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Fungi in the main vegetable crop seeds and their fungal biological characteristics

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Abstract. Fungal contamination in vegetable crop seeds poses a significant threat to agricultural productivity and food security. This manuscript investigates the presence of fungi in the main vegetable crop seeds and explores their fungal biological characteristics. The study employed a comprehensive approach involving sample collection, fungal isolation, morphological identification, and molecular characterization. The research collected a diverse range of vegetable crop seeds from different locations of Uzbekistan and examined them for the presence of fungal pathogens. Aseptic techniques were utilized to isolate and culture fungi from the seed samples. Morphological characteristics, including colony appearance, spore production, and hyphal structure, were evaluated to identify the fungal species. In cases where morphological identification was challenging, molecular techniques were employed for accurate species determination. The research of 36 species of fungal phytotoxic qualities was done using seeds that were collected and preserved during the growing of vegetable crops in farms in the Tashkent region of Uzbekistan. The findings are presented in this paper. Based on the impact on vegetable crop root and stem growth and seed germination, phytotoxic characteristics were identified. Phytotoxic fungi were defined as those that lowered these markers by 30% when compared to the control.
Keywords. Seed, fungus, phytotoxic, strain, tomato, bell pepper, onion, cabbage, metabolite, toxin.

1 Introduction

Vegetable crops play a vital role in providing essential nutrients and dietary diversity to human populations worldwide. However, the agricultural productivity of these crops is often threatened by various factors, including fungal pathogens [1]. Fungi can cause significant damage to vegetable crops, leading to yield losses, reduced quality, and economic repercussions for farmers. The presence of fungal pathogens in vegetable crop seeds serves as a potential source of infection, leading to subsequent plant diseases in the field [2].

Understanding the fungal communities associated with vegetable crop seeds and their biological characteristics is crucial for devising effective disease management strategies [3].

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By identifying the prevalent fungal species and comprehending their biological characteristics, we can gain insights into their pathogenic potential, mode of transmission, and strategies for control [4, 5].

Numerous studies have highlighted the presence of fungal pathogens in various plant parts, including leaves, stems, and roots [6]. However, the investigation of fungal communities specifically in vegetable crop seeds is an area that warrants further attention. Seeds serve as a reservoir for fungi, carrying them from one growing season to another and facilitating their dispersal [7]. Moreover, seeds play a crucial role in the transmission of fungal pathogens across geographical regions and between different planting sites [8-10].

More than 30-35 types of vegetable crops are grown in large areas under production conditions around the world. Depending on the agro-climatic conditions, 10-15 types of vegetables are grown in each region. Among these vegetable crops, tomato, onion, cabbage and bell pepper are grown in large areas in Uzbekistan [2, 3].

The use of high-quality seeds is very important in obtaining abundant harvests from agricultural crops. There is no guarantee that a quality seed collected will retain this characteristic until it is planted. Because the microorganisms present in the air and the environment settle on the surface of ripening or ripe seeds. These microorganisms release various metabolites as a result of their life activity. Among these substances, special physiologically active substances-toxins that slow down or accelerate the growth and development of seeds occupy a special place [1, 4, 6]. The concept of toxin is understood as any substance of the pathogen that has a negative effect on the organism of the host. They are inductive substances that change the biological process of the plant as a result of chemical action [7-9].

2 Materials and methods

Based on the foregoing, it was intended to investigate the phytotoxic qualities of 36 species of fungus that were isolated from the principal vegetable crops in Uzbekistan, such as tomato, onion, cabbage, and bell pepper, and harvested and kept in the farms of the Tashkent region. In this instance, research was carried out in a lab setting.

The isolated fungal strains from the seeds were initially grown in wort nutritional medium before being used in the tests. This was accomplished by placing 250 ml of wort food into flasks, sealing them with stoppers, and tying them shut with paper. The flasks were then sterilized at 121°C for 40 minutes at a pressure of 1 atm. The fungal strains of each species were planted in separate flasks in a laminar box after chilling the suspension media in the flasks.

The flasks were put in thermostats set at a temperature of 24-26°C for the growth of fungus, and they were left there for 10 days. The culture medium in which strains of each variety of fungus were cultivated was cooked for 24 hours with 100 seeds of each tomato, onion, cabbage, and bell pepper. The seeds used as a control were defrosted in sterile water. In batches of 25, these seeds were equally distributed in sterile Petri plates coated with wet filter paper.

Then, for the growth and development of seeds, Petri dishes were put in a thermostat with a temperature of 24-26°C. Starting on the third day, 15 days were tallied for seed germination.

3 Results and discussion

Phytotoxic properties of 36 species of fungal strains isolated from seeds were determined based on their effects on tomato, onion, cabbage and bell pepper seed germination and root and stem development. Fungal strains that reduced these indicators by 30% compared to the control were found to have phytotoxic properties [10-12].

If we look at the data obtained as a result of the experiments, the strongest phytotoxic properties were shown by fungi belonging to the *Alternaria brassicae, A.solani, Aspergillus niger, Botrytis allii, B.cinerea, Fusarium culmorum, F. oxysporum f. conglutinans, F. oxysporum f. lycopersici, F. oxysporum f. vasinfectum, Mucor saturninus, Penicillium puberulum,* and *Stemphulium allii* species. Germination of seeds thawed in their culture fluids was 10.0-30.0% (Table 1).

Table 1. Effect of fungi isolated from seeds on seed germination of vegetable crops.

#	Fungi	Vegetable crops Seed germination, %			
		Tomato	**Onion**	**Cabbage**	**Bell pepper**
1	*Alternaria brassicae*	24.0	22.0	15.0	29.0
2	*A.cheiranthi*	68.0	59.0	51.0	55.0
3	*A.dianthicola*	57.0	70.0	56.0	61.0
4	*A.solani*	30.0	27.0	21.0	30.0
5	*A.tenuis*	31.0	43.0	45.0	50.0
6	*Aspergillus flavus*	35.0	44.0	45.0	50.0
7	*A.fumigatus*	52.0	51.0	83.0	53.0
8	*A.melleus*	44.0	48.0	50.0	31.0
9	*A.niger*	15.0	30.0	10.0	22.0
10	*A.ochraceus*	52.0	71.0	56.0	61.0
11	*Botrytis allii*	28.0	21.0	30.0	29.0
12	*B.cinerea*	28.0	27.0	23.0	26.0
13	*Cephalosporium coremioides*	51.0	60.0	75.0	52.0
14	*Cladosporium herbarum*	35.0	41.0	50.0	43.0
15	*C.lycopersici*	31.0	47.0	46.0	35.0
16	*C.transchelii*	56.0	59.0	53.0	68.0
17	*Fusarium culmorum*	27.0	13.0	29.0	30.0
18	*F.oxysporum f.conglutinans*	30.0	28.0	22.0	29.0
19	*F.oxysporum f.lycopersici*	21.0	29.0	28.0	25.0
20	*F.oxysporum f.solani*	51.0	74.0	60.0	54.0
21	*F.oxysporum f.vasinfectum*	25.0	30.0	29.0	23.0
22	*F.solani*	41.0	45	47.0	46.0
23	*Heterosporium allii-cepae*	51.0	52.0	80.0	58.0
24	*Hormiscium stilbosporum*	54.0	49.0	65.0	61.0
25	*Mucor saturninus*	28.0	30.0	27.0	26.0
26	*M.mucedo*	44	33.0	49.0	40.0
27	*Nigrospora sphaerica*	35.0	49.0	50.0	61.0
28	*Penicillium citrinum*	51.0	65.0	58.0	54.0
29	*P.puberulum*	21.0	22.0	30.0	25.0
30	*P.glaucum*	36.0	47.0	50.0	40.0
31	*P.griseo-roseum*	54.0	52.0	77.0	59.0
32	*Rhizopus nigricans*	31.0	45.0	40.0	36.0
33	*Stemphylium allii*	27.0	20.0	25.0	29.0
34	*Trichothecium roseum*	38.0	50.0	44.0	45.0
35	*Verticillium dahliae*	31.0	46.0	50.0	37.0
36	*V.nigrescens*	37.0	47.0	50.0	48.0
37	Control	80.0	86	96.0	65.0

Phytotoxic properties of *Alternaria tenius, Aspergillus flavus, A.melleus, Cladosporium herbarum, C. lycopersici, F.solani, Mucor musedo, Nigrospora sphaerica, Penicillium glaucum, Rhizopus nigricans, Trichothecium roseum, Verticillium dahliae, V.nigrescens* fungal species were moderate, and it was noted that the germination of vegetable crops was 31-50% under their influence.

The phytotoxic properties of the rest of the fungal species were very weak, and it was observed that the germination of seeds frozen in their culture liquid was 51-83%. The effect of these fungi on the development of roots and stems of sprouts sprouted from tomato, onion, cabbage and bell pepper was also studied.

Compared to tomato and bell pepper seeds, the culture fluids of *Alternaria solani, Aspergillus niger, Cladosporium lycopersici, Fusarium oxysporum f. conglutinans, F. oxysporum f. lycopersici, F. oxysporum f. solani, F. oxysporum f. vasinfectum, Mucor saturninus, Nigrospora sphaerica, Trichothecium roseum, Verticillium dahliae* species showed strong phytotoxic properties and slowed down the root and stem development of seedlings by 50.1-89.1% compared to the control (Tables 2 and 3).

Table 2. Effect of fungi isolated from seeds on seed growth and development of vegetable crops (tomato and onion).

	Fungi	**Vegetable crops**							
		Tomato				**Onion**			
		Seedling growth and development in % compared to control							
		Root growth		**Stem growth**		**Root growth**		**Stem growth**	
		Acc.	**Red.**	**Acc.**	**Red.**	**Acc.**	**Red.**	**Acc.**	**Red.**
1	*Alternaria brassicae*	-	33.1	-	49.6	-	12,4	-	15,1
2	*A.cheiranthi*	-	27.4	-	21.9	-	13,1	-	17,3
3	*A.dianthicola*	-	25.6	-	18.4	-	15,3	-	21,8
4	*A.solani*	-	87.3	-	77.9	-	17,8	-	20,4
5	*A.tenuis*	-	47.0	-	39.8	-	19,2	-	23,7
6	*Aspergillus flavus*	-	30.6	-	27.5	10,1	-	0,4	-
7	*A.fumigatus*	28.2	-	-	1.3	-	15,3	-	7,5
8	*A.melleus*	17.9	-	0.3	-	-	17,2	-	7,6
9	*A.niger*	-	65.0	-	59.0	-	79,7	-	58,2
10	*A.ochraceus*	15.6	-	0.5	-	-	16,9	-	6,8
11	*Botrytis allii*	-	20.4	-	17.3	-	82,3	-	67,5
12	*B.cinerea*	-	27.6	-	21.5	-	15,8	-	24,2
13	*Cephalosporium coremioides*	-	29.0	-	0.6	-	14,5	-	24,3
14	*Cladosporium herbarum*	-	11.1	-	18.1	-	2,6	-	1,7
15	*C.lycopersici*	-	54.8	-	75.3	-	1,9	-	0,8
16	*C.transchelii*	-	12.9	-	20.3	-	3,5	-	2,0
17	*Fusarium culmorum*	-	27.3	-	29.6	-	78,1	-	69,5
18	*F.oxysporum f.conglutinans*	-	62.1	-	54.5	-	24,5	-	21,3
19	*F.oxysporum f.lycopersici*	-	89.1	-	73.6	-	19,7	-	28,4
20	*F.oxysporum f.solani*	-	70.4	-	65.9	-	27,5	-	33,6
21	*F.oxysporum*	-	64.2	-	70.3	-	33,1	-	41,6

	f.vasinfectum								
22	*F.solani*	-	25.0	-	12.4	-	15,2	-	27,1
23	*Heterosporium allii-cepae*	-	38.4	-	39.7	-	49,3	-	58,3
24	*Hormiscium stilbosporum*	-	32.1	-	31.4	-	47,0	-	41,9
25	*Mucor saturninus*	-	75.2	-	56.3	-	42,1	-	38,5
26	*M.mucedo*	-	40.4	-	38.9	-	37,6	-	32,3
27	*Nigrospora spharica (Sacc.)Mason*	-	73.5	-	51.2	-	42,1	-	30,3
28	*Penicillium citrinum*	6.8	-	12.1	19.3	-	55,9	-	50,1
29	*P.puberulum*	-	11.7	-	8.7	10,5	-	7,7	-
30	*P.glaucum*	-	15.2	-	19.3	12,1	-	14,3	-
31	*P.griseo-roseum*	-	14.8	-	13.5	-	30,2	-	37,5
32	*Rhizopus nigricans*	-	28.9	-	29.4	-	12,6	-	15,2
33	*Stemphylium allii*	-	50.1	-	45.7	-	49,4	-	58,1
34	*Trichothecium roseum*	-	57.3	-	51.0	-	25,2	-	22,4
35	*Verticillium dahliae*	-	74.0	-	51.3	-	18,1	-	20,3
36	*V.nigrescens*	-	48.9	-	41.2	-	30,2	-	34,5
37	Control	10.2		28.4		33.5		29.0	

Table 3. Effect of fungi isolated from seeds on the growth and development of seeds of vegetable crops (Cabbage and bell pepper).

	Fungi	**Vegetable crops**							
		Cabbage				**Bell pepper**			
		Seedling growth and development in % compared to control							
		Root growth		**Stem growth**		**Root growth**		**Stem growth**	
		Acc.	**Red.**	**Acc.**	**Red.**	**Acc.**	**Red.**	**Acc.**	**Red.**
1	*Alternaria brassicae*	-	53.0	-	67.6	-	30,2	-	44,5
2	*A.cheiranthi*	-	22.1	-	29.9	-	20,5	-	21,3
3	*A.dianthicola*	-	18.3	-	24.7	-	24,2	-	15,8
4	*A.solani*	-	37.8	-	42.5	-	80,5	-	71,6
5	*A.tenuis*	-	20.4	-	27.1	-	44,6	-	32,5
6	*Aspergillus flavus*	-	23.9	-	29.1	-	24,2	-	21,7
7	*A.fumigatus*	-	44.6	-	48.6	30,4	-	-	2,0
8	*A.melleus*	-	47.7	-	44.3	19,2	-	0,5	-
9	*A.niger*	-	89.9	-	75.6	-	61,0	-	52,3
10	*A.ochraceus*	-	40.5	-	49.2	17,4	-	0,4	-
11	*Botrytis allii*	-	55.6	-	51.2	-	18,9	-	15,4
12	*B.cinerea*	-	82.3	-	68.4	-	28,3	-	19,2
13	*Cephalosporium coremioides*	-	58.0	-	54.7	-	27,5	-	0,3
14	*Cladosporium herbarum*	-	58.6	-	77.7	-	10,7	-	14,1

15	*C.lycopersici*	-	37.2	-	45.3	-	50,2	-	63,8
16	*C.transchelii*	-	50.1	-	68.3	-	13,2	-	21,6
17	*Fusarium culmorum*	-	51.4	-	50.5	-	24,5	-	29,1
18	*F.oxysporum f.conglutinans*	-	85.0	-	74.3	-	58,2	-	50,3
19	*F.oxysporum f.lycopersici*	-	24.0	-	22.5	-	78,5	-	64,2
20	*F.oxysporum f.solani*	-	29.7	-	28.9	-	63,9	-	55,7
21	*F.oxysporum f.vasinfectum*	-	43.7	-	30.2	-	81,5	-	76,4
22	*F.solani*	-	14.9	-	21.5	-	20,3	-	10,5
23	*Heterosporium allii-cepae*	-	52.0	-	55.3	-	36,4	-	37,2
24	*Hormiscium stilbosporum*	-	38.1	-	31.4	-	30,9	-	303
25	*Mucor saturninus*	-	33.2	-	30.5	-	70,2	-	51,4
26	*M.mucedo*	-	29.4	-	21.3	-	45,8	-	40,7
27	*Nigrospora spharica (Sacc.)Mason*	-	29.3	-	23.9	-	70,0	-	49,2
28	*Penicillium citrinum*	-	52.3	-	57.4	8,3	-	15,3	-
29	*P.puberulum*	8.2	-	5.3	-	-	10,2	-	5,6
30	*P.glaucum*	10.4	-	12.5	-	-	13,8	-	15,7
31	*P.griseo-roseum*	9.5	-	7.6	-	-	6,7	-	5,4
32	*Rhizopus nigricans*	-	20.1	-	17.3	-	27,6	-	29,5
33	*Stemphylium allii*	-	17.4	-	19.2	-	52,3	-	48,7
34	*Trichothecium roseum*	-	20.1	-	16.5	-	59,4	-	54,5
35	*Verticillium dahliae*	-	15.9	-	17.4	-	70,1	-	52,0
36	*V.nigrescens*	-	27.4	-	29.6	-	45,3	-	38,4
37	Control	41.7		32.1		11.7		30.5	

Culture fluids of some of these fungi, including *Aspergillus fumigatus, A.melleus, A.ochraceus, Penicillium citrinum*, accelerated root and stem development of vegetable crops by 0.3-30.4% compared to control.

Aspergillus niger, Botrytis allii, Fusarium culmorum, Heterosporium allii-cepae, Penicillium citrinum, Stemphylium allii culture fluids of fungi showed strong phytotoxic properties by reducing the development of root and stem of onion seedlings by 50.1-82.3% compared to the control.

Average phytotoxic properties were shown by *F.oxysporum f.vasinfectum, Hormiscium stilbosporum, Mucor saturninus, M.mucedo, Nigrospora sphaerica, Penicillium griseo-roseum, Verticillium nigrescens* species, and these indicators were 30.2-49.4%.

Phytotoxic properties of culture fluids of other fungi taken for the experiment were weak and they slowed down the development of onion roots and stems by 0.8-28.4%, while some *Aspergillus flavus, Penicillium puberulum, P.glaucum* species accelerated the development of roots and stems of seedlings by 0.4-14.3% compared to the control.

Alternaria brassicae, Aspergillus niger, Botrytis allii, B.cinerea, Cladosporium herbarum, C.transchelii, Fusarium culmorum, F.oxysporum f.conglutinans, Heterosporium allii-cepae, Penicillium citrinum fungal species showed strong phytotoxic properties by reducing the root and stem development of seedlings sprouted from cabbage seeds by 50.1-85.0% compared to the control [5].

Moderate phytotoxic properties were observed in cabbage seeds soaked in culture fluids of *Alternaria solani, Aspergillus fumigatus, A.melleus, A.ochraceus, Cladosporium lycopersici, Fusarium oxysporum f.vasinfectum, Hormiscium stilbosporum, Mucor saturninus* fungi. Under their influence, the root and stem development of seedlings slowed down by 30.2-49.2%. In other remaining fungi, this figure was less than 30.0%. Culture fluids of *Penicillium puberulum, P.glaucum* and *P.griseo-roseum* fungi accelerated the growth of cabbage roots and stems by 5.3-12.5% compared to the control.

In the control variant, the average length of the root of tomato seedlings was 10.2 mm and the length of the stem was 28.4 mm, in onion seedlings these indicators were 33.5 mm and 29.0 mm, in cabbage 41.7 mm and 32.1 mm, and in bell pepper 11.7 mm and 30.5 mm.

4 Conclusions

Based on the data obtained as a result of the experiments, it can be concluded that when there are favorable conditions for the development of fungi found in the seeds of vegetable crops, some of them cause diseases in the seeds, and some of them do not cause diseases, but the metabolites released by them, that is, toxins, slow down the germination of seeds, the growth and development of seedlings. done. Experiments have once again proven that the use of quality, healthy and fungal spores-free seeds for planting is the guarantee of abundant harvest.

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