



## Epidemiology and Management Strategies of Ginger Leaf spot Disease (*Phyllosticta zingiberi*)

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### Abstract

Ginger is one of the imperative spice crops belonging to the family Zingiberaceae. The plant owns a mixture of numerous attributes and possessions, making it a very valued crop that has large demand in the worldwide market. However, the cultivation of ginger is extremely restricted by disease and pests, which highly attribute to yield damage. The crop is exposed to several fungal, bacterial, viral and nematode invasions throughout the growing period, causing variable degrees of crop injury and yield decrease. In Ethiopia, amongst; the various foliar diseases the leaf spot disease caused by *Phyllosticta zingiberi* is taking as a significant disease due to its severe leaf spotting, which abolishes the chlorophyllous tissues, resulting in significant loss decrease in yield. This pathogen causes 13 to 66% yield losses depending upon severity. Therefore, knowing the pathogen biology, ecology, epidemiology and management strategies is very important. *Phyllosticta zingiberi* has a compound disease cycle linking several causes of primary inoculum and various modes of distribution of secondary inoculum. This consequences in explosive increases during suitable environmental conditions. Disease losses can be reduced through combined management practices that comprise cultural, host resistance and chemical spray.

**Keywords** – Epidemics – Pathogen – Spices – Symptom – Yield loss

### Introduction

Ginger (*Zingibe officinale* Rosc.) is vital spice belonging to the family Zingiberaceae. The crop is thought to be a native of Tropical Asia (Mishra et al. 2012). It is an herbaceous perennial plant grown in the tropical and sub-tropical areas of the world as a spice and medicinal plant. It has got important stature among the spices universal due to its worldwide appeal. It is a plant of very ancient cultivation and the spice has long been used in Asia. Also, it is one of the earliest oriental spices known to Europe and Africa, including Ethiopia (Kandiannan et al. 1996), which is still in great demand today.

The plant possesses a combination of many attributes and properties thereof making its utility diverse. Ginger contains volatile oil, fixed oil, pungent compounds, resins, starch, protein, and minerals. The characteristic organoleptic properties are contributed by the volatile oil and non-volatile solvent-extractable pungent compounds. Among the many components, alpha Zingiberene is the predominating component of the oil. Gingerol and shogaol are the pungency-contributing components. The refreshing aroma and pungent taste make it an essential ingredient of most world cuisine and the food processing industry (Ravindran & Babu 2004).

Ginger is prone to many serious diseases, which are caused by fungal, bacterial and nematode infections. Other non-pathogenic maladies include sunburn, lime induced chlorosis, and chilling injuries which cause varying degrees of crop damage and yield reduction. The major diseases causing hindrance in ginger production includes soft rot (*Pythium* spp.), yellows (*Fusarium* spp.), Rhizome rot complex (fungi, nematode/ insect interactions), leaf spot (*Phyllosticta* sp.) and storage rots (*Pythium* spp., *Fusarium* spp.) (Rajan et al. 2002, Senapati & Ghose 2005). Among these, *Phyllosticta* leaf spot caused by *Phyllosticta zingiberi* is considered the most destructive appearing in mild or severe form in all the ginger growing tracts of the country (Sood & Dohroo 2005, Singh 2015). During the recent years the disease has become significantly important due to its severe leaf spotting which destroys the chlorophyllous tissues causing significant reduction in yield in Ethiopia. Sarma et al. (1994) have recorded 13-66% yield loss depending upon its severity. Yield losses of 48.3% and 65.9% were recorded on mother rhizome and fresh rhizome, respectively (Sood & Dohroo 2005).

### **Distribution of the disease**

Leaf spot disease of ginger is a widely prevalent disease occurring in almost all the ginger growing areas, including Ethiopia. During the recent years the disease has become significantly important due to its severe leaf spotting which destroys the chlorophyllous tissues which, in turn, leads to a significant reduction in yield and for this reason is considered as a destructive foliar disease of ginger (Singh et al. 2000). The disease was first reported from India (Ramakrishnan 1942). Thereafter the disease has been reported from all over the world. In Philippines, it was reported by Chanliongco in 1966 and subsequently in 1969 by Mailum and Divingarcia (Sood & Dohroo 2005) and in Sarwak (Anonymous 1972). In Ethiopia, the report of prevalence of the disease has been made from various ginger growing areas in 2019 by Plant protection section of Tepi Agricultural Research centre from the vicinity of Tepi and other producing areas.

### **Disease symptoms and pathogen biology**

Ramakrishnan (1942) observed that the disease was common during August, September and October. The spots differed in size as some were small and roundish, being a millimetre in length and half millimetre in breadth, while others were oval or elongated, having  $9-10 \times 3-4$  mm. The spots were white in colour in the centre, thin and papery and more often torn up. Minute blackish pycnidia could be observed in the centre of the spots. These had dark brown margins completely surrounded by a yellow halo. The spots were usually isolated but may also be confluent resulting in big patches which later lead to complete drying of the leaves. Mailum & Divingarcia (1969) observed that the lesions exhibited by *P. zingiberi* on leaves were numerous, circular or irregular with pycnidia and sometimes with shot-holes. Later the leaves turned brown and dried.

Anonymous (1972) reported from Sarawak that the disease caused numerous circular, oval or elongated spots on leaves. The spots had a whitish centre with dark brown margins surrounded by yellow halos, giving the crop yellowish appearance. Shukla & Haware (1972) reported similar symptoms. The spots measured  $8.0-10 \times 3.5-4.0$  mm in size and were usually isolated. However, under humid condition these coalesced with one another forming big lesions. In severe case all the leaves were affected and the disease was evident from a distance in the field due to severe discoloration. In later stage of disease development black, minute pycnidia in the white papery centre was conspicuous.

Sood & Dohroo (2005) observed that the disease appeared in the form of minute, pinhead, yellowish green spots which, with the progress of the disease, enlarged and became round to oval, measuring  $5.4-8.9 \times 2.5-4.7$  mm and coalescing to form bigger spots covering most of the leaf. These had characteristic greyish white papery centres in which numerous dark brown dot-like pycnidia of the fungus were embedded in the host tissues. These were surrounded by dark brown margins and demarcated by yellow halos. The centre of the spots remained either intact or fell off giving rise to shot hole appearance. In later stages, yellowing and drying of the foliage occurred. The symptoms also appeared on pseudo stems and their sheaths. On these spots the spots were

irregular, measuring 11.2-13.1 mm and without brown margins and yellow halos. These later, coalesced to form bigger spots which were also found to be embedded with pycnidia.

### **Disease cycle and epidemiology**

The infected debris or seed serves as primary inoculum for the disease. In leaf, pycnidiospores and mycelia remain viable for 14 months under laboratory conditions (Bhardwaj et al. 1988). Pycnidia survive in the leaf debris throughout the summer having temperature range of 30-35°C. The pycnidiospores remain viable in soil even at 25 cm depth for 6 months. The optimum temperature range for mycelial growth of *Phyllosticta* was 25 to 27.5°C with maximum and minimum to be 32.5 and 10°C, respectively. At 5 and 35°C complete inhibition of mycelial growth was observed (Cerezine et al. 1995).

The extent of dispersal of causal fungus depends upon the intensity of precipitation. Higher intensity of rain accompanied by wind seems to exert greater impact on target leaf so that spores are splashed to greater distances resulting in liberation of tremendous amount of spores and increasing disease incidence. The disease begins to appear towards the end of June. During this period, the temperature varies between 23.4 to 29.6°C and relative humidity is between 83.3 to 90.2%. Later in July when the number of rainy days and total rainfall increase, the disease aggravates and spreads very fast (Dake 1995). The influence of environmental factors viz., air temperature, relative humidity and rainfall on the disease development is to an extent of 85.5% (Sood & Dohroo 2005). Ginger plants up to the age of 6 to 7 months are susceptible to the disease and two weeks old leaves are most susceptible. It was observed that temperature range of 23 to 28°C with intermittent rain favoured disease development. Disease incidence was found to be less when ginger is grown under partial shade or as intercrop with other crops (Senapati et al. 2012). Continuous cultivation of ginger in the same field builds up higher concentrations of inoculum and early infection of the plant reduce the vigor leading to reduction in the rhizome yield (Singh 2015).

### **Disease Management Strategies**

#### **Cultural Practices**

Shade plays an important role in reducing the severity of *Phyllosticta* leaf spot. Research done in India shows partial shading of mandarian orange provided a favourable environment for growth of ginger and disease intensity remained often less as compared to that of open cultivation (Patiram & Singh 1995). The disease severity and sun burn were statistically lower in heavy shade in comparison to open sun grown ginger. However, considering all the parameters viz; reduction in *Phyllosticta* leaf spot and sun burn of leaves, increased the number of tillers per clump and yield, growing of ginger in partial shade may be recommended to avoid the fungicidal spray for controlling *Phyllosticta* leaf spot and consequently avoiding fungicidal pollution (Singh et al. 2004).

#### **Chemical Management**

Ramakrishnan (1942) observed that spraying Bordeaux mixture (1%) once or twice during the season successfully checked the outbreak of *P. zingiberi*. (Chauhan & Patel 1990) reported the use of Zerlate, Vancide Z-76 and Diathane M-22 to be effective against controlling *Phyllosticta* leaf spot of ginger. Cerezine et al. (1995) observed that captan and mancozeb (1000 mg) a.i./ml and triadimenol (100 mg) a.i./ml completely inhibited the mycelial growth of the fungus. Partial inhibition was observed with iprodione, thiophanate methyl and chlorothalonil up to 1000 mg/ml. They also reported that highest reduction in disease was observed in chlorothalonil spray followed by dithianon, copper oxychloride, folpet, mancozeb and captan whereas, iprodione, benomyl, triadimenol and methyl thiophanate failed to control the disease.

Also, Sohi et al. (1973) suggested the use of six sprays of Dithane Z-78 (0.2%), Filt 406 (0.3%), Dithane M-22 (0.2%) and Bordeaux mixtures (1%) at fortnightly intervals starting from the second week of July against the disease. They observed that all the test fungicides were effective in

reducing the disease incidence compared to control. The best protection was afforded by Dithane Z-78 closely followed by Filt 406, Dithane Z-78 and Bordeaux mixture. However, complete control of the disease was not observed. Sood & Dohroo (2005) reported that rhizome treatment as well as foliar sprays with Bordeaux mixture (1%), Companion (0.2%), Indofil M-45 (0.25%), Unilax (0.2%) and Baycor (0.05%) was effective in checking the severity of *P. zingiberi*. It was also observed that application of Bordeaux mixture and Companion effectively increased the rhizome yield of ginger.

Lu et al. (2007) analyzed the efficacy of fungicides *in vitro* against *P. zingiberi*. They observed that Kasugmycin completely controlled the fungus when added 400 times of water. *P. zingiberi* was controlled above 61% on Mancozeb, Bavistin, Famoxate and Kasugamycin which were respectively added 1500, 800, 1000 and 500 times of water. Singh (2015) studied the efficacy of foliar/soil-based fungicides combination for control of *P. zingiberi* using Team (Mancozeb/Carbendazim), Hi-shield (Mancozeb) and Funguran- OH (Copper oxide). These chemicals were used as sole and in various combinations for both soil and foliar treatment. Team (Mancozeb/Carbendazim) when applied as sole and in combination showed more efficacy than others.

Singh (2015) studied the efficacy of fungicides for the control of *P. zingiberi* under the field conditions of Chhattisgarh. He observed that three sprays of Carbendazim (0.1%), starting with the first appearance of symptoms in the field and subsequent two sprays at monthly intervals was effective in reducing the severity of disease (21.3%) with a consequent increase in fresh rhizome yield (173 q/ha). Similarly, it was followed by Metalaxyl (118 q/ha) and Thiophanate methyl (116 q/ha).

### **Host resistance**

Pertinent to the literature available it is observed that not a single variety has been found to be resistant against *Phyllosticta zingiberi* causing leaf spot disease in ginger. However, studies show that few moderate resistant sources have been identified. None of the 18 cultivars tested were resistant to *Phyllosticta* leaf spot (Setty et al. 1995). However, some cultivars were classed as moderately resistant with a disease index less than 5%. In India, none of the tested material of ginger was rated resistant to *P. zingiberi*, however, 8 lines showed moderate resistance (Dohroo et al. 1986). Different workers obtained variable results and none of the tested cultivars showed high degree of resistance (Dohroo et al. 1986, Setty et al. 1995). Nageshwar et al. (1995) screened 100 accessions of ginger for their reaction and tolerance to leaf spot under field conditions and of them, 11 accessions were found tolerant and a further 42 were moderately tolerant. Senapati et al. (2012) found that two ginger cultivars as moderately resistant out of 135 ginger cultivars tested.

### **Integrated Disease Management**

The main goals of integrated disease management are to eliminate or reduce the initial inoculums, reduce the effectiveness of the initial inocula, increase the resistance of the host, delay the onset of disease and slow secondary cycles (Agrios 2005). Control of *Phyllosticta zingiberi* has proven to be difficult due to its broad distribution and wide host range, and the limited means of protection measures available. Also, single control methods are not effective. Therefore, this calls for an integrated disease management strategy which is sustainable and ecologically friendly. Dohroo (1995) suggested an integrated approach to combat ginger leaf spot disease, included foliar spray with mancozeb and carbendazim and use of cultural practices. Hasnat et al. (2014) observed the lowest disease incidence (27.78%) in Ridomil Gold which was statistically similar to the plots applied with poultry waste, Bavistin 50WP, Dithane M-45 and sawdust at 240 days after planting. Integrated disease management reduced leaf spot disease by 20–100% in the field and typically combined two or three methods among cultural practices and chemical methods (Dake 1995).

### **Conclusion**

This review discloses that leaf spot disease infestation on ginger is very dangerous and is one the primary cause of low production in Ethiopia. The pathogen was characterized by amphigenous,

subglobose, dark brown ostiolate pycnidia. The typical symptoms of the disease are small oval to elongated spots on the leaves. Later on, the spots show white papery center and dark brown margins with a yellowish halo surrounding it. The spots increase in size and coalesce to form larger lesions. The affected leaves become shredded and may suffer extensive desiccation. Symptoms appear first on younger leaves. As the plants put forth fresh leaves, these get infected subsequently.

If not taken care of, this disease infestation can lead to the desertion of ginger farms and production in Ethiopia. Leaf spot infestation affects ginger production and also the yield of farmers per year. This disease infestation has impacts on the quantity and quality of ginger rhizome. Also, it affects the health of the crop and, finally livelihood. So far, diverse control strategies have been implemented against the pathogen; however, there is no sole effective control measure against the pathogen. Therefore, undertaking an integrated disease management tactic is critical. Thus, more exertion should be made to increase soil health and farmers' knowledge of the appropriate production system and recommended chemicals. Combined disease management options must be developed and promoted for smallholders in each ginger producing areas of Ethiopia.

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