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MDMV SPREAD AND ITS CONTROL UNDER THE CLIMATIC CONDITIONS OF TASHKENT REGION, UZBEKISTAN

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SUMMARY

The following research comprised the discussion on the spread of the maize dwarf mosaic virus (MDMV), virus transmission, and scientifically based measures to combat the virus. The MDMV monitoring centered on the spread, diagnosis, and impact of the virus on morphophysiological traits and productivity of different maize cultivars. Over the past four years of research, the MDMV infection in corn samples was 44.7% (2020), 35.9% (2021), 27.0% (2022), and 23.0% (2023). The MDMV level of infection declined every year due to comprehensive measures to combat MDMV. In identifying reserve plants and vectors (aphids) of the virus, the main provision aimed at the use of various methods in combating the MDMV. The results revealed *Sorghum halepense* Pers. was the chief reservoir of MDMV. The complex control measures include selection of cultivars and hybrids resistant to MDMV. Based on the results, determining the corn cultivars emerged from their resistance to the MDMV. The hybrids Legend F1 from France, DKS 4141 F1 from Turkey, and Phenomenon F1 from Switzerland were notable with an average degree of MDMV infection. The degrees of infection were highest in the maize cultivar Mazza from Uzbekistan and the hybrid Megaton F1 from France, which proved not resistant.

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Keywords: Maize dwarf mosaic virus (MDMV), maize cultivars and hybrids, virus host and transmission, *Sorghum halepense* Pers., vectors, morphophysiological traits, productivity

Key findings: For the maize dwarf mosaic virus (MDMV), the *Sorghum halepense* Pers. was apparently the main reservoir. In complex control measures, the corn cultivars' identification occurred from their resistance to MDMV.

INTRODUCTION

Maize (*Zea mays* L.) is a vital cereal crop worldwide and crucial in global food security and various industrial applications. Maize cultivation faces considerable challenges from several insect pests and pathogens, including the leaf aphid (*Rhopalosiphum maidis*) and maize dwarf mosaic virus (MDMV) (Bastakoti *et al*., 2024). MDMV belongs to the genus *Potyvirus* of the family Potyviridae, which includes species totaling 195, and is justifiably one of the most common genera of viruses that affect crop plants. However, in this genus, four main viruses exist that influence the maize crop. These mosaic viruses include the Johnsongrass, sugarcane, sorghum, and MDMV, where the MDMV is the most common in maize fields (Kannan *et al.,* 2018).

The virus' main sources in the field are infected plants and, to a lesser extent, infected seeds. Among the host plants, various species of the Poaceae family serve as natural sources of the virus. Among them, the most important are Johnsongrass (*Sorghum halepense*), corn (*Zea mays*), wheat, millet (Makhmudov *et al*., 2023, 2024, 2025) and sorghum (*Sorghum bicolor*) (Sobirova and Fayziev, 2021, 2023; Sobirova *et al*., 2023, 2025). The maize dwarf mosaic virus (MDMV) spread from introduced virus-infected Johnsongrass to the adjacent susceptible cornfields in 1979 and 1980 (Knoke *et al.,* 1983).

MDMV overwinters in the rhizomes of gumai (*Sorghum halepense Pers*) before transferring to healthy plants mechanically through sap inoculation. Young plants appeared most susceptible to the virus. In corn plants, the pathogenic effect of the virus shows a manifestation to a greater extent when infection occurs at the early stages of development and at the 5–7 leaf phases (https://fish-info.ru/disease/virus-karlikovoy-mozaiki-kukuruzy/). The aphids, being a vector, also infect young plants with the virus and transmit the infection to healthy plants of corn, sorghum, and Sudan grass.

Viral plant diseases differ from other infectious diseases by their difficulty to eliminate with one method or one chemical. Additionally, the spread of viral diseases occurs spontaneously, damaging the vegetative and generative organs of plants. The frequency of viral infection depends on the influence of abiotic and biotic factors. Plant viruses' transmission can transpire vertically (from parents to offspring) and horizontally (from diseased plants to healthy ones) (Nazarov *et al.,* 2020). Often, most plant viruses actively spread from infected plants to healthy ones with the help of a carrier organism (vector). Vectors can consist of mechanical, in which the pathogen does not spread, and biological, wherein part of the life cycle of the virus takes place (Gray and Banerjee, 1999).

The virus transmittal could be through many aphid species, including *Rhopalosiphum maidis, Schizaphis graminum,* and *Myzus persicae*, and transmission occurs in a non-persistent manner. This means aphids acquire the virus during a short period of feeding on an infected plant and can transmit it in a short time, usually a few hours. The MDMV spread under field conditions depends on several factors, including aphid population, host plant availability, and weather conditions. Warm weather and high humidity favor aphid reproduction and, eventually, virus spread. Controlling aphid populations and removing infected plants can help reduce the MDMV spread.

Aphids are the most common vectors of plant viruses and can easily transmit both persistent and non-persistent viruses. Aphids non-persistently transmit more than 200 species of plant viruses (Davranov, 1984).

Among these insects, the order of Homoptera insects with their piercing-sucking mouthparts were evidently highly effective carriers of plant viruses. Within this order, the soft-bodied aphids (family Aphididae) make up more than 50% of the vector species, transmitting more than 60% of viruses (Shaikh *et al*., 2008). In addition, more than 20 different species of aphids are capable of non-persistent transmission of the vesicular keratitis/conjunctivitis murine virus (MKMV), also known as the murine vesicular disease (MVD) (Hill *et al*., 1973; Kannan *et al.,* 2018). The wide range of aphids includes *Rhopalosiphum maidis* Fitch, *Myzus persicae* Sulzer, *Rhopalosiphum padi* Linnaeus, *Rhopalosiphum poae* Gill, and *Rhopalosiphum fitchii* Sand (Chen *et al*., 2019).

Virus transmission by aphids showed a close linkage to virus persistence in stylets. Past studies revealed the MDMV persistence was much longer with increasing collection time, with recorded lag times of around 15–20 minutes (Ammar, 1994; Kannan *et al*., 2018). However, longer periods of up to 240 minutes have also been notable for the retention of MDMV-A *Myzus persicae* Sulzer (Davranov, 1984). Two viral factors exist that mediate the attachment of viruses to aphid appendages: CP as a component of the virion and the helper component-proteinase (HC-Pro) (Hill *et al.,* 1973; Kannan *et al*., 2018). The accessory component is a non-structural protein found in diseased plants but not found in healthy tissues. The HC-Pro protein forms an interaction between the vector stylet and the viral envelope protein, thus performing its function as a 'molecular bridge' (Valli *et al*., 2017). The viral vectors involved in transmission are fairly obvious. The receptors in aphids that allow retention, as well as inoculation of non-persistent viruses, remain unidentified but seem localized at the distal edge of the appendage bundle.

The viral infection, penetrating into the plant tissues through the bite of aphids, destroys the cellular structures. In conducting tissues, gradually destroying cell by cell, viral particles pass through the system of the infected plants. Aphids are one of corn's serious pests and a carrier of viral diseases. The interaction between maize, the insect vectors, and MDMV offers an ideal model for understanding plant-insect-pathogen relationships, which is critical for developing effective management strategies. More than 20 different species of aphids are capable of transmitting MDMV intermittently, causing discoloration and dwarfing, infertility, and sometimes, premature death of crop plants (Kannan *et al.,* 2018).

Interestingly, several aphid species (including *Rhopalosiphum maidis, Myzus persicae, Rhopalosiphum padi, Rhopalosiphum poae, Brevicoryne brassicae,* and *Rhopalosiphum fitchii*) typically transmit MDMV intermittently in maize (Kunkel 1921; Bastakoti *et al*., 2024). Among them, the corn leaf aphid (*Rhopalosiphum maidis*) is one of the main insect vectors (Kannan *et al*., 2018). Viral pathogens carried by *R. maidis* have numerous reports in all maize-growing regions and caused losses ranging from 38.9% to 98.8%, with an average loss of 71.7% (Yoon-Sup, 2003). Transmission of MDMV by aphids, particularly *R. maidis*, poses a significant threat to maize production worldwide (Bastakoti *et al*., 2024).

The host range of MDMV includes several species, such as maize, sorghum *(Sorghum bicolor)*, sugarcane *(Saccharum officinarum),* and millet *(Panicum miliaceum).* Holophrastic MDMV has usual transmission from aphids and thrips in a non-persistent manner. Maize plants infected with MDMV display symptoms such as mosaic, chlorosis, and stunted growth with significant reduction in biomass, ear size, and kernel number. Some factors can cause the spread of MDMV. Various studies have found that the spread of viral diseases in corn plants was due to the preservation of the virus in seeds (Davronov, 1984). In his research, he found preserving MDMV can occur in corn grains, causing the spread of the virus ranging from 0.5% to 20.0%.

In Uzbekistan, out of 220,000–240,000 hectares annually, grain corn growing prevails on 70,000–75,000 hectares. The average yield is 35–40 tons for silage and 5.5–5.8 tons for cereals, reaching the gross yield of 385,000–400,000 tons (Ostonaqulov *et al*., 2025). This result does not solve the problem of silage shortage in agriculture. In providing sufficient feed for livestock, it is necessary to grow varieties of corn resistant to viral diseases. Plant viruses pose a serious threat to a wide range of crops, while the economic losses caused by viruses are second only to the losses caused by other pathogens. Moreover, some viruses can infect more than 1,000 different plant species, comprising more than 85 families (Nazarov *et al*., 2020).

MDMV affects several cultivated and wild plants from the Poaceae family. The main hosts are maize, wheat, sugarcane, and sorghum. The MDMV virus sometimes infects the host plant in combination with other viruses, with other aphid populations involved in their transmission. The study showed adults of *R. maidis* are the most efficient in transmitting the sugarcane mosaic virus; therefore, for effective management of maize lethal necrosis disease, successful management of aphid vectors is critical (Kinyungu *et al*., 2018).

A complex viral infection of plants is a real disaster for crops. When a plant bears attacks from several viruses at once, this leads to serious consequences, including tissue necrosis. It was precisely this problem in the cornfields that alarmed farmers in 2020 in the Tashkent Region. Hence, the presented study aimed to monitor the MDMV spread and comprehensively combat the virus in maize fields of the Tashkent Region, Uzbekistan.

MATERIALS AND METHODS

Determination of virus contamination

In determining the level of plant infestation, 20 areas of 1 m^2 received markings along a line diagonally intersecting a 1-ha area. The maize plants located in these areas sustained checking, calculating the level of infestation based on the following formula by the method of Yu. I. Vlasov (Davranov, 1984).

$$P = \frac{n \times 100}{N}$$

Where P is the degree of damage (damage rate – P, %), n is the number of diseased plants, and N is the total number of plants examined.

The samples collected from infected maize plants had the following order: from each 10-m point of 1 ha of a field sown with corn, taking four leaves came from the upper, middle, and lower parts of the stem of maize plants with signs of the disease. They sustained wrapping in paper bags that practically do not absorb moisture. Information about the samples (cultivar, symptoms of the disease, and date of collection) became labels written on the packaging, and storage proceeded in a thermos refrigerator.

The study used the Vlasov method to determine the infestation by counting the number of plant bushes in each plot (each plot contains separate cultivars of corn) and, later, counting the number of infected bushes in each plot. Factors facilitating the spread of MDMV include contact with infected plants, spread through insect vectors, and seed dispersal. The scientific research in studying the spread of viral diseases includes research into the mechanisms of virus transmission, development of diagnostic and control methods, and identification of new virus strains. Prevention and control of viral diseases could be efficient by using resistant cultivars, applying chemical and biological means of protection, and employing measures for the sanitary treatment of crops.

Field research and data analysis

In the next phase, the visual and immunodiagnostic studies continued in cornfields sown in 10 crop farms located in different areas of the Tashkent Region, which also attained thorough monitoring for viral diseases. The number of infected corn plants, as determined, also used the Vlasov method. The scientific research conducted in farmer fields in the Kibray District during 2020–2023 revealed vectors spread viral diseases in cornfields (Sobirova, 2024). In this four-year research, we also studied the symptoms of the virus, the nature of infection, the dynamics of spread, transmission routes, and the impact of the virus on the growth, development, and grain yield of maize.

According to disease symptoms, various manifestations were noteworthy on the corn plants: the presence of striped mosaic, red necrosis along the veins of the leaf tissue, yellow mosaic along the veins of the leaf, and symptoms of dwarfism of plants. In studies to determine the species affiliation of this viral disease, it succeeded in establishing that this virus was the Uzbek isolate MDMV.

Integrated methods of combating MDMV

For the different maize cultivars procured locally and abroad, it was necessary to find out the best ones for specific local conditions, the most productive, and early ripening. But most importantly, it is essential to determine cultivars resistant to diseases and insect pests and more responsive to fertilizers. In this research, 15 maize cultivars obtained from the collection of the Research Institute of Plant Genetic Resources became samples.

Establishing the resistance in corn cultivars and developing methods to combat these pests are highly critical from agricultural and breeding points of view, as viral plant diseases, unlike other diseases, are less susceptible to traditional treatment. Given this, viruses are very resistant and develop faster. Therefore, it is crucial to determine the virus species and their nature. Most viruses have acquired various adaptations in their life cycle during evolution (Figure 1). One of the best methods of combating viruses is the use of resistant cultivars. In the next phase of the study, numerous corn cultivars, selected and planted in an experimental field, underwent later studies for their resistance to the virus. For this, we artificially infect the corn cultivars at different stages of development by mechanical inoculation, with the infected plants counted. The studied corn cultivars incurred groupings based on their degree of resistance to the virus.

In the studies conducted with different corn cultivars, none of the cultivars appeared equally resistant to the dwarf mosaic virus. One should also consider local corn cultivars proved more resistant to viral diseases. This may be because local cultivars adapted better to the environmental conditions of the area than the exotic cultivars. The study also revealed the degree of damage increases with the development of plants in different phases.

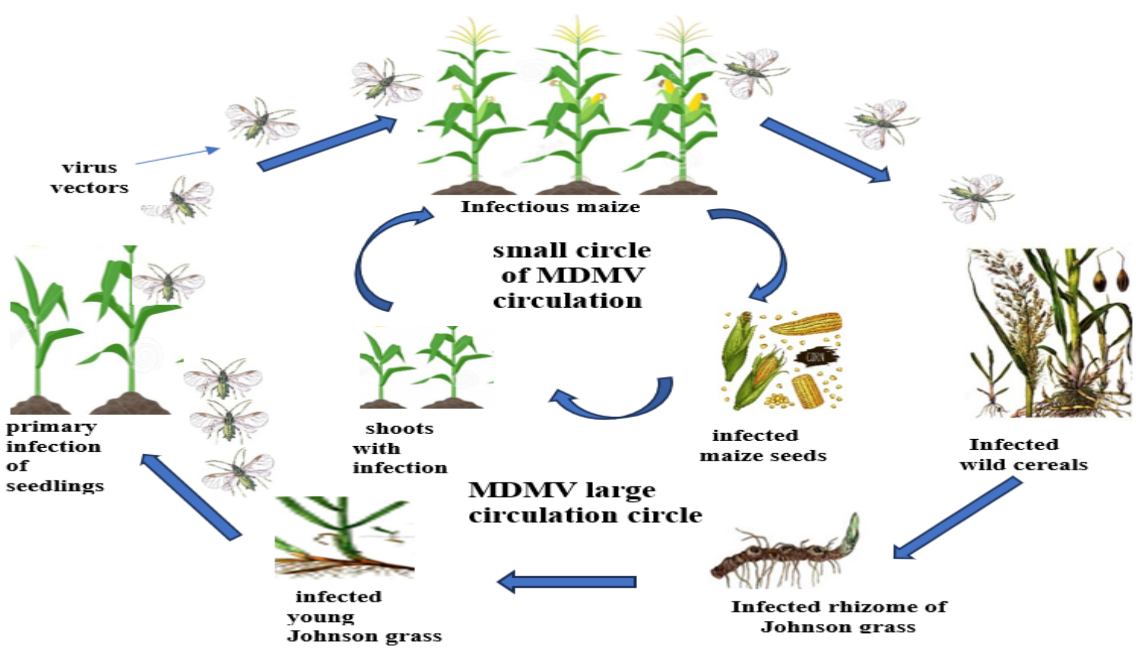

Figure 1. The MDMV spread cycle.

RESULTS

In the study region during 2020, the weather was dry compared to previous years. Most farmers chose sweet corn cultivars, with poor processing, and a dry, hot climate allowed viral diseases to spread widely. For example, in the fields of Istiklol Myrzakhmetov Mirgiyes Mirzakarimovich, the viral infection rate was 50%–68%, while in the Mirusmon Mirholik Baraka Region, the said infection ratio was 40%–56%, which were the highest levels of corn virus infection. Unfortunately, viral diseases reduced the growth and development of corn plants, and as a result, the grain yield also decreased. The choice of cultivars was wrong, and the weather conditions were also favorable for the disease to spread. We advised the farming community to select corn cultivars resistant to viral diseases to improve the situation. This year, in the maize fields of Temir-Kadam and Kenzhaev Zhakhongir-Fayz, the prevalence of viral disease ranged from 15% to 25%. These results did not particularly worry the farmers; however, the viral diseases were still evident. One of the important reasons for the difference in the dynamics of distribution was the instability of maize cultivars to viral diseases. Given the viral threat, the researchers suggested farmers choose more resistant corn cultivars.

In 2021, the yield increased slightly, which was due to farmers selecting the more resistant cultivars, following our recommendations. These maize cultivars succeeded in planting as per the instructions, with the spread of viral diseases in different farms monitored and instructions for eliminating the disease proposed. The results showed the prevalence of the viral disease ranged from 15% to 48%. Most farmers chose the virus-resistant corn cultivars; however, in some fields at the Mukhiddin-Gold and Istiklol-Yuksalish, the prevalence of the viral disease ranged from 30% to 48%.

Monitoring the prevalence of viral diseases showed corn plant infection with MDMV partially lowered in 2022 compared to previous years. For example, in the fields of Istiklol Myrzakhmetov Mirgiyes Mirzakarimovich, the virus infection was 10%–15%, and in Mirusmon Mirkholik Baraka, the infection was 9%–22%. Compared to 2020, the infection decreased by 40%–50%. This was because farmers chose the cultivars resistant to viral diseases and used comprehensive measures to combat the virus, including combating the carrier and regenerator of the virus. The prevalence of MDMV corn viral diseases in 2023 attained partial reduction compared to previous years. However, the change was not as high compared to 2022.

According to the analysis of the monitoring data based on the spread of viral disease, it was clear that the viral disease was present to a greater or lesser extent. By analyzing the corn cultivars, the degree of infection varied depending on the type of pathogen, ranging from 10% to 68% in various corn cultivars. The level of disease spread ranged from 30% to 68% in the maize cultivar Mazza-Uzbekistan. The cultivar Uzbekskaya Zubovidnaya had an infestation rate of 25%–36%. The F1 hybrid PR-31 P-41 had an infestation rate of 32%–48%. However, the lowest virus infestation (10%–25%) resulted in the maize cultivars and hybrids, viz., Eurek from Uzbekistan, Uzbekistan-306 AMV, Uzbekistan-601 ESV, Uzbekskaya Zubovidnaya, and Golden Batam F1 from France. The significant frequency of virus identification in the cultivar Mazza-Uzbekistan and F1 hybrid PR-31 P-41 was noteworthy (Table 1).

In the next phase of study, several corn cultivars, selected and grown in the experimental field, entailed studies for their resistance to the virus. For this purpose, the corn cultivars sustained artificial infection at different stages of growth and development by mechanical inoculation, with the infected plants counted. The studied cultivars underwent groupings based on their degree of resistance to the viruses. The results revealed corn cultivars were apparently not equally resistant to the dwarf mosaic virus. However, the local corn cultivars proved more resistant to viral diseases. This could refer to their better adaptation to the environmental conditions of the area compared with exotic cultivars. The study also showed the degree of damage increases with the development of plant phases (Table 2).

Table 1. Monitoring the dynamics of the viral disease spread over four years in maize fields of the Tashkent regions.

No.	Name of the farm	Cultivars and hybrids 2020	MDVM infectivity, 2020 (%)	Cultivars and hybrids 2021	MDVM infectivity, 2021 (%)	Cultivars and hybrids 2022	MDVM infectivity, 2022 (%)	Cultivars and hybrids 2023	MDVM infectivity, 2023 (%)
1.	Istiklol Mirzakhmedov Mirgies	Mazza	68±0.015	PR 31 P41 F1	22±0.098	Uzbekistan-601 ESV	15±0.047	Uzbekistan-601 ESV	18±0.081
2.	Umid-Agro	PR 31 P41 F1	48±0.08*	Uzbek Dent	46±0.012	PR 31 P41 F1	36±0.041	Uzbekistan-601 ESV	31±0.036
3.	Muhyiddin-Gold	Mazza	51±0.04*	PR 31 P41 F1	32±0.072	PL-700	20±0.039	PL-700	21±0.019
4.	Kibray Erkinova N	Uzbek Dent	36±0.07*	60-63	44±0.083*	Al-Bayrak	25±0.098	PL-700	24±0.011
5.	Baytkurgon-Bobokhon	Uzbek Dent	34±0.08*	PR 31 P41 F1	34±0.031	Uzbekistan-601 ESV	28±0.012	Uzbekistan-601 ESV	19±0.09
6	Temir-Kadam	PR 31 P41 F1	43±0.012	PL-538	25±0.027	PL-538	38±0.072	PL-538	23±0.01
7	Kenzhaev JahongirFayz	Mazza	49±0.011	Toro	48±0.098	Uzbekistan-306 AMV	19±0.01*	Uzbekistan-306 AMV	16±0.088
8	Istiklol-yuksalish	DKC 4141 F1	37±0.098	PR 31 P41 F1	37±0.034	Uzbekistan-601 ESV	21±0.012	Uzbekistan-601 ESV	18±0.012
9	Istikolol	Uzbek Dent	36±0.016	DKC 4141 F1	46±0.012*	Mazza	18±0.086	Uzbekistan-306 AMV	21±0.065
10	Mirusmon Mirholik Baraka	Mazza	54±0.013	Mazza	25±0.011	Uzbekistan-601 ESV	22±0.057	PL-700	20±0.074
	Means		45.6		35.9		24.2		21.1

Note: $P \leq 0.05$ – significant in relation to the control, ** – samples from healthy plants were taken as a control. n=3.

Table 2. Determination of resistance in maize cultivars and hybrids to MDVM.

No.	Corn cultivars and hybrids	Corn development phases						
		3-leaf phase Infection (%)	5-leaf phase Infection (%)	7-leaf phase Infection (%)	9-leaf phase Infection (%)	11-leaf phase Infection (%)	clotting Infection rate (%)	bloom Infection (%)
1	Mazza (Uzbekistan)	3±001	15±0.09	37±0.5*	57±0.08	57±0.06*	57±0.08	57±0.1
2	Megaton F1 (France)	2±0.04	17±0.06	28±0.07	42.7±0.1	42.7±0.3	53.8±0.9	54.5±0.8
3	Sweet Star F1 (Netherlands)	4±0.08	23.7±0.2	30.7±0.3	38.4±0.9	50±0.04*	53±0.15*	53±0.5*
4	Lejeune F1 (France)	0	4±0.07	27.2±0.4	18.1±0.2	18.1±0.7	18.1±0.6	36.2±0.1
5	Eureka (Uzbekistan)	0	6±0.03*	8.3±0.08	7.5±0.13	6.6±0.5*	3.3±0.31	3.3±0.23
6	Uzbek Dent	0	13.3±0.6	12±0.18*	12±0.07	15±0.03	15±0.07*	15±0.33*
7	Uzbekistan-601 ECB	0	3.2±0.5	11.5±0.5	11.5±0.3	11.5±0.6	11.5±0.4	11.5±0.7
8	Uzbekistan-306 AMV	0	9.3±0.1	9.3±0.6*	15.6±0.1	18.7±0.4	12.5±0.6	9.3±0.11
9	Golden Batam F1 (France)	0	12±0.08	7.6±0.09	11.5±0.4	11.5±0.1	11.5±0.1	11.5±0.6
10	DKS 4141 F1 (Turkey)	0	16.6±0.2	36.6±0.1	50±0.06	53.3±0.9	36.6±0.3	36.6±0.1
11	PR 31 P41 F1 (Switzerland)	2±0.09	8±0.06*	33.3±0.6	33.3±0.3	33.3±0.2	33.3±0.1	29.1±0.8
12	W 28 (USA)	0	4.1±0.9*	7.6±0.09	15.3±0.1	23±0.17*	23±0.04*	23±0.09*
13	Sp38330941 (USA)	0	18.1±0.1	18.1±0.1	22.7±0.5	27.2±0.4	31.8±0.5	22.7±0.5
14	Phenomenon F1 (Switzerland)	0	29.7±0.3	34.6±0.8	44.4±0.8	44.4±0.1	47.2±0.1	41.6±0.2
15	Thermo (Switzerland)	0	12±0.08	23±0.23*	23±0.06*	23±0.21*	23.4±0.1	24±0.04*

Note: $P \leq 0.05$ – significant in relation to the control, ** – samples from healthy plants were taken as a control. n=3.

Table 3. Maize cultivar groups by resistance to MDMV.

Resistance groups				
Immune	Practically Stable	Low level of infection	Average level of infection	Unstable
Distribution limits of infection groups				
0%	10%–12%	15%–30%	30%–50%	50%–70%
-	Eureka (Uzbekistan), Uzbekistan-306 AMV, Uzbekistan-601 ESR	Uzbek toothed, Golden Batam F1 (France)	Legene F1 (France), DKS 4141 F1 (Turkey), Phenomenon F1 (Switzerland)	Mazza (Uzbekistan), Megaton F1 (France)

The assumption reached confirmation that the degree of damage increases in parallel with the development of plants, i.e., the higher the phases, the higher the infestation. However, the degree of damage reaches its peak in the 11th leaf phase. In the following phases, due to the wilting of plants, the degree of infestation decreases. Cultivars with a degree of damage close to 0% are more resistant; up to 10% infected = almost resistant, low resistance = 25%, average = up to 50%, and unstable cultivars = the degree of infestation is more than 50% (Table 3).

Practical resistant cultivars, such as Eureka from Uzbekistan, Uzbekistan-306 AMV, Uzbekistan-601 ESV, Uzbekskaya Zubovidnaya, and Golden Batam F1 from France, were favorable to breeders as resistant cultivars. These cultivars succeeded in planting in the fields of Istiklol Mirgiyos Mirzakhmedov and Mirusmon Mirkholik Baraka, where MDMV was widespread in the Tashkent Region, with the above-mentioned comprehensive control measures applied. The incidence of viral infection in the Mirusmon Mirkholik Baraka farm decreased to 25% in 2021 and 15% in 2022, respectively. Using comprehensive measures in these corn crop farms, the incidence reduced by 24.5%, and the grain yield increased by 30%–45%.

The seed-borne transmission mechanism of MDMV poses a serious threat, as infected seeds can lead to the emergence of foci of infection in new areas. Moreover, insect vectors, such as aphids and leafhoppers, play a vital role in the spread of MDMV. These insects are capable of transferring the virus from infected plants to healthy ones, thereby facilitating its rapid spread in corn crops. As a result of the research, an experiment proceeded to determine the virus content in seeds collected from infected plants by mechanical inoculation. For this purpose, these seeds involved planting in an experimental field, where determining seed germination and the level of plant disease ensued.

As visible from Table 4, the highest average germination of healthy corn cultivar seeds was 89.68%, and the germination of seeds obtained from diseased cultivars was 57.62%. Seeds obtained from diseased plants also entailed planting in the same quantity as healthy ones, with the incidence of the germinated plant determined. According to the results, the incidence of the virus in corn cultivars at the 5–7 leaf phase of development was, on average, 19.58%. As a result of these studies, sorting seeds taken for planting samples with symptoms of the disease from the sowing field in seed farms made it possible to prevent the spread of the virus (Table 4).

DISCUSSION

An alarming trend in Uzbekistan exists, and the spread of the corn dwarf mosaic virus (HCV) poses a serious threat to cultivated cornfields. This virus, which affects corn plants, can lead to a significant decrease in yields and, as a result, cause economic losses for farming communities. Maize (*Zea mays* L.) is the most cultivated cereal crop worldwide, planted on more than 135 million hectares in the globe. In our country, a large area reaches advanced harvesting; however, the corn crops often face

Table 4. Effect of MDMV on seed germination.

Catalog number	Name of cultivars	Seed germination (%)		Disease incidence (%) of samples grown from diseased and healthy seeds	
		K	З**	K	З**
NS13866	Osnova 209	83.3±0.12	48.4±0.07*	0	24.2±0.09
NS16695	Extra Early Dightau209	87.4±0.27	57.5±0.09	0	19.5±0.05*
NS17641	San Pedro LATA	93.5±0.09	59.1±0.19*	0	17.1±0.096*
NS17646	Sherzod	97.1±0.14	67.4±0.06	0	14.3±0.045
NS24935	Hickax	92±0.08	64.7±0.17*	0	22±0.089*
NS25033	205-2	86.3±0.16	43.2±0.08*	0	16.6±0.067*
NS25897	San Pedro2 IMTA	88.2±0.11	63.1±0.18	0	23.4±0.053
Means		89.68	57.62	0	19.58

Note: $P \leq 0.05$ – significant in relation to the control, ** – samples from healthy plants were taken as a control. n=3.

exposure to viral diseases (Kengesbayeva *et al.,* 2022). Phytoviruses alter the morphophysiological characteristics of cultivated plants and impact their productivity (Sattorov *et al.,* 2020).

Johnsongrass is a common weed growing adjacent to maize and sorghum fields. MDMV overwinters in Johnsongrass and provides an inoculum of the virus for maize and sorghum crops. Understanding this wild strain of MDMV in Johnsongrass can be the key to resolving the evolutionary relationships of MDMV with its domesticated MDMV strains (Wijayasekara and Ali*,* 2017).

Aphids are the most widely spread vectors of plant viruses and have the potential to transmit both persistent and non-persistent viruses. Aphids transmit more than 200 species of plant viruses in a non-persistent way (Kannan *et al*., 2018). MDMV transmittal transpires from infected plants to healthy aphids. Sweet corn seed from several maize dwarf mosaic virus (MDMV)-infected hybrids grown in the field incurred testing for transmission of MDMV through the seed (Mikel *et al.,* 2008). Reports of MDMV seed transmission stated rates of ca. 0.2%–0.4% (Hill *et al.,* 1974; Mikel *et al.,* 1984). Wheat streak mosaic virus also has reports of seed transmission in maize at rates of 0.2% and 0.1%, respectively (Hill *et al.,* 1984). But the results of this latest research prove the probability of transmission of the virus through seeds is higher.

For a long time, numerous studies have demonstrated the relationship of aphids and plant viruses, with emphasis on interactions between plant viruses, aphids, and plants, as well as the molecular mechanisms underlying these interactions (Shukla *et al.,* 1989; Seifers *et al.,* 2000; Lapierre and Signoret*,* 2004; Kannan *et al*., 2018). In reducing the harm from viruses and their spread, it is necessary to strengthen control over them (Akhmadaliyev *et al.,* 2024). Therefore, it is essential to promptly identify the new viruses and their mutations, as well as monitor the spread of known phytoviruses. This requires a well-developed network of laboratories capable of performing fast and accurate analyses, as well as an effective information exchange system among the breeders (Jones *et al.,* 2017). By studying the biological, ecological, molecular, and genetic characteristics of a particular virus, one can recommend distinguishing it from other infections by using a pure virus (Yusubakhmedov *et al.,* 2024).

The present team conducted a series of studies aimed at monitoring the spread of the virus, its diagnostics, and assessing the impact on the morphophysiological properties of corn. The different corn cultivars obtained assessments to determine their resistance to MDMV and identify the most resistant and susceptible ones. The results showed the virus not only causes visual symptoms, such as dwarfism and mosaic leaves, but also negatively affects the photosynthetic activity of plants, which, in turn, leads to a decline in productivity.

Controlling maize dwarf mosaic virus requires an integrated approach based on scientific advancements and modern agronomic practices. The presented research aimed at developing effective strategies to help minimize damage from MDMV and ensure stable maize yields in the future. Integrated measures to combat MDMV include the selection of corn cultivars and hybrids resistant to this pathogen. A result of the studies determines the degree of resistance of different corn cultivars to MDMV, which allows agronomists and farmers to plan their maize crops more effectively. One of the key aspects scientists point out was the persistence of the virus in corn seeds. This phenomenon poses a serious threat to agriculture, as infected seeds can become the main source of infection for new maize plants.

CONCLUSIONS

The four-year studies on monitoring of MDMV spread in the climatic conditions of the Tashkent Region showed the viral incidence in corn crops by year, on average, was 45.6% (2020), 35.9% (2021), 24.2% (2022), and 21.1% (2023). Studies to establish the resistance of corn cultivars revealed cultivars and hybrids Eureka from Uzbekistan, Uzbekistan-306 AMV, Uzbekistan-601 ESV, Uzbekskaya Zubovidnaya, and Golden Batam F1 from France emerged resistant to MDMV, which were recommended for cultivation. The hybrids Legend F1 from France, DKS 4141 F1 from Turkey, and Phenomenon F1 from Switzerland belong to the average degree of infection. The cultivars Mazza of Uzbekistan (57.0%) and Megaton F1 of France (54.5%) provided the highest degree of infection, proving not resistant. The studies confirmed the MDMV's transmittal through seeds had a rate of 19.5%. Sorting the corn seeds can help manage lesser virus spread.

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