent region.

Table-1

Biological efficacy of fungicides applied against gray mold disease in strawberry plants under greenhouse conditions

(*Small-scale experiment, Tashkent region, Tashkent district, Tashkent Scientific-Experimental Station of the Research Institute of Horticulture, Viticulture and Winemaking named after Academician M. Mirzayev, Charly variety of strawberry, in 2023*)

Name of the preparation and active substance	Application rate l/ha	Disease prevalence, %	Disease severity, %	Biological efficacy, %
Control *(preparation free)*	-	25,6	12,4	-
Flusil 40 e.c. *(flucilazole)*	0,05	5,2	1,9	84,7
	0,07	4,7	1,7	86,3
	0,1	3,3	1,6	87,1
Skor 25% e.c.	0,10	6,7	3,1	75,0

(difenoconazole)	0,12	7,1	2,8	77,4
	0,15	4,9	2,0	83,9
LSD05				3,2

In the control variant, the prevalence of gray mold disease in strawberries was 26.1%, while the disease severity was 13.1%, and the disease index was recorded at 19.8%. An average yield of 210 centners per hectare was obtained from the greenhouse (as shown in Table 2).

In the variant with the application of the fungicide Flusil 40 e.c against strawberry gray rot at a rate of 0.1 l/ha, a biological effectiveness of 90.4% was achieved. The prevalence of the disease was noted to be 2.8%, the severity was 1.3%, and the disease index was 2.05%. An average yield of 280 centners per hectare was achieved from the greenhouse.

Also, in the variant with the application of the fungicide Skor 25% e.c. at a rate of 0.15 l/ha, the biological efficacy was 86.0%. The prevalence of the disease was 4.2%, and the severity was 1.9%, while the disease index was 3.05%. An average yield of 270 centners per hectare was obtained from the greenhouse.

Table-2

Biological efficacy of fungicides applied against gray mold disease in strawberry plants under greenhouse conditions

(*Large-scale experiment, Tashkent region, Qibray district, "Fauna" LLC, Seolhyan variety of strawberry, in 2024*)

Name of preparation and active substance	Application rate, l/ha	Disease prevalence, %	Disease severity, %	Disease index, %	Biological efficacy, %	Yield, c/ha
Control *(preparation free)*	-	26,1	13,6	19,8	-	210
Flusil 40 e.c. *(flucilazole)*	0,1	2,8	1,3	2,05	90,4	280
Skor 25% e.c. *(difenoconazole)*	0,15	4,2	1,9	3,05	86,0	270
Bordeaux mixture (*standard*)	1 %	10,5	5,7	8,1	58,0	230
LSD05					2,7	

In the standard variant, the prevalence of the disease was 10.5% and the severity of the disease was 5.7%, while the disease index was observed up to 8.1%. Biological effectiveness reached 58.0%. The average yield from one hectare of greenhouse was 230 centners.

In greenhouse conditions, to protect strawberry plants from gray mold disease, an application of a chemical treatment using either the fungicide Flusil 40 e.c. (0.1 l/ha) or Skor 25% e.c. (0.15 l/ha) at a rate of 400 liters of working solution per hectare upon the appearance of disease symptoms creates the opportunity to cultivate a high-yielding, high-quality, and export-grade crop.

Large-scale field trials under open-field conditions: In 2024, the fungicides Flusil 40 e.c. (0.1 l/ha) and Skor 25% e.c. (0.15 l/ha), which demonstrated high effectiveness in small-scale field trials in 2023, were tested in large-scale field trials against gray mold disease of strawberries at the "Istiqlol Salar Fayz" farm located in Qibray district, Tashkent region (as shown in Table 3).

Table-3

Biological efficacy of fungicides applied against gray mold disease in strawberry plants in the open field conditions

(*Large-scale filed experiment, Tashkent region, Qibray district, "Istiqlol Salar Fayz" farm, Karalevsky variety of strawberry, in 2024*)

Name of preparation and active substance	Application rate, l/ha	Disease prevalence, %	Disease severity, %	Disease index, %	Biological efficacy, %	Yield, c/ha
Control *(preparation free)*	-	23,7	10,2	16,	-	80,4
Flusil 40 e.c. *(flucilazole)*	0,1	3,7	1,3	2,5	87,2	124,6
Skor 25% em.k. *(difenoconazole)*	0,15	6,2	1,6	3,9	84,3	120,5
Bordeaux mixture (*standard*)	1 %	9,3	3,7	6,5	63,7	105,0
LSD_{05}					3,5	

In the variants where 1% Bordeaux mixture was used as a standard, the disease prevalence reached 9.3%, disease severity 3.7%, and the disease index stood at 6.5%, while the biological efficacy of the treatment reached up to 63.7%. The yield was recorded at 10.5 tons per hectare. In the control variant, however, the prevalence of gray mold disease in strawberries was recorded at 23.7%, with a disease severity of 10.2%, and an average yield of 8.04 tons per hectare was obtained.

When the fungicide Flusil 40 e.c. was applied at the rate of 0.1 l/ha against gray mold disease, the disease prevalence was 3.7% and severity was 1.3%. Moreover, a biological efficacy of 87.2% was achieved. This treatment created the opportunity to obtain an average yield of 124.6 tons per hectare.

When the fungicide Skor 25% e.c. was applied at a rate of 0.15 l/ha, it demonstrated a biological efficacy of 84.3%. Disease prevalence was recorded at 6.2%, and severity at 1.6%. An average yield of 12.05 tons per hectare was achieved.

In conclusion, it was determined that under open-field conditions, applying either Flusil 40 e.c. (0.1 l/ha) or Skor 25% e.c. (0.15 l/ha) fungicide at the onset of disease symptoms effectively ensures the production of a high-yielding and high-quality strawberry crop.

Conclusion. Following laboratory experiments conducted in 2023, which demonstrated the effectiveness of certain fungicides against the fungus responsible for gray mold in strawberries, these fungicides were further evaluated in large-scale field trials during 2024.

In greenhouse conditions, applying a chemical treatment at a rate of 400 liters of working solution per hectare using either Flusil 40 e.c. (0.1 l/ha) or Skor 25% e.c (0.15 l/ha) at the first symptoms creates the opportunity to cultivate a high-yielding, high-quality, and export-grade crop.

In the variant where the fungicide Flusil 40 e.c. was applied at a rate of 0.1 l/ha against gray mold disease in strawberries, a biological efficacy of 90.4% was achieved. Disease prevalence was recorded at 2.8%, severity at 1.3%, and the disease index stood at 2.05%.

Used references:

1.Abdullaeva H., Allayarov A. The phenological phases and ripening period of strawberry fruits planted in the open field areas. American Journal Of Agriculture And Horticulture Innovations (ISSN –2771-2559)VOLUME04ISSUE03 P.30-37.
2.Govorova G.F., Govorov D.N. Fungal diseases of Fragaria spp. (Gribnye bolezni zemliyaniki – klubniki). Mosgow: prospect, 2019. – 153 p.
3.Horowitz S., Freeman S., Zveibil A., Yarden O. A mutation in the nira-like transcription factor causes lack of pathogenicity in Colletotrichum acutatum on strawberry // Phytoparasitica. 2005, 33, 3. -P. 293-294.
4.Korolev, N., Mamiev, M., and Elad, Y. (2010). Monitoring for resistance to fungicides in Botrytis cinerea and Sclerotinia sclerotiorum, the pathogens of sweet basil. Communications in agricultural and applied biological sciences, 75(4), 705-707.
5.M.Zuparov, A.Allayarov, J.Eshmurzaev, Sh.Yuldashev. White spot disease of strawberry crops cultivated in greenhouse conditions. “Agro-chemical protection and quarantine of plants” J. 2-edition, 2024, p. 50-52.
6.M.Zuparov, A.Allayarov, J.Eshmurzaev, Sh.Yuldashev. Inoculation of the fungal pathogen Botrytis cinerea affecting strawberries on nutrient media and the study of the effect of temperature under laboratory conditions, “Bulletin of Agricultural Science of Uzbekistan” J. 2-edition, 2024, p. 109-111.
7. Newton A.C., Duncan J.M., Augustin N.H., Guy D.C., Cooke D.E.L. Survival, distribution and genentic variability of inoculum of the strawberry red care pathogen, phytophthoro fragaria var. fragariae, in sail. Plant pathology. 2010 59 (3); 472479. DOI; 10.llll/i. 1365 – 3052010.02273.x.
8.Andrenko I. A. Inheritance of Resistance to White Spot Disease in Hybrid Progeny of Garden Strawberry // Fruit and Berry Growing of Russia. 2019, (56). – P. 106–111.
9.Bilay V.I. Fusaria. –Kyiv: Naukova dumka, 1977. p-443.
10.Govorova G.F., Govorov D.N. Fungal Diseases of Strawberry. – Moscow: INKVARTA, 2010. – 168 p.
11.Grishanovich, A.K. Strawberry Diseases in the Conditions of the BSSR and Measures for Their Control: Abstract of the Diss.for the Degr.of Cand.of Agri.Scien.: 06.540 – Phytopathology / A.K. Grishanovich; Ministry of Agriculture of the BSSR, Belarusian Research Institute of Agriculture. – Minsk: [publisher not specified], 1971. – 22 p – Bibliography: p. 22 (9 titles).
12.Marchenko L.A., Pshichacheva Z.U. Resistance // Fruit and Berry Growing of Russian № 2 b 2010. – p . 204-207.
13.Merkulova L.S. Protection of Strawberries from Pests and Diseases in the Moscow Region // Plant Protection and Quarantine, No. 4, 2012. – P. 47.
14.Muslimov Z. Research and Application of Antagonistic Microorganisms in the Control of Gray Mold in Strawberry – Botrytis cinerea Pers. // Abstract of Candidate Dissertation. – Tashkent: 1964. – 16 p.

15.Natalina O.B. Diseases of Berry Crops. – Moscow: Publishing House of Agricultural Literature, Journals and Posters, 1963. – 272 p.
16.Pidoplichko N.M. Fungi – Parasites of Cultivated Plants. Volume I. – Kyiv: Naukova Dumka, 1977. – 269 p.
17.Skripka O.V., Alexandrov I.N., Durchenko I.P., Surina T.A., Nikiforov S.V., Noskin M.B. Species Composition of Mycoflora in Strawberry and Raspberry Plantations // Plant Protection and Quarantine, 2010, No. 3. – Pp. 55–57.
18.Kholod N.A. Strawberry Diseases in Southern Russia // Plant Protection and Quarantine, 2013, No. 10. – Pp. 28–30.
19.Khrabrov I.E., Antonova O.Yu., Shapovalov M.I., Semyonova L.T. Resistance of Strawberry to Major Fungal Phytopathogens: R genes and their DNA markers // Plant Biotechnology and Breeding. 2019, 2(3). – Pp. 30–37.
20.Chumakov A.E., Zakharova T.I. Harmfulness of Diseases of Agricultural Crops. – Moscow: Agropromizdat, 1990. – 128 p.
21.FAOstat, 2022. http://www.fao.org/faostat/en/#data/QC
22. Ministry of Agriculture. https://www.agro.uz