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STUDIES ON DISEASES OF MAIZE I : FOLIAR DISEASES

BY

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A four-year survey on disease situation in maize was made in the Kalimpong hills of West Bengal, which represents average agro-climatic conditions of the North Eastern Hill region of India. The study revealed a number of foliar diseases some of which are new records.

A number of foliar diseases cause considerable loss in yield. A total number of twelve foliar diseases has been recorded during the four years of study. Among the foliar diseases which were found to be most prevalent and causes most damages of leaves are Tarcicum leaf blight caused by *Helminthosporium turcicum* Pass. [=*Setosphaeria turcica* (Luttrell) Leonard and Suggs.]. Phaeosphaeria leaf spot caused by *Phaeosphaeria maydis* (P. henning) Rane, Payak & Renfro, and leaf and sheath blight caused by *Rhizoctonia* zeae *(=Corticium sasakii)*.

INTRODUCTION

Maize (*Zea mays* L.) is an important grain crop in the North Eastern Himalayan hills including Darjeeling district of West Bengal. In this mountainous region upto 1500 meter altitude, it is considered to be a staple crop. Of the total area under this crop in the state of West Bengal approximately fifty per cent is located in Darjeeling district. Sikkim which is adjacent to Darjeeling hills is considered to be one of the centres of origin of this crop in this region (Dhawan, 1964).

Though maize occupies a very important position as food crop in this area, still it is cultivated in a traditional manner in most cases. Local varieties or varieties that have been introduced many years back are still under cultivation. They have low yield potential. Steps are now being taken to increase total production and productivity per hectare by introduction of suitable varieties and adoption of appropriate package of practices.

Hilly tracts in Darjeeling district are characterised by high rainfall, which extends over a period of eight months. The mean annual rainfall varies from 2000 mm to 4000 mm. Though rainfall is well distributed from February to October, it is heavy during the months from May to September and during this period, sometimes there are more than 20 rainy days in each month. Sky remains cloudy from June to early part of September with bright sunshine of only 3 to 4

hours per day and relative humidity remains as high as more than 90 per cent throughout the day. In the maize growing belt in Darjeeling district, the mean daily maximum temperature in the growing season ranges from 23 to 25°C and minimum 17 to 19°C. Hence from ecological point of view, weather conditions may be considered to be coducive to the development of many diseases.

Before steps are taken for introduction of varieties with high yield potential, it is necessary to have detailed information on the disease situation in this area. Ullstrup (1960) made a prelimenary survey in a few areas of this region ; but no systematic survey has yet been made. Hence it was felt necessary to make as far as practicable a detailed study of prevalence and intensity of different diseases over a period of four years on a large number of improved lines or varieties of maize. Major purpose of investigation is to have a clear picture of the disease situation before large scale replacement of present varieties are attempted by potentially high yielding ones and to provide back ground information on the disease potentiality of the lines to the breeders for development of suitable varieties.

MATERIALS AND METHODS

The present investigation was carried out in the Kalimpong Experimental station situated at an altitude of 1,070 meter in the Himalayan Hills in the district of Darjeeling. For observations on disease incidence, plants were grown in four consecutive growing seasons. Randamised Block Design with two replications with average population of twenty plants in each replication was adopted. Usual cultural practices were followed in all experiments. No fungicidal application was made at any stage of growth during the period of study. A total number of 172 germplasms were used for the study.

Methods of rating and observation

Data were recorded for different diseases in different stages of plant growth namely (a) before tasseling of plants, (b) one to two weeks after tasseling (c) a month after tasseling (d) the time of harvest, specially for ear rot studies.

For foliar diseases, scoring was made in the scale of (0-5). In the present study individual plant in each culture was scored for different diseases.

Most of the workers classified relative resistance of plants in six grade : '0' indicating immunity ; 0.5, very light infection ; and 5.0 indicate extreme susceptibiliy. The other three fall between these ratings (Jugenheimer, 1975).

For leaf and sheath blight caused by *Rhizoctonia zeae,* the following rating scale was followed.

Numerical grade	*Degree of infection*
1.0	Infection on leaf sheath. Number of lesions one to few non-coalescent.
2.0	Infection on 2-3 leaf sheath, lesions few and non-coalescent on 3rd sheath.
3.0	Infection not upto ear-shoot but more than two.
4.0	Infection upto ear-shoot but shank not infected.
5.0	Infection present even above ear shoot ; reduced ear size ; husk leaves bleached and caked ; kernel formation poor and rudimentary.

Scoring of other foliar diseases excepting brown stripe downy mildew were recorded in the scale of (0-5) almost the same scale of scoring of *Helminthosporium turcicum* leaf blight where zero score was recorded as immunity. Brown strip downy mildew was recorded as per cent of plant infected.

In case of smuts and stalk rots, data were presented as per cent of plant infected. Scoring of ear rot and cob rot were recorded as the per cent of infected ears.

The different germplasms studied were marked as resistant to highly susceptible graded on the basis of their weighted mean in the following manner.

a) For foliar diseases :

Numerical grade	*Degree of infection*
1	Highly resistant (H. R.)
2	Resistant (R)
3	Moderately susceptible (M. S.)
4	Susceptible (S)
5	Highly susceptible (H. S.)

b) For other diseases which were recorded as percentage basis :

0—2%	Highly resistant (H. R.)
above 2—5%	Resistant (R)
above 5—14%	Moderately susceptible (M. S.)
above 14—20%	Susceptible (S)
above 20%	Highly susceptible (H. S.)

Data were recorded on the diseases as occured under natural field conditions and weighted mean of each replication was taken in each case to present final reaction of the disease on each variety (germplasm).

RESULTS

A total number of twelve foliar diseases were found to occur of which some were found to be serious.

1. Leaf blight caused by *Helminthosporium turcicum* Pass. [=*Setosphaeria turcica* (Luttrell) Leonard and Suggs.]

This leaf blight disease has been found to be the most serious amongst all foliar diseases observed. In India it has been observed to be prevalent in both the Eastern and Western Himalayan areas and adjoing areas where climate during the growing season of the crop is comparatively cooler and more humid.

In course of the study, variations in the intensity of infection were noted from year to year. Among the varieties tested, strictly speaking, no variety were found to be immune to infection, but resistant reactions to varying degrees were noted in a number of varieties. In general three categories of variations were observed among them.

i) Constant reaction ; variations from year to year being comparatively negligible. A large number of varieties showed resistant reaction throughout the years of study.

ii) Comparatively more number of varieties showing higher disease intensity in the years of 1974 ann 1975 when weather conditions appeared to be more favourable for the disease.

iii) A few varieties showing distinctly higher disease intensity in 1975 than noted in 1974.

Low level of leaf blight was observed in 1976 as shown in Table 1. This variation in the intensity of infection might be explained on the basis of weather conditions.

TABLE 1. *Data (summarised) on incidence of leaf blight due to* Helminthosporium turcicum *in the years of study*

Year	Percent of variety affected	Highest disease score of the season	Lowest disease score of the season	Average disease score of the season
1974	100.00	4.05	0.05	1 47
1975	100.00	3.85	0 03	1.48
1976	100.00	4.50	0.01	1 26
1977	100.00	4.00	0 03	1.32

The most critical month for appearance of disease and expression of its severity was found to be July. In 1974, total rainfall recorded in July was 945 mm with 26 rainy days where as in 1975 and 1977 rainfall was 366 mm (in 17 rainy

days) and 717 mm (in 26 rainy days) respectively. In these three years of study higher disease incidence were recorded in the years where rainfall in the month of July was high. Popov (1968) confirmed that high relative humidity. moisture and thick sowing favoured infection. Markov (1969) also reported that several days of rainfall and dew were found to be necessary for mass out break of this disease. Low disease incidence was observed in 1976 when rainfall in July was comparatively less Somewhat lower disease incidence was observed in 1975 season than in 1977 though rainfall in 1975 recorded in July was higher than in 1977. This might be explained due to the appearance of downy mildew disease. In 1975, a higher degree of downy mildew infection was observed in comparison to 1977. In course of observation it was observed that where incidence of downy mildew was high, leaf blight due to *H. turcicum* was of lower intensity, particularly when mildew infection appeared early.

It might be stated that in 1976, downy mildew infections appeared early in the season and infection was widespread (25.49 per cent), highest in the period of study (Table 2).

TABLE 2. *Data (summarised) on incidence of brown stripe downy mildew in the years of study*

Year	Percent of variety affected	Highest disease incidence of the season	Lowest disease incidence of the season	Average disease incidence of the season
1974	15.30	90.00	1.85	3.54
1975	23.07	100.00	10.00	7.72
1976	25.49	90 00	5,00	9.99
1977	16.36	60.00	4.04	2.93

2. Leaf blight caused by *Helminthosporium maydis* Nishikado & Miyaka (*Cochliobolus heterostrophus* Drechsl.)

Appearance of this leaf spot disease was sporadic which might be due to cool and humid weather which does not favour its incidence. However, the disease was observed in the later phases of growth—the later parts of July and August when average maximum temperature was above 24°C and occasionally as high as 26.25°C.

Intensity of infection of the disease was found to vary from year and variety to variety. None of the varieties was found to show susceptible to highly susceptible reaction during the four years of study. From the Table 3, it would be evident that the disease intensity was somewhat higher in 1974, in which year average maximum temperatures in July and August were 26.25°C and 25.82°C respectively, highest in the four years.

Ullstup (1955) also observed the disease to thrive better at somewhat higher temperature than *H. turcicnm*. Nelson (1957) also reported that this disease sometimes become more distructive in the Southern States of U S.A., where high temperature and high humidity prevail.

TABLE 3. *Data (summarised) on the incidence of different foliar diseases of maize in the years of study*

Year	Name of the disease	Percent of variety affected	Highest disease score of the season	Lowest disease score of the season	Average disease score of the season
1974	Leaf blight	100.00	4.05	0.05	1.47
1975	caused by	100.00	3.85	0.03	1.48
1976	*Helminthosporium*	100.00	4.50	0.01	1.26
1977	*turcium*	100.00	4.00	0.03	1.32
	Average	100.00	4.10	0.03	1.38
1974	Leaf dlight caused	34.69	1.00	0.10	0.130
1975	by *Helminthosporium*	24.61	2.00	0.05	0.081
1976	*maydis*	20.90	2.00	0.05	0.065
1977		6.36	0.25	0.05	0.007
	Average	21.64	1.31	0.06	0.070
1974	Physoderma brown	54.08	1.40	0.09	0.20
1975	spot	46.92	1.25	0.05	0.15
1976		34.64	1.00	0.06	0.10
1977		25.45	1.00	0.02	0.06
	Average	40.27	1.16	0.06	0.13
1974	Diplodia leaf spot	54.08	1.42	0.02	0.19
1975		40.76	2.70	0.05	0.17
1976		35.52	2.00	0.02	0.09
1977		40.00	2.50	0.01	0.13
	Average	42.59	2.16	0.03	0.15
1974	Phaeosphaeria leaf	67.34	2.00	0.10	0.46
1975	sort	59.23	3.50	0.10	0.44
1976		60.78	3.90	0.10	0.57
1977		62.72	3.50	0.07	0.45
	Average	62.52	3.23	0.09	0.48
1974	Leaf and sheath	31.63	2.50	0 15	0.32
1975	blight	47.69	4.50	0.22	0.88
1976		47.71	4.10	0.20	0.86
1977		52.72	3.66	0.15	0.76
	Average	44.94	3.69	0.18	0.71
1974	Common rust	65.30	2.05	0.02	0,38
1975		58.46	2.00	0.10	0.31
1976		46.40	3.00	0.02	0.31
1977		66.36	2.00	0.10	0.54
	Average	59.13	2.26	0.06	0,39

3. Physoderma brown spot caused by *Physoderma maydis* Miyabe

This disease has been found to be of major importance on maize in warm humid regions. High temperature and abundant moisture are pre-requisites for proper development of this disease (Jugenheimer, 1975). In the Kalimpong hills though abundant molsture is available during the growing season due to high rainfall. temperature never becomes congenial for this disease. Consequently in these areas the disease was not found to be widespraed or severe. Sporadic infection was however, observed when the crop attained full vegetative growth. It was commonly observed late in the season—the later part of July and August when when temperature tended to become high. Highest incidence of the disease was recorded in 1974 in which year total rainfall in July and August and also average maximum temperature in both the months (July and August) reached 26.25 and 25.82°C respectively—the highest in the four years of study (Table 3).

Lal and Chakravorty (1975) also reported severity of disease to be greatest in highest rainfall areas and disease development was favoured by a temperature range of 20-30°C.

Burns and Shurtleff (1973) are of opinion that disease incidence is favoured by warm and wet spring weather.

4. Diplodia leaf spot caused by *Diplodia macrospora* Earle.

Diplodia leaf spot caused by *Diplodia macrospora* was observed to be widely distributed in the Kalimpong hills. In India the disease has been reported by Ullstrup (1960) from Sikkim and Kalimpong hills in West Bengal. Appearance of this disease has not been reported elsewhere in India. Leaf sheath infection was also observed in a number of varieties namely DH 401, Uruguay 667, 11049, variety No. 5. The per cent of varieties affected ranged from 35 52 to 54.08 in the four years of study, but infection never attained the magnitude as noticed in case of leaf blight caused by *Helminthosporium trucicum*.

Though intensity of infection were more or less uniform, a slightly higher degree of infection was observed in 1974 probably due to comparatively higher temperature and precipitation in the months of July and August. Infection was found to be much less in early sown crop than in the late sown ones.

5. *Phaeosphaeria* leaf spot caused by *Phaeosphaeria maydis* (P. hebnings) Rane, Payak, Renfro.

This disease was reported by Rane, Payak and Renfro (1966) from the Eastern Himalayan region, High rainfall seemed to favour incidence of this disease. As this disease is rather new to India and confined to a very limited areas in the Himalayas and it's foothills, a detailed description of the disease as noticed in the field is considered to be very essential for identifying the disease.

Initially the spots were pale-green to chlorotic and later became bleached and dried up and surrounded by brownish margin. Spots were elongated, round to

oblong, scattered over the leaf blade measuring 2-15 mm in diameter. At later stage they coalesced and became irregular in shape (Fig. 1).

Fig. 1 : Phaeosphaeria leaf spot caused by *Phaeosphaeria maydis*

Numerous gregarious and brown coloured perethecia of the fungus were found on the older spots on upper leaf surface. Infection was found to be established first on the older middle leaves. The disease was not observed in the earlier stages of plant growth. Generally infection was found to start at least 2 3 weeks after silking and progressed till the leaves remined green. Leaves of the seriously infected plants quickly dried up. This disease would be more serious than *H. turcicum* leaf spot it would appear in the earlier stages of plant growth,

or in very late planted crops. A large number of varieties ranging from 59.23 to 67.34 per cent were found to be affected during the period of study. A higher disease intensity of 0.57 (average scora) was observed in 1976, where rainfall in August was recorded as 770.00mm, being highest in four years. This indicated that disease might be favoured by high rainfall, apart from other conditions. Jugenheimer (1975) was also of the opinion that the disease was favoured by high rainfall.

6. Leaf and sheath blight caused by *Rhizoctonia zeae* Voorhes.

This disease was reported to occur in abundance in areas with high rainfall and moderate temperature (24-28°C). In the Himalayan hills this disease was found to be prevalent every year with some degree of severity though the intensity of infection varied from year to year.

Infection generally started from the early phases of plant growth if sufficient rainfall was available Disease appeared when the plants were 3-4 weeks old. At seedling stage, infection generally appeared on lowermost leafsheaths almost at soil level. It progressed upwards through the leafsheath, both to the leaf as well as to the leafsheath. In case of severe attack, infection proceeded upto the tassel. In such cases, all the leaves drooped down exposing the bar stem. Whitish mycelial growth as well as sclerotia were observed in the infected areas. Sclerotia were abundant, generally round, flat bottom, elongated to irregular, 2-6mm in length, tan to deep chocolate in colour when mature. Im-mature sclerotia were however whitish in colour. They were present, on leaf-sheath, in between the leaf-sheath, even on leaf.

Incidence of the disease was comparatively low in 1974, where rainfall in the earlier phase of plant growth was comparatively less. In other years of study the disease intensity was high because of higher rainfall in the early phases of plant growth. Higher rainfall in the earlier phases of plant growth (May and June) was considered to be favourable for the appearance of the disease.

Number of varieties affected ranged from 31.63 to 52.72 per cent with high degree of disease intensity in some cases.

Downy mildews :

Six downy mildews pathogens have been reported on maize in India by different workers of which three cause extensive damage in different maize growing areas of India These are *Sclerophthora sorghi*, *Sclerospora philippinensis* and *Sclerophthora rayssiae* var. *zeae*. Of these *Sclerophthora rayssise* var *zeae* was found to be more prevalent in the Kalimpong hills.

7. Brown stripe downy mildews caused by *Sclerophthora rayssiae* var. *zeae*. Payak, Renfro.

Infection was observed to take place from seedling stage and older leaves were found to be more vulnerable to infection than young developlng ones. No malformation or deformation of any vegetative or floral parts was noticed during the four years of study. The most characteristics feature in infection of *Sclerop-thora rayssiae* var. *zeae* was the formation of narrow, linear, chlorotic yellowish or purplish parallel stripes in the intravenal regions extending from the base to the tip. Stripes were found to attain a length of about 5-15 cm or more and were observed to coalesce with one another covering the whole leaf blade which might become straw coloured. In case of severe infection, leaves presented a burnt or withered appearance, but stredding of laaves did not take place. Though sporangia could develop on both the leaf surface, they were more on the lower surfaces as whitish growth.

This disease was observed to occur in all the years under study. Per cent of varieties affected ranged from 15.30 to 25.49 with an average of 20 per cent. Temperature and rainfall towards the later stages of plant growth appeared to influence the development of the disease. Temperature which tended to be comparatively higher towards the later stages of growth, in July and August, and high rainfall in these months were observed to favour infection.

8. Common Rust Caused by *Puccinia sorghi* Schw.

Chattopadhyay and Sengupta (1955) first reported the occurrence of *Puccinia sorghi* in West Bengal from Kalimpong.

Common rust was found to be wldely prevalent in the Eastern Himalayan hills including Kalimpong hills of West Bengal but level of infection was found to be moderate. Moderate temperature and high relative humidity favour the deve-lopment of this pathogen on susceptible host (Jugenheimer, 1975). Both these conditions are present in the Eastern Himalayan hills. From the Table 3 it would be evident that a large number of varieties were affected, ranging from 46.40 to 66 36 per cent with an average disease score of 0.39 only. The disease was observed to appear usually in the middle of June and onwards. Intensity of infection progressively increased after silking. A considerable degree of variation in disease intensity was noticed amongst the varieties. One interesting feature was that in case of severe rust infection, other foliar diseases particularly leaf blights incited by *Helminthosporium turcicum, H. maydis* and others were much less.

9. Leaf spot : *Didymella exitialis* (Mor.) Muller.

This leaf spot disease which has been reported to be present in Sikkim, was observed at Kalimpong. This disease is of minor importance. Only a few variaties namely Thai DMR comp. 1, Quintal Amarillo Baja, Phil 1-5 (Garift comp.) (M-3) C^8 (F^8), CC 2638, were ovserved to be affected by this disease.

10. Leaf spot caused by *Pithomyces maydicus* (Sacc.) Ellis

This disease has been reported by Das and Chaudhuri (1976) for the first time in India from Kalimpong hills of West Bengal. The disease causes minor leaf injury and affected only a few varieties.

11. Common smut caused by *Ustilago maydis* (DC.) Cda.=*(U. zeae)*.

In the Eastern Himalayan region, common smut is widely prevalent. Infection might be noticed from the early stages of plant growth of about one month old seedling till maturity. At seedling stage smut galls were found to be formed on leafsheath, and auxilary buds of the nodes. In mature plants galls would be noticed on any aerial part of the plant including leaves. They were also found to be on tassel-break. Only a few varieties (ranging from 8.16 to 14.37 per cent) were found to be effected. A slightly higher level of disease incidence was observed in 1976 season where more tassel-break infections were recorded in mature plants.

12. Head smut caused by *Sphacelotheca railiana* (Knehn.) Clint.

During the four years of study, only a few varieties namely Early DMR-2, Sadaf, Hybrid-187, and Puerto Rico Gr. I were found to be affected. Tassel infection were found to be more common than ear infection. This might be first report of its occurence in West Bengal.

DISCUSSION

From the persual of the data presented, it is evident that a number of leaf disease were found to cause major threat to maize in Kalimpong in the Himalayan hills which may be considered to be representative of the average agro-climatic conditions in North Eastern Himalayan region. Leaf blight incited by *Helminthosporium turcicum* appeared to be most important of all the foliar diseases. Weather conditions during the period of growth of the crop appeared to be congenial for this disease which made its appearance early and progressively increases in intensity. Naturally it is likely to cause extensive damage. None of the varieties were found to be immune.

On the other hand Phaeosphaeria leaf spot which makes its appearance quite late in the season, about 2—3 weeks after silking might cause much damage if it would appear early. Though 62.52 per cent of variety with an average disease score of 0.48 were recorded, during the four years of study, damage of the leaf was less extensive than Turcicum leaf blight due to the slow progress and late appearance of the disease.

Rust incited by *Puccinia sorghi* is of common occurence no doubt, but its intensity of attack is moderate. It did not appear to cause any serious problem, particularly in promising varieties or lines. The same is also true in case of Physoderma brown spot and Diplodia leaf spot.

Leaf and sheath blight which appearance in quite early even at seedling stage might cause much damage if weather condition is congenial for the development of the disease. From the observation it is evident that abundant rainfall in the early phase of plant growth favours infection and cause much damage of leaves. Infection may reach upto the tassel of the plant resulting total loss in yield.

Downy mildew and smuts as a whole were not noted to cause much damage. For downy mildew temperature was comparatively low to cause extensive damage. Smut is generally favoured by dry condition which is abscent in the Kalimpong hills.

It was interesting to note that where downy mildew was observed to appear early, leaf blight due to *Helminthosporium turcicum* was comparatively mild and less extensive. A somewhat similar situation was observed in respect of Southern Corn leaf blight in U. S. A. where male sterile rust resistant cultivars were found to be susceptible to leaf blight due to *Helminthosporium maydis*. This aspect needs further study, as different factors for resistance might be involved in these two cases.

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