CHAPTER 5

GENERAL DISCUSSION

5.1. Taxonomy and Host Specificity

Plant pathogenic fungi which causing negative aspects in agriculture have been studying and observing by mycologist, taxonomist, agronomist, and other related fields. They can ravage crops and are the major cause of plant diseases. Recently, over 10,000 species attack economically valuable crops, ornamental plants, and many wild plants (Agrios, 1997; Farr *et al.*, 1989). They also have the ability to destroy any type of harvested agricultural commodity that is not carefully stored or marketed (Sumbali, 2005). The plants that infected by fungi show some external and internal reactions or alterations that appear on the host plant are referred to as symptoms. Diseases caused by *Cercospora* and its allied genera are showed by the spots on the leaf. The spots are relatively small and separate or may merge and coalesce, resulting in the leaf blights. The symptom of *Cercospora* on the different host plants and geographic locations sometimes show different characters. *Cercospora* dispersal mostly intermediate by wind and/or rain drops animals due to the facts that conidia of *Cercospora* are detached easily and often blown in long distances by the wind. The fungus is favored by moderate to high temperature and high humidity. Therefore the fungi of *Cercospora* and its allied genera probably are most destructive in the summer months and warmer climate. Plant pathogenic fungi mostly produce specific enzyme to penetrate or to infect the plant cell wall likewise *Cercospora*. They produce specific enzyme called cercosporin, which acts as a photosensitizing agent in the cells,

which causes disruption of cell membranes and loss of electrolytes from cells. Several taxonomists used this physiological character as a tool to classify *Cercospora* and allied genera (Fajola, 1978; Goodwin *et al.*, 2001). Classification of plant pathogenic fungi particularly *Cercospora* and allied genera remains some problems due to the mycologists and plant pathologists who worked in taxonomy have still been using host specificity as a base for species epithet in the plant pathogenic fungi classification. In classification system of the *Cercospora* and allied genera, some authors such as Deighton (1967a, 1967b, 1971, 1973a, 1973b, 1974, 1976, 1979, 1983, 1987), Pons and Sutton (1988), Braun (1988, 1989, 1990, 1994, 1997), Crous and Braun (2003) and others have still been using morphology and host specificity as the criteria of classification. Therefore most of *Cercospora* and allied genera are still named based on their morphology characteristics and host specificity.

The developing of molecular phylogeny analyses in the plant pathogenic fungi particularly Cercosporoid fungi classification system seems to be promising to reveal and solve the problem. Crous *et al.* (2000a, 2001a, 2001b, 2002, 2003), and Goodwin *et al.*, (2001); however the relationship between morphology and molecular data in several cases is still uncertain, although several researchers have tried to solve it by using molecular phylogeny. The problem that found in the cercosporoid fungi classification using molecular phylogeny is that *Mycosphaerella*, teleomorphic state of cercosporoid genera, is monophyletic and *Cercospora* and allied genera is polyphyletic (Goodwin, 2001). Another complication is the fact that *Mycosphaerella* has more than one anamorph genus such as *Cercospora* Fresen., *Septoria* Sacc., *Cladosporium* Link. (Its teleomorph was excluded from *Mycosphaerella*, now its teleomorph is *Davidiella*), *Pseudocercospora* Speg., etc. (Crous and Braun, 2003).

Despite the classification system is still uncertain for the plant pathogenic fungi, several plant pathologists and mycologists using Koch's postulate to prove the host specificity on the plant-fungi interaction (Suassuna *et al.*, 2004). Koch's postulate has been assumed as a method to prove the host specificity in the host-pathogen interaction of cercosporoid genera.

Koch's rules are possible to implement, although not always easy to carry out, with such pathogens as fungi. Cercosporoid fungi can be isolated and cultured, or can be purified, and they can then be introduced into the plant to see if they cause the disease.

This effort seems to be promising, however the result is only limited on the specificity relationship between pathogenic fungi and plant host and reveal the process of infection and aggressiveness of pathogenic fungi. The contribution in the taxonomy of plant pathogenic fungi is still uncertain.

In this report, still rely on the morphological characters and host specificity to identify and classify the cercosporoid fungi found in northern part of Thailand. During the research, we have found 15 new recorded species of cercosporoid genera belong to five genera (table 3) is:

1. *Cercospora* (on *Phlogacanthus curviflorus, Melampodium paludosum, Bridelia ovata, Ellaeocarpus hygrophilus, Ficus religiosa, Solanum pseudocapsicum* and *Solanum wrightii*);
2. *Pseudocercospora* (on *Raphistemma pulchellum, Trevesia palmata, Haldina cordifolia, Ficus rumphii* and *Solanum trilobatum*);
3. *Phaeoramularia* (on *Phaseolus vulgaris*);

4. *Cercosporella* (on *Nymphaea stellata*).

5. *Passalora* (on *Lycopersicon esculentumcer* var. *asiforme*)

However, in this thesis we have not yet given the species name to those new recorded cercosporoid genera due to several considerations is:

1. We need more observation based on different view of tools such as molecular phylogeny to view the relationships between cercosporoid species as a base of taxonomy.
2. We need some suggestions and inputs from the experts who worked in the taxonomy of plant pathology fungi particularly on the cercosporoid genera classification;
3. We have to admit and publish the species on the acknowledged international papers.
4. There are 90 species of plants as new host recorded, based on the recent publications on the plant-pathogen interaction and taxonomy of fungal pathogen on plants led to new species.

5.2. Distribution

Distribution of plant pathogenic fungi are considered by several authors has a close relationship with some dispersal agents such as wind, water, animal, etc. Several authors have reviewed aerial dissemination of fungi pathogenic to higher plants. It is recognized that light, powder-like seeds afford more rapid transit than plumed or winged seeds. Most fungi have even small spores, a spherical spore 5 µm in diameter. It is obvious that a slight current of air will support most fungus spores or conidia,

provided they can escape from their sporophores or conidiophores. Furthermore, most fungi produce spores in vast numbers. Viable spores have been caught thousands of feet up in the air (Spooner and Roberts, 2005). However, a spore is not likely to get across an ocean, or to be still alive if it does. Even though a fungus has no device for getting its spores into the air, although they fall to the ground, the wind may pick them up with dust. Another agent in fungal distribution is animals. Many fungi, such as Phallales, Sphaeropsidales, Melanconiales and about one-fourth of the Moniliales, have slime spores spreaded by contact with an animal, for example or by water (Spooner and Roberts, 2005). Many different animals disseminate spores in sundry ways. The most possible, animals that spread fungal conidia or spores are insects and birds. They have many relations with fungi. They may gather spores, particularly slime-spores, accidentally; often they are attracted to a spore-mass by odor (*e.g.*, Phallales, decomposing vegetation), taste (*e.g.*, a sweet secretion accompanying the conidia of ergot and the pycniospores of rusts), sight (brightly coloured spore masses), or by appeals to two or three of these or comparable senses. Spores are then carried away on or in the insect's body. Birds, particularly migratory birds, may carry spores in long distances (Spooner and Roberts, 2005). In my opinion, human and their transport agencies have disseminated many fungi over the world rapidly. We can frequently trace such dispersal of parasitic fungi, commonly spread with seeds or other parts of plants, but it is seldom possible to decide whether a saprophyte is native or introduced. Another factor that has a great affects to the distribution of plant pathogenic fungi, particularly cercosporoid fungi, is climate. Climate is of primary importance in the distribution of vascular plants, the host or substratum in the distribution of fungi. In other words, climate affects fungi more indirectly, or at a

stage once removed. Phanerograms cultivated over wide areas, *e.g.* corn tomato potato, have numerous parasites that attack them anywhere. Nevertheless, climate has a controlling effect on the distribution of many fungi, including various parasites of crop plants. It is not surprised to find certain species of *Cercospora* and allied genera such as *Cercospora*, *Pseudocercospora, Passalora*, etc. almost anywhere. The range of a fungus is often quite different from that of its hosts or substrata, climatic or other factors must then be involved in limiting its distribution. Temperature, precipitation, humidity, length of season and other climatic factors definitely also affect the distribution of fungi; however it is not always easy to evaluate these factors. Climate has a controlling effect on the distribution of many fungi. There are other factors, such as plant succession, amount of disturbance of the environment, light and length of season, the effects of which are difficult to evaluate. In this study, we described the distribution of the cercosporoid fungi based on the host and climate regions. It is considered that the distribution of the host plants has been affected by the climates; therefore the relationship between host, climate and pathogen should not be recognized partially. We categorized 5 climatic regions based on modification of Koppen Classification System as follows:

A. Humid tropical climates (equatorial location); South America, Papua New Guinea, Indonesia, Eastern and Central Africa.

B. Dry, desert and semi-desert climates; western US, western and southern South America, Northern and southern Africa, southwest Asia, central Asia, Australia.

C. Humid, temperate climates; southwestern US, southwestern South America, Europe, southeastern China, northern and central India, South Korea, southern Japan, southeastern and southwestern Australia.

D. Humid, cold climates; northern North America including Midwestern US and New England, northern Scandinavia, Eastern Europe, northern Asia. There is no D climate land in the southern hemisphere.

E. Polar climates (P)

The distribution of *Cercospora* and allied genera found in this study is figured out based on climatic regions and geographical range. The analyses of distribution are conducted by description and explanation not by statistical analyses due to the focus of this study mainly is about taxonomy not ecological aspect.

5.2.1. *Cercospora*

Recently 2,897 species of *Cercospora* have been recorded worldwide (Index Fungorum online, 2006). In this study, 74 species recorded in Northern Thailand, which found mostly on the Cruciferae and Compositae, each 7 species; Euphorbiaceae and Solanaceae, each 6 species; and Acanthaceae, Leguminosae, and Verbenaceae, each 4 species respectively. Seven species of *Cercospora* found in this study are new to Thailand. However, to perform some new species from this observation is still needed some suggestion from experts.

Two of the new recorded *Cercospora* grow on *Solanum* sp. This fact showed that monitoring and assessment of biodiversity of plant pathogenic is urgent and should be conducted annually or continuously due to the facts that many pathogenic

fungi are still unrevealed and undescribed. Some of the *Cercospora* found, have exclusively distribution such as *Cercospora andrographidicola* only found in China; *C. strobilanthis, C. basellae-albae, C. jatrophigena, C. bauhiniae-variegatae, C. leucaenae, C. broussonetiae, C. capsicigena, C. lycopersici* in India; *C. ehretiicola* in Pakistan; *C. myriactidis* in Thailand; *C. physalidis-angulatae* in Gabon.

On the other hand, some species of *Cercospora* have a wide distribution throughout the world such as *C. celosiae* that distributed from humid tropical climate (Indonesia, Malaysia), dry climate (Sudan, Uganda), humid temperate climate (U.S.A and China), to humid cold climate (southern China). Other *Cercospora* that has worldwide distribution are *C. ipomoeae, C. brassicicola, C. beticola, C. citrulina, C. ricinella, C. canescens, C. coffeicola* and *C. apii.* Some *Cercospora* only found in the humid tropical climate such as *C. barlericola, C. plumeriae, C. cucurbitaceae,* and *C. rufula*. The remain *Cercospora* that found in this study distributed from dry, desert and semidesert climate to temperate and cold climate such as *C. tridacis-procumbentis* that found in the desert and semi-desert climate, *C. convolvuli* that found in the temperate climate region.

5.2.2. *Pseudocercospora*

Twenty-two species of *Pseudocercospora* recorded in Northern Thailand during the observation. They were found mostly in family Acanthaceae, Asclepiadaceae, Apocynaceae, Araliaceae, Balsaminaceae, Bignoniaceae, Caprifoliaceae, Combretaceae, Compositae, Euphorbiaceae, Leguminosae, Loganiaceae, Lythraceae, Musaceae, Saururaceae and Verbenaceae, each 1 species; Dioscoreaceae and Solanaceae, each 2 species respectively. Three species of

Pseudocercospora that found in this study are new to Thailand. However, to perform some new species from this observation is still needed some suggestion from experts and more examination by other methods such as molecular phylogeny. Two of the new recorded *Pseudocercospora* grow on *Solanum* sp. and *Dioscorea* sp. This fact showed that monitoring and assessment of biodiversity of plant pathogenic is urgent and should be conducted annually or continuously due to the facts that many pathogenic fungi is still unrevealed and undescribed. On the other hand, some species of *Pseudocercospora* have a wide distribution throughout the world such as *Pseudocercospora rhinacanthi* that distributed from humid tropical climate (Indonesia, Philippines and Thailand), humid temperate climate (China). Other *Pseudocercospora* that has worldwide distribution that are *P. balsaminae, P. viburnigena, P. fici, P. contraria, P. stizolobii P. musae* and *P. solani-melongenicola.* Some *Pseudocercospora* only found in the humid tropical climate such as *P. tecomae-heterophyllae , P. quisqualidia* and *P. melanolepidis.* The remain *Pseudocercospora* that found in this study distributed from dry, desert and semidesert climate to temperate and cold climate such as *P. contraria* and *P. stizolobii* that found in the desert and semi-desert climate, *P. carbonacea* that found in the temperate climate region.

5.2.3. *Phaeoramularia*

Up to now, 124 species of *Phaeoramularia* have been recorded worldwide (Index Fungorum online, 2006). In this study, one species recorded in Northern Thailand. They found on *Phaseolus purpureus* belonging to family Leguminosae. *Phaeoramularia* sp. that found in this study are new to science. However, to perform

a new species from this observation is still needed some suggestion from experts and more examination by other methods such as molecular phylogeny. The fungi have distribution only from type locality in Thailand.

5.2.4. *Cercosporella*

The present, 258 species of *Cercosporella* have been recorded worldwide (Index Fungorum online, 2006). In this study, 3 species recorded in Northern Thailand. We found in the Compositae, Nymphaeaceae and Oleandraceae, each 1 species. Two species of *Cercosporella* that found in this study are new to science. However, to perform some new species from this observation is still needed some suggestion from experts and more examination by other methods such as molecular phylogeny. Two of the *Cercosporella* sp. that found on *Nymphaea stellata* and *Nephrolepis biserrata* have exclusively distribution only found in Thailand and also both of these fungi are the first record from Thailand. On the other hand, *Cercosporella virgaureae* has a wide distribution throughout the world, including Abkhasia (Transcaucasia), Argentina, Austria, Brazil, Bulgaria, Canada, China, Colombia, Czech Republ., Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Japan, Kazakhstan, Kirghizia, Korea, Latvia, Netherlands, Norway, Poland, Puerto Rico, Romania, Russia (Asian part), Slovakia, Spain, Sweden, Switzerland, Thailand, Turkmenistan, Ukraine, U.S.A (CO, DE, ID, IL, KS, LA, MS, MT, NC, NE, NJ, OK, OR, TX, WA, WI), Uzbekistan, Taiwan and Virgin Islands. This fungi distributed from the humid tropical climate, dry, desert, semidesert climate to temperate, cold climate and the temperate climate region.

5.2.5. *Passalora*

Currently, 271 species of *Passalora* have been recorded worldwide (Index Fungorum online, 2006). In this study, 7 species recorded in Northern Thailand, which found in the Compositae, Malvaceae, Nyctaginaceae and Verbenaceae each 1 species and Leguminosae 2 species respectively. One species of *Passalora* that found in this study are new to science. However, to perform some new species from this observation is still needed some suggestion from experts and more examination by other methods such as molecular phylogeny. *Passalora gmelinae-arboreae* found have exclusively distribution only found in India. On the other hand, some species of *Passalora* have a wide distribution throughout the world such as *Passalora arachidicola* that distributed from humid tropical climate (Indonesia, Malaysia and Philippines), dry climate (South Africa, Sudan and Uganda), humid temperate climate (U.S.A and China), to humid cold climate (Hong Kong and China). Some *Passalora* only found in the humid tropical climate such as *P. bugainvilleae* and *P. gmelinae-arboreae*. The remain *Passalora* that found in this study distributed from dry, desert and semidesert climate to temperate and cold climate such as *P. bataticola* that found in the desert and semi-desert climate, *P. aenea* that found in the temperate climate region.

5.2.6. *Phaeoisariopsis*

Only 65 species of *Phaeoisariopsis* have been recorded. In this study, 1 species recorded in Northern Thailand. It was found in family Leguminosae, *Phaeoisariopsis griseola* on *Phaseolus vulgaris*. Based on the recent references, the species is new to science. However, to perform some new species from this

observation is still needed some suggestion from experts and more examination by other methods such as molecular phylogeny. On the other hand, *Phaeoisariopsis griseola* have a wide distribution throughout the world including Angola, Argentina, Armenia, Australia, Austria, Bhutan, Brazil, Bulgaria, Burundi, Cameroon, Canada, China, Colombia, Congo, Costa Rica, Croatia, Cuba, Dominican Republ., Ecuador, E1 Salvador, Ethiopia, Fiji, France, Georgia, Germany, Ghana, Great, Britain, Greece, Guatemala, Haiti, Hungary, Jamaica, Japan, India, Indonesia, Iran, Ireland, Israel, Italy, Ivory Coast, Jamaica, Japan, Kenya, Korea, Laos, Latvia, Malawi, Madagascar, Malaysia, Mauritius, Mexico, Mozambique, Nepal, Netherlands, Netherland Antilles, New Caledonia, New Caledonia, New Zealand, Nicaragua, Nigeria, Norfolk Island, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Puerto Rico, Reunion, Romania, Russia, Rwanda, Saint Helena, Senegal, Sierra Leone, Singapore, Slovenia, Solomon Island, Somalia, South Africa, Spain, Sudan, Suriname, Swaziland, Taiwan, Tanzania, Thailand, Trinidad and Tobago, Turkey, Uganda, Ukraine, U.S.A (CT, DE, Eastern states, FL, HI, IN, MA, MD, ME, MI, MS, NC, NH, NJ, NY, OK, PA, SC, TX, VA, WI), Vanuatu, Venezuela, Vigin Islands, Yugoslavia, Zambia and Zimbabwe.

5.3. Conclusion

Based on the data obtained that the conventional classification methods that used in this study, It is concluded that:

1. Some species of *Cercospora* and allied genera have specific and worldwide distribution. These data suggests that monitoring of dispersal and distribution of plant pathogenic fungi is very important in

quarantine and pest control management to anticipate appearing of new plant pathogenic agent factor.

2. Some plants can only grow in the humid area and other plants distribution of hosts and substrata primarily control distribution of fungi. On the other hand, a parasite is commonly specific to the species of host, so that its range and diversity at the species and/or interspecies level can be greater than saprophyte.

3. Climatic factor has a correlation to the distribution of the plant pathogenic fungi, despite plant host has extremely an important influence on the pathogenic fungi distribution. However, It should consider that the distribution of the host is affected by climate in the desert area and so on.

4. Other factors, including the nature and density of phanerogram, light, and particularly the activities of man, influence the distribution of many fungi.