

Economical important phytopathogenic diseases in *Vanilla planifolia*: A review paperNurdiana Ab. Kadir¹, Laila Naher^{1,2*}, Noorhazira Sidek¹¹Faculty of Agro-Based Industry, Universiti Malaysia Kelantan, 17600, Jeli, Kelantan, Malaysia²Institute of Food Security and Sustainable Agriculture, Universiti Malaysia Kelantan, 17600, Jeli, Kelantan, MalaysiaReceived 1 July 2018
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Abstract

The vanilla orchid is one of the high value and most favorite culinary crops in the world. The aroma or flavor of vanillin make the plant as an important economic crop in the food and beverage industry. Nevertheless, the production of vanilla is hindering by two main factors which are the propagation and diseases. Devastating disease has cause losses in bean production as it can infect the vines at any times and at all stages of the plant growth. As a result, it is cause the losses of quality and quantity of pod production. Some of important diseases associated with fungal and viral on vanilla such as *Fusarium* root and stem rot, anthracnose, black rot, *sclerotium* rot, rust, mosaic and stem necrosis are discussed in this review paper.

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1. INTRODUCTION

Vanilla is an herbaceous perennial vine, uses trees or others support to climb to a height of 10-15m by adventitious roots (Suseela Bhai et al., 2009, Weiss, 2002). For an economic production, warm and humid climates is the optimum environment for the vanilla to grow properly (Suseela Bhai et al., 2009). For the conventional propagation, vanilla takes almost two years from sowing the seed to direct planting on the soil in open air. However, in commercial industry, stem cutting is more preferable due to short leaf germination. Stem cutting requires only 30-40 days for the shoots start to develop after planting. Nevertheless, this method of propagation favors the spread of viral diseases through the stem cutting. To overcome this situation, nowadays, many researchers try to have mass propagation on vanilla plants through tissue culture technique (Davidonis & Knorr, 1991; Geetha & Shetty, 2000; Philip & Nainar, 1986). Another factor that hinder the production of vanilla is diseases (Sharma et al., 2010). Diseases has caused huge losses in vanilla plantation since it can affect the whole plant parts. Common vanilla diseases have been reported are stem, leaf and root rot, stem blight, brown spots and anthracnose caused by several fungal pathogens (Pinaria et al., 2010; Suprpta, 2012). In Indonesia, vanilla stem rot is found to be the biggest challenge to the vanilla production, where up to 80% of the crop losses have been recorded (Pinaria et al., 2010).

Vanilla is one of the most popular plants which provides natural flavors in agro-food industry. Other than that, vanilla also being used in the household products, dairy products, pharmaceutical products, oral care, perfumes and toys industries (Havkin-Frenkel et al., 2011). *Vanilla planifolia* and *Vanilla xtahitensis* are the vanilla species that have been cultivated commercially (Palama et al., 2012). The high demand had attracted many farmers to increase the production by extending the area of cultivation (Bhai & Kumar, 2008). However, as a result of poor management practice and good sanitary awareness, the plants become susceptible to a number of fungal, bacterial and viral pathogens, which in return affect the vanilla production. This review paper is focused on some important fungal and viral diseases in vanilla plant.

2. FUNGAL DISEASE IN VANILLA

There are several fungal species have been found associated with the diseases in vanilla. For example, the species of *Fusarium*, *Colletotrichum*, *Phytophthora*, *Sclerotium Rhizoctonia solani*, *Cylindrocladium quinqueseptatum* and *Mucor racemosus* (Bhai & Dhanesh, 2008). However, the major pathogenic fungal reported to affect vanilla are *Fusarium oxysporum f. sp. vanilla massae*, *Colletotrichum vanilla Massae* and *Phytophthora meadii McRae* (Bhai & Kumar, 2008).

2.1. Root and Stem Rot disease

Fusarium species is a soil-borne pathogen which can cause rot in many plants as well in parts of root, stem, leaf and fruit. The species of *Fusarium oxysporum* has caused stems, roots, leaves and shoots rot in vanilla plant (Bhai & Kumar, 2008; Suprpta & Khalimi, 2009; Tombe & Liew, 2010) and many others cultivars such as banana, wheat, rice, papaya. In fact, it is the most pathogenic pathogen in agriculture world. In vanilla, the effect of diseases caused by *Fusarium* is most severe when the fungus infects the stem and root of vanilla plant (Tombe & Liew, 2010). This will cause huge yield losses due to rotting of the stem and root of the plants. The disease has been notice as the plant was cultivated commercially in several countries such as Indonesia, Madagascar, India, Puerto Rico, the Seychelles, Reunion Island and Polynesia (Tombe & Liew, 2010). In the host range studies, it is showed that *F. oxysporum* f. sp. *Vanilla* (syn. *F. batatatis* var. *vanillae*) is host specific which cause no infection to the alternatives crops such as tomato, potato, groundnut, cucumber, ginger and cotton (Bhai & Kumar, 2008).

F. oxysporum f. sp. *vanilla* is reported as the main constraint in the vanilla production due to the stem rot problems (Pinaria et al., 2010). The species cause a cessation of shoot growth and the increased of aerial roots productions but die once reached the soil surface (Tombe & Liew, 2010; Weiss, 2002). Flaccidity and shriveling of the stem can be observed as the infected aerial roots entering the soil and die (Tombe & Liew, 2010). The flaccid condition of stems and leaves can be observed which caused stem and leaves to shrivel and desiccated from the plant (Tombe & Liew, 2010; Weiss, 2002). At the same time the roots are either brown, drying or dead. Browning and death of root, stem (Figure 1) are the common disease symptoms caused by *Fusarium*. The symptoms may appear at any stages of growth and at any time of the year (Tombe & Liew, 2010). For the foliar infection, the disease is more obvious during the rainy seasons. In other study, the root, stem and beans rot of vanilla is caused by *F. oxysporum* Schlecht (Vijayan et al., 2012). Root infection initially shows as the browning appearance, which lead to death of the plants (Tombe & Liew, 2010). For the root rot, the moisture condition determines the infected root either to become soft and watery or dry (Bhai & Kumar, 2008; Tombe & Liew, 2010).

Plant extract formulation have been study to suppress stem rot disease on vanilla seedling (Suprpta & Khalimi, 2009). Among four plant species studied, extract formulation containing both *Eugenia aromatica* and *Piper betle* is the most effective extracts to suppress the growth of population in the soil, which in turn can suppress the stem rot disease on vanilla seedlings (Suprpta & Khalimi, 2009). The disease caused by *Fusarium* sp. has caused reduction in the production area, in turn the vanilla

production also decreases since 1992 (Suprpta & Khalimi, 2009).



Figure 1: The symptoms of vanilla stem rot. The stem turns into dark brown lesion and later lead to the death of the stem.

The disease of *Fusarium* wilt in vanilla often occurs when vanilla is propagated in monocropping system (Xiong et al., 2016). Recent study concludes that the incidence of *Fusarium* wilt disease significantly less in the orchard with continuously cropped with black pepper (Xiong et al., 2016). In addition, the diversity of the fungal is higher in the black pepper-vanilla system in both bulk and rhizosphere soils compared to the monocropping system of vanilla. Also, the abundance of pathogenic *F. oxysporum* is low in this system with a great increased in the beneficial fungal species such as the species of *Trichoderma* and *Penicillium* (Xiong et al., 2016). This is one of the propose way to have an agro-ecological system way to produce and maintaining the vanilla sources in industry (Xiong et al., 2016).

Rhizoctonia spp is also pathogenic to vanilla plant where the species of *R. oxysporum* and *R. solani* cause foot rot and wilting to the vanilla plant (Elad et al., 1980; Ravindran & Shaik, 2013). A study on these species have been done on pulse crops whereby the pathogenicity and the genetic variability of these isolates were assessed (Sundravada et al., 2011).

2.2. Anthracnose

Anthracnose disease is causes by the species of *Colletotrichum*. The pathogenic *Colletotrichum* species attacks leaves, fruits, stems and lowers of the vanilla plants. Several report have discovered that anthracnose or brown spot in vanilla is caused by *C. gloeosporioides* (Talubnak & Soyong, 2010). *C. gloeosporioides* (teleomorph *Glomerella cingulate*) has a wide range of host pathogenicity such as vanilla and other agronomic cultivars such as chili, papaya, mango, banana and avocado, depending on the conditions and places (Talubnak & Soyong, 2010; Tombe & Liew, 2010).

Talubnak and Soyong (2010) reported in their study of pathogenicity test by anthracnose in vanilla plant can be appeared within two weeks after inoculation. The symptoms at first were found as a small brown spots on the leaves which later gradually enlarged and coalesced (Talubnak & Soyong, 2010). In same study, the bi-culture test done on the effect of *Emericella nidulans* on controlling of *C. gloeosporioides* showed that this biocontrol agent can inhibit the growth of mycelia growth of *C. gloeosporioides* at 49.44% and sporulation at 75.31% (Talubnak & Soyong, 2010). The other characteristic of the disease are small sunken dark coffee spots and also the irregular color of the plant host (Havkin-Frenkel & Belanger, 2010). The stem and leaves of the vanilla plants get affected by this pathogen during the cold air and moderate rain. The symptoms started to develop from the first five young leaves of the apical part of the plant. However, during the humid and warm seasons, anthracnose cause fruit damage, called 'pintos', which might also cause by other pathogenic fungus. The surrounding experiment such as the excess shade and extensive planting also favors the spread of anthracnose, root rot and stem rot development. Anthracnose causes up to 50% reduction due to this disease since the fruit will fall before maturity stage as acquired for commercial (Havkin-Frenkel & Belanger, 2010). Moreover, the infected leaves cause in a reduction of the new vine growth.

Recent, *Cylindrocladium quinquesseptatum* have been found to cause brown spot on *V. planifolia* (Bhai & Anandaraj, 2006). In Malaysia, a study has been done on the leaf spot and blight diseases in vanilla (Siddiqui & Meon, 2009). There are four species found to be associated with the lesions, which are *C. gloeosporioides*, *Phytophthora sp.*, *Curvularia lunata* (leaf blight) and *F. oxysporum*. Meanwhile, Weiss (2002) reported *Glomerella vanillae* is another pathogen caused anthracnose in vanilla. The initial symptoms for the anthracnose caused by this pathogen are the present of small lesions on the stem apex and leaves, which subsequently cause plant to wilt (Figure 2). The beans will fall off from the tree after turning black at the tips and midsection. The plant will die as the roots is infected. *Nectria vanillae* also the pathogen which caused brown spot in vanilla (Weiss, 2002). Brownish- black appearance of the leaves as the plant get affected and hence, die. Unhealthy and over mature plant are the most susceptible vanilla to this disease.



Figure 2: The symptoms of anthracnose caused lesion on vanilla leaf still attached to vines.

The *Fusarium* rot and anthracnose infection on the root is difficult to distinguish as they share similar symptoms. However, these diseases can be distinguished by observing the internal tissue, once the external symptoms appeared (Tombe & Liew, 2010). *Fusarium* rot can be observe by the presence of internal discoloration within the vascular tissue. For the anthracnose, the vascular tissue appears healthy but the epidermis or superficial layers shows disease symptom (Tombe & Liew, 2010). For the disease management, healthy root systems and adequate plant nutrition can be applied in disease control strategy. The fungicide practice also can be done such as the use of mancozeb. The affected leaves or other plant organs need to be removed to avoid further infection sources.

2.3. Black Rot

Phytophthora is very aggressive fungus which can cause black rot in vanilla plants such as the shoot and bean rot (Havkin-Frenkel & Belanger, 2010; Tombe & Liew, 2010) (Figure 3). However, the incidence is not significant as *Fusarium* rot and anthracnose (Tombe & Liew, 2010). Shoot rot is a serious problem in Polynesia since it can lead to the death of seedling, but not a serious problem in Indonesia (Tombe & Liew, 2010). All vanilla plants parts are susceptible to *Phytophthora sp.* To get worse, the plant can be killed in a few days.

The characterization of the disease are the watery injuries of greenish to blackish color and cause the plant to rot (Bhai & Kumar, 2008; Havkin-Frenkel & Belanger, 2010). The mycelium of the fungus can be observed after a week of infection. The infection begins at the apical part of the plant before it spreads to other such as the stem, leaves, aerial roots and all the plants parts.



Figure 3: The rot symptom of naturally infected shoot by *Phytophthora capsici* in vanilla farm (inset: symptom after artificial inoculation of *Phytophthora capsici*) (Andriyani et al., 2017).

Prolonged rains, poor soil drainage, excess shade, high plant density and weeds are the conditions favors the development of the disease. The symptoms of disease are similar with the disease caused by *Fusarium* but differs in mycelium formation on the injured plant part and the size of conidia. This disease also causes a great loss due to rotting, fruit falling and loss of plants. Disease incidence can be reduced by taking care of the plants distances and also the rows. The support tress (tutors) should be pruned to increase the light intensity and also weed controlling. Three species of *Phytophthora* have been identified to infect vanilla plants, such as *P. palmivora* in Polynesia (Tsao & Mu, 1987) and Thailand (Sangchote et al., 2004), *P. capsici* in Indonesia (Slamet, 1991) and *P. meadii* McRae in India (Bhai & Kumar, 2008).

2.4. Sclerotium rot

Sclerotium rot is a disease infect the vanilla stem five centimeters above the soil surface (Tombe & Liew, 2010). *Sclerotium rolfsii* can be persist in the soil for years as a dormant structure. This pathogen does not have any conidia or any reproductive structures and easily spread by rain splash and run off, contaminated soil, animals and farming equipment (Tombe & Liew, 2010). The dormant structure, sclerotia, will form mycelia mats to colonize the host tissue. It colors is initially white before turn to pale to darker brown as matured (Tombe & Liew, 2010).

Sclerotium rot is a new type of bean rot which affect the bean bunches (Thomas and Bhai, 2000). Rainy seasons favors the infection incidence as the humidity is high (Tombe & Liew, 2010). Excess shade, overcrowding, waterlogged, the presence of pathogen inoculum favors the infection which caused bean rot (Tombe & Liew, 2010). In a bunch, there are few beans will rot and worsen, all the beans in a bunch will rot (Thomas & Bhai, 2000). Sclerotium rot begin at the tips of the bean and began to

spread to the stalk (Thomas & Bhai, 2000). Before rot, the bean surface is covered with white feathery mycelia mat of the fungus (Thomas & Bhai, 2000; Tombe & Liew, 2010). The thick fungal mat on the surface of vanilla bean later will cause the bean to rot (Thomas & Bhai, 2000; Tombe & Liew, 2010). Deep sunken wound like area, which appeared reddish brown in color is the example of the symptoms of sclerotium rot. Some of the bean showed completely rotten and some of them appeared as reddish brown. The developing thread of fungal mat which appeared as reddish brown sunken lesion can be seen on the leaves and beans, but rarely on stem (Thomas a& Bhai, 2000).

2.5. Rust

Rust is the vanilla disease which causes by *Uromyces sp* (Havkin-Frenkel & Belanger, 2010) and *Puccinia sp.* (Correll, 1953; Tombe & Liew, 2010). The disease is described as the presence of yellow-orange spots on the leaves, before it spreading more to be pustules coalesce and eventually causing the leaves to become dried. The high percentage of the disease happens in the production area where the ventilation is poor with an excess shade, and in a very rainy places. The growth and development of the vines stopped as the disease attacks. Defoliation of the plants cause the production capacity to decrease. The disease is familiar in poor management practice of vanilla plantation such as overcrowding, too much shade which cause lack of sunlight and too much moisture due to insufficient drainage. Application of fungicide and proper management practice such as better sunlight penetration can help to reduce the incident of rust disease.

3. VIRAL DISEASE IN VANILLA

Viruses had cause reduction in the production of vanilla worldwide (Bhat et al., 2004). Virus diseases in vanilla was first detected in 1986 in the Leeward Island after an intensive vanilla production was done due to high demand (Richard et al., 2009). There are five viruses are identified for attacking vanilla vines throughout the world which are *Cucumber mosaic virus* (cucumovirus), *Cymbidium mosaic virus* (Potexvirus), *Odontoglossum ringspot virus* (Tobamovirus), *Vanilla Mosaic Virus* (potyvirus) and *Vanilla necrosis virus* (Bhat et al., 2004). However, there are also two viruses from Potyvirus and Rhabdovirus genera had been yet to characterize reported in this study. However, in later publication, ten viruses have been reported to infect vanilla, which are four similar with earlier study by Bhat et al (2004) except Vanilla necrosis virus. The other six are from potyviruses types, listed as Watermelon mosaic virus, bean common mosaic virus, bean yellow mosaic virus, cowpea aphidborne mosaic virus, *Ornithogalum mosaic virus* and *wisteria vein mosaic virus* (Richard et al., 2009). Two viral diseases namely, mosaic and stem necrosis were reported in various

locations in India (Bhat et al., 2004). Both mosaic and stem necrosis were noticed in all ages of vanilla crop, however the symptoms of the diseases are more prominent on younger leaves. Mosaic is the common symptom observed in most of the plantation survey in India. Several mosaic types were observed such as mild mottle, mild mosaic and mild chlorotic mottle streak.

Mosaic is associated with leaf distortion and wavy margins (Bhat et al., 2004). The size of leaves was reduced and in advanced stages, become brittle and severely crinkled with twisting of leaf lamina and growing point of stem region. Mosaic virus also shows chlorotic to yellow green patches with distorted leaf margins. *Cymbidium mosaic virus* is one of the most widespread vanilla viruses which induces floral and foliar necrosis in many orchids (Bhat et al., 2006). In early 1990s, vanilla is planted intensively but without good sanitary practices and knowledge, which caused the spread of vanilla vine is mainly due to disease from *Cymbidium mosaic virus* (Palama et al., 2012). *Cymbidium mosaic virus* infection are always asymptomatic but the chlorotic and necrotic symptoms can be observed on leaves (Bhat et al., 2006; Palama et al., 2012). The effect of *Cymbidium mosaic virus* on the growth of vanilla plants were study. They found that the infected plants did not show any symptoms, neither necrosis nor flecking. However, the growth rate of almost all vanilla vines tested also affected such as in term of vines length, number of leaves, internodes length and stem diameter (Palama et al., 2012).

Stem necrosis disease is characterized with the presence of brown necrotic patches of varying length from 1 mm up to 15 cm on the stem (Bhat et al., 2004). The necrotic region of the plant is very dry and brittle with a shriveled appearance and gave a cracking sound when broken. An array of dead tissues is seen when the disease region is cut open. Necrosis will lead to the death of the vine due to the failure of water and other nutrients uptake to the rest of the vine. The management of the vanilla vine from viral infection through agnostics against viruses is very crucial since vanilla is propagated through cutting, which promote the spread of disease.

4. CONCLUSION

Vanilla is legacy plant for the ingredient in many foods. Vanilla flavor is the first choice by most of the people. Very few countries are cultivating of this plant. This is because the propagation of this plant is bit critical compare to other plant. Besides that, the diseases also very important to cultivate the plant for good production. Thus, extensive knowledge and technology in disease management by farmer need to improve for sustainable vanilla production.

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