

## MANAGEMENT OF MAIZE DISEASES IN INDIA

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Maize is known to be attacked by as many as 16 disease of major importance under Indian condition. These include : (1) four foliar diseases, (2) five stalk rots, (3) four downy mildews, (4) two that affect leaf, sheath/ear and (5) one nematode disease. The loss in yield as well as estimated loss in crop value (in US \$) in respect of some of the major diseases have been presented in tabular forms. Among the various approaches of management practices, that of managing host genes or resistance breeding has received greatest attention followed by management with chemicals. Manipulation of some agronomic practices has been useful also in a number of cases. Useful recommendations of management practices in respect of some other diseases like (1) seed and seedling blights, (2) ear, cob and kernel rots, (3) smuts and (4) virus diseases have been briefly presented. Suggested ways and means in respect of overcoming important postharvest problems have been also included. The cost : benefit ratio in case of fungicidal seed treatment for some special purpose has been also stated.

### INTRODUCTION

Maize (*Zea mays* Linn.) was introduced in India during the sixteenth century and today it is an important food crop as well as fodder crop in India. Maize is intensively grown in the Himalayan region. It is also grown in the North Western Plains, North Eastern Plains and peninsular India. A substantial proportion of the production is obtained from the crop grown in *kharif* season (Summer/monsoon). Major stress factors adversely affecting the crop are excessively high or low rainfall resulting in water logging or inadequate moisture. During *kharif* the incidence of diseases, insect-pests and weeds are also higher.

Since 1961 under the aegis of the All India Coordinated Maize Improvement Project (AICMIP) 15 double-cross and three way or double top cross hybrids have been released for cultivation. However, certified seed of only five or six hybrids is currently being produced by the National and State Seed Corporations. But the overall area coverage by the hybrids has been uneven and low (around 20%). Lack of enthusiasm among the farmers for planting for new certified seed for each crop has been one of the major causes of the low spread of hybrids. Farmers have not been adequately enlightened with regard to the necessity of regular seed replacement in a cross pollinated crop as opposed to self pollinated ones like wheat or rice.

The AICMIP has also released 11 composites and varieties. Among them Vijay has proved to be most popular even in Pakistan. Currently emphasis is placed on population improvement methodology based on half and full-sib or other recurrent selection schemes. This approach appropriately takes care of farmer's reluctance for seed replacement of each crop season.

With the introduction of hybrid and composite maize varieties cultivation practices have become very intense and such practices seem to favour several diseases. Subsequently, the studies on maize diseases have gained much attention (Payak and Renfro, 1974) and more numbers of workers are associated with the maize diseases for the last 20 years or so as the impact of diseases on maize cultivation is being gradually felt. Payak and Sharma (1980) in their inventory of maize diseases have listed as many as 61 diseases under Indian condition. Out of these 16 are considered to be major ones, that is those significantly lower crop production and/or are widespread in both tropical and temperate environments as delineated by Renfro and Ullstrup (1976). These are listed below in a tabular form.

Disease 1	Causal organism 2	Distribution 3
<i>A. Foliar diseases</i>		
1. Turcicum leaf blight	<i>Exserohilum turcicum</i> (pass.) Leon. & Suggs. <i>Setosphaeria turcica</i> (Luttrell Leon. & Suggs.)	Himalayan region & Peninsular India.
2. Maydis leaf blight	<i>Helminthosporium maydis</i> Nisikado & Miyake (Drechslera state of <i>Cochliobolus heterostrophus</i> )	North Eastern Plains & North Western Plains.
3. Common rust	<i>Puccinia sorghi</i> Schw. II & III stages only	Himalayan region, North Eastern Plains, North Eastern Plains & Peninsular India.
4. <i>Phaeosphaeria</i> leaf spot	<i>Phaeosphaeria maydis</i> (P. Henn.) Rane, Payak & Renfro.	Himalayan region & North Western Plains.
<i>B. Stalk rots</i>		
5. Bacterial stalk rot	<i>Erwinia chrysanthemi</i> var. <i>zeae</i> (Sabet) Victoria, Arboleda & Munoz.	Himalayan region, North Eastern Plains & North Western Plains.

1	2	3
6. <i>Pythium</i> stalk rot	<i>Pythium aphanidermatum</i> (Eds.) Fitzp. ( <i>Pythium butleri</i> Subram.)	Himalayan region, North Eastern Plains & North Western Plains.
7. <i>Fusarium</i> wilt and stalk rot	<i>Fusarium moniliforme</i> Sheld.	North Eastern Plains, North Western Plains & Peninsular India.
8. Late wilt	<i>Cephalosporium maydis</i> Samra Sabet and Hingorani	North Eastern Plains, North Western Plains and Peninsular India.
9. Charcoal rot	<i>Macrophomina phaseolina</i> (Goid.) Tassi.	Himalayan region, North Eastern Plains, North Western Plains and Peninsular India.
<i>C. Downy mildews</i>		
10. Brown stripe downy mildew	<i>Sclerophthora rayssiae</i> var. <i>zeae</i> Payak and Renfro.	Himalayan region, North Eastern Plains, North Western Plains and Peninsular India.
11. Philippine downy mildew	<i>Peronosclerospora philippinensis</i> (Weston) Shaw.	Himalayan region, North Eastern Plains and Peninsular India.
12. Sorghum downy mildew	<i>Peronosclerospora sorghi</i> (Weston and Uppal) Shaw.	Peninsular India.
13. Sugarcane downy mildew	<i>Peronosclerospora sacchari</i> (Miyake) Shirai and Hara	North Eastern Plains and North Western Plains.
<i>D. Leaf sheath/ear disease</i>		
14. Brown spot	<i>Physoderma maydis</i> Miyake.	Himalayan region, North Eastern Plains and North Western Plains.
15. Banded leaf and sheath blight	<i>Rhizoctonia solani</i> Kuhn. ( <i>Thanatephorus sasakii</i> (Shiraj) Tu and Kimbrough)	Himalayan region and North Western Plains.
<i>E. Nematode</i>		
16. Cyst nematode	<i>Heterodora zeae</i> Koshy, Swarup and Sethi.	North Eastern Plains and North Western Plains

Payak and Sharma (1985) have accounted six major epidemics in India since 1960 in respect of bacterial stalk rot, brown stripe downy mildew, sorghum downy mildew, common rust, Turcicum leaf blight and banded leaf and sheath blight in some of the released hybrid varieties such as Ganga-5, Ganga rafed 2, Hi-starch, Deccan, Kisan and Pio x 104. They have also accounted loss in yield by 10 major diseases under experimental condition in susceptible cultivars (Table 1) including estimated loss in crop value due to some major diseases in India ( Table 2 ).

Table 1. Loss in yield by 10 major diseases of maize under experimental conditions in susceptible varieties

Disease	% Loss in yield	Reference
Bacterial stalk rot	100	Thind and Payak (1978)
Pythium stalk rot	100	—do—
Late wilt	50.9	—do—
Charcoal rot	39.5	—do—
Maydis leaf blight	30.3	—do—
Turcicum leaf blight	66	—do—
Common rust	32	Sharma <i>et al</i> (1982)
Brown spot	27	Lal and Chakravarti (1976)
Brown stripe downy mildew	63	Anonymous (1972)
Banded leaf & sheath blight	40.5	Singh and Sharma (1976)

Table 2. Estimation of Losses due to some major disease of maize in India (Payak and Sharma, 1985)

Disease group	% Loss	Annual grain loss (tonnes)	Value of crop* (million US\$) 1983-84
Seed and seedling blights	0.1	7,923.5	0.9
Downy mildews	2.1	166,395.4	18.0
Foliar diseases (Turcicum leaf blight, Maydis leaf blight, <i>Phaeosporia</i> leaf spot, rust & Brown stripe downy mildew)	5.0	396,180	42.9
Stalk rots, root rots and ear rots	5.0	396,180	42.9
Sheath blights & smuts	1.0	79,236	8.6
Virus diseases	—	—	—
<b>Total</b>	<b>13.2</b>	<b>1,045,915</b>	<b>113.2</b>

\*Exchange rate=Rs.12/US\$

Management practices in most of the diseases listed above have been recommended in India mainly due to the intensive research works carried out by the staff of AICMIP for the last 20 years or so. Among the various approaches of maize disease management that of managing host genes or resistance breeding has received greatest attention. Other approaches are management with chemicals, or by manipulation of agronomic practices. A brief account of the management practices of some maize diseases :economically important in India are included here. Recommended management practices in respect of some other diseases such as (1) seed and seedling blights, (2) ear, cob and kernel rots, (3) smuts, (4) virus diseases, (5) Nematodes and (6) root rots have been also included. The ways and means for overcoming some post-harvest problems have been also suggested.

#### *Manupulation of agronomic practices*

Studies on the manipulation of some agronomic practices such as time of planting and population density inorder to keep some diseases in check were undertaken at various research stations under All India Coordinated Maize Improvement Project (Payak, 1975). Field trials were conducted on time of planting in relation to disease incidence of Maydis leaf blight, brown spot, downy mildew, late wilt, bacterial stalk rot and *Pythium* stalk rot. The effect of plant population on the incidence of late wilt and *Pythium* stalk rot was also studied. Data from Udaipur station are conclusive in respect of sorghum downy mildew. It has been observed that early or normal sowings of maize suffer least from this disease when planting is made before 15th of July. At Pantnagar it has been observed that early sown crop during the month of May suffered highest amount of damage by bacterial stalk rot (*E. chrysanthemi*) and its incidence was least when planting was done in July. The incidence of brown stripe downy mildew was highest in the crop sown on 20th June and least on that planted on 30th July. The incidence of sugarcane downy mildew, however, increased in the crop sown after 30th June.

Chang and Chen (1965) observed that sun-drying of seeds leads to inactivation of mycelium of downy mildew fungus present in seed and also reduces moisture levels. Seeds with less then 20% moisture content produces healthy plants. Thus use of solar energy in post-harvest drying is a good measure for preventing outbreak of downy mildews through seeds as suggested by Payak and Sharma (1985). Plant population may also play direct role on the incidence of diseases and therefore, by adjusting the plant population the disease may be kept in check as has been observed in case of *Pythium* stalk rot where a plant population of 40000/ha as compared to agronomic recommendation of high plant population of 52000-55000/ha showed significantly low incidence to this disease. However, increase or decrease in the plant population have no significant effect on the incidence of late wilt (Payak, 1975).

Diwakar and Payak (1980) have observed that in respect to host factors plant population and plant maturity were found to be decisive in determining incidence

of *Pythium* stalk rot. Accordingly, their recommendations that have emerged for managing this disease are : (1) regulation of planting time between 10 and 20 July in North India, (2) plant population not to exceed 50,000/ha, (3) good field drainage and (4) removal of previous crop debris/wheat straw.

#### *Management with chemicals*

Chemicals control of maize diseases in the field is mainly accomplished with protective and systemic fungicides. Informations available in this regard are described as follows.

#### *Foliar diseases*

Use of protective fungicides of thiocarbamate group has been found to be most effective against some of the foliar diseases (Payak, 1975). Both Turcicum leaf blight and Maydis leaf blight can be effectively controlled by spraying with Dithane Z-78 or Zineb at the rate of 2.0 kg/ha in 1100-1200 litres of water as soon as the first symptoms of the disease become apparent on leaves or when the crop is at knee-lugh stage, 2 to 4 sprayings may be required depending on the disease intensity. The same fungicide may also be used against common rust at the rate of 1.8-2.6 kg/ha in 910-1820 litres of water if the plant population is around 55000. Gupta (1978) reported that 3 sprayings of Dithane M-45 at an interval of 15 days beginning from 31st January was found to be effective against common rust.

Payak and Sharma (1985) have pointed out that because of the presence of zinc in zineb, the crop registers overall improvement in growth. In recent years Indian soils have been found to be quite deficient in this micronutrient. The cost : benefit ratio at US \$ 7.00 per 100 kg of shelled grain works out to 1 : 3 in a susceptible cultivar like Basi. In hybrid Deccan 101 the cost : benefit ratio comes to 1 : 5 (Sharma *et al*, 1977).

#### *Downy mildew and brown spot*

Chemical control of downy mildews is now a very effective practice brought about by the development of systemic fungicides. One such fungicide, Ridomil, a Ciba Geigy product, has been tested by most of the research stations under All India Coordinated Maize Improvement Project (Anonymous, 1978). Seed treatment with 25% WP of the chemical at the rate of 1.5 gm/kg of seed before planting has been found to be highly effective against both brown stripe downy mildew and *Peronosclerospora* downy mildey. Full control of *Peronosclerospora* downy mildews has been obtained also by seed treatment with Apron 35 (Metalaxyl) at the rate of 2 gm/kg of seed ( a.i.0.7 gm ) before planting ( Anonymous, 1980 ). Lal ( 1975 ) has reported that Brestan (0.02%), Brestanol (0.03%) or Bordeaux mixture (4 : 4 : 50) could be used as foliar spray to get effective control against brown stripe downy

mildew. But care should be taken when copper fungicides are used, as maize leaf is quite sensitive to copper.

Use of systemic fungicides like benlate (50% WP), bavistin (50% WP) and plantavax (75% WP) have been effective also in the control of brown spot disease (Thakore, 1974).

Payak and Sharma (1985) have pointed out that chemical control of foliar diseases is quite feasible and it is becoming particularly profitable on high value materials like pop corn/sweet corn or seed crop.

#### *Stalk rots*

Several attempts have been made for the effective control of *Erwinia* stalk rot of maize by the application of antibiotics like streptomycin and streptocycline (Sabet, 1956; Rangarajan and Chakravarti, 1970).

But the spraying with these antibiotics may not be effective or economical and their soil application is not feasible due to their high cost and their binding and inactivation in soil (Maier, 1960). Recently, stable bleaching powder (Calcium hypochlorite) having inhibitory effect against *Erwinia* has been found to be most suitable for soil application. Thind and Payak (1972) have showed that about 94% of this disease could be controlled in the field by the application of this chemical containing 33.3% active chlorine at the concentration of 100 ppm as soil drench with water at the rate of 10 litres for 40 sq. meter area at 1, 2, 3 and 4 week interval after flowering. Field experiments conducted at various maize research stations have proved that bleaching powder used at the rate of 1000 ppm or 33.3 gm in 10 litres of water as soil drench before flowering to cover an approximate area of about 200 sq. ft. can effectively control the disease (Anonymous, 1978). Kaiser and Mukherjee (1979) have further observed that the application of this chemical at the same concentration before flowering can effectively reduce the charcoal rot incidence.

In case of *Pythium* stalk rot Payak (1975) observed that the maximum inhibition of the *in vitro* growth of the pathogen occurred with Captan followed by Demosan. Thus they selected these two fungicides for use in the field and observed that Captan at the rate of 150 gm/100 litres of water was effective as soil drench when the crop was 5-7 weeks old.

#### *Resistance breeding*

Control of foliar diseases can be effectively achieved using host resistance which has been quite successful. Breeding for resistance to some major disease of maize is being effectively carried out in India by All India Coordinated Maize Improvement Project for several years. A brief account of the results achieved so far are presented below.

### *Leaf blights*

It has been observed that the genetic resistance against two leaf blight pathogens *E turcicum* and *H. maydis* in most corn genotypes is polygenic and it is determined quantitatively. Resistance may be partially dominant and controlled by many genes, some of which can produce major effects (Jenkins and Robert, 1952; Ullstrup, 1952; Handoo, 1969). Using this concept breeding for resistance to leaf blights in maize is effectively accomplished by simple procedure such as phenotype recurrent selection or mass selection as has been practiced for several years under artificial epiphytotic condition. Sources of resistance against *Turcicum* leaf blight have been observed in the inbreds CM103, CM104, CM106, CM113, Eto18B, Eto28, Ph DMR1 Ph DMR 5 and Cuzco. Against *Maydis* leaf blight the sources of resistance are CM103, CM104, CM105, CM106, CM111, CM113, CM201, source Eto28A, Eto81, Eto182C, Ph DMR5 and Cuzco. Kaiser (1986, in the press) has also recorded resistance to *Turcicum* leaf blight in Ph. DMRI, Ph.DMR Composite, Virendra and Ganga-5 under Kalimpong conditions.

### *Common rust*

Resistance in maize to common rust is of two types, (1) specific and (2) non-specific or generalised (Vander plank, 1968; Hooker, 1969; Saxena, 1974). The specific resistance is usually expressed as necrotic or chlorotic flecks when the fungus comes in contact with the host. This resistance is race specific i. e. a plant with specific resistance may be highly susceptible to another. Generalised resistance is race nonspecific and manifests as reduced number of rust pustules in adult plants and is considered to be polygenic. Mature plant resistance to Indian pathotypes of this rust is available in many inbred lines and other cultivars of maize (Payak and Sharma, 1979). Therefore, these should be given preference over specific resistance or monogenic sources of resistance. Sources of resistance to common rust have been observed in the inbreds CM103, CM104, CM105, CM106, CM113, and Cuzco.

Both hybrids and composites possessing resistance to the above foliar diseases have been released. These include Hybrids Ranjit, Ganga 5, Ganga 101, Deccan, Himalayan 123 and Composites Jawahar and Kisan (Payak and Sharma, 1985).

### *Downy mildews*

Resistance to both types of downy mildews (*Peronosclerospora* and brown stripe) have been found to be controlled by both additive and nonadditive genes. Genetic analysis has shown that additive gene action has played greater role in disease resistance. Therefore, considerable genetic advance can be achieved through mass selection (Handoo *et al*, 1970; Asnani and Bhusan, 1970). A large number of hybrids, composites and early maturing varieties, and several materials from

international programme including CIMMYT have shown a good deal of resistance to both types of downy mildews under Indian condition. Materials such as CM103, CM104, CM105, CM106, CM113, CM500 and Cuzco have provided a good deal of resistance to brown stripe downy mildew whereas CM106, Tx601, MDRI, MDRII Ph. DMRI, Ph. DMR5 and Ph. DMR9 to sorghum downy mildew.

#### *Brown spot and banded leaf & sheath blight*

In brown spot, resistance is also determined quantitatively and polygenic in nature. Payak and Sharma (1970) after recurrent selection listed some inbred lines CM106, CM108, CM300, SSIII, Ge440 and Cuzco resistance to this disease. In case of banded leaf and sheath blight the nature of resistance is not yet known. However, the following inbreds CM103, CM104, CM105, CM300, CM600, P127407 and hybrid VL43 have been found to be resistant under field condition (Singh and Sharma, 1976; Ahuja and Payak, 1981).

Although individual sources of resistance such as inbred lines CM104, CM105, and CM300 have been identified the approach has been to combine it with resistance to other major diseases in two populations designated as multiple disease resistance I and II (Payak and Sharma, 1985).

#### *Stalk rots*

Resistance of maize to stalk rots involve many physiological, morphological and perhaps functional characteristics which are in turn influenced by a number of factors (Christansen and Wilcoxon, 1966). Two types of resistance operate in plants against bacteria, (i) constitutive resistance which involves inhibition of the pathogen by toxic substances or combination of the adverse physiological factors and (ii) induced resistance which includes hypersensitive reaction and protection response.

The role of constitutive system in the resistance of *Erwinia* stalk rot has been confirmed by Kelman and Sequeria (1972). From studies made in the All India Coordinated Project it is concluded that inheritance of resistance to *Erwinia* stalk rot is governed by one or two qualitative genes and the resistance is dominant over susceptibility (Anonymous, 1971-73, Singh, 1979). A large number of inbreds, hybrids, local varieties and composites have been screened under artificial epiphytotic conditions to know their degree of resistance against *Erwinia* stalk rot. The results obtained indicate that behaviour of most of the germplasm with respect to this pathogen was very unstable and greater variation was commonly observed in the same germplasm from one year to another. Among the hybrids Ganga-2 was least susceptible while among inbreds CM104, CM105, and CM600 exhibited high degree of resistance after years of testing (Lal *et al.*, 1970; Singh, 1979).

Breeding for resistance against *Pythium* stalk rot was also carried out and the materials which showed high degree of resistance to this stalk rot were CM104, CM110, CM400, CM600, CM400x CM300, hybrid Ganga Safed-2 and hybrid Hi-starch (Diwakar and Payak, 1975). Sources of resistance against charcoal rot have been achieved also in a number of inbreds such as CM103, CM104, CM106, CM107, CM111, CM112, CM202, CM300, CM600, Tx601, Ph.DMR1, Ph.DMR5, Ph.DMR9, MDRI and MDRII.

A great degree of variability in respect of disease reaction against late wilt have been observed among inbreds, single and double cross hybrids and open pollinated varieties (Mohamad *et al.* 1966). Kassem *et al.* (1975) reported almost complete phenotypic and genetic dominance for resistance over susceptibility. Payak and Sharma (1979) listed a few maize germplasm resistant to late wilt. These are CM103, CM104, CM111, CM202, CM300, CM400, CM103 x CM104, CM400x CM300, Ranjit and Ganga-5.

Payak and Sharma (1985) has reported that the most promising germplasm both in terms of resistance and yield to charcoal rot and late wilt has been the single cross CM202 x CM111. It is the female parent of the most commonly cultivated hybrid Ganga-5. This single cross has been found to be free of the problem known as 'premature drying'.

However, a resistant variety may lose its resistance against a pathogen due to evolution of new race and, therefore, search is to be made in such case for selecting a new source of resistance. It may be further mentioned that, so far, among the materials released which are resistant to one disease, or one set of diseases, most turn out to be susceptible to another set of diseases. Therefore the development of multiple resistance to the major diseases prevalent in the diverse agroecosystem of India seems more appropriate which has been successfully achieved through population improvement programme as has been described earlier.

#### MANAGEMENT PRACTICES IN RESPECT OF SOME OTHER DISEASES

##### *Seed and seedling blights*

Although a variety of pathogens are associated with seedling blights including species of *Pythium*, *Fusarium*, *Acremonium*, *Aspergillus*, *Penicillium*, *Sclerotium* etc., in different parts of the country particularly in the major tropical environments no effort has been made in developing resistance because fungicidal seed treatment is a cheap and simple measure for controlling these diseases. The cost works out to US \$ 0.50 for 20 kg of seed which is enough for 1 ha. The cost : benefit ratio works out to 1 : 14 (Payak and Sharma 1985).

##### *Ear, cob and kernel rots*

Among as many as 10 ear rot diseases the most prevalent are *Fusarium* ear rot

and kernel rot ( *E. moniliforme* ), *Aspergillus* kernel rot ( *A. niger* ) and *Botryodiplodia* cob and kernel rot ( *B. theobromae* ). Sometimes *Nigrospora* and *Macrophomina* cob rots are also observed. Most of these pathogens inciting ear rots are also involved in causing stalk rots. Payak and Sharma (1985) after field observations suggested development of resistant cultivars with tight husk covers on the ears as the incidence of these diseases is high in humid moist environment as well as by insect injuries.

#### *Virus diseases*

Among the two virus diseases, namely maize mosaic virus-1 ( a strain of sugarcane mosaic virus ) and veination the former one has been found to be prevalent in the several states of India and its incidence ranges from 2.2 to 10.6%. Resistance of high order even immunity has been identified in CM103, CM104 and CM105 and the improved released cultivars have not been reported, to suffer much from virus diseases ( Payak and Sharma, 1985 ).

#### *Nematodes*

Among the seven nematode pathogens associated with maize cyst nematode is a serious problem in the states of Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh ( Koshy and Swarup, 1971 ). The recommended management practice includes crop rotation and the eradication of *Setaria* a grass on which the causal organism thrives ( Payak and Sharma, 1985 ).

#### *Post-harvest problems*

Three types of post-harvest problems are mainly faced during the post-harvest period ( Payak and Sharma, 1985 ). These include : (1) those of plant pathological significance, e. g. *Cephalosporium acremonium*, *Fusarium moniliforme*, *Peronosclerospora philippinensis*, etc.; (2) those having toxicological implications, e.g. *Aspergillus flavus*, *Aspergillus niger*, *Botryodiplodia theobromae*, *Macrophomina phaseolina*, *Penicillium funiculosum* : (3) those having storage significance, these include 11 species of *Aspergillus* and 7 species of *Penicillium*. Kandhari *et al* (1980) reported that the use of propionic acid in high moisture maize grain ( 15.5 to 40% ) at 10 ml/kg seed inhibited mould growth including that of *Aspergillus flavus*. Storage rots can be effectively checked by maintaining the seed moisture level below 13%.

#### *Root rots*

Although two types of root rot problems, one caused by *Helminthosporium pedicellatum* (Bhargava and Kamal, 1968) & the other by *Pythium aphanidermatum* (Mahmud, 1952) have been recorded so far, their importance has not been assessed because of lack of definite work.

### DISCUSSION

The present information has highlighted the importance of maize diseases that act as constraints on production in India Agriculture. The percentage of loss in yield and estimated loss in crop value in US have been also accounted here. The figure of 13.2% loss by diseases in India as given by Payak and Sharma (1985) does not appear to be an overestimate as the overall loss estimate has been calculated at 12.0% by James (1981) caused by various disease groups in maize in USA.

Among the various approaches of management practices highest importance has been accorded to the exploitation of host resistance. There are various information in respect of identifications of resistance to stalk rots, foliar diseases; downy mildews, leaf and sheath blights and virus diseases. The present information indicate that resistance to foliar diseases is common in some genotypes such as CM103, CM104 and CM105 which possess high degree of resistance to Turcicum leaf blight, Maydis leaf blight, Brown stripe, downy mildew, common rust and maize mosaic virus (sugarcane strain). It may be further noted that the inbred CM104, carries resistance to bacterial stalk rot and *Pythium* stalk rot whereas the single cross CM202 × CM111 carries resistance to charcoal rot and late wilt. Similarly, some exotic materials from Philippines and Thailand possessing resistance to *Peronosclerospora* downy mildews are also highly resistance to leaf blights.

But it has been observed for the last few years that the released materials, which are resistant to one disease, or one set of diseases, are turn out to be susceptible to another set of diseases. Therefore, the development of multiple resistance to the major diseases prevalent in the diverse agro-ecosystem of India seems more appropriate. Works in this regard are in progress since 1973 through population improvement programme by recurrent selection breeding schemes (mostly half and full-sib family selection methodology but partly also  $S_1$  testing). The main objective of this programme is to increase the frequency of genes to major diseases in a gradual way without markedly diluting the original genotype. At present two multiple disease resistant populations, namely MDRI and MDRII possess acceptable level of resistance to as many as 12 diseases (Payak and Sharma, 1979; Kaiser and Chowdhuri, 1986 in press).

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