I The prevalence of maize and soybean diseases in Thailand

Summary

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The purpose of the present report was to investigate the prevalence of diseases of maize and soybean plants when upland crops such as maize and soybean are introduced into the paddy fields of the central plain of Thailand as second crops during the dry season. Sorghum downy mildew, brown stripe downy mildew, Curvularia leaf spot, southern leaf blight, northern leaf blight etc. were important diseases of maize. Among them, sorghum downy mildew was the most destructive disease for maize plants. The disease was distributed in all of the maize cultivated regions in Thailand except in the northernmost part of the country. There was a serious outbreak of sorghum downy mildew in the fields during the wet season. However, sorghum downy mildew burst out on maize plants in the test field at the Suphanburi Rice Experiment Station during the dry season. It is considered that inoculum was abundantly present in the field under the conditions created by all year round cultivation of maize. The fungus involved possessed conidia of a shape different from that of conidia present in *Sclerospora sorghi* found on the infected leaves of sorghum downy mildew.

Curvularia leaf spot was a very common disease in Thailand and the disease was observed in every region where maize was cultivated. Causal organisms of Curvularia leaf spot, namely *Curvularia pallescens, C. lunata* and *C. lunata* var. *aeria* could be isolated. Southern leaf blight was recognized in the whole country, but the disease appeared under a mild form in central Thailand. The prevalence of northern leaf blight was observed to be more severe in the northern part of Thailand than in the central plain.

Soybean rust was the most destructive disease for the cultivated area of soybean during the wet season. It became evident that rust broke out seriously in spite of the dry season when inoculum was present abundantly in the field under the conditions of all the year round cultivation. Moreover, other soybean diseases were bacterial pustule, Phyllosticta leaf spot, frog-eye leaf spot, Alternaria leaf spot, downy mildew, anthracnose, Sclerotium rot, Fusarium wilt/blight, Rhizoctonia blight and charcoal rot.

I Introduction

The joint research project on "Land and Water Utilization on Paddy Fields in Thailand" was set up in cooperation with the Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand, and Tropical Agriculture Research Center, Ministry of Agriculture, Forestry and Fisheries, Japan, for the purpose of introducing agricultural techniques for the cultivation of upland crops in paddy fields in the dry season in the central plain of Thailand.

The authors took charge of the plant pathology section of the research work from 1973 to 1975 and conducted a study on "The prevalence of maize and soybean diseases in Thailand". The purpose of this work is to clarify the kinds and the aspects of diseases in upland crops such as maize and soybean when these are introduced as second crops in the paddy fields during the dry season. The survey on maize and soybean plants diseases was carried out in upland fields during the wet season and in irrigated fields during the dry season. The study should provide information on the epidemiology of maize and soybean diseases in Thailand, distribution of these diseases in the country and seasonal prevalence of the diseases during the year.

II Materials and methods

To study the outbreaks and the distribution of maize and soybean diseases, field surveys were conducted in the central plain region as well as in the northern, southern and north-eastern parts of Thailand. Also, to determine the seasonal prevalence of major diseases of maize and soybean, an experimental field was set up at the Suphanburi Rice Experiment Station, Suphanburi province, which also served as the fixed point of observation.

1 Field surveys of maize and soybean diseases

Field surveys of maize and soybean diseases were conducted in central, north, north-east and south Thailand for two years from April 1973 (wet season) to April 1975 (dry season). During the wet season, the disease survey was done in the irrigated fields. Observation fields of maize and soybean were selected among farmers' fields at random near the road-side or were among the fields belonging to the Agricultural Experiment Station. The number of provinces visited in the course of the field survey on maize and soybean diseases was 43 and 20, respectively, while the total number of observation fields was 256 (maize) and 188 (soybean). A minimum of 100 stands of maize and soybean plants were observed in each field and the percentage of plants infected with different diseases was calculated. Also the disease index was calculated for major diseases such as downy mildew of maize or rust of soybean in taking into account the severity of the disease affecting the plants. The disease index was calculated by the following formula:

$$\text{Disease index} = \frac{1 \times \text{Number of plants with mild infection} + 2 \times \text{Number of plants with moderate infection} + 3 \times \text{Number of plants with severe infection}}{3 \times \text{number of total plants}} \times 100$$

legend: healthy; O, disease severity, mild; 1, moderate; 2, severe; 3

2 Disease observation at the Suphanburi Rice Experiment Station

1) Plot

The experiment field (0.8 ha) was divided into two parts : the lowland (48 a) and upland field (32 a). The lowland field was cultivated with rice plants during the wet season, and with upland crops during the dry season. The upland field was cultivated with upland crops such as maize and soybean all the year round. The upland field was made out of 30 cm earth laid on the paddy field before the experiment. The soil was taken from the surface soil of a paddy field near the experiment station. During the dry season the lowland field was divided into 4 plots planted with maize, soybean, maize and soybean, and one plot was let lie fallow. The surface of each plot measured 1,026 m^2. The upland field was divided into 3 blocks and each block was divided into 3 plots planted with maize, soybean and interplanting of maize and soybean. The surface of each plot measured 300 m^2.

2) Variety, cropping system and cultivation methods

The varieties of crops used in every test during the experiment period were RD-1 in the case of rice, PB-5 for maize and SJ-1 for soybean. In the lowland field, rice was cultivated during the wet season, and upland crops were cultivated by means of irrigation during the dry season. The same fields were continuously used during the experiment. Maize and soybean in the upland field were cultivated in each plot with about 40-day interval between the beginning of sowing in the first plot (February, 1974) and the tenth plot (January, 1975). Thus, each field was replanted in cycles of 120 days. The rotation system of the upland field consisted of a first cropping : maize, a second cropping : soybean, a third cropping : interplanting of maize and soybean, in the proportion of 4 rows of soybean to one row of maize. No fungicides nor insecticides were used in any experimental field.

3) Observations of experimental fields

Observations for diseases of maize and soybean plants were conducted periodically at two-week intervals and involved more than 500 plants in each experimental plot. The number of diseased plants and the severity of the disease were recorded in each crop. Disease percentage and disease index were calculated as mentioned above.

3 Identification of pathogenic organisms

Some lesions were removed and transferred to a moist chamber for fungi sporulation. In some cases, the isolation of causal organisms from the diseased plants was performed by ordinary isolation techniques. The fungi grown on the media were examined under a microscope and were identified. In some isolates, single spore isolation was achieved by spore dilution method or lifting method of spore. These fungi were used for the inoculation test. Inoculation test was carried out using detached leaves, hypocotyls or seedling in the moist chamber and/or seedling plants in pots. The plants were covered with a polyethylene bag to maintain high moisture or kept in the incubator for inoculation. Sterilized vermiculite was used instead of soil for the inoculation test of root rot pathogens. Inoculum consisted of a mycelial agar disk of PDA (8 mm in diameter) or a spore suspension of fungi.

III Results

1 Disease survey of maize and soybean plants

1) Maize diseases confirmed in Thailand from 1973 to 1975

Diseases of maize recognized in the country are shown in Table 1. Among them, sorghum

downy mildew of maize, *Sclerospora sorghi*, was the most important disease of maize in Thailand. Brown stripe downy mildew, *Sclerophthora ryssiae* var. *zeae*, was also observed in cultivated districts of Thailand. In plants with symptoms of sorghum downy mildew, two kinds of conidia of *Sclerospora* were found on the diseased leaves of maize under natural conditions. One of them was identified as *Sclerospora sorghi* Weston et Uppal. The other one showed oval, obovate or obpyriform conidia with an apiculus. The fungus (*Sclerospora* sp.) could possibly be different from the species of *Sclerospora* reported in Thailand so far (Table 2). A fungus was also identified in plant with brown stripe downy mildew disease. The description of *Sclerospora* sp. is as follows :

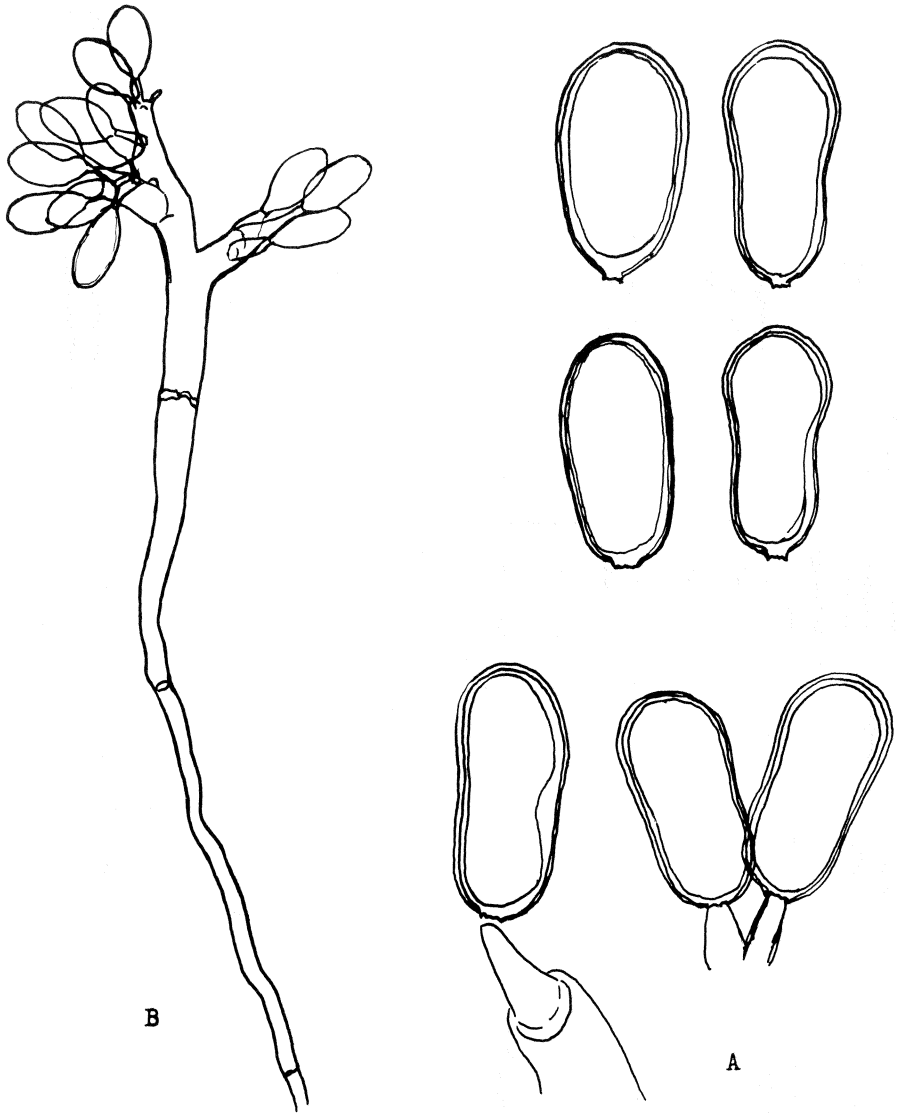
Conidiophore erect, spreading, hyaline, slender, usually dichotomously branched with an expanded apex and basal cells, measuring approximately 160 to 600 μm from the top of sterigmata to the base, conoid with a hemispherical tip. Conidia: oval, obovate or obpyriform, thin-walled, minute apiculus at the base, varying from 21 to 44 μm in length and 12 to 21 μm in breadth (32 × 16 μm an average), ratio of length to breadth varying between 1.65 to 2.73, most frequently 1.93 to 2.23 (2.01 on average), germination by germ tube. Oospores not yet identified (Fig. 1).

Table 1. Diseases of maize observed in Thailand from 1973 to 1975

Disease	Pathogenic agent
Sorghum downy mildew	*Sclerospora sorghi* (Kulk.) Weston et Uppal
	Sclerospora sp.
Brown stripe downy mildew	*Sclerophthora ryssiae* var. *zeae* Payak et Renfero
Northern leaf blight	*Trichometasphaeria turcica* Luttrell (*Helminthosporium turcicum* Pass.)
Southern leaf blight	*Cochliobolus heterostrophus* (Drechsler) Drechsler (*Helminthosporium maydis* Nishik. et Miy.)
Curvularia leaf spot	*Curvularia lunata* (Wakker) Boedijn
	C. lunata (Wakker) Boed. var. *aeria* (Bat., Lim. et Was.) Ellis
	C. pallescens Boedijn
Rust	*Puccinia polysora* Underw
Common smut	*Ustilago maydis* (DC.) Cda.
Water-soaked curvularia leaf spot (tentative name)	*Curvularia pallescens* Boedijn
	C. lunata (Wakker) Boedijn
	C. lunata (Wakker) Boedijn var. *aeria* (Bat., Lim et Vas.) Ellis
Bacterial wilt	unidentified
Purple leaf sheath	non-parasitic factor

Table 2. Characteristics of *Sclerospora*, downy mildew of maize observed in Thailand

Disease (*Symptom)	Pathogen	Length of conidiophore (μm)	Basal cell	Size of conidia (μm) mean(range)	Ratio of length / breadth of conidia	Shape of conidia	Germination	Remarks
Sorghum downy mildew	*Sclerospora sorghi*	190-660	Present	23 × 17 (14 - 41 × 12 - 25)	1.32	Globose, broadly ellipsoidal	Germ tube	
Do. *	*Sclerospora* sp.	190-660	do.	32 × 16 (21 - 44 × 12 - 21)	2.01	Oval, obovate with apiculus	do.	
Brown stripe downy mildew*	*Sclerospora* sp.	208-468	do.	30 × 15 (26 - 36 × 13 - 17)	1.97	do.	do.	
Sorghum downy mildew	*Sclerospora sorghi*	180-300	Present	15 - 29 × 15 - 27		Sub-orbicular	Germ tube	Weston *et al.* 1932
Philippine downy mildew	*S. philippinensis*	245-400	do.	44 × 14 (31 - 58 × 11 - 16)		Cylindrical	do.	Phitakpraiwan *et al.* 1974
Java downy mildew	*S. maydis*	180-300	do.	28 - 45 × 16 - 22		Spherical, subspherical	do.	Dickson 1956 (from Butler 1913)
Sugarcane downy mildew	*S. sacchari*	160-170 (190-280)	do.	25 - 41 × 15 - 23		Elliptical, cylindrical, ovate	do.	Waterhouse 1964 (from Miyake 1911)



A : x400, B : x 250

Fig. 1. Conidia and conidiophore of *Sclerospora* sp. identified in sorghum downy mildew of maize in Thailand

Northern leaf blight, *Trichometasphaeria turcica* (*Helminthosporium turcicum*), is a common disease, observed widely in northern Thailand. Southern leaf blight, *Cochliobolus heterostrophus* (*Helminthosporium maydis*), and Curvularia leaf spot, *Curvularia pallescens, C. lunata* and *C. lunata* var. *aeria* are also commonly observed in Thailand, particularly the latter is seen in a large number of maize fields. Maize rust, *Puccinia polysora*, was restricted to Pakchong, Nakhonratschasima, in 1973. Common smut, *Ustilago maydis* was often observed on maize heads following the flowering or silking stage. Wilt of maize seedling was found in the provinces of Suphanburi and of Saraburi. Symptoms are those of bacterial wilt of maize, but the causal organism has not been identified. Water-soaked lesions of Curvularia leaf spot were often seen on leaves of maize and *Curvularia pallenscens, C. lunata* and *C. lunata* var. *aeria* were always isolated from the lesions which varied from small round to irregular spots extending over several centimeters.

Leaf blight, leaf spot and purple leaf sheath, which differ from the typical southern leaf blight and Curvularia leaf spot, were commonly and frequently noticed in maize plants cultivated in many provinces. The following fungi were isolated from plants with leaf blight: *Curvularia pallescens, C. lunata, C. lunata* var. *aeria, C. clavata, Helminthosporium turcicum, H. maydis, H. carbonum, Nigrospora oryzae, Phialophora fastigiata, Fusarium oxysporum, Fusarium* sp., *Diaporthe* sp., *Epicoccum* sp., *Cladosporium* sp., *Septoria* sp., *Stagnospora* sp., *Phyllosticta* sp., *Alternaria* sp., *Penicillium* sp., *Mucor* sp. and some other fungi.

The following fungi were isolated from and/or confirmed in lesions of leaf spot: *Curvularia pallescens, C. lunata, C. lunata* var. *aeria, Helminthosporium maydis, Stemphylium botryosum, Hansfordia ovalispora, Virgaria nigra, Fusarium oxysporum*, etc. In the results of inoculation tests of the fungi from leaf blight and leaf spot lesions, only *Curvularia pallescens, C. lunata, C. lunata* var. *aeria, Helminthosporium maydis,* and *H. Turcicum* were responsible for symptoms on maize leaves. From the results mentioned above, it appears that leaf blight and leaf spot were characteristic among the various symptoms observed in these complex diseases.

Purple leaf sheath is generally observed on the stalk of maize after the vegetative or silking stage. According to Shurtleff et al, 1973, purple leaf sheath has been reported as a disease caused by non-parasitic fungi such as *Fusarium* spp., yeast, etc. *Helminthosporium hawaiiensis, H. turcicum, Curvularia pallescens, C. lunata, C. lunata* var. *aeria, Phyllosticta* sp., *Cylindrocephalum* sp., *Gliocladium* sp., *Alternaria* sp., *Epicoccum* sp., *Cladosporium* sp., *Fusarium* sp., *Penicillium* sp. were isolated from or confirmed in the lesions of diseased leaf sheath.

Necrotic lesion caused by downy mildew is commonly recognized as being one of the symptoms of the diseased leaves. Fungi isolated from the necrotic lesion caused by downy mildew were: *Curvularia pallescens, C. lunata, C. lunata* var. *aeria, C. clavata, Helminthosporium maydis, H. turcicum, Fusarium oxysporum, F. solani* and *Alternaria tenuis*.

2) Soybean diseases confirmed in Thailand from 1973 to 1975

Soybean diseases observed in Thailand from 1973 to 1975, are shown in Table 3. Among them, rust (*Phakopsora pachyrhizi*) was the most destructive disease, especially during the wet season in all the cultivated areas of Thailand. Bacterial pustule (*Xanthomonas phaseoli* var. *sojensis*) was also a very common disease in the same areas, leading to the loss of seed productivity along with complications of rust disease. Downy mildew (*Peronospora manshurica*), anthracnose (*Colletotrichum dematium* var. *trumcata*), brown spot (*Septoria* sp.), Phyllosticta leaf spot (*Phyllosticta* sp.), frog-eye leaf spot (*Cercospora* sp.) and Alternaria leaf spot (*Alternaria* sp.) were other fungal leaf diseases of soybean in Thailand. A large number of fungi were isolated from or confirmed in plants with symptoms of atypical leaf spot and leaf blight. *Cladosporium cladosporioides, C. sphaerospermum, Curvularia pallescens, Nigrospora oryzae, Septoria* sp., *Phyllosticta* sp.,

Cercospora sp., *Alternaria* sp., *Periconia* sp., *Chaetomium* sp. were isolated from lesions of atypical leaf spot while *Colletotrichum dematium* var. *truncata, Cladosporium cladosporioides, Curvularia pallescens, C. lunata, C. eragrostidis, Alternaria tenuis, Epicoccum purpurascens, Periconia byssoides, Nigrospora oryzae, Stemphylium botryosum, Fusarium oxysporum, Diaporthe* sp., *Septoria* sp., *Phyllosticta* sp., *Helminthosporium* sp., *Pullularia* sp., *Hansfordia* sp., *Aspergillus* sp., *Trichocladium* sp. and *Meterizium* sp. were identified in lesions of atypical leaf blight. Among these fungi, *Septoria sp., Phyllosticta sp., Colletotrichum dematium* var. *truncata, Curvularia lunata, C. pallescens* and *C. eragrostidis* were responsible for the symptoms of leaf blight of seedling leaves of soybean.

Table 3. Diseases of soybean observed in Thailand from 1973 to 1975

Disease	Pathogenic agent
Mosaic	Virus
Bacterial pustule	*Xanthomonas phaseoli* (Smith) Dowson var. *sojense* (Hedges) Starr et Burkholder
Rust	*Phakopsora pachyrhizi* Sydow
Downy mildew	*Peronospora manshurica* (Naoum) Sydow
Sclerotium rot	*Sclerotium rolfsii* Sacc.
Anthracnose	*Colletotrichum dematium* (Pers. ex Fr.) Grove var. *truncata* (Schw.) Arx.
Brown spot	*Septoria* sp.
Phyllosticta leaf spot	*Phyllosticta* sp.
Frog-eye leaf spot	*Cercospora* sp.
Alternaria leaf spot	*Alternaria* sp.
Fusarium wilt/blight	*Fusarium oxysporum* Schlechtendahl *Fusarium solani* (Martius) Appel et Wollenweber
Charcoal rot	*Macrophomina phaseolina* (Tassi) Goid.
Rhizoctonia blight	*Rhizoctonia solani* Kühn

Sclerotium rot (*Sclerotium rolfsii*), Rhizoctonia blight (*Rhizoctonia solani*), Fusarium blight wilt (*Fusarium solani, F. oxysporum*), charcoal rot (*Macrophmina phaseolina*), anthracnose (*Colletotrichum dematium* var. *truncata*) were recovered from plants with root rot disease and in other samples, *Gliocladium* sp. was found to give rise to lesions of root rot disease (Table 4). *Curvularia lunata* and *C. pallescens* were isolated from root rot disease of soybean. Such findings were confirmed by means of the inoculation test. However, the following fungi *Cephalosporium* sp., *Trichoderma viride, Mycogen* sp. and *Neurospora* sp. which were isolated from root rot did not give rise to symptoms in soybean plants by means of the inoculation test.

Table 4. Pathogenicity of fungi isolated from hypocotyl and root of soybean plants

Isolated fungi	Area sampled	Appearance of symptoms and recovery
Sclerotium rolfsii Sacc.	Chieng Mai Chainat	+
Rhizoctonia solani Kühn	Suphanburi	+
Macrophomina phaseolina (Tassi) Goid	Chieng Mai Chainat	+
Fusarium solani (Mart.) App. et Woll.	Sukhothai Suphanburi Singburi Nakhonratchasima	− or +
Fusarium oxysporum Schlecht.	Nakhonratchasima	− or +
Colletotrichum dematium (Pers. ex Fr.) Grove var. *truncata* (Schw.) Arx.	Chieng Mai Suphanburi Chieng Rai	+
Gliocladium sp.	Chainat	+
Curvularia lunata (Wakker) Boedijn	Chieng Rai Chainat	+
Curuvularia pallenscens Boedijn	Suphanburi	− or +

2 Distribution of maize and soybean diseases in Thailand

1) Maize diseases

Results of surveys on maize diseases are shown in Tables 5 - 6. Analytical data on diseases of maize in Thailand are outlined below.

(1) Sorghum downy mildew

The prevalence of sorghum downy mildew of maize in respective provinces of Thailand is shown in Tables 5 - 6, following observations made during the period extending from the wet season of 1973 to the dry season of 1974 - '75 (Fig. 2). As seen in Fig. 2, sorghum downy mildew of maize was distributed in the central plains, the meridional part of northern and western provinces of north-east Thailand. No sorghum downy mildew was found in the northern area of Chieng Mai, Lamphun, Lamphang, Chieng Rai and Nan provinces, in the north-eastern area of Sakhon Nakhon, Mahasarakham, Surin and Ubon Rajathani provinces, and in the southern area of Chomphon, Krabi, Trang, Patthalung, Songkhla, Pattani and Yala provinces. In Saraburi province in the central plain, diseased plants were not found in the large corn fields. As the disease severely affected the neighbouring provinces, its absence in Saraburi outlines interesting aspects relating to the mode of propagation of downy mildew of maize. Furthermore sorghum downy mildew was present in the northern part of Prachupkirikhan province but the southern part of the province was free from the disease.

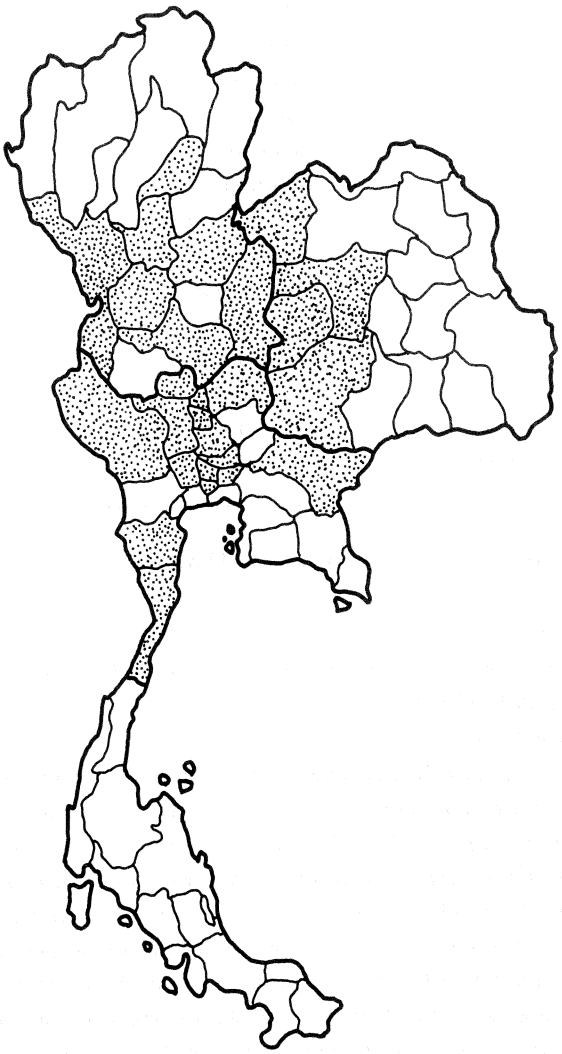


Fig. 2. Distribution map of sorghum downy mildew of maize confirmed in Thailand from 1973 to 1975.

(The dotted areas indicate the provinces where the infection was observed)

Table 5. Distribution of maize diseases observed during the wet season, 1973 and 1974

Region	Province	Soghum downy mildew	Brown stripe downy mildew	Northern leaf blight	Southern leaf blight	Curvularia leaf spot	Rust	Common smut
Central	Phranakhorn	–	–	–	+	+	–	–
	Nonthaburi	+	–	+	+	+	–	–
	Pathunthani	++	+	–	+	+	–	–
	Ayuthaya	++	+	+	+	+	–	–
	Ang Thong	++	+	+	+	+	–	–
	Singburi	+	+	+	+	+	–	–
	Chainat	+	+	+	+	+	–	–
	Saraburi	–	–	+	+	+	–	–
	Lopburi	+	–	+	+	+	–	–
	Nakhonpathom	++	+	+	+	+	–	–
	Kanchanaburi	++	+	+	+	+	–	–
	Suphanburi	++	+	–	+	+	–	–
	Petchburi	+	–	+	+	+	–	–
	Prachuapkhiri-khan	+	–	+	+	+	–	–
	Prachinburi	+	+	+	+	+	–	–
	Tonburi	++	–	–	+	+	–	+
North	Nakhonsawan	++	+	+	+	+	–	–
	Kamphenphet	++	+	+	+	++	–	–
	Tak	+	+	–	+	+	–	–
	Sukhothai	++	–	+	+	+	–	–
	Phisanulok	++	–	–	+	+	–	–
	Chieng Mai	–	–	+	+	+	–	–
	Chieng Rai	–	–	+	+	+	–	–
	Lamphun	–	–	+	+	+	–	+
	Lamphang	–	–	+	+	+	–	–
	Nan	–	–	+	–	+	–	–
	Petchabun	+	–	+	+	+	–	–
	Phrae	+	+	+	+	+	–	–
North-east	Nakhonrat-chasima	++	+	+	+	++	+	+
	Chayaphum	++	–	+	+	+	–	–
	Khonkaen	++	+	+	+	+	–	–
	Loei	+	+	+	+	+	–	–
	Mahasarakham	–	–	+	+	+	–	–
	Sakon Nakhon	–	–	–	+	+	–	–
	Sri Saket	–	–	+	+	+	–	–
	Surin	–	–	+	+	+	–	–
	Ubon Rajathani	–	–	+	+	+	–	–
South	Chumphon	–	–	+	+	+	–	–
	Krabi	–	–	–	+	+	–	–
	Pattani	–	–	–	–	+	–	–
	Phattalung	–	–	+	+	+	–	–
	Songkhla	–	–	–	+	+	–	–
	Trang	–	–	–	–	+	–	–
	Yala	–	–	+	+	+	–	–

– : No disease, + : disease index, light to moderate, ++ : severe

Table 6. Distribution of maize diseases observed during the dry season, in 1973 to 1974 and in 1974 to 1975

Region	Province	Sorghum downy mildew	Brown stripe downy mildew	Northern leaf blight	Southern leaf blight	Curvularia leaf spot	Rust	Common smut	Bacterial wilt
Central	Singburi	–	–	–	+	+	–	–	–
	Suphanburi	++	+	+	+	+	–	+	+
	Chainat	–	–	–	+	+	–	–	–
	Saraburi	–	–	+	++	++	–	–	+
	Lopburi	–	–	–	–	+	–	–	–
North	Chieng Mai	–	–	–	+	+	–	+	–
	Petchabun	–	–	–	–	+	–	+	–
	Sukhothai	–	–	–	+	+	–	+	–
	Lamphang	–	–	–	+	+	–	–	–
	Nan	–	–	+	–	+	–	–	–
North-east	Nakhonratchasima	+	–	+	+	+	–	–	–

(2) Brown stripe downy mildew

Brown stripe downy mildew of maize was recognized in the central plain, southern part of north Thailand, in Tak, Kamphengphet, Nakhon Sawan and Petchabun provinces, and in the Nakhon Ratchasima province in the north-east (Table 5). The distribution of the disease involves a smaller area than in the case of sorghum downy mildew.

(3) Curvularia leaf spot

As shown in Tables 5 - 6, Curvularia leaf spot of maize was observed in maize fields all over Thailand. Among the diseases, ordinary Curvularia leaf spot is a typical symptom and is very common in every field. The so-called water-soaked Curvularia leaf spot was not seen as frequently as the ordinary spot. The disease was observed all over Thailand except in the southern part of the country. Ordinarily, Curvularia leaf spot is distributed almost uniformly in the field. The diseased plants of so-called water Curvularia leaf spot are irregularly distributed in the field i.e, some plants can be very seriously infected while the neighbouring plant appears completely healthy. Among the *Curvularia* spp. responsible for Curvularia leaf spot, *Curvularia pallescens, C. lunata* var. *aeria* were observed in all the test fields and *C. lunata* was widely recognized in Thailand. *C. clavata* was detected from leaf blight and necrotic lesions of downy mildew of maize in Pathun Thani and Ayuthaya provinces.

(4) Other diseases

Southern leaf blight of maize prevails all over Thailand (Tables 5-6), but the disease is mild in the central plain.

Northern leaf blight of maize can be observed in the cultivated areas of almost every province (Tables 5-6). It was recognized that more than 20 percent of the plants were affected in the northern part of northern Thailand, in north-east Thailand and in the Lopburi and Phechabun provinces of the central plain (Fig. 3).

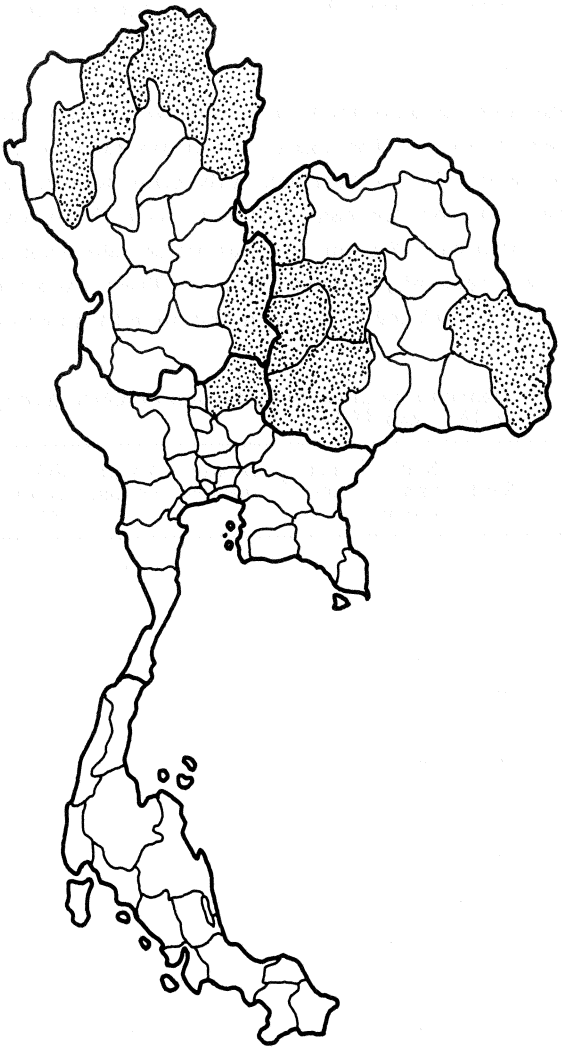


Fig. 3. Distribution map of northern leaf blight of maize confirmed in more than 20 per cent of the diseased plants in Thailand from 1973 to 1975.
(The dotted portion shows the provinces infected with leaf blight)

Common rust caused by *Puccinia polysora* was observed once at Pakchong, Nakhorn Ratchasima, 1973, but thereafter rust was not any longer reported in any fields.

Common smut was recognized all over the country, but the percentage of diseased plants was very low in all of the surveyed areas.

2) Soybean diseases

The results of survey on soybean plants are shown in Tables 7 - 8, and indicate the prevalence of the diseases in the provinces during the period extending from the wet season of 1973 to the dry season of 1975.

(1) Rust

Soybean rust was found in all of the surveyed provinces except Saraburi, Nakhon Ratchasima and Chieng Rai provinces (Fig. 4). The disease was distributed in all of the cultivated areas of the north, north-east and central plain of Thailand. In the main cultivated areas such as Sukhothai and Chieng Mai, there was a tendency for many diseases to occur. When soybean was first cultivated at the Suphanburi Rice Experiment Station, rust was not prevalent but after several cultivations of soybean the disease was frequently observed (Fig. 8). There was a mild outbreak of rust in the experimental field of the Agricultural Experiment Station in the north-east.

Table 7. Distribution of soybean diseases observed during the wet season, in 1973 and 1974

Region	Province	Rust	Bacterial pustule	Leaf spot *	Downy mildew	Anthracnose	Sclerotium rot	Damping off**	Root rot**	Virus (mosaic)
Central	Suphanburi	++	++	+	–	+	–	+	+	+
	Prachuap-kirikhan	–	+	–	–	–	–	–	.	–
	Lopburi	+	+	+	–	–	–	–	.	–
North	Chieng Mai	++	+	+	+	+	–	–	+	+
	Chieng Rai	–	–	–	–	–	–	–	+	–
	Sukhothai	++	++	+	–	+	–	–	+	+
	Khanphang-phet	+	–	+	+	–	–	+	.	+
	Lamphang	+	–	+	–	–	–	–	.	+
	Pechabun	+	+	+	–	–	–	–	.	–
	Phrae	+	+	+	–	–	–	+	.	–
	Utradit	+	+	+	–	–	–	–	.	–
North-east	Kalasin	+	–	–	–	–	–	–	+	+
	Khonkaen	+	+	+	–	+	–	–	.	+
	Loei	+	+	–	+	–	–	–	.	+
	Mahasara-kam	+	+	+	–	–	–	–	.	–
	Roiet	+	+	+	–	–	–	–	.	–
	Sakhon Nakhon	+	+	+	–	–	–	–	.	–

* : Phyllosticta leaf spot and other leaf spot varieties ** : Symptoms

+ : Disease index, light to moderate, ++ : Severe, – : No disease, . : Not checked

Table 8. Distribution of soybean diseases observed during the dry season, from 1973 to 1974 and from 1974 to 1975

Region	Province	Rust	Bacterial pustule	Leaf spot*	Downy mildew	Anthracnose	Sclerotium rot	Damping off**	Root rot**	Virus (mosaic)
Central	Singburi	+	+	+	–	–	+	+	+	–
	Suphanburi	++	+	+	–	+	+	+	+	+
	Chainat	+	–	+	–	+	+	–	+	–
	Saraburi	–	–	+	–	–	–	–	.	–
North	Chieng Mai	+	–	+	+	+	+	+	+	+
	Petchabun	–	–	+	–	–	+	–	.	+
	Phrae	+	–	+	–	–	–	–	.	+
	Lamphang	+	–	+	–	–	+	–	.	+
North-east	Nakhon-ratchasima	–	–	+	–	–	–	–	.	–

* : Phyllosticta leaf spot and other leaf spot varieties
** : Symptoms
+ : Disease index, light to moderate, ++ : Severe, – : No disease, . : Not checked

(2) Bacterial pustule

Bacterial pustule of soybean was observed in 13 out of 20 provinces surveyed. The disease widely prevails in the soybean fields of the north, north-east and central plain regions of the country. In the majority of the cases, bacterial pustule appears on leaves along with soybean rust, and both play an important role in the fall of leaves.

(3) Downy mildew

Outbreaks of downy mildew of soybean are limited to the north and to a part of north-east Thailand, Chieng Mai, Khanphengphet and Loei provinces. At the Suphanburi Rice Experiment Station, Suphanburi, no downy mildew was found throughout the year round cultivation of soybean. Downy mildew is a common disease in northern Thailand, during the wet season. The disease was recongized in plants cultivated in the irrigated fields in Chieng Mai and Petchabun provinces, even during the dry season.

(4) Sclerotium rot

Sclerotium rot of soybean widely prevails in the cultivated fields of Thailand in Singburi, Suphanburi, Chainat, Petchabun, Lamphang and Chieng Mai provinces and the disease became serious in the irrigated fields during the dry season.

(5) Phyllosticta leaf spot, brown leaf spot and frog-eye leaf spot

Leaf spot diseases such as Phyllosticta leaf spot, brown leaf spot and frog-eye leaf spot were observed in all of the provinces. Those diseases were listed as leaf spot in Table 7 - 8. Except for Phyllosticta leaf spot they caused very slight damage to plants at the seedling stage. Phyllosticta leaf spot sometimes seriously infects seedlings of soybean but thereafter the disease causes no problem in plants at the vegetative or flowering stage.

(6) Anthracnose

When the disease occurs on leaves of soybean plants it assumes the appearance of a leaf blight.

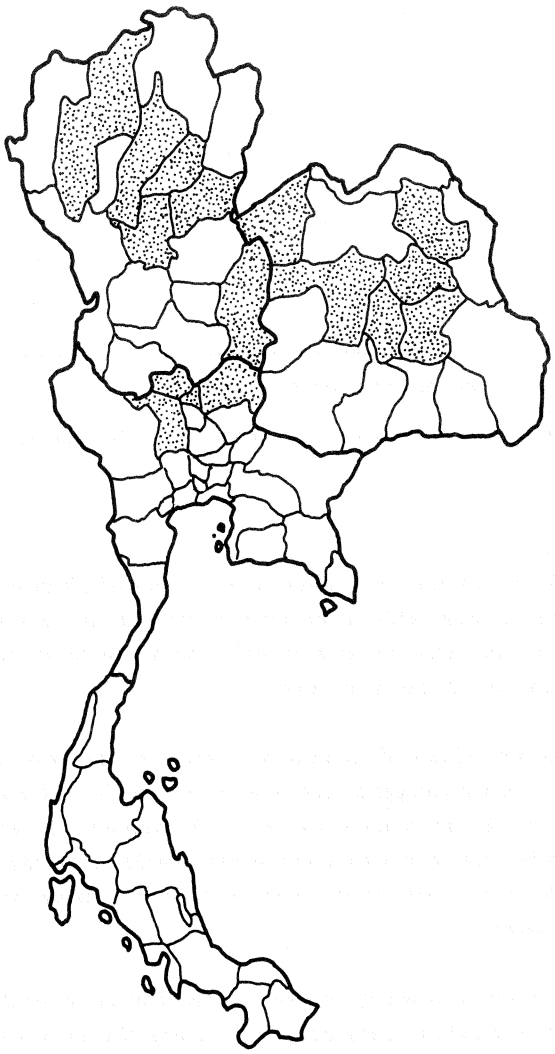


Fig. 4. Distribution map of rust of soybean confirmed in Thailand from 1973 to 1975.
(The dotted portion shows provinces infected with the disease)

Anthracnose was observed on the leaves in Sukhothai, Konkhen and Chieng Mai provinces. Anthracnose of hypocotyl and root was recognized in seedlings of soybean in Chieng Mai, Suphanburi and Chainat provinces (Tables 7 - 8).

(7) Root diseases

Wilt, root rot and/or hypocotyl rot caused by *Fusarium, Rhizoctonia, Macrophomina, Colletotrichum* and *Gliocladium* were observed in soybean plants at the seedling stage in a large number of districts of Thailand all the year round (Tables 7 - 8). These diseases caused slight damage to soybean as compared with others under the present cultivation conditions. Hypocotyl and root rot caused by *Colletotrichum* was detected in Chieng Mai, Chieng Rai and Suphanburi provinces, and Fusarium wilt or root rot was observed in Chieng Mai, Chieng Rai, Chainat, Singburi and Suphanburi provinces respectively. Rhizoctonia root rot was recognized in Chainat and Suphanburi provinces, charcoal root rot was observed in Chieng Mai, Chainat, Singburi and Suphanburi provinces, while root rot caused by *Gliocladium* was found in Chainat province.

3 Seasonal prevalence of maize and soybean diseases

1) Maize diseases

(1) Downy mildew

A comparison was made between the wet and dry season as regards the number of fields infected with downy mildew of maize. The results shown in Table 9 apply to farmers' field, during the period extending from 1973 to 1975. What is evident from Table 9 is the difference in the prevalence of sorghum downy mildew during the wet and dry season i.e. sorghum downy mildew was prevalent during the wet season, and was not observed during the dry season. The prevalence of downy mildew was found in almost all of the observation fields in 1973 to 1974. No outbreaks of downy mildew disease were recognized during the dry season of 1973 to 1974, but the disease was observed in 2 fields during the dry season of 1974 to 1975. One of the fields infected with downy mildew, during the dry season of 1974 to 1975 was located near the experimental field of the Suphanburi Rice Experiment Station where maize is cultivated all the year round. New healthy maize plants were severely infected in spite of the unfavourable conditions present during the dry season. The other diseased field was the one cultivated with sweet corn all the year round in Pakchong, Nakhonratchasima province by means of irrigation. There was no downy mildew in the farmers' field during the dry season, because maize was not cultivated during the dry season except in the special case mentioned above.

Table 9. Number of fields observed for sorghum downy mildew of maize in Thailand from 1973 to 1975

Year	Season	No. of diseased fields/No. of fields observed					Diseased plants (%)
		Whole	Central	North	North-east	South	
1973	Wet	21/40	13/24	5/13	3/3	-	0 - 100
1973-'74	Dry	0/15	0/8	0/6	0/6	-	0
1974	Wet	22/60	7/11	7/21	8/18	0/10	0 - 100
1974-'75	Dry	2/10	1/7	0/2	1/1	-	0 - 20

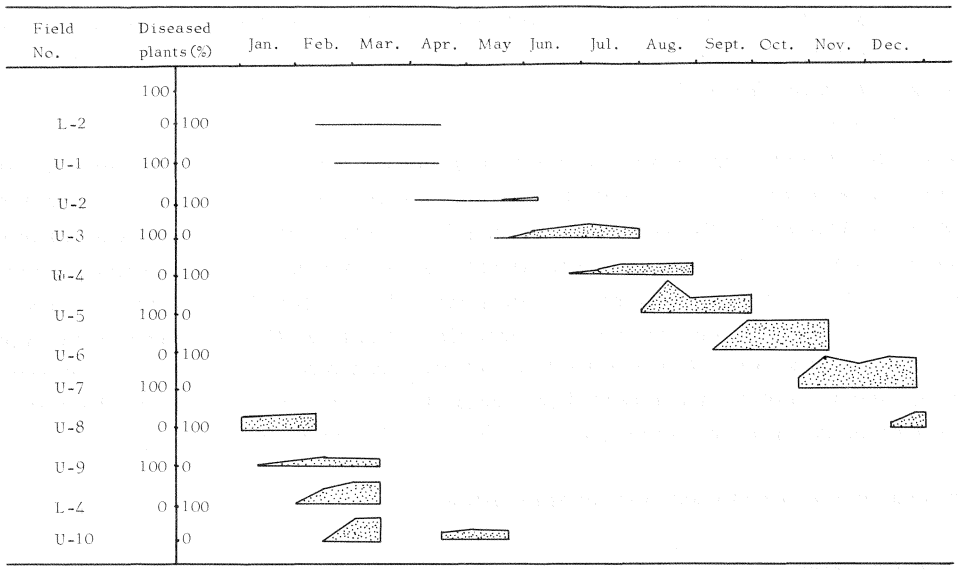


Fig. 5. Seasonal variation of diseased maize plants (maize plot) infected with sorghum downy mildew at the Suphanburi Rice Experiment Station from 1974 to 1975.

The seasonal prevalence of sorghum downy mildew of maize at the Suphanburi Rice Experiment Station where maize was cultivated all the year round is shown in Fig. 5. Downy mildew of maize was found in the lowland 2 plots (L-2), upland 1 and 2 fields (U-1, U-2) until May during the dry season. In the upland 2 fields, sorghum downy mildew of maize was observed in poorly growing maize plants in the maturing stages in early June. The percentage of plants with sorghum downy mildew disease of maize rose to about 30 percent in the upland 3 (U-3) and 4 (U-4) fields as rainfalls increased in frequency.

In the upland field 5 (U-5), the percentage of infection decreased from 90 percent in the middle of August to 40 percent in early September. This was due to the decrease in maize seedlings in the field owing to the disease. During the heavy rainfalls of September, the percentage of plants infected with sorghum downy mildew of maize rose by 90 to 100 percent in the upland 6 (U-6) and 7 (U-7) fields. When the dry season came in December, the percentage of infection with downy mildew of maize decreased by about 30% in the upland 8 field (U-8). During the dry season, the percentage of plants infected with downy mildew of maize in the upland 9 field (U-9) decreased. The infection ratio of sorghum downy mildew, however, rose by 58 and 61 percent in the lowland 4 (L-4) and the upland 10 (U-10) fields in spite of the dry season. This was due to the presence of rainfalls in the middle of January. All of the plants in the upland 10 field (U-10) were removed before the silking stage so as to prevent dissemination of downy mildew to other experimental fields. Thereafter, the percentage of infection of maize which was sown in the same place, decreased by about 26 percent.

As indicated in Fig. 5, sorghum downy mildew disease of maize occurred at the seedling stage, and thereafter, the diseased plants remained at the same level. It thus appears that sorghum downy mildew of maize can be observed even during the dry season if there is a large amount of inoculum in the field.

The seasonal prevalence of sorghum downy mildew of maize in the plants which were cultivated in the interplanting plot with soybean, was similar to that observed in single crop culture of maize. Also, seasonal variation of the disease index of sorghum downy mildew of maize was com-

parable to that of the percentage of diseased plants. Maize of upland 6 (U-6) and 7 fields (U-7), recorded a remarkably high disease index corresponding to the heavy rainfalls which occurred in that year.

Brown stripe downy mildew of maize was very rare in the test field of the Suphanburi Rice Experiment Station for about one year. The disease was recognized in upland 4, 5, 9 and 10 fields (U-4, U-5, U-9, U-10) among 12 maize fields with single crop plots. The disease was observed during the wet season from the end of July till the end of September and during the dry season from the middle of March till the end of May. As regards the seasonal prevalence of brown stripe downy mildew of maize, no distinctive characters were noted, as outbreaks of the disease were not severe. Brown stipe downy mildew of maize was also noted in the interplanting plot with maize and soybean. The prevalence was similar to that of maize in the single crop culture plot.

(2) Curvularia leaf spot

Curvularia leaf spot of maize was seen in all of the surveyed fields in every district of Thailand during the wet season (Table 10). During the dry season, the occurrence of Curvularia leaf spot disease was less frequent than during the wet season in the central plains. Fifty percent and over of the plants were affected in 65 % of the surveyed fields. During the wet season, in 29 % of the surveyed fields, from 11 to 49 % of the plants were affected, and in 7 % of the surveyed fields, less than 10 % and less of the plants were affected (Table 11). During the dry season, in 32 % of the surveyed fields, 50 % and over of the plants were affected, and in 32 % of the surveyed fields, less than 10 % and less of the plants were affected.

Table 10. Comparison of the prevalence of Curvularia leaf spot of maize between the wet and the dry season in Thailand from 1973 to 1975 as regards the number of the diseased fields

Location	Wet season		Dry season	
	No. of diseased fields / No. of observed fields	Ratio	No. of diseased fields / No. of observed fields	Ratio
Central	35 / 35	100 %	11 / 16	69 %
North	34 / 34	100	7 / 7	100
North-east	21 / 21	100	2 / 2	100
South	10 / 10	100	-	-
Whole country	100 / 100	100	20 / 25	80

Table 11. Comparison of the occurrence of Curvularia leaf spot of maize between the wet and the dry season as regards the percentage of diseased plants

Diseased plants (percentage)	Wet season		Dry season	
	Number of fields	Ratio	Number of fields	Ratio
50 % and over	38	65%	6	32 %
49 - 11	17	29	3	16
10 and less	4	7	6	32
0	0	0	4	21
Total	59	100	19	100

The seasonal prevalence of Curvularia leaf spot of maize in the Suphanburi Rice Experiment Station is shown in Fig. 6. It is clear that Curvularia leaf spot appears all the year round. In some cases such as in upland 1 (U-1) and lowland 4 (L-4) fields during the dry season, the outbreak of the disease was less frequent than during the wet season, but in the case of upland 8 (U-8) and 9 (U-9) fields, the disease was as severe as during the wet season. Maize of upland 6 (U-6) and 7 (U-7) fields was affected by Curvularia leaf spot regardless of the season. Also it was thought that maize plants had been infected very severely with sorghum downy mildew. To sum up, it was evident that outbreaks of Curvularia leaf spot disease of maize occurred all the year round all over Thailand, and that these were more severe during the wet season as compared with the dry season.

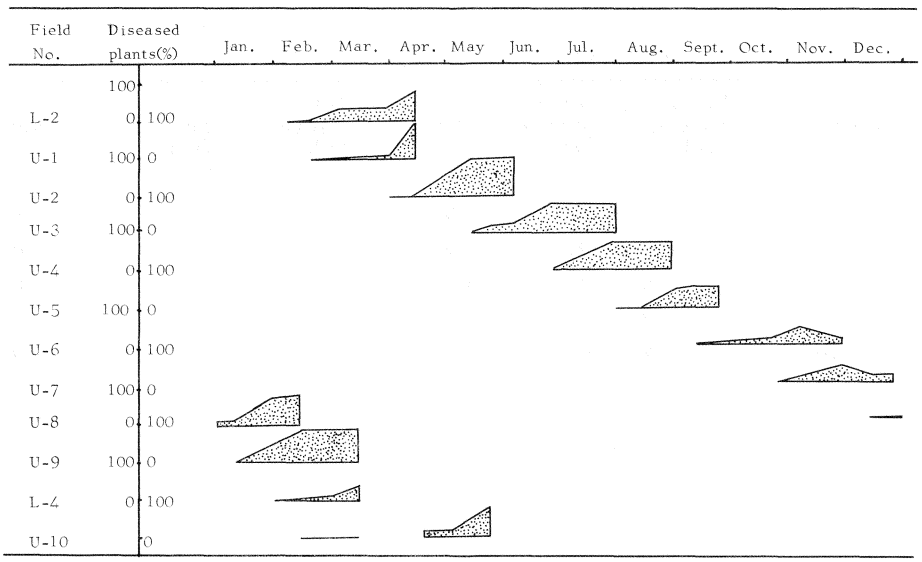


Fig. 6. Seasonal variation of diseased maize (maize plot) infected with Curvularia leaf spot at the Suphanburi Rice Experiment Station from 1974 to 1975.

(3) Southern leaf blight

As seen from Tables 12 and 13, the percentage of southern leaf blight of maize was higher during the wet season than during the dry season. In 14 % of the surveyed fields, 50 % and over of the plants were affected during the wet season. During the dry season, however, in none of the surveyed fields were there 50 % and over of the plants affected by the disease (Table 13). Also, in 5 % of the surveyed fields, no disease was observed during the wet season, but during the dry season, this percentage rose to 45 % (Table 13). At the Suphanburi Rice Experiment Station, occurrence of the disease was limited except for an outbreak observed in upland 8 (U-8) and 9 (U-9) fields (Fig. 7). From the above data, the tendency toward seasonal prevalence could not be established.

Table 12. **Comparison of the prevalence of southern leaf blight of maize between the wet and the dry season in Thailand from 1973 to 1975 as regards the number of the diseased fields**

Location	Wet season			Dry season		
	number of diseased fields	/ number of observed fields	Ratio	number of diseased fields	/ number of observed fields	Ratio
Central	34	/ 35	97 %	6	/ 16	38 %
North	29	/ 34	85	5	/ 7	72
North-east	20	/ 21	95	2	/ 2	100
South	5	/ 10	50	-		-
Whole country	88	/ 100	88	13	/ 25	52

Table 13. **Comparison of the occurrence of southern leaf blight of maize between the wet and the dry season as regards the percentage of diseased plants**

Diseased plants (percentage)	Wet season		Dry season	
	Number of fields	Ratio	Number of fields	Ratio
50 % and over	6	14 %	0	0 %
49 - 11	22	50	3	16
10 and less	14	32	7	39
0	2	5	8	45
Total	44	100	18	100

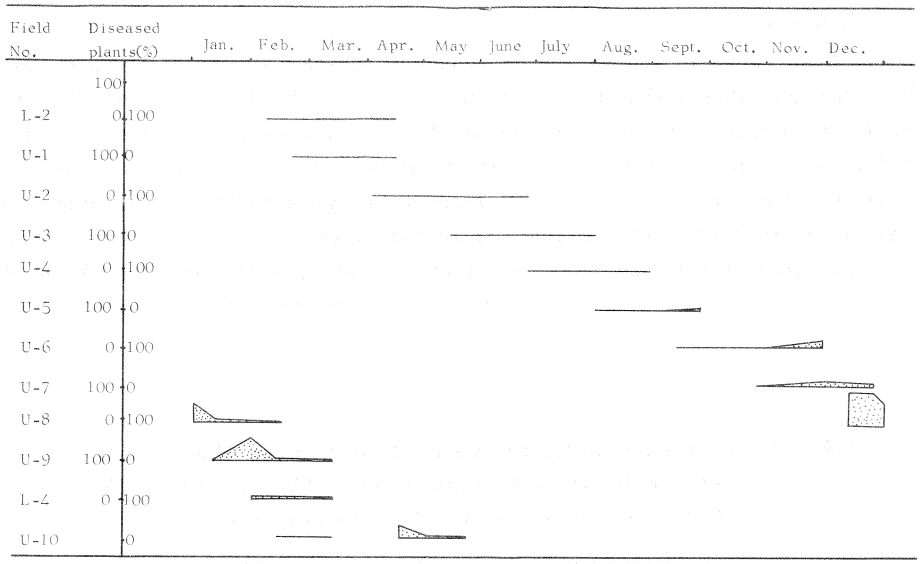


Fig. 7 Seasonal variation of diseased maize plants (maize plot) infected with southern leaf blight at the Suphanburi Rice Experiment Station from 1974 to 1975.

(4) Northern leaf blight

Ninety percent of the surveyed fields in northern Thailand were affected by northern leaf blight and during the wet season, this percentage in Thailand amounted to 64 % on average (Table 14). During the dry season, 29 % of the surveyed fields in northern Thailand were affected while this percentage amounted to 20 % on average for the whole country. Also, fields where 11 to 49 % of the plants were affected by the disease during the wet season represented 55 % of the surveyed fields (Table 15), while during the dry season fields where no infection was found represented 84 % of the surveyed fields. No data for the seasonal prevalence of northern leaf blight were obtained from the test fields of the Suphanburi Rice Experiment Station.

Table 14. Comparison of the prevalence of northern leaf blight of maize between the wet and the dry season in Thailand from 1973 to 1975 as regards the number of diseased fields

Location	Wet season		Dry season	
	No. of diseased fields / No. of observed fields	Ratio	No. of diseased fields / No. of observed fields	Ratio
Central	11 / 27	47 %	2 / 16	13 %
North	26 / 29	90	2 / 7	29
North-east	15 / 20	75	1 / 2	50
South	3 / 10	30	-	-
Whole country	55 / 86	64	5 / 25	20

Table 15. Comparison of the occurrence of northern leaf blight of maize between the wet and the dry season as regards the percentage of diseased plants

Diseased plants (percentage)	Wet season		Dry season	
	Number of fields	Ratio	Number of fields	Ratio
50 % and over	1	2 %	0	0 %
49 - 11	23	55	0	0
10 and less	11	26	3	16
0	7	17	16	84
Total	42	100	19	100

2) Soybean diseases

(1) Rust

The number of diseased fields and the severity of the disease during the wet and the dry season are shown in Table 16. During the wet season, a greater number of fields were infected with soybean rust then during the dry season. Also, the disease was most severe during the wet season than during the dry season. Rust disease was found in almost all of the observed fields and the severity of the disease varied during the wet season. During the dry season, the number of diseased fields per number of surveyed fields exceeded 40 to 50 % and the plants were not severely affected. The prevalence of rust disease during the dry season is worth noticing in the case of severe outbreaks of rust where large-scale cultivation will be made possible through irrigation techniques. Fig. 8 provides a good example of serious prevalence of rust during the dry season.

Soybean plants of upland 8, 9, 10 (U-8, U-9, U-10) and lowland 4 (L-4) fields were seriously infected by rust disease during the dry season. The results of the seasonal prevalence of rust in the experimental field of the Suphanburi Rice Experiment Station where cultivation is practiced all the year round are shown in Fig. 8. It is clearly evident from Fig. 8 that the prevalence of rust was recognized throughout the year. Rust in the first soybean culture at the lowland 2 (L-2) field appeared in small amount at the maturing stage of soybean in contrast with the second cropping plot i.e. upland 1 (U-1) field, where 100 % of the diseased plants were at the maturing stage. Therefore, soybean was very seriously infected by rust with almost 100 % of diseased plants. This trend continued subsequently until the next dry season. Nearly 100 % of soybean plants were infected in

Table 16. Number of fields observed in Thailand from 1973 to 1975 for soybean rust and severity of the disease

Year	Season	Number of diseased fields / Number of fields observed	Intensity of the disease
1973	Wet	4 / 9	Light to severe
1973-'74	Dry	8 / 20	Light
1974	Wet	17 / 17	Light to severe
1974-'75	Dry	2 / 4	Light

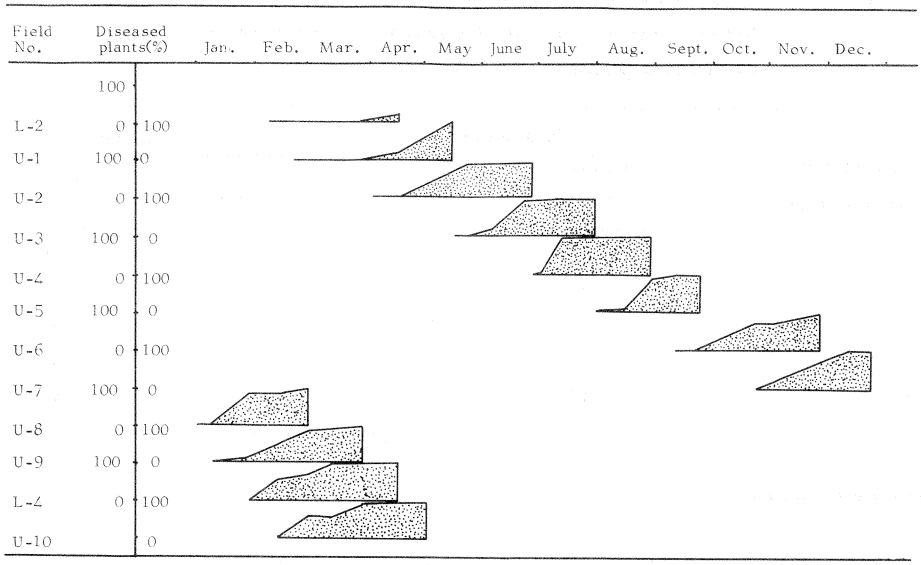


Fig. 8 Seasonal variation of diseased soybean plants (soybean plot) infected with rust at the Suphanburi Rice Experiment Station from 1974 to 1975.

every experimental plot during the wet and the dry season, except for lowland 2 (L-2) plot. Results listed in Fig. 8 indicated that there was a difference in the number and severity of the outbreaks between the experimental field at Suphanburi which was cultivated all the year round and the farmers' fields which were cultivated once or twice a year.

Rust infection in soybean plants was observed in the early stage of growth when there was a large amount of inoculum but in the middle stage of growth outbreaks were not severe. The prevalence of the disease was identical throughout the year as far as the disease index is concerned.

(2) Bacterial pustule

A comparison was made between the wet and the dry season during the period extending from 1973 to 1975, as regards the prevalence of bacterial pustule. As indicated in Table 17, the disease was frequently observed during the wet season in the ordinary fields and the disease index showed light to severe involvement. During the dry season, outbreaks were unfrequent and the disease index showed slight involvement. In the test field of the Suphanburi Rice Experiment Station, however, a high percentage of diseased plants was noted even during the dry season as compared with ordinary farmers' fields (Table 17, Fig. 9). Such findings are similar to those reported in the case of sorghum downy mildew of maize or of soybean rust.

The seasonal variation of the percentage of diseased plants is shown in Fig. 8. The disease was severe in the upland 4 (U-4) and 5 (U-5) fields during the rainy season, while during the dry season, 30 to 50 % of diseased plants were seen in every plot.

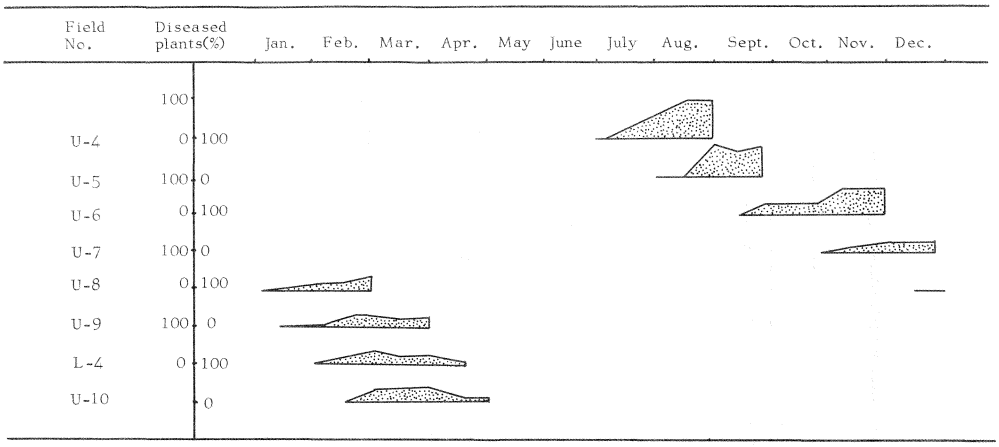


Fig. 9 Seasonal variation of diseased soybean plants (soybean plot) infected with bacterial pustule at the Suphanburi Rice Experiment Station from 1974 to 1975.

Table 17. Comparison of the prevalence of bacterial pustule of soybean between the wet and the dry season in Thailand from 1973 to 1975

Year	Season	Number of diseased fields / Number of fields observed	Intensity of the disease
1973	Wet	2 / 7	Light to severe
1973-'74	Dry	0 / 19	Nil
1974	Wet	15 / 17	Light to severe
1974-'75	Dry	1 / 4	Light

(3) Leaf spot, downy mildew, anthracnose and Sclerotium rot

The prevalence of leaf spot, downy mildew, anthracnose and Sclerotium rot of soybean during the wet and the dry season was investigated in the farmers' fields. Results listed in Table 18 show the number of diseased fields in relation to the number of the observed fields. Leaf spot caused by Phyllosticta showed a high ratio during the wet and the dry seasons. No difference in ratio was recorded for downy mildew and anthracnose of soybean during the two seasons. Sclerotium rot was only observed in fields irrigated during the dry season and no difference in the frequency and intensity of outbreaks of Sclerotium rot was recorded both in the test field of the Suphanburi Rice Experiment Station and in the farmers' fields (Table 18).

Table 19. Seasonal variation of root rot disease of soybean plants (soybean plot) at the Suphanburi Experiment Station from 1974 to 1975

Field No.*	Observation time	Days after seeding	Root rot (%)	Items (%)				
				Fusarium root rot	Anthracnose	Sclerotium rot	Damping off	Other
L - 2	Feb. 8, 1974	16	63.6	+	-	-	1.2	
U - 1	Feb. 21	16	22.7	+	-	-	0	
U - 2	April 2,	15	55.6	+	-	-	0	
U - 3	May 14	12	9.3	+	0.2	-	0.2	
U - 4	June 27	22	88.0	+	-	-	0	
U - 5	July 31	15	20.7	12.1	8.6	0	0.2	
U - 6	Sept. 21	9	29.5	3.8	25.6	0	1.4	
U - 7	Oct. 24	21	100.0	71.6	28.4	0	2.5	
U - 8	Dec. 13	25	89.0	81.5	0	0	6.9	7.5 Rhizoctonia rot
U - 9	Jan. 9, 1975	22	45.6	36.9	2.9	2.9	0	
L - 4	Jan. 30	16	34.5	31.9	0	1.8	0	
U - 10	Feb. 13	13	42.4	34.7	7.6	0.7	0	

L : Lowland, U : Upland.

Table 18. **Comparison of the prevalence of leaf spot, downy mildew, anthracnose and Sclerotium rot of soybean between the wet and the dry season in Thailand from 1973 to 1975**

Diseases	Number of diseased fields / Number of fields observed	
	Wet season	Dry season
Leaf spot*	20 / 23	18 / 23
Downy mildew	2 / 23	3 / 23
Anthracnose	5 / 13	4 / 19
Sclerotium rot	0 / 22	7 / 23

* Includes Phyllosticta leaf spot, brown spot, frog-eye leaf spot and Alternaria leaf spot.

(4) Root rot

Seasonal prevalence of root rot including wilt and hypocotyl rot of soybean, in the soybean plots of the Suphanburi Rice Experiment Station, is shown in Table 19. The disease was observed in 93 to 100 % of the plants and no seasonal pattern was recognized. Occurrence of root rot of soybean in the interplanting plot with soybean and maize was the same as above. Fusarium rot was most frequently observed and affected from 3.8 to 81.5 % of the plants. Moreover there was no seasonal predominance. Anthracnose responsible for root rot or hypocotyl rot was found in about 26 to 28 % of the diseased plants in the upland 6 (U-6) and 7 (U-7) fields, but was not frequently observed in the other plots. Sclerotium rot was only found in the upland 9 field (U-9) since January. This was in agreement with the phenomenon of prevalence mentioned above in Table 18.

Ⅳ. Discussion

Eight species of maize diseases, observed in farmers' fields in Thailand from 1973 to 1975, were recorded in the host list of diseased plants published by Chandrasrikul and Puckdeedindan (1962, '66, '68).

Sorghum downy mildew and brown stripe downy mildew were observed while Phillipines downy mildew, which was reported by Phitakpraiwan et al. (1974) in Thailand, was not found during the survey on maize diseases. However, sporangium of *Sclerospora* which was clearly different in shape and in size from that of *Sclerospora sorghi,* the pathogenic agent of sorghum downy mildew was found in maize leaves infected with sorghum downy mildew. The fungus has an oval, ovate or obpyriform sporangium with an apiculus. Some *Sclerospora* have a sporangium with an apiculus, such as *S. spontanea, S. philippinensis* and *S. sacchari* (Waterhouse 1964). Among them, *S. spontanea* and *S. philippinensis* have an ellipsoidal or cylindrical sporangium. These fungi differ from the fungi concerned in the shape of the sporangium (Waterhouse 1964). According to Miyake (1911) and Waterhouse (1964), the sporangium of *S. sacchari* is elliptical or oblong and the size of the conidia is 25 to 41 by 15 to 23 μm. These results are similar to those reported in the fungi, but precise identification requires more careful investigations. Pupipat et al. (1975) also reported the same facts including several more types of sporangia of *Sclerospora.* Also, *S. sacchari* had been re-

ported in maize in Thailand (Pupipat et al. 1975). Despite the existence of downy mildew of sorghum found in maize in Thailand, sorghum plants are not infected with this organism as reported by Pupipat et al. in 1975. These findings suggest that this organism differs in pathogenicity depending on the nature of the plants in spite of morphologically similar sporangium. Payak (1975) proposed that sorghum downy mildew be divided into two races, the sorghum race and the maize race. And he pointed out that downy mildew in Thailand was related to the maize race.

Pathogenic agent of Curvularia leaf spot of maize was found to be represented by *Curvularia lunata* by Packdeedindan (1966) and *C. pallescens, C. lunata* and *C. lunata* var. *aeria* were isolated from Curvularia leaf spot of maize. Also, *C. clavata* was recognized in northern leaf blight and in necrotic lesion of brown stripe downy mildew. *Curvularia* is a common fungus as secondary or pathogenic agent in the tropical areas. As reported in the book entitled "A compendium of corn diseases", 9 species of *Curvularia* have been identified in maize diseases. *Curvularia* spp. has been isolated in all the cases of typical necrotic lesions and in water-soaked lesions of Curvularia leaf spot. The same species was found in both lesions. The necrotic lesions of Curvularia leaf spot showed a uniform distribution in the diseased plants in the field, but only a few diseased plants showed the lesions of water-soaked Curvularia leaf spot. Disease severity of so-called water-soaked Curvularia leaf spot, however, was more serious as compared with that of common Curvularia leaf spot of maize.

Helminthosporium turcicum, H. hawaiiensis, Curvularia lunata, C. lunata var. *aeria, C. pallescens* and others were isolated from lesions of purple leaf sheath of maize. Purple leaf sheath occurred when saprophytic fungi such as yeasts and *Fusarium* spp. or bacteria developed on pollen and between the stalk and leaf sheath. Therefore, it is necessary to get more precise information on the inoculation test of those fungi when performed on developed maize plants.

The results of the disease survey on sorghum downy mildew of maize from 1973 to 1975 confirmed that the disease was distributed in central, north, and north-east Thailand except for the northernmost part and some of the north-eastern part of the country. These results are in agreement with the reports of Pupipat et al. (1973, '75). Judging from the distribution pattern of infection reported in the United States, it appears that the fungus can adapt to a wide range of weather conditions such as those prevalent in tropical and subtropical zones (Frederikson et al. 1975). Therefore sorghum downy mildew might spread to the whole of Thailand where maize cultivation is being promoted. In the Lopburi province located in the central plain, downy mildew was not observed extensively during the wet season in spite of several outbreaks recorded in neighbouring provinces in 1973, '74. Moreover, infection of downy mildew was limited to seedlings of maize (Chang 1968, Kajiwara 1975). These facts suggest that maize plants may be able to escape from downy mildew if cultivation methods such as selection of healthy seeds, change in the sowing time or thinning of the diseased plants are applied. In the central plain, sorghum downy mildew was recognized in limited fields during the wet season, as also reported by Sriwatanspongse (1975).

Infection of sorghum downy mildew appears to be affected remarkably by several factors such as age of maize, susceptibility, inoculum density, temperature, relative humidity, presence of dew, etc. Shah (1973) reported that the infection was optimum when the inoculum density amounted to 135,000 conidia per ml in a temperature range fluctuating from 18°C to 24°C. Generally, sorghum downy mildew is not severe when it appears during the dry season, except for the experience recorded in the test field of the Suphanburi Rice Experiment Station. If the inoculum is abundant in the field and as cultivation takes place all the year round, downy mildew is likely to affect a large number of plants and will cause serious damage to maize. Tantera (1975) reported that the ratio of infection during the dry season was as high as that during the wet season.

As reported by Yamashita et al. (1961), outbreaks of northern leaf blight are more severe

when the temperature is low as compared with southern leaf blight. Our observations are in agreement with this report.

Soybean rust caused by *Phakopsora pachyrhizi* was the most destructive disease among those affecting soybean. Rust was distributed in all the regions where soybean is cultivated in Thailand, as already pointed out by Sawangwong in 1972. The prevalence of rust has been mainly reported in oriental countries e.g. China (Kurofugi 1919, from Kitani et al. 1960), Japan (Phytopath. Soc. Japan 1975), Thailand (Sawangwong 1972), India (Sydowetal 1906, from Kitani et al. 1960), Indonesia (Oda, 1972) in addition to the West Indies (Hiratsuka 1932, from Kitani et al. 1960). Therefore, studies on rust disease should be carried out more actively and be centered on the ecology of the pathogen and development of control methods through breeding of resistant varieties and chemicals application.

Rust is generally not observed during the dry season, but as in the case of downy mildew of maize, a serious outbreak of rust was noted in irrigated fields of the Suphanburi Rice Experiment Station where cultivation is undertaken all the year round and where the inoculum was abundant.

Two species of pathogenic agents of anthracnose have been reported: *Glomerella glycines* and *Colletotrichum dematium* var. *truncata* (Dickson 1956). In Thailand, however, the latter only was found to infect leaf, hypocotyl and root of soybean.

Sclerotium rot of soybean can be observed under high temperature and high humidity conditions (USDA 1966). The disease was found to affect soybean at the seedling stage more seriously in the irrigated field during the dry season than in the upland field during the wet season.

Root rot disease caused by *Rhizoctonia solani, Colletotrichum dematium* var. *truncata, Fusarium solani* and *Macrophomina phaseolina* and wilt caused by *Fusarium oxysporum* damage soybean plants lightly. However when soybean will be cultivated in the upland fields of some areas of the country, the disease will lead to serious problems.

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