Soybean mosaic disease (SMD): a review

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ABSTRACT

Soybean Mosaic Disease (SMD) is one of the most serious, devastating, and widespread diseases of Glycine max (L.) Merr. caused by Soybean Mosaic Virus (SMV). It is more prevalent in low-lying and warm areas of soybean cultivation. SMV is also associated with severe mosaic, epinasty, and premature death of Passiflora spp. By soybean (Glycine max) seed, the transmission of soybean mosaic virus is at very rare chances. The studies and investigations made in the field of resolving the issues of transmission of soybean mosaic virus suggest that infected seed plays a vital role in disease transmission, but still there are no proper investigations to study the roles of several factors that may influence the SMV seed transmission. These are virus classification, virus transmission and establishment, symptoms of damage, electron microscopy, viral morphology, and control, which have been reviewed in this review article from currently available sources.

Introduction

Agriculture, being an important sector of Pakistan’s economy, directly supports the major share of the population [1]. The agricultural share in GDP is about 22%. In the major cash crop of Pakistan, Soybean (Glycine max L.) is an important cash crop. It is relatively new in the majority of farmers. Soybean has been recognized as the Golden bean of the 21st century [2]. Soybean is an important source of protein and oil and most commonly used in the diets of both humans and animals [3]. However, soybean grain yield is comparatively less than its potential. Main factors include climate unevenness, lower germination percentage, inappropriate growing time, improper planting space, meager quality scarcity of seed irrigation, weed [2], and diseases. Among the major diseases of Soybean, Soybean Mosaic Disease (SMD) is an important disease. There are great variations in seed transmission of Soybean Mosaic Virus (SMV) in different soybean germplasms [4]. There are no proper evidences about the said variations in seed transmission of SMV in different soybean germplasms. Still there are some misunderstandings about whether the time of inoculation may or may not affect the incidence of transmission of SMV through seed relative to the time of flowering. Infections at the stage of the embryo have great importance in affecting the seed transmissibility of SMV.
SMV presence in reproductive plant parts can be compared in field-grown and manually inoculated soybean [5]. There is a 100% presence of SMV in flowers, immature seeds and green pods. But in the case of the dry pods, there is mostly no detection of SMV. The percentage of mature seeds containing SMV founded from many of the research is the same as the percentage of SMV-infected seedlings arising from those seeds [6]. There is the reduction of incidence of SMV transmission through seed over the storage of seed at low temperature.

As SMV is an aphid-transmitted and seed-transmitted virus. It causes significant yield losses in Glycine max plants [7]. Seed-borne pathogens are the primary sources of the spread of SMV infections. About 0–43% of transmission of SMV occurs through infected seeds. SMV can also be poorly transmitted by the Asian soybean aphid, Aphis glycines [8].

**Soybean mosaic virus**

Soybean mosaic virus (SMV) belongs to the genus Potyvirus and the family Potyviridae. Its main hosts that are adversely infected by SMV are mainly plants belonging to the family Fabaceae. It can also infect other economically important crops. SMV occurs in all the soybean-production areas of the world. Soybean is one of the most vital sources of edible oil and proteins and pathogenic infections cause the annual yield losses of billions of dollars. Therefore, SMV is the most important and prevalent pathogen in soybean production worldwide. SMV is a single-stranded positive-sense RNA virus and its genome is about 9.5kb that encodes at least 11 proteins [9]. SMV virion is nonenveloped, flexuous, and filamentous particle of about 720–800 nm long and 12–15 nm in diameter [10].

**Virus classification**

- **Class:** Stelpaviricetes
- **Order:** Patatavirales
- **Family:** Potyviridae
- **Genus:** Potyvirus
- **Species:** Soybean Mosaic Virus

**Virus transmission and establishment**

Many different methods of viral transmission are used for the assessment of viral establishment maintenance and viral propagation at the laboratory level [11].

**Mechanical transmission**

The transmission of soybean mosaic virus can be done by the mechanical transformation method. In this method, the crude plant is firstly diluted by 0.01 M phosphate buffer and a pH of 7.2 is maintained [12]. Before applying the inoculum of SMV, the testing of the leaf by 600 mesh carborundum is done [13]. The inoculation is done by applying inoculum over the injured leaf of the soybean plant. Then the inoculated plant is set in a greenhouse at the temperature of 21°C [12]. The temperature has a great impact on the incubation period. The time range between infection and the appearance of symptoms is from 4 days at 29.5°C to 14 days at 18.5°C [14].

**Insect transmission**

The natural and one of the main methods of soybean mosaic virus transmission is transmission by insects. In the case of SMD, the virus is transmitted by leafhoppers. In this case, firstly the leafhoppers (Nephotettix nigropictus) feed over the soybean plant that is already infected with SMV and then feed over the healthy soybean plant. The new infected plant shows the same symptoms as produced in the previously infected plant from which the leafhoppers (Nephotettix nigropictus) got viruliferous [15]. The incubation period between infection and the appearance of the septum is 4–14 days [14].
Grafting transmission

Different types of grafting can be used to propagate the horticultural plant but wedge grafting is mostly used for the transmission of soybean mosaic virus. The scion collected from the infected plant is cut to make a wedge, and then a cut is made in the healthy plant, and scion is inserted into the incision of the stock plant and then tied with grafting tape [16]. The symptoms of SMV will appear on the development of new leaves on the stock plant.

Symptoms produced on viral transmission

The appearance of yellow vein clearing on new trifoliolate leaves is the first symptom of SMD on the mechanically infected plant of soybean at the greenhouse. The downward curving of the leaf margin at the sides and upward curving of the leaf tip also occur in the infected plant of soybean [17]. The leaves give course and leather appearance and become brittle before their maturity stage. The growth is stunted and less number of poles are reduced infected plant compared to the healthy plant. Mottling also occurs during cold weather conditions and the plant becomes masked during warm conditions. The localized lesions are also produced on the leaves [18].

Physical stability of virus

Different tests can be carried out for studying the physical properties of viral isolates of soybean mosaic virus. It is noted that the virus becomes inactivated after heating at 70°C for 10 min as a thermal inactivation point (TIP) [19]. The dilution endpoint (DEP) of soybean mosaic virus is 1:10,000 and the Longevity In vitro (LIV) of soybean mosaic virus is 7 days at 21°C that is room temperature [4].

Electron microscopy

For the determination of morphology and size of viral particles associated with soybean mosaic disease, the infected leaf is negatively stained and then examined. The transmission electron microscope can be used for the examination of intracellular distribution of viral particles by using an embedded ultrathin section of infected plant leaf [20].

Viral morphology

It is demonstrated that the Potyviridae is associated with soybean mosaic disease. Many other flexuous, rod-shaped particles are also found in association with soybean mosaic disease when tested by ELISA [21]. The range of sizes of soybean mosaic virus is compared able to those of the members of the Potyviridae family with a size range of 182–420 nm, mostly in between 338–371 nm and 79–93 nm width. The study of ultrathin section of leaf proves that it is a cytoplasmic type of virus [22].

Control

Like other nonpersistently transmitted viruses, the application of insecticides against aphid vectors of SMV results in a little reduction in SMV incidence [23,24]. However, a lower incidence of SMV infection has been shown on soybean cultivars with extra-dense pubescence as compared to glabrous cultivars [24]. The plantation of virus-free seeds and deployment of resistant soybeans containing pyramided R-genes are the best management strategies for SMD [26]. In transgenic plants, high levels of resistance to SMV have also been produced that express the genomic regions of the SMV [27]. The transgenic plants can significantly lower the incidence of SMV in the field [28].

Conclusion

Soybean Mosaic Virus is a successful Potyvirus with a wide distribution range but having a restricted natural host range. It is a filamentous particle with 7500 Å length and 120 Å in diameter with single-stranded, positive-sense, polyadenylated RNA. Due to its restricted host range, it
mostly causes diseases in the species of genus Glycine including *Glycine max* (cultivated soybean) and *Glycine soja* (wild soybean). The transmission of soybean mosaic virus is mostly done by mechanical transmission, aphid, or through seed. It can be controlled only by using the pathogen freed seeds, avoiding mechanical injuries, and by using the species having one or more R genes.

**Disclosure statement**

No potential conflict of interest was reported by the authors.

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