

A Review On Major Fungus Associated With Black Pepper (*Piper nigrum* L.)Diseases In Malaysia

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Abstract— Black pepper or *Piper nigrum* L.is widely known as king of spice and among the most important spice in the world. The commercial value is from the dried matured fruits call berries. Black pepper was a perennial woody climbing plant which belong to family Piperaceae. It was grown in tropical region and native from South Western region of India. . Like other perennial crops, pest and disease attacks has become the main constrains for black pepper production that affects the quality and the yield.This review summarize the major important diseases of black pepper in Malaysia. Four major diseases have been identified as the main diseases of black pepper which are fusarium wilt (*Fusarium solani*), black berries (*Colletotrichum capsici*, *C.piperis* and *C.gleosporiodes*), *Phytophythora* foot rot disease (*Phytophythora capsici*) and velvet blight (*Septobasidium* spp.). Further and recent studies is needed in order to control the diseases incidence and maximize the pepper production.

Index Terms— Black Pepper, Fungus, Plant Diseases, *Fusarium* wilt, Black berries, *Phytophythora* foot rot, Velvet blight.

1 INTRODUCTION

BLACK pepper or *Piper nigrum* L.is widely known as king of spice and among the most important spice in the world. It was originated from tropical evergreen forest of Western Ghats and Malabar coast of India before being carried to Indonesia and Malaysia by traders and travelers [41]. This plant has been cultivated over 26 countries and produce about 315-320 000 tons of pepper including both black and white pepper [42]. The commercial value were from the dried matured fruits called berries [42] and it was known for its exquisite aroma and pungency.

In Malaysia, Malaysian Pepper Board (MPB) is an agency that responsible for development of Malaysian Pepper Industry including production, marketing and research, they are statutory body under the Ministry Of Plantation Industries & Commodities, established on 1st January 2007 under the Malaysian Pepper Board Act 2006 [25]. The transformation of the black pepper industry in Malaysia as profitable commodity crop has seen many smallholders have ventured into pepper planting. It was one of the crucial commodities in Malaysia. Black pepper were planted on 17,134 where 98% was in Sarawak and 2% in Sabah and Peninsular Malaysia with 31,073 ton of production in 2018 [27]. Now Malaysia was the sixth largest producing country and exporting 11,713 tonnes equal to RM201 millions to other European and Asian countries [25]. Sarawak pepper was widely considered as one of the best peppers in the world with geographical indication (GI) status recognition since 2003 [28]. The International Pepper Community recorded the production of Malaysian pepper to increased 29,245 tonnes with the total export of 12,199 tonnes which worth RM490.1 million in 2016. In addition, domestic consumption of pepper shot up by 11% to 13,500 tons in 2015, compared to 12,000 tons in 2014. The demands of pepper-based products were expected to increase in future [24].

Crop loss due to pest and disease incidence has been identified as one of the major pepper production constraints. Similar with other major crops in Malaysia, black pepper also been attacked with fungal pathogens that could reduce the qualities and quantities of these crop.These have resulted in a yearly reduction of about 2% of the total pepper area [28]. However, scientific report and intense study on fungal pathogen related with berries, leaf, stem and root diseases of black pepper need an intensive studies over the times. The major important diseases of black pepper in Malaysia have been identified as *Phytophythora* foot rot disease (*Phytophythora capsici*), *Fusarium* wilt (*Fusarium solani*), Black berries (*Colletotrichum capsici*, *C.piperis* and *C.gleosporiodes*), and Velvet blight (*Septobasidium* spp.). These diseases have being a problematic since the early stage of planting and infecting a large scale of area. Yellow diseases of *Fusarium* wilt can be considered as a new problematic disease in black pepper plantation as it shows symptoms of yellowing and curling of the leave later on vines become yellow and slender, and declining of the yield accure [36]. *Phytophythora* blight cause by *Phytophythora capsici* was considering as serious diseases in black pepper. Even all black pepper variety were prone to be infected by these pathogen. There still some information lacking especially on the degree of disease tolerance, modes of attacks and plant defence mechanism[33].

2.0 MAJOR DISEASES OF BLACK PEPPER

Based on previous literature, there were eleven economically important diseases of black pepper (*Piper nigrum* L have been reported worldwide. Seven of the diseases attack on arial part of pepper while the other four responsible on damaging root systems and lower part of the pepper [20]. Among all seven diseases the first to cause 50% crop losses was black berries caused by *Colletotrichum capsici*, *C.piperis* and *C.gleosporiodes*. The second destructive disease is wrinkle leave cause by virus infection that lead to the stunted growth of pepper. Then,

another destructive diseases are pink diseases caused by *Corticium salmonicolor*, thread blight disease caused by *Marasmius scanden*, horse hair blight disease caused by *Marasmius equirin* and velvet bligh disease caused by *Septobasidium* spp. . While the other four major disease are more prone on underground parts of the pepper which are *Phytophthora* foot rot (*Phytophthora capsici*), root-knot (*Meloidogyne incognita*, *M. javanica* and *M. arenaria*), white root (*Rigidoporus lignosus*) and slow decline of the influence of environmental features such as rainfall, temperature, soil water holding capacity, soil pH and soil texture on the incidence, development and spread of these disease[20]. However, this pepper will review the most prominent disease that attacks black pepper in Malaysia.

2.1 Black berries

Black berries or also known as anthracnose disease is the most prominent disease that attacks black pepper in Malaysia. This disease have been identified to be cause by fungus known as *Colletotrichum gleosporoides*, *C.capsici*, and *C.piperis*. The infections cause great losses on immature and matured fruits which tremendously reduce the black pepper production. Genus *Colletotrichum* spp. and other plant pathogen causing major production losses of plant crop worldwide [17]. The pathogen are responsible for post harvest losses on final product but also can create diseases on other part of plant including leaves, stem, and seed [56]. *Colletotrichum* species have different life cycle and most of them can sequentially switches [35]. They can be catogorised as necrotrophic, hemibiotrophic, latent or quiescent and endophytic. [1]. The symptom of infection and colonization quite similar among species. It is difficult to deal with *Collectotrichum* species as they have an abilities to cross infect wide range of host and switch their life cycle [37]. The current taxonomy status of *Colletotrichum* species was still unclear [53].



Figure 1: The symptoms of black berries disease

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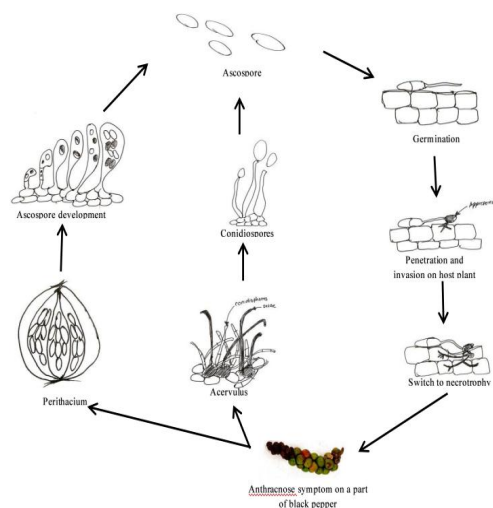


Figure 2 : General life cycle of *Colletotrichum* spp.

Necrotrophic life style refer to pathogen that actively infect and colonise the plant cell and leading the cell to death [57]. Mostly all *Colletotrichum* species develop this life style at certain stage of their life cycle except for those few exist as endophytes [39]. Biotrophic life style is where pathogen remain in plant cell without killing but absorb the nutrient for their survival [30]. Biotrophic happen during the early stage in their life cycle then switch to necrotrophic as refered to hemibiotrophic life style .Primary infection was formed on the epidermal cell and does not kill the plant but necrotrophic stage on secondary infection will invade and kill the plant [6]. Quiescent life style refers to pathogen that exist dormant at the first phase before switch to active phase [39]. *Colletotrichum* often remain dormant until the symptom appear during the harvest, storage, transportation and sales of product [39]. endophytic life style where fungi live within plant cell as symbionts without causing diseases [58]. Usually *Colletotrichum* species exist as endophytes in most of their life cycle in every types of crops [44].

Colletotrichum infect wide variety of plant crop causing anthracnose disease and having both sexual and asexual phase [52]. *Colletotrichum* symptom on black pepper can be figured out once all of the whole berries at the spike turn black and fall. The symptom of necrosis start at the end tips of berries stalk soon dark lesions appeared on the other infected berries and the center of each berries started to crack and fall [27]. The infection of spores start with rain splash onto pepper plant and dispersed to other berries and in some other cases spores being dispersed through unsanitize equipment during handling of the infected plant [40]. *Colletotrichum* can survive in wet and warm condition with temperature of 27 °C and 80% humidity [43].

Penetration and colonization of *Colletotrichum* spores on

host tissues start with the germination of conidia through the entry of narrow penetration peg on host cuticle and epidermal cell wall [38]. First lesion appear as soft, sunken and light brown in color then covered with concentric ring pink spots known as fruiting bodies called acervuli which produces *Colletotrichum* spores to spread the diseases [52]. Conidia spores produce in acervuli dispersed by wind, rain splash and others land infect plant host and spread as infection appear once mycelium break the epidermal surface and produce acervuli [52]. The sexual cycle start once two hyphae from different individual fuse together producing spores called ascospore which can survive longer on different conditions and environment [52]. Sexual stage of *Colletotrichum* rarely being observed as it is poorly understood while the asexual stage more related with diseases symptom [19].

Many control measures are available to reduce the infection of this disease. One of the measures is by growing black pepper together with leguminous tree such as *Erythrina indica* and *Gliricidia sepium*. These leguminous tree become a support system for climbers tree such as black pepper and at the same time improve the soil fertility [26]. In Malaysia, resistance varieties likes Semenggok Aman and Semongok Emas have been introduced as alternative to tolerate these diseases. Several chemical pesticides have been used to treat black berries disease such as Benomyl, Crypronazole, Carbendazim, Manzeb + Zink salt, Prochloraz manganese chloride and phosphorus acid [26].

2.2 *Fusarium* wilt

Fusarium wilt also known as yellowing diseases is one of the most important diseases of black pepper [48]. The symptom of *Fusarium* wilt are yellowing of foliage and root rot [10]. At the early age of pathogen establishment, the black pepper produce normal appearance but after 4 months of infection, yellowing symptom will start to appear at the vines. The symptoms will lead to leaf discoloration from the bottom of vines and spread to the top [49]. As the the infection reach advance stage, plant suffer from defoliation. Reddish discoloration on xylem vessel could be observed when the stem were cut. This disease can occur on both young and old vines. At certain stage main roots lose their feeder roots causing dieback and death of vines [21].



Figure 2 : The symptoms of *Fusarium* wilt

Fusarium wilt cause crop loses in India, Malaysia, Indonesia, Brazil and Thailand [48]. The infection could reduce the black pepper economic life span from 20 years to 6-8 years [10]. Infected plant can survive for just several years and gradually died over 3-4 years [2]. In Malaysia there is still little information about *Fusarium* wilt on black pepper is available. Extensive studies on the pathogen is crucial as the impact of the disease is very high towards the sustainability of black pepper crop [49].

Fusarium species can be soil-borne, airborne, carried in plant residue and can be recover from any part of plant at the end of deepest roots up until top of the flower [50]. *Fusarium* spp. usually block xylem vessel resulting to plant wilt and die. Many *Fusarium* spp. have been identified associated with wilting symptoms such as *F. eumartii*, *F. oxysporium*, *F. avenaceum*, *F. solani*, *F. sulphureum* and *F. tabacinum* [36]. However, The dominant parasitic fungus causing yellowing diseases of Malaysian black pepper is *F. solani* which have been confirm throughout series of research conducted in Sarawak and Johor [49].

Fusarium produce macroconidia and microconidia including mycelia and chlamydospores which responsible in infecting host plant [36]. Life cycle of these pathogen can be classified as dormant, parasitic and saprophytic stages [7]. The dormant stage involve inhibition and germination of resting phase in soil. While parasitic stage include penetration and colonization at the vascular system of plant roots including movement in xylem vessel resulting to death of host plant. Saprophytic stage is a resting structure in the dead host [51]. Mycelia, chlamydospores, macroconidia and microconidia available in the infected soil during dormant phase due to mycistasis [16]. Later the parasitic stage happen once any of propagule penetrates the host through formation of crack or wound at the roots part [18]. There are several reports that certain nematode attacks will produce wound and provide an entry point for the *Fusarium* to enter the plant [32]. *Fusarium* are also considered as saprophytes as they can easily found in all types of soil [31]. The abilities of these species in spore dispersion give an advantage for them to attack a wide range of host plant [34]. Undoubtedly there are many species of *Fusarium* has been identified as plant pathogen. One of Key feature in differentiate the species were through the presence of macroconidia and microconidia as well as the chlamydospores [9].

Among important control methods that have been suggested by Malaysian Pepper Board to reduce the *Fusarium* wilt infection is through proper field sanitation. Nematodes colony can be control by using by using carbofuron and other organic fertilizer. *Fusarium* spores that still present in plant residue can be controlled with Dazomet [26].

2.3 Velvet blight

In 1970, a researcher from Sarawak, Malaysia named this disease as *Septobasidium* blight which later refers as Velvet blight in 1972. Velvet blight were caused by fungus *Septobasidium* spp. Starting point of fungal infection is due to initiation from insect attack known as *Pinnaspis* spp [23]. Infection by fungus can be identified once the fungus turned from grey to purple. This disease have been found in India, Malaysia and Indonesia with various level of attack starting from seedling until the old ones [11]. Velvet blight are considered harmful and there were no special method to inhibit the attack. Disease attacks caused wrinkle on leaves, fruit spike and break twigs. The symptom can spread easily during raining season and severe infection can break the twigs or branch resulting in yield loss [11].



Figure 3: Symptoms of velvet blight on leaf and stem

Septobasidium spp can be identify through the presence of resupinate fruiting bodies, ashly to brown color with size range from 1mm to 25cm. The species also can be distinguish from the number of septa and the spore shape [14]. Visual symptom of *Septobasidium* species infection also can be characterize through the presence of symbiotic scale insect underside of branches and leaves [8].

Uniqueness of *Septobasidium* is they exist as symbiotic with scale insects ranging from obligate parasite to mutualistic [15]. They provide shelter and protection to the parasitoid wasps rather than killing the insect as they can benefits from waste product that the insect produce [54].

Field monitoring and inspection must be done frequently to remove any parts of plant that shown the symptom of velvet blight . Treatment with 0.15% of Tridermoph and 1% Bordeaux is also suggested every time after harvest the yield to control the infection [26]. The level of scale insects also must be reduced with the application of insecticides.

2.4 *Phytophythora* foot rot disease

Black pepper plantation in India, Indonesia and Malaysia have been reported with serious damaged caused by *Phytophythora* foot rot diseases [29]. In Malaysia *Phytophythora* foot rot disease was caused by *Phytophythora capsici* [26]. Diseases usually spread during raining season and once it infect any part of plant it cannot be treated. In these mean time, no specific pesticides has been found to treat the disease. Infection occurs through wind, water and through soil[3].

Symptom started with dark spot on the leaf margins and the plant leaf will start defoliated once the infection spread to entire laminar. The symptoms of infected shoots were obvious and easily to identified as the fungus spore will produce thin layer of white mycelium on the stem. The infected stem will abruptly will and lead to death of the plant. Berries turn black when the infection reached the spike. The plant root will also start to deteriorate and cause yellowing of leaf . The name of foot rot was obtain from the feeder root infection that reach collar through main root system [4].



Figure 4: Symptoms of *Phytophythora* foot rot disease

Three asexual and one sexual spore involve in life cycle of *Phytophythora* [47]. 4 main steps involve which are early contact to the host, zoospore encystment, spore germination and penetration and lastly the colonization [13]. Sporangia spores produce on infected plant part and able to germinate directly on healthy target or soil, it also can produce zoospores. While zoospores are prone to wet surface. Sporangia spores and zoospores can be dispersed by the same agent. Chlamyospore are produce by mycelium and germinate under favourable conditions to form sporangia. Oospores produce from mating types of two organism which is potential in producing genetic variation and resistances [45,47]. The fungus can adapt to diverse environmental conditions that able to produce some sort of survival structure later enhance their availability to survive without host plant [12]. Major causes lead to fungal infect the healthy tissues such as roots stems and fruits was the favorable condition [55].

In Malaysia, current practise used to control these disease using chemical pesticides such as matalaxy and dazomet. Grower were advised to cut down the infected plant to avoid more serious loses as the fungus able to survive in the contaminated soil up to 19 month with the presence of host plant [22,26]. A good drainage system also can help to lower the risk of disease incidence [46].

3 CONCLUSION

Malaysia have wide varieties of crop for commodities and some of growers prefer to practice mix cropping in one piece of land in maximizing the potential use of land and their profit. These situation have lead to high impact of diseases. Meanwhile, the choice of planting pepper on ex planting of rubber is a bad decision because mostly pepper will expose moore to the plant pathogen due to improper sanitation before planting. The use of the same equipment while operating the infected and healthy plant also encourage pathogen attacks and disease infection. As a result, the uses of high doses and unrecognized chemicals to control black pepper diseases have creates resistance toward fungicides. An accurate identification of causal pathogen along with knowledge of handling the impacted diseases are essential in developing specific management strategies to control each diseases. This review pepper hopefully could provide valuable information for further investigation of plant pathogen especially fungus associated with black pepper disease.

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