1. DOWNY MILDEWS OF MAIZE IN INDIA

M. M. PAYAK*

Areawise, India is the fifth largest maize growing country in the world, while on production basis it slide down to the tenth rank. In the Asian region it is next to China accounting for 37%of area and 34% of production (Anon., 1973a). Within India, maize ranks fifth (both in area and production) after rice, wheat, sorghum and pearl millet.

In the entire Himalayan Region as well as in certain districts of Bihar, Gujarat, Madhya Pradesh and Rajasthan maize constitutes a major source of sustenance. In some states such as Karnataka and Tamil Nadu where it was introduced in the sixties, it is competing with well established crops like *ragi* (*Eleusine Coracana*) and sugarcane.

Though 90% of the produce in the country goes for human consumption, in recent years a trend toward diversified utilization notably in pharmaceutical, confectionery, poultry and starch industries, is discernible.

Grain production amounted to 7.4 million tonnes in 1970–71 from an area of 5.6 million hectares. Since then there has occurred a noticeable decline in production but the prospects for the current 1974 season look bright because the market prices are ruling at a high level.

Maize in India is subject to attack not only by downy mildews but also by leaf and sheath blights, stalk rots, rust and smuts as well as ear rots which altogether add up to about 35. Payak and Renfro (1973) have conservatively estimated the national annual loss in grain output, ascribable to diseases, to be 3,706,450 quintals.

The crop is attacked by three species of Sclerospora: *S. philippinensis*, *S. sacchari* and *S. andropogonis-sorghi* and one of *Sclerophthora*: *S. rayssiae* var. *zeae*. The occurrence of Crazy Top (*S. macrospora*), as reported by Singh *et al.* (1966) requires confirmation. In many parts of India infection with Head Smut (*Sphacelotheca reiliana*) leads to deformation especially of tassel and stimulates production of leafy structures on the latter which easily gets confounded with crazy top. The figures of oospores in the report of Singh *et al.* (1966) bear a striking resemblance to pollen grains of maize.

Philippine Downy Mildew (*Sclerospora philippinensis*):

The first record of a downy mildew on maize in India was made by Butler (1913). This is the disease, the causal fungus of which was to be described eight years later by Weston (1920) as *S. philippinensis* from the Philippines. However, the pathogen is erroneously referred to as *S. maydis* (Rac.) Butl. or as *S. indica* Butl. (Ananthanarayan, 1963). Morphologically, the fungus found in India bears no resemblance to the true Java Downy Mildew of Indonesia the correct citation of which is *S. maydis* (Rac.) Palm. The latter pathogen so far has not been found in India.

The disease occurs in Bihar, Punjab and the Union Territory of Delhi (Fig. 1) where foliar and stalk rot diseases are also common. Accordingly, it is difficult to assess the loss that this pathogen may be causing by itself. While in the Philippines the losses may be 40–60% and occasionally even 100%, under Indian conditions also these

* Maize Pathologist (Associate Project Coordinator), Indian Agricultural Research Institute, New Delhi-110012, India

may be as much as 60%.

In Delhi, *Saccharum spontaneum* (*Kans* in vernacular) has been demonstrated as a collateral host of this downy mildew (Chona and Suryanarayana, 1955). The disease first appears on the grass and in maize fields adjacent to the grass its incidence may be upto 5% or it may be even 50%.

Gattani (1950) has claimed that 5:5:50 strength Bordeaux mixture spray eliminated "secondary spread" though severely affected plants did not recover. It may be noted that maize foliage is "copper shy" and use of fungicides having high copper concentration leads to phytotoxicity.

In the late sixties, outbreaks of this disease occurred at Ludhiana (Punjab) where it has continued to appear in moderate to high intensities.

Since 1970, the International Downy Mildew Nursery organised by the I.A.C.P. is being planted at Ludhiana every year. Disease ratings of the entries have been carried out on the basis of natural infection. As reported earlier (Payak, 1973), Tainan composite 10 and Philippine DMR 5 have consistently shown zero disease rating for three successive years indicating that they possess a high degree of resistance. A wide range of resistant maize germ plasm is available for use in any breeding programme.

Sugarcane Downy Mildew (*Sclerospora sacchari*) :

The first report of occurrence of this downy mildew was made by Subramanian (1931) from Pusa, Bihar on sugarcane. In 1967, it was recorded on maize by Singh (1968) in an area where sugarcane is planted widely (Tarai area of Uttar Pradesh) and yet natural infection on the latter host has not been observed so far. The occurrence of oosporic stage was reported by both Singh (1968) and Singh and Chaube (1968).

The disease damage has been noted to be severe in the Tarai area of Uttar Pradesh (Nainital district). Its incidence is especially high in July-planted crop; it may be 30% or more in hybrids such as Ganga 5 and Hi-starch and as much as 64.2% in composites such as C_2 (Anon., 1973b).

Since 1969 germ plasm evaluation has been carried out on an extensive scale under conditions of artificial inoculation and entries showing resistance have been enumerated (Payak, 1973).

Sorghum Downy Mildew (*Sclerospora andropogonis-sorghi*) :

The disease on sorghum has been known since 1913 but on maize, as far as the records go, it first broke out in epidemic proportions in 1968.

Elsewhere I have portulated the existence of two pathotypes—a sorghum race and a maize race. What is prevalent in Rajasthan possibly belongs to the latter which, in absence of oospores, might be perennating on some grass. Dange *et al.* (1973) have reported that this possibly occurs on *Heteropogon contortus*. The form prevalent in peninsular and southern parts of India may belong to the sorghum race.

Among Sclerosporas on maize in India this species is the most damaging type. Although losses in production for Rajasthan are not computable accurately because of occurrence of other diseases, in the states of Karnataka and Tamil Nadu damage to the crop can be ascribed mainly to this downy mildew through rust (*Puccinia sorghi*) and leaf blight (*Helminthosporium turcicum*) also occur.

In Karnataka, the area under maize, on the basis of 1971–72 data, has been estimated to be 80,300 hectares production from which amounted to 308,400 metric tonnes of grain. This area principally lies in the districts of Bangalore, Kolar, Tumkur, Mysore, Dharwar and Belgaum. The disease incidence may range from 30–70% in Ganga 5 which is the hybrid principally grown in the State. On the basis that almost all infected plants fail to produce very little or no grain, the loss would be 30% taking the lowest value of the incidence range for the purpose of computation. The loss would amount to 92,520 metric tonnes for the state of Karnataka.

In Tamil Nadu, almost all the maize area is concentrated in the district of Coimbatore which has been estimated to be 13,900 hectares for 1971–72. Production in the same period was 15,300 metric tonnes. The range of downy mildew incidence is similar to that obtaining in Karnataka. Estimates of loss on a similar basis lead to a figure of 4,590 metric tonnes.

In Rajasthan, as pointed out earlier, the occurrence of other diseases complicates the situation. The estimates are being provided with some reserve because they may be somewhat off the mark. The principal maize growing districts (over 50,000 hectares in each) are Udaipur, Bhilwara, Chittorgarh, Banswara, Dungarpur and Ajmer. The downy mildew has been found to be prevalent in Udaipur, Banswara and Chittorgarh. The total area under maize in these three districts comes to 340,326 hectares for the year 1970–71. The average yield for Rajasthan has been computed to be 1226 kg/hectare for the same year. Production in these districts approximated to 418,390 tonnes. The overall average incidence of the disease might be taken at 1–5%. The reduction in

grain would amount to 4,183 metric tonnes if the incidence were to be only 1%. The total loss in grain production in all the three states adds upto 101,293 metric tonnes. The ruling market prices are higher than Rs. 1000 per tonne although the official price is pegged around Rs. 700 per tonne. The monetary loss thus works out to Rs. 70,905,100 per annum.

During 1973, two Philippine varieties Ph DMR 1 and Ph DMR 5 have shown absolute resistance (10% disease in 3 tests) in Karnataka as well as in Tamil Nadu. These and a few other populations received from Thailand have been combined to form a composite. Double top cross hybrids using Ph DMR 1 and Ph DMR 5 have also been produced which are under yield test in the current 1974 season. By this year end it is hoped resistant materials for release to the farmers in these states especially would become available.

Brown Stripe Downy Mildew (*Sclerophthora rayssiae* var. *zeae*) :

This disease occurs in 13 out of 20 states of the Indian Union in which maize is grown (Fig. 2). Its severity has been observed to be high in Uttar Pradesh, Himachal Pradesh, Southern Rajasthan and adjacent parts of Madhya Pradesh and hilly areas of West Bengal. Disease damage is especially widespread in the Himalayan foot hills in several states extending upto an altitude of 1500 metres.

Widespread epidemics occurred in the mid-sixties in the Tarai area of Uttar Pradesh. One of the probable reasons was the cultivation of susceptible hybrid Ganga 3. The hybrid's susceptibility was traced to the parental inbred line CM 110 extracted out of a Punjab variety. In general, local open-pollinated varieties, *Basi, Sathi, KT 41,* etc. are highly susceptible and so also is the hybrid VL-54.

The losses that the disease may inflict on a crop in a given area varies in a complex way. Since the disease is soil-borne, the lowermost leaves are the first to be affected—a situation akin to *Helminthosporium turcicum* leaf blight. The increase in loss perhaps occurs in a graduated way, so to speak, parallel with the stepwise rise in disease intensity. In general, if 3/4th or more area of the foliage is affected prior to flowering, than the loss may be total that is ear formation is suppressed altogether or markedly attenuated. Grain yield reductions may vary from 20–90%. Losses above 70% may occur only in highly susceptible cultivars grown in conditions favourable for the disease.

Experiments carried out at Pantnagar (Anon., 1973) have provided interesting results. Two susceptible entries—Rudrapur local and VL-54 were in one case inoculated and in the other protected with Dithane M-45. The disease intensity was graded on 0 (no disease) to 5 (maximum disease) scale. In Rudrapur local the treatment "inoculated" yielded 23% less than the protected one while in VL-54 in spite of a higher disease score the loss in unprotected treatment was only 17%. To assess the loss on a national basis thus requires precise data of a varied kind.

In a broad way it has been observed that disease severity may be heavy in areas receiving an average of 100–200 cm of rainfall, moderate in areas with 60–100 cm of annual rainfall and light in areas where it ranges from 40–60 cm (Payak and Renfro, 1970). A quotation from our paper (Payak and Renfro, 1973) appears appropriate to conclude this presentation: "In the Tarai region of Uttar Pradesh maize cultivation had received a set back because of epiphytotics of Brown Stripe Downy Mildew in the mid-sixties. While the disease does appear there even now, the picture is not bleak or desperate. Disease damage has been prevented to a significant extent. Monetarily, its extent is computable in at least a few crores of rupees".

Bibliography

Ananthanarayana, S. (1963). The genus *Sclerospora* in India. *Mycopath. mycol. appl.* **20**: 315–327.

Anonymous (1973a). *Maize* (Report of Study Team of National Commission on Agriculture), New Delhi, 117 pp.

Anonymous (1973b). Research on Diseases of Maize. Annual Rept. 54 pp. *G. B. Pant Univ. Agric. & Tech.*

Butler, E. J. (1913). The downy mildew of maize, *Sclerospora maydis* (Rac.) Butl. *Mem. Dept. Agric. Bot. Ser.* **5**: 275–280.

Chona, B. L. and D. Suryanarayana (1955). The occurrence of *Sclerospora philippinensis* Weston on *Kans* (*Saccharum spontaneum* L.) in India. *Indian Phytopath.* 8: 209–210.

Dange, S. R. S., K. L. Jain, B. S. Sirdhana and R. S. Rathore (1973). *Heteropogon contortus* as a collateral host of sorghum downy mildew (*Sclerospora sorghi*) of maize in Rajasthan. *Curr. Sci.* **42**: 834.

Gattani, M. L. (1950). Control of secondary infection of downy mildew of maize. *Curr. Sci.* **19**: 90.

Payak, M. M. (1973). Progress in the control of downy mildew diseases of maize: An inventory of resistant sources. *Proc. 9th IACP Works.*, 65–68, Kuala Lumpur.

Payak, M. M. and B. L. Renfro (1970). The biology, distribution and differential re-

sponse of maize to *Sclerophthora rayssiae* var. *zeae* in *Plant Disease Problems*. 383–387. *Indian* Phytopath. Soc., New Delhi.

Payak, M. M. and B. L. Renfro (1973). A decade of research on maize diseases—impact on production and its international cooperative outreach in *Current Trends in Plant Pathology* pp. 166–170.

Singh, J. P. (1968). *Sclerospora sacchari* on maize in India. *Indian Phytopath.* **21**: 121–122.

Singh, R. S., R. N. Khanna and H. S. Chaube (1966). Crazy top of maize, a new record for India. *Labdev. J. Sci. & Tech.* 4: 62–63.

Singh, R. S. and H. S. Chaube (1968). Occurrence of *Sclerospora sacchari* Miyake and its oospores on maize in India. *Labdev. J. Sci. & Tech.* **6**: 197–200.

Subramanian, L. S. (1931). A note on downy mildew of sugarcane in India. *Agric. & Lives. India.* **1**: 32–33.

Weston, W. H. Jr. (1920). Philippine Downy Mildew of Maize. *J. Agric. Res.* 97–122.

Question and Answer

A. J. Ullstrup, U.S.A.: Please explain the nomenclature of *Sclerospora andropogonis-sorghi* versus *Sclerospora sorghi.*

Answer: Under Article 60 of the International Code of Botanical Nomenclature, Recommendation 60 (2) reads "When an intra specific taxon becomes a species or the inverse change occurs, the original epithet should be retained unless the resulting combination is contrary to the code".

Weston & Uppal, while raising the variety to species, did not retain the original epithet *andropogonis-sorghi* of Kulkarni, and hence *sorghi* should be considered invalid unless action is taken to conserve this name because of its widespread currency in plant pathological literature.

N. Murata, Japan: Could we hear more about the resistance of Indian local varieties to *Sclerospora maydis* or *S. philippinensis?* Is there any variation of local varieties in terms of the resistance which might suggest the possibilities of finding useful gene sources for the resistance?

Answer: *Sclerospora maydis* (Java downy mildew) does not occur in India. What has been described under this name is *S. philippinensis* (Philippine downy mildew).

We have not carried out a comprehensive evaluation of local maize varieties. However, with *Sclerospora sacchari* (Sugarcane downy mildew) tolerance has been observed in "Rudrapur local".

S. Y. Mah, Malaysia: Has anyone collected quantitative data on % loss of yield, when maize plants were affected by downy mildew at different stages of growth? Has loss of yield been computed by visual observations only?

Answer: Dr. Sangam Lal has carried out field trials with brown stripe downy mildew.