Chapter 5
Spike Diseases Caused by Viruses

As mentioned elsewhere, there are over 30 viral diseases reported to occur in wheat but only a few are economically important. Some of the viral diseases are overlooked because of their low economic importance or else because their symptoms are rather ambiguous and at times attributed to nutritional deficiencies of the plant. Viruses cause several disorders in the wheat plant including foliar chlorosis appearing as mottles, dashes, blotches or streaks (Zaitlin and Palukaitis 2000; Jones et al. 2010; Bockus et al. 2010). Only four viral diseases are described in the following pages, especially considering their economic importance.

5.1 Barley Stripe Mosaic

5.1.1 Symptoms

Barley stripe mosaic is the only viral disease of wheat transmitted through seeds. Infected seed show no symptoms of the disease. It occurs in several countries where wheat is grown but without causing any appreciable yield losses. It was first described in the USA in 1910, but its causal agent was not identified until 1951 (McKinney 1951). Its presence in some countries including Paraguay in 2012 was reported (McKinney 1951; Mehta 1993).

The symptoms of the disease are similar in wheat and barley and depend on the strain of the virus and the wheat cultivar (McKinney and Greeley 1960). Infected plants are stunted with excessive tillering and the leaves show chlorotic stripes which later become brownish (Fig. 5.1).

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Fig. 5.1 Symptoms of barley stripe mosaic on wheat. *Courtesy*: M.C. Bassoi

5.1.2 Causal Organism and Epidemiology

The disease is caused by Barley yellow stripe Mosaic Virus. The virus particles are rod-shaped and measure 30–160 nm. The virus can survive for several years in the seed (McKinney 1951; McNeal and Afanasiev 1955; McKinney and Greeley 1960; Phatak 1974; Albrechtsen 1993).

The disease occurs on oats, rye, maize, millet and several grass species. No virus vector of this disease is yet known. Several strains of this virus are known to exist (McKinney and Greeley 1960). The dissemination of the disease in the field is probably through the contact of healthy plants with diseased plants. Natural hosts are members of the Gramineae, but species of Chenopodiaceae, Solanaceae, Amaranthaceae and Primulaceae can be artificially infested (Atabekov 1971). Normally the percentage of seed infection is not very high, but in certain cases it can reach up-to 67 % (Phatak 1974) and very rarely reach 81 % (McNeal and Afanasiev 1955). In barley for example, the seed infection can reach 90 % (Albrechtsen 1993).

5.1.3 Control

Certification schemes and seed health testing using ELISA could help discard seed lots showing high levels of seed infection (Carroll 1983).

5.2 Barley Yellow Dwarf

Barley yellow dwarf occurs all over the world and is one of the most important viral diseases of wheat. Infected plants produce 5–20 % less grains. Gill (1970a, 1970b), estimated a yield loss of 34 % in Manitoba. In Brazil, the losses could be between 20 and 30 % (Caetano 1982). In an epidemic year, however, the yield losses have reached up-to 70 % in England (Western 1971).

5.2.1 Symptoms

Symptoms of the disease depend on the strain of the virus, the temperature and the resistance of the cultivar. By and large, the infected plants are stunted and their leaves show yellow, red and purple discoloration. This kind of coloration starts from the tip of the leaf and advances to its base. Sometimes green stripes between the yellowish leaf areas can be seen along with some necrosis. In case of severe infection the whole plant becomes yellow with little, or at times, excessive tillering (Fig. 5.2). The root system of severely infected plants is drastically reduced and the plant does not produce any grains. Normally, the infected plants are scattered in the field.

5.2.2 Causal Organism and Epidemiology

The disease is caused by a virus called barley yellow dwarf virus (BYD). The virus moves systemically within the plant and occurs in phloem cells. There are seven identified strains of the virus. They are characterized as: **RMV**: transmitted regularly by aphids *Rhopalosiphum maidis*; **RPV and PAS**: transmitted regularly by *R. padi*; **MAV**: transmitted regularly by *Macrosiphum avenae*; **PAV and PAS**: transmitted regularly by *R. padi* and *M. avenae*; **SGV and GPV**: transmitted by *Schizaphis graminum* and *R. padi* (Rochow 1969; Gill 1970a; Rochow and Muller 1971; Bockus et al. 2010).

The barley yellow dwarf virus is transmitted only by aphid vectors. The dissemination of this disease depends on the presence of different species of aphids. After a few hours of feeding on an infected plant, the aphids are capable of transmitting the virus to other plants. The virus is persistent in the aphids. Cool temperatures of about 20 °C are favorable for the development of the disease (Figueira 2010).

Fig. 5.2 Wheat plant infected with barley yellow dwarf virus (BYD)

5.2.3 Control

The disease can be kept at tolerable levels by controlling the aphids through the use of insecticides. Biological control of aphids however, has been successful to some extent in Brazil and Bolivia. Although cultivars differ in their level of resistance, no high level of resistance is yet known to exist in wheat. Nevertheless, Ohm et al. (2005) reported that highly effective resistance to yellow dwarf virus was introgressed into wheat (*Triticum aestivum*) from *Thinopyrum intermedium*. They further reported that such lines also have resistance against other diseases like soil-borne mosaic virus, powdery mildew, stem rust, stripe rust and tan spot.

5.3 Rice Hoja Blanca

Rice hoja blanca occurs in Japan and in the American continent (Gibler et al. 1961; Caetano et al. 1970). The disease is of little economic importance.

5.3.1 Symptoms

Infected plants show leaf mottling and complete chlorosis. Severely infected plants dry prematurely without forming grains. The spikes become white and are distributed in the field. Similar white spikes may also be due to the attack of the stem borer *Diatrea saccharalis* Fabr., or because of frost. The Rice hoja blanca can be distinguished from the other causes, since *D. saccharalis* creates a small hole at the base of the stem which can be easily observed and in the case of frost damage, the spikes can be easily removed by fingers from the stem.

5.3.2 Causal Organism and Epidemiology

Hoja blanca is caused by RHBV (Rice hoja blanca virus). Other than wheat the RHBV attacks rice (Lamey et al. 1964). It is transmitted by insects of the genus *Sogata*. Two species of *Sogata S. cabana* Crawf. and *S. orizicola* Muir, are known as vectors of this virus. In these insects the virus is circular and persistent. In the absence of wheat the vector migrates to other fields of rice. After the rice harvest, the vector comes back to the wheat fields and completes the life cycle of the disease.

5.3.3 Control

No specific control measures are recommended.

5.4 Soil-Borne Wheat Mosaic

Soil-borne mosaic has been known to occur in the USA since 1919. It is also known to exist in the Latin American region (Argentina and Brazil) and is quite common in the State of Rio Grande do Sul, Brazil. In 1971, severe outbreaks of this disease were observed in 30 different districts. Later, the disease occurred in lower intensities in the same State (Caetano 1982). Yield losses caused by this disease are very variable (Dalbosco et al. 2001). Quinsberry and Reitz (1967) reported losses of about 1.5–3.0 million dollars during some epidemic years. Later, Kucharek and Walker (1974) reported losses between 42.5 and 52.5 % in commercial fields in Florida. Kuhne (2009) has given a comprehensive review of soil-borne viruses attacking cereals. According to this author, soil-borne viruses could still be a threat to wheat cultivation.

Fig. 5.3 Symptoms of soil-borne wheat mosaic

5.4.1 Symptoms

Soil-borne mosaic virus encompasses different strains showing variable symptoms between whitish-green to yellow mosaic on leaves (Quinsberry and Reitz 1967). The leaves of infected plants are stunted, mottled and show chlorotic stripes parallel to veins (Fig. 5.3). Rye, barley and *Bromus* spp. are the hosts of this virus.

5.4.2 Causal Organism and Epidemiology

The virus particles of soil-borne mosaic are rod-shaped and are present in the infected tissues. They measure 35–422 × 24–34 nm. The in vitro dilution end point of the virus is between 10^{-3} and $10^{-3.5}$ and remain viable for 48 h. The thermal inactivation is between 58 and 60 °C for a few minutes (CMI 1971). The virus is transmitted through the obligate fungus parasite *Polymixa graminis* Led. However, recently some doubts were raised whether *Polymixa* spp. are the specific carriers of plant viruses (Legreve et al. 2008).

P. graminis invades the wheat plant through its roots but does not produce any symptoms on the plant. After penetration the fungus forms plasmodial bodies in the epidermal cells of the cortex of the primary root. As a consequence, cristoforos

(compacted mass of spores) are formed in the plasmodial bodies and later, mature zoosporangia can later be observed on the epidermal cells of the root.

The disease spreads from one field to another through agricultural machinery. The resistant spores of *P. graminis* gives shelter to the virus and can survive in the soil for several years (Figueira 2010).

5.4.3 Control

Being a soil-borne disease, no specific control measures are indicated. However, crop rotation with non-host leguminous species may offer good results. Black oats (*Avena strigosa*) are considered resistant to this virus in Brazil. Continuous wheat in the infested area should be avoided.

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