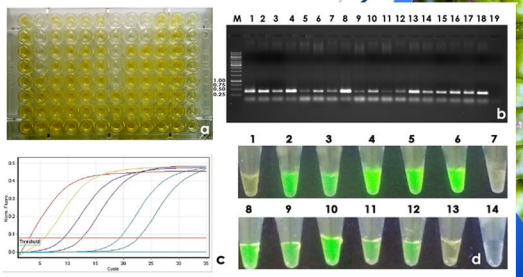

Figure 3 Mealybug species involved in transmission of Piper yellow mottle virus. (a) Ferrisia virgata (b) Plancoccus citri.

Management in the main field

- Cuttings obtained from good bearing pathogen-free mother vines are raised in a nursery under insect-proof conditions (Fig. 5).
- The nursery potting mixture is heat sterilized using steam or by soil solarization. Then the mixture is fortified with plant growth-promoting rhizobacteria consortia and Trichoderma.
- Nursery plants also have to be checked for pathogens periodically and rouging of dis eased plants should be done whenever noticed.
- Whenever insects (aphids, mealybugs) are seen, spraying of plants with recommended insecti cides is necessary.
- The pathogen-free stocks from the nurseries are then multiplied in secondary nurseries or used for planting in the main field.

Figure 4. Detection of the virus through (a) Enzyme linked immunosorbent assay (b) polymerase chain reaction (c) real-time polymerase chain reaction (d) loop-mediated isothermal amplification

Management in the main field

The infection in plants may vary from apparently healthy to mild, moderate or severe categories. Severely infected plants show severe deformation of leaf, reduction in leaf size and internodal length leading to severe stunting of plants and poor yield. It is uneconomical to retain such severely infected plants; they should be removed and burnt or buried deep in soil. Studies carried out at the ICAR-Indian Institute of Spices Research, Kozhikode showed that the mild and moderately infected plants can be revived. However, taking runners/cuttings for propagation from all categories of virus infected plants including apparently healthy should be avoided.

To revive and sustain the health and yield of the mild and moderately virus infected plants the following package is recommend:

- Correct the soil acidity through application of amendments like lime or dolomite, based on the soil test
- Apply FYM @10-15 kg per standard
- Adopt site specific NPK application based on the soil test
- Apply black pepper specific PGPR consortia and Trichoderma, twice (June and September) either by fortifying with FYM (and applied 10-15 kg) or as drenching (2-3 L per standard).
- Apply micronutrient (IISR Black pepper special) as spray on leaves @ 5g/L twice, first spray after spike emergence during May-June and second spray after spike setting during August-September.

Not only the individual nutrient supply or concentration in soil or leaf, but the combined effect of each nutrient and its balanced supply matters for proper uptake and its utilization. Hence, location/site specific crop management programmes should form the basis for balanced nutrient application and need based foliar supplementations for sustaining the health and yield of the black pepper plants.

Control of vectors in the main field

Insect vectors such as aphids, lace bugs and mealybugs on the black pepper plant or standards once noticed should be managed by spraying with recommended insecticides such as imidacloprid (0.5 ml per litre) or thiometon (0.5 g per litre).

Other package of practices recommended for the crop may strictly be followed for better crop growth, yield and quality of the produce

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VIRAL DISEASE OF BLACK PEPPER AND ITS MANAGEMENT

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OCCURRENCE, DISTRIBUTION, INCIDENCE AND YIELD LOSS

The viral disease was first noticed in the black pepper nursery at Neriamangalam, Idukki District, Kerala during 1975. It is known by different names such as mosaic, little leaf, wrinkled leaf, stunted disease and reported from different black pepper growing countries such as Brazil, China, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand and Vietnam. In India, higher incidence of the disease is reported from black pepper plantations located at high altitudes such as Wayanad and Idukki Districts of Kerala, and Kodagu and Hassan Districts of Karnataka. The yield loss due to the disease varies from 16% to 85% depending on the severity.

SYMPTOMS

A wide range of symptoms are observed on infected vines under field conditions. Mosaic, mottling, leaf deformation, stunting of whole plant are the most visible symptoms in the field (Fig. 1). The initial symptoms of the disease include yellow mottle, vein clearing and mosaic followed by deformation of the leaves (Fig.1). Severe symptoms sometimes develop sporadically on flushes of new growth, while other leaves show milder symptoms or remain symptomless. The infected vines produces short spikes with poor filling leading to yield reduction. In severe cases, the leaves become abnormally narrow and appear sickle shaped (Fig. 1). The internodes of vines become abnormally short leading to stunting of plants and affected branches give a typical witche's broom appearance in advanced stages. Sometimes depending on the season and abiotic factors, the disease affected plants do not produce any visible external symptoms. This kind of masking of symptoms in certain affected plants may be seen during monsoon and winter months while symptoms are best exhibited during summer months. Studies carried out at the ICAR-Indian Institute of Spices Research, Kozhikode have shown that symptom expression depends on environmental factors and soil nutrient status. Severe symptoms appear when plants are subjected to high temperatures and high relative humidity. The virus infected symptomless plants can act as source for secondary spread of the virus in the field.

CAUSAL VIRUSES

The disease is caused by Piper yellow mottle virus (PYMoV) belonging to the genus Badnavirus of the family Caulimoviridae. PYMoV is a circular double-stranded DNA virus having bacilliform particle shape (Fig. 2). A few black pepper plants infected with PYMoV, also show co-infection with cucumber mosaic virus (CMV) (genus, Cucumovirus in the family, Bromoviridae). CMV has isometric particles that contain three positive-sense single-stranded RNA as its genome.

TRANSMISSION

The major spread of both viruses occurs vegetatively through use of stem cuttings from infected vines used for fresh planting. The viruses can also be experimentally transmitted through grafting. In addition, PYMoV can also get transmitted vertically from one generation to the other through infected seeds. Within a field PYMoV can spread from diseased plant to healthy black pepper plant through different species of mealybug such as Ferrisia virgata and Planococcus citri while CMV can spread through different species of aphids (Fig. 3).

DETECTION AND DIAGNOSIS FOR VIRUSES

Though symptoms are the good criteria for detection, many a times depending on the season, and other factors, the disease can be difficult to identify or detect visually. Hence symptoms cannot be used as the criterion to identify virus-free plants. Unlike fungi and bacteria, viruses cannot be seen through a compound microscope, they can be seen only through electron microscope. Viruses can be best detected using diagnostic assays such as enzyme linked immunosorbent assay (ELISA), polymerase chain reaction (PCR), real-time PCR or loop-mediated isothermal amplification (LAMP) (Fig. 4). Any of the above assays can be used to identify virus-free plants for vegetative propagation and virus infected plants can be avoided for vegetative multiplication.

MANAGEMENT

There is no resistant variety of black pepper available against both the viruses. Hence efforts should be made to reduce sources of infections to limit the spread of viruses by vectors and to minimize the effect of infection on yield. Vertical transmission of the disease through planting material appears to be the major mode of disease spread since black pepper is vegetatively propagated. When infected plants are used as source of planting material, the cuttings will also carry the virus resulting in disease spread. Adequate care should be taken to plant healthy, virus-free cuttings, especially in new areas where the incidence of the disease is not observed in the field. Hence the primary aim should be to focus on production of virus-free planting materials. Insect vectors and a number of weeds and other hosts, which might act as reservoirs for the virus may also contribute to disease spread. Though use of resistant varieties is the best option to manage the disease, so far no resistant variety against the virus is available in any of the black pepper growing countries. The following measures may be adopted for managing the disease.

PRODUCTION OF VIRUS-FREE PLANTING MATERIAL

The most successful method to control the disease would be the identification and use of virus-free cuttings for planting. Though symptoms are the good criteria for identification of virus-free plants, many of the virus infected plants remain symptomless during certain seasons. Hence there is a need to use sensitive techniques such as ELISA, PCR and LAMP to identify virus-free plants to be used for vegetative multiplication. Stem cuttings from indexed virus-free plants may be used for establishment of mother garden and production of planting material in the nurseries as indicated below.

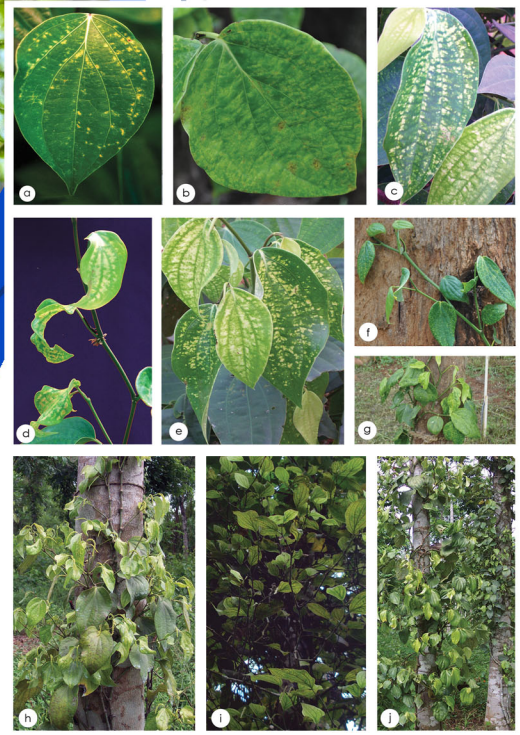

Figure 1. Symptoms of viral disease affected black pepper

Establishment of mother garden

- Good bearing and disease free vines of known varieties should be indexed for viruses
- Only cuttings from virus-free plants should be planted in mother garden.
- It is advisable to maintain these mother plants under insect-proof conditions which should be periodically (at least once in a year) indexed for viruses and other pathogens.
- Regular monitoring and rouging of diseased plants should be done whenever noticed.
- Whenever insects (aphids, mealybugs) are seen, spraying of recommended insecticides such as imidacloprid (0.5 ml per litre) or thiometon (0.5 g per litre) is necessary.

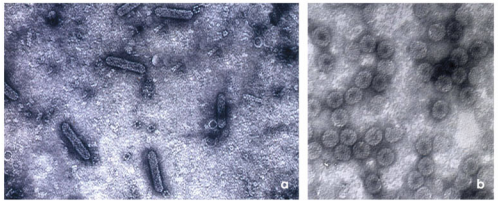

Figure 2. Particles of Piper yellow mottle virus (a) and cucumber mosaic virus (b) as seen in the electron microscope