

PRESENT STATUS OF KNOWLEDGE ON COMMON RUST OF MAIZE IN INDIA

BY

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Common rust of maize (*Puccinia sorghi* Schw. = *P. maydis* Bereng.) is an economically important disease. Virulent strains of the pathogen appeared from 1973 onward on released hybrids Ganga Safed 2 and Hi-starch in Bihar.

At least five races of the pathogen are present in India, two of which are capable of attacking monogenic resistant sources. Two types of resistance in maize to *P. sorghi* are so far known- (1) specific and (2) non-specific or generalised. However, non-specific or generalised resistance which is polygenic and found in adult plants, is available in many inbred lines and other cultivars of maize and this can be effectively used against the Indian pathotypes (races) of *P. sorghi* in a breeding programme. But specific resistance can be used if needed as a supplement to mature plant resistance or non-specific resistance.

Chemically, the disease can be effectively controlled by spraying with Dithane Z-78 (Zineb) @ 1.8 to 2.6 kg/ha in 910 to 1320 litres of water or Dithane M-45 (Maneb) @ 2.0 kg/ha in 1100 to 1200 litres of water. However, the best way to control the disease would be the development of resistant varieties which have been already released. These include Ganga 5, Ganga 101, Deccan and Himalayan 123 (hybrids), Jawahar and Kisan (composites) and CM 103, CM 104, CM 105, CM 106 and Cuzco (inbreds) showing acceptable level of resistance to *P. sorghi*.

INTRODUCTION

Maize (*Zea mays* Linn.) is infected by three rust diseases, namely (1) Common rust (*Puccinia sorghi* Schw.), (2) Southern rust (*P. polyspora* Underw.) and (3) Tropical rust (*Physopella zeae* Cumm. & Rama which occur in different parts of the world. Out of these common rust is found to be prevalent wherever maize is grown. In India, only common rust caused by *P. sorghi* Schw. II & III stages only (= *P. maydis* Bereng.) is known to occur for a pretty long time (Butler, 1918). Subsequently it has been reported from various regions of the country, particularly from the hilly areas, such as the Nilgiri hills (Ramakrishnan *et al.*, 1953), Kalimpong hills (Chattopadhyay and Sen Gupta, 1955), New Delhi (Vasudeva, 1960), Simla (Misra and Sharma, 1964) and Mysore (Kushalappa and Hegde, 1970). At present, the disease is widely prevalent over different states of India including Jammu & Kashmir (J&K), Himachal Pradesh (HP), Sikkim, West Bengal (WB), Meghalay, Punjab, Haryana, Rajasthan, Delhi,

Uttar Pradesh (UP), Bihar, Madhya Pradesh (MP), Maharashtra, Andhra Pradesh (AP), Karnataka and Tamil Nadu, the hot spots being Dholi (Bihar), Kalimpong (WB) and Karnal (Haryana). The disease appears in the *kharif* season (summer/monsoon) as well as in the *rabi* season (winter/spring) depending upon the weather conditions. But it appears mostly during the *kharif* particularly in the hilly areas whereas during the *rabi* it generally appears in the plains (Punjab, Haryana, U.P., Bihar and AP). Under the favourable conditions, the disease may cause considerable loss in grain yield upto 32% (Sharma *et al.*, 1982). The pathogen has shown its great affinity particularly on some released hybrid varieties in the recent years as well as in the past. Virulent strains of *P. sorghi* appeared in a large scale from 1973 onwards on hybrids Ganga Safed 2 and Hi-starch in Bihar resulting an epidemic in the cultivated area (Gupta, 1982). Hence, from plant pathological point of view the disease may be considered of great economic importance in this country.

Symptoms of the disease and morphology of the causal fungus

Gupta (1982) has described the symptoms of common rust as follows. The disease is recognised by the appearance of circular to elongate, cinnamon brown, powdery pustules scattered over both surfaces of the leaf. The powdery nature of the pustules are due to the presence of masses of urediospores that form beneath and break through the leaf. As the crop approaches maturity black pustules are formed on both the surfaces of the leaf and the brown urediospores are replaced by the black teliospores. In case of severe infection the entire plant appears brownish and rusted. Rust pustules may appear on any above ground part of the host but they are most abundant on the leaves.

The morphological description of the common rust fungus as found in India is as follows (Sharma, 1982). Pycnia are amphigenous but more often epiphyllous, clustered, flask-shaped with ostiolar periphyses. Aecia are aeciaoid, generally hypophyllous surrounding the pycnia, cupulate, orange-yellow, 0.15 to 0.2 mm in diam., aeciospores are angularly globoid or ellipsoid, 15.0 to 24.0 μ m in diam., wall hyaline, verrucose, 1.0 to 2.0 μ m thick. Uredia are amphigenous, but more often hypophyllous, subepidermal, erumpent, irregularly scattered, elliptic or oblong, 1.0 mm in diam., separate coalescent, cinnamon brown and upto 10.0 mm long. Urediospores are globose or subglobose, 24.0 to 29.0 $\times$ 22.0 to 29.0 μ m thick with 3 to 4 germ pores. Telia are like uredia but black; teliospores are ellipsoid, smooth, cylindrical or clavate, obtuse or subacute, usually slightly constricted at the septum, light to chocolate brown, 35.0 to 50.0 $\times$ 16.0 to 25.0 μ m long and 1.0 to 1.5 μ m thick, germ pores at the upper cell apical, conspicuous, basal pore immediately below the septum, obscure, 3.0 to 6.0 μ m at the apex; pedicels are persistent, yellowish, upto 90 μ m long.

Stage O (Pycnia and pycniospore) and Stage I (Aecia and aeciospore) of the fungus are found on species of *Oxalis* while Stage II (basidia and basidiospores) and Stage III (telia and teliospore) on *Z. mays*, *Z. maxicana*, *Z. perennis* and *Tripsacum* under Indian condition.

Life cycle

The fungus *P. sorghi* is an obligate pathogen and completes its life-cycle on more than one host (heterocious). The pycnia and aecia of the fungus are produced on alternate host *Oxalis* sp., whereas the uredia and telia are produced on maize. Pycnia are produced on *Oxalis* sp. as a result of infection by the sporidia (Stage IV) on the upper surface of the leaves. Pycnia may be (+) or (—) in their sexual tendencies, and by the process of their fusion they lead to the formation of aecia leaving numerous yellow aeciospores on the lower surface of the leaves of young maize plants where they germinate and infect the leaf tissues under favourable conditions. After an incubation period of several days cinnamon brown urediospores are formed on the uredia pustules which repeat the cycle several times on the same host (maize) and then continue to produce new infections on leaves under favourable condition of moisture and temperature. As the host plant matures, black teliospores are formed in the pustules in place of the urediospores. The teliospores are hardy and capable of withstanding under adverse conditions. They overwinter and germinate in the spring after a resting period to form small, colourless, thin-walled secondary spores called basidiospores or sporidia on the elongated basidia. As already indicated sporidia are unable to infect maize but can infect certain species of *Oxalis* viz., *O. corniculata*, *O. europaea* and *O. stricta* etc. But the alternate host, *Oxalis*, is not required in the climate where the uredial stage is repeated several times.

Gupta (1982) is, however, of the opinion that the telia, under the conditions prevailing in India, plays less significant role. Since the urediospore can survive by repeating the life cycle on maize and other hosts like teosinte, perpetuation of the fungus seems assured. In some areas of the country maize is grown after maize in the same field or nearby fields and the crop stands in the area almost throughout the year thus facilitating the perpetuation and survival of the pathogen and therefore, he is doubtful over the role of *Oxalis* in the life history of *P. sorghi* on maize in the maize-growing regions of the country.

Factors favouring infection

Cool and moist weather in which maize leaves are exposed and covered with a film of water for a long period favour development of common fungus. Reports from outside India reveal that a temperature range of 12° to 16°C is found

optimum for the germination of *P. sorghi* (Le Roux and Dickson, 1957; Jugenheimer, 1975). In a trial conducted at Dholi (Bihar) the maximum germination of the urediospores was obtained at 22°C followed by 25°C and 20°C (Gupta, 1982). Das and Chattopadhyay (1984a, b) from Kalimpong (WB) observed that moderate temperature (17° to 22°C) and high relative humidity (90% and above) favoured the development of *P. sorghi* on the susceptible maize varieties. They further observed that the disease appeared usually in the middle of June and onwards. Intensity of infection progressively increased after silking. Uredial pustules were observed on about one month old seedlings but the full development of the disease was not usually evident until 1 to 2 weeks after tasseling stage.

Economic importance

Gupta (1982) in a field trial conducted at Dholi (Bihar) observed that losses due to *P. sorghi* varied between 12.6% in Luxmi to 28.2% in Hi-starch and 37.1% in Diara under artificial epiphytotic condition, while it varied from 11.2% in Luxmi to 17.8% in Hi-starch and 33.6% in Diara under natural condition. As already mentioned, outbreak of virulent strains of *P. sorghi* from 1973 onwards in Bihar resulted an epidemic in that area.

Physiologic specialisation

Considerable variation is observed in the population of *P. sorghi* which exists in nature atleast in the form of four different races (Stakman and Christensen, 1926; Mains, 1926; Stakman *et al.*, 1928; Le-Roux and Dickson, 1957; Schieber and Dickson, 1963). Reports from India also indicate the presence of all the four races. Roy and Prasada (1966) differentiated four races of *P. sorghi* on the basis of samples collected from Solan, Mashobra, Flowerdale, Matiana (Simla hills) Arbhavi (Karnataka) and Dholi (Bihar). Later, Sharma (1977) reported the presence of atleast five pathotypes (races) in India, two of which are capable of attacking the monogenic resistant sources.

Inheritance of resistance to P. sorghi

Resistance in maize to *P. sorghi* is of two types: specific, and non-specific or generalised (Van der Plank, 1968; Hooker, 1969; Saxena, 1974). The former is usually expressed as necrotic or chlorotic flecks when the pathogen 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 non-specific and manifests as reduced number of rust pustules in adult plants and is considered to be polygenic. The inheritance of specific resistance has been extensively worked out in USA (Hooker, 1955, 1963; Hooker and Russel, 1962; Hagan and Hooker, 1965; Hooker and Saxena, 1967; Wilkinson and

Hooker, 1968) and five major loci in respect of host resistance have been identified with the designations R_{P1} , R_{P3} , R_{P4} , R_{P5} and R_{P6} . Inheritance of generalised or mature plant type of resistance has been also studied in India (Sharma, 1977; Sharma and Payak, 1979) and other countries (Hooker, 1969) Kim and Brewbaker, 1976) in detail and it was established to be polygenic but the number of genes conferring resistance may not be large. From the studies conducted at Hawaii (Kim and Brewbaker, 1976) and in India (Sharma, 1977; Sharma and Payak, 1979) it was observed that at least two parental lines CM 104 and CM 105 were common and CM 105 was determined to be a good general combiner for resistance to this rust. However, CM 104 was rated to be susceptible at Hawaii while it showed resistant reaction in India.

So far as use of monogenic sources of resistance is concerned, Payak *et al.*, (1974) have indicated that as pathotypes capable of attacking R_{P1d} which occur in India, their use or mobilisation in the breeding programme does not seem to be justified. Mature plant resistance to Indian pathotypes of *P. sorghi* is available in many inbred lines and other cultivars of maize (Payak and Sharma, 1979). Therefore, these should be given preference over monogenic resistance sources. However, specific resistance can be used if needed as a supplement to mature plant resistance.

Estimation of losses in yield

Sharma *et al.*, (1982) have suggested a method for estimating yield losses due to *P. sorghi* where plant-to-plant observations on disease as well as yield have been preferred over those on row/plot basis. Their experience has shown that average data of whole rows or plots do not reflect the true relationship as well as yield levels; the data were insignificant for all the three varietal entries when recorded on row/plot basis. However, on plant-to-plant basis the data were significant (Table 1 and Table 2).

Table 1. Loss (%) in grain yield due to *P. sorghi* recorded on individual plant basis in three maize cultivars (Sharma, *et al.*, 1982)

Cultivar	Treatment	Disease index (1-5 scale)	Yield kg/ha	Loss (%)	't' value
Ganga Safed 2	Inoculated	2.8	5325	28.37	6.50**
	Protected	1.0	8800	—	—
EH 3047	Inoculated	2.5	4262	32.18	14.04**
	Protected	4.0	8112	—	—
Basi local	Inoculated	4.2	3525	27.81	4.55*
	Protected	1.0	5735	—	—

* Significant at 5% ** Significant at 1%

Table 2. Loss (%) in grain yield due to *P. sorghi* recorded on middle two rows in three maize cultivars (Sharma *et al.*, 1982).

Cultivar	Treatment	Disease index (1-5 scale)	Yield kg/ha	Loss (%)	't' value
Ganga Safed 2	Inoculated	2.0	4950	5.00	0.3
	Protected	1.0	5225	—	—
EH 3047	Inoculated	1.8	5087	6.98	1.5
	Protected	1.0	5500	—	—
Basi local	Inoculated	3.3	3437	9.68	1.4
	Protected	1.0	3850	—	—

Control measures

Chemically common rust can be controlled by the application of protective fungicides of thiocarbamate group which has been quite successful. Payak (1975) reported that the disease could be effectively controlled by spraying with Dithane Z-78 or Zineb (Zinc ethylene bis dithiocarbamate) @ 1.8 to 2.6 kg/ha in 910 to 1320 litres of water if the plant population is around 55,000; 2 to 4 such sprayings will be required depending on the disease intensity. Gupta (1978) also reported that 3 sprayings of Dithane M 45 or Maneb (Manganese ethylene bis dithiocarbamate) @ 2.0 kg/ha in 1100 to 1200 litres of water at an interval of 15 days beginning from 31st January was effective against this rust.

However, the best way to control the disease is the development of resistant varieties. Both hybrids and composite possessing acceptable level of resistance to common rust have been released in India. These include hybrids Ranjit, Ganga 5, Ganga 101, Deccan, Himalayan 123 and composites Jawahar and Kisan (Payak and Sharma, 1985). Sources of resistance to common rust have been observed in the inbreds CM 103, CM 104, CM 105, CM 106, CM 113 and Cuzco which may be effectively used in the breeding programme for the development of synthetic varieties (Singh, 1982).

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