RECENT PROBLEMS AND STUDIES ON DOWNY MILDEW OF MAIZE IN INDONESIA

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In 1967 the area of maize *(Zea mays* L.*)* was approximately 3.3 million hectares (11) in Indonesia while the intensification program on maize in 1975 was approximately 370,000 hectares (1). Downy mildew (DM) of maize in Indonesia was first recorded by Raciborski in 1897. The disease is most prevalent below 900 m altitude (9) and is reported to occur most frequently on heavy soils (5, 9). An overdose of nitrogen increases while potasium decreases susceptibility (2). Late planted, early rainy season maize was found to be more severely damaged by DM. Maize planted after maize or sugarcane was found to be the most highly diseased (3, 6, 9). There are slight differences in susceptibility among varieties (10) and the distribution of DM has increased since 1973 (13). The DM of maize in Java and Madura is incited by *Sclerospora maydis* (Rac.) Butler. The DM fungus of Minahasa (North Celebes) is *Sclerospora philippinensis* Weston (4) while the fungi in other islands including the new area of distribution in Lampung Province, South Sumatra have not yet been determined. This paper summarizes the recent information on studies of the maize DM diseases in Indonesia. Some of the data and results were previously reported in 1972 (7).

The Pathogen

Studies on conidia of *Sclerospora* on maize from Lampung, South Sumatra were conducted by Sudjadi (12). Conidial shape revealed spheric and subspheric forms. The conidial size of the *Sclerospora* species from Lampung is rather different from that of Java. However, further studies in detail are still needed to clarify this taxonomic difference.

Spore population studies were carried out by spore trapping. Conidia were trapped by glass slides placed in open fields not planted to maize at a height of 1.5 m above the soil surface and a distance of 100, 500 and 800 m from the inoculum sources. The data in Fig. 1 indicate that the number of conidia trapped increased when precipitation occurred 2 days before observations were made. It seems that conidial formation is induced by high moisture and humidity.

Evaluation of Fungicides

Studies on evaluation of 0.1% Demosan, 0.2% Dithane M-45 and 0.8% Copper oxychloride were done by foliar application under laboratory condition. Time of application varied from 1-7 days before inoculation. The incidence of maize DM was observed on the maize varieties, Harapan and Bala-bala, which mature in 115 and 90 days, respectively. Seedlings were grown in 30 cm pots and trials were replicated four times. When seedlings were 5 days old, treatment with fungicides were begun at 1 day intervals. Inoculations were made on 12 day-old seedlings and placed under humid conditions for 48 hours. Data on the percentage of plants infected were taken 6 weeks after inoculation.

It appears that application of 0.1% Demosan and 0.2% Dithane M-45 to variety Harapan significantly reduced the incidence of maize DM. On the other hand, time of application with 1 day intervals was not significant (Table 1). Table 2 shows that 0.1% Demosan, 0.2% Dithane M-45 and 0.8% Copper oxychloride significantly reduced the incidence of maize DM on variety Bala-bala but the intervals of application were not significant.

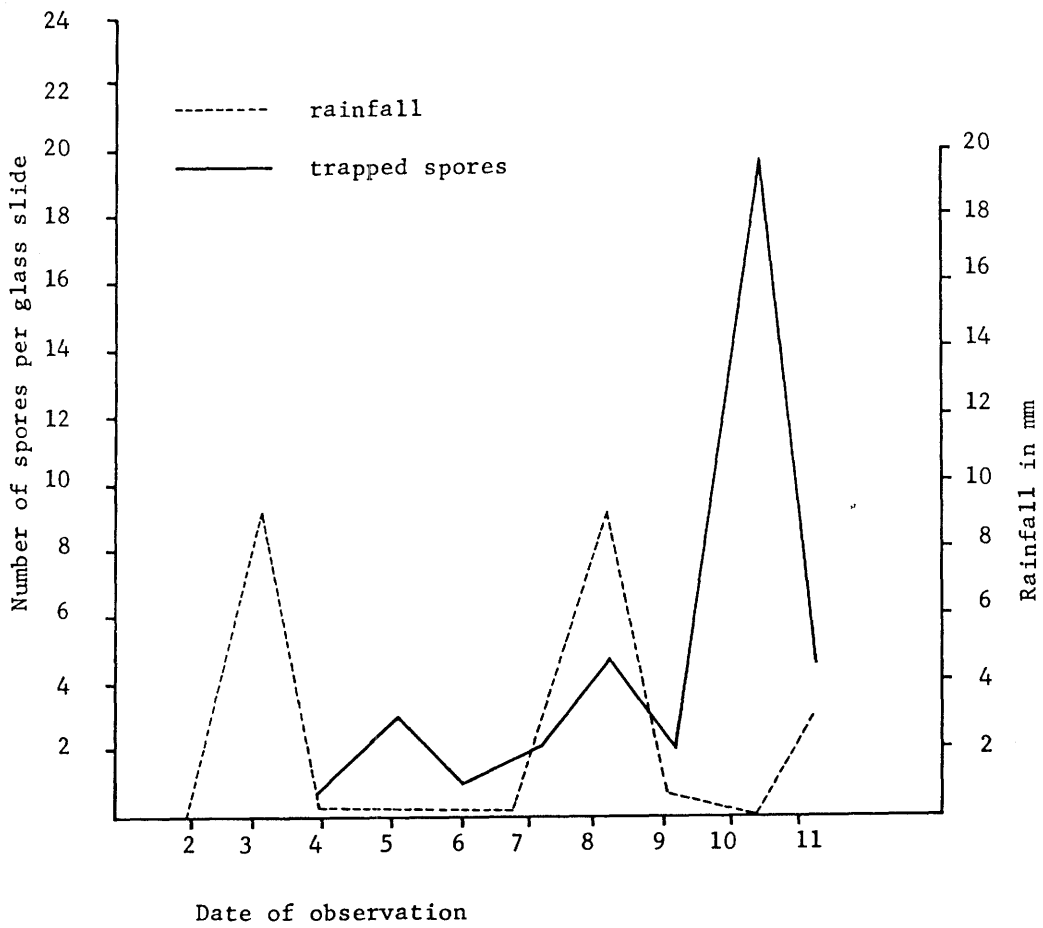

Figure 1: Relationship between number of trapped spores and the rainfall in mm in Lampung, South Sumatra (Source: Sudjadi *et. al.*)

Table 1. Percent downy mildew after application of fungicides on Harapan variety*.

Days after application	Fungicide				Average
	0.1% Demosan	0.2% Dithane M-45	0.8% Copperoxy-chloride	Control	
7	64.6	57.5	65.3	65.0	63.1
6	59.6	54.8	66.3	65.0	61.4
5	62.3	54.8	70.5	66.9	63.6
4	61.3	52.6	64.2	66.6	61.2
3	61.9	57.5	64.6	63.4	61.9
2	58.7	56.4	57.9	64.6	59.4
1	58.2	53.1	57.9	65.0	58.6
Average	60.9	55.2	63.8	65.2	61.3

L.S.D. 0.05 = 3.59 * Transformed data.

Table 2. Percent downy mildew after application of fungicides on Bala-bala variety*.

Days after application	Fungicide				Average
	0.1% Demosan	0.2% Dithane M-45	0.8% Copperoxy-chloride	Control	
7	20.4	50.8	27.4	48.7	36.8
6	21.6	42.0	28.7	48.7	35.2
5	19.2	32.1	24.1	51.1	31.6
4	23.1	28.7	24.1	51.1	31.8
3	21.3	28.1	23.1	52.7	31.3
2	18.9	23.1	23.2	51.1	29.1
1	20.3	23.1	23.4	50.2	29.1
Average	20.7	32.6	24.9	50.5	32.1

L.S.D. 0.05 = 3.59 * Transformed data.

Mechanism of Resistance

Studies on the mechanism of resistance of maize to DM have been made with special reference to describing the relationship between resistance and stomatal density, stomatal opening, guttation water and leaf extract of maize seedlings. Seven maize varieties were planted in pots and the seedlings directly inoculated at the funnel development stage. The seedlings were then covered with glass jars and pieces of diseased leaves were attached to the inner bottom of the jars. Disease recordings were made 30 days after inoculation.

Field observations were made using four rows of each variety. Each row was planted with 40 seeds in 20 hills. The spacing within rows was = 70 cm and 1 meter between rows. After the seedlings reach the funnel stage, one row of diseased plants was planted between each four rows of the test entries. Reading of disease infection was made 30 days after planting of the infection sources. The tests demonstrated that Harapan and Bogor Composite are the most susceptible and Genjah Kodok is the most resistant variety (Table 3).

Stomatal density was observed on the first leaf which has a rounded apex. For the stomatal opening measurement, pieces of first leaves were cut 3:00 AM and fixed directly in absolute alcohol. Genjah Kodok, the most resistant variety, has the smallest number of stomata and the narrowest stomatal opening, but no such correlation was found on the other varieties (Table 4).

Table 3. Reaction of seven maize varieties to Java downy mildew.

Variety	Infection	
	In laboratory	In the field
Harapan	65.0	36.1
Bogor Composite	65.0	36.3
Opaque	45.0	32.1
Popcorn	45.0	24.5
Genjah Kertas	42.5	19.3
Bala-bala	27.5	10.8
Genjah Kodok	22.5	8.8

The influence of guttation water on the germination of conidia was carried out by collecting guttation water during the night using eye pipettes. The solutions were placed on watch glasses used for trapping the conidia which were produced by diseased leaves in glass jars. Spore collections were made at 2:00-4:00 AM and the germination counted at 8:00 AM. The leaf extract was made of 1 gram of fresh leaves and 5 ml of distilled water. The leaves were taken from 7-day-old seedlings. The conidia were

Table 4. Stomatal density and stomatal opening at 3:00 AM of the first leaves of maize seedling.

Variety	Number of stomata per mm^2	Opening of stomata in micron
Harapan	27.0	13.3
Bogor Composite	23.2	16.7
Opaque	29.4	19.3
Popcorn	26.8	16.7
Genjah Kertas	26.2	15.0
Bala-bala	35.4	16.9
Genjah Kodok	20.0	12.6

trapped on the leaf extract in watch glasses at 2:00-4:00 AM and the counting of germinated conidia was carried out at 2:00 PM. A strong correlation was found to exist between the degree of susceptibility of the varieties and stimulation of conidial growth (Table 5). However, the data did not show any inhibitory effect on conidial germination of the guttation water and the leaf extract of the resistant varieties.

Table 5. Germination percentage of conidia of *S. maydis* in guttation water and leaf extract from seven maize varieties.

Variety	Guttation water	In leaf extract
Harapan	85.5	79.7
Bogor Composite	76.3	75.0
Opaque	77.7	75.5
Popcorn	74.8	73.9
Genjah Kertas	71.8	65.7
Bala-bala	63.5	62.3
Genjah Kodok	49.8	52.4
Distilled water	33.8	53.7

Studies of the compounds found in the guttation water and leaf extract were made by thin layer chromatography, using a one dimension system. Solvents for detection of amino acid and sugar were n-butanol, glacial acetic acid and water. Spray solutions for recording amino acid and sugar were ninhydrin and benzidine, while time for heating were 110°C for 10 minutes and 85°C for 30 minutes, respectively. The results are given in Tables 6 and 7.

Table 6. Reaction with ninhydrin reagent.

Constituent	Rf	Spot colour
Guttation water	-	-
Leaf extract	0.149	yellowish red
Alanine	0.163	red purple
Glycocol	0.112	yellowish red
Serine	0.124	red purple

Table 7. Reaction with benzidine reagent.

Constituent	Rf	Spot colour
Guttation water	-	-
Leaf extract	0.600	light brown
Glucose	0.569	brown
Fructose	0.578	light brown

It would appear that the leaf extract contained a sugar, probably glucose or fructose, and an unidentified amino acid. The guttation water did not contain measurable quantities of either. Some additional unidentified factor in both the guttation water and leaf extract appear to stimulate conidial germination.

Our future plans are concerned with the continuing study of taxonomy, epidemiology and spread of DM to new areas, field trials on application of fungicides to describe the economic balance, and screening new varieties of maize to DM.

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