DOWNY MILDEW OF MAIZE IN NEPAL

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Maize (*Zea mays* L.) is the second most important crop in Nepal and is grown in all 14 zones of the country. It is cultivated from an elevation of 90 to 3600 meters and where the average yearly rainfall is 1400 mm in the west to 2200 mm in the east. The crop is extensively grown in the hills under rain-fed conditions where it is the staple food of the common people and where it usually takes 6-9 months to mature. In certain tarai and inner-tarai areas maize ripens in a shorter period of time and is becoming increasingly popular and farmers have begun winter cultivation. During the period of 1961-62 through 1974-75 the area varied from 412 to 458 thousand hectares, production from 765 to 954 thousand metric tons and the average annual yield from 1.72 to 1.93 MT.

Assessment of the present knowledge of downy mildew. — Three downy mildew (DM) diseases have been reported to attack maize in Nepal. These are Philippine DM (*Sclerospora philippinensis* Weston), sorghum DM (*S. sorghi* Weston & Uppal) and brown stripe DM (*Sclerophthora rayssiae* var. *zeae* Payak & Renfro), however the presence of the latter two diseases needs confirmation. The first report of Philippine DM was from Rampur of Chitwan valley (11). In 1967, the first epidemic of this disease was recorded there. It caused serious damage to local cultivars and was especially damaging to late sown maize. The disease spread rapidly to a small area of the adjoining district of Hitauda and a second epidemic was recorded in 1970 (13). In 1971 the disease spread to another adjoining district, Nabalpur, and a third epidemic occurred in all three districts in 1973. In the same year the disease was observed in Trisuli, a place quite distant from the site of first report. Since then the disease has been confined to these areas and has occurred rather sporadically. The reason for the present confinement of the disease to these areas is not well understood as there are other areas having congenial climatic conditions for its development. After harvest of the main crop in these areas a dry period extends from September to May. It seems that conidial production is limited to few weeks and then is interrupted completely by the absence of a susceptible host. This is unlike Philippine conditions where the cyclic chain of conidial production is more or less assured by the availability of a living host under prolong congenial climatic conditions (15) and in Taiwan where Sugarcane DM occurs.

It is not clear how the pathogen survives during the long dry, cool weather months. Infected seed, as reported for most of the DM diseases, does not play any part in this respect, since the seed is rigorously selected by farmers, well dried and often chemically treated before being stored for a long period. Kans (*Saccharum spontaneum* L.) is widespread in these areas and DM infection has been reported (11). However, its role in perpetuation of the disease is confused even though it has been demonstrated as a collateral host in New Delhi (3). In the Philippines, Kans and a number of other hosts have been reported (5) but, most of those do not occur in the infected areas of Nepal and, therefore, do not seem to be involved. No oospores have been recorded so far in our areas, which is again contrary to the Philippine situation (1).

The relationship of humidity, temperature and wetting period to conidial production and germination, under natural conditions of Rampur, were studied in detail (Shah, unpublished). It was found that conidia are produced from 2400 to 0600 hours with the maximum number being produced between 0200 and 0400 hours.

Humidity above 90% with a minimum wetting period of 3 hours prior to sporulation were needed for the production of conidia. Rainfall at or 2 hours before sporulation either delayed or completely suppressed sporulation. Temperature requirements do seem to be critical as it varied from 20-28°C at the time of sporulation. The best time for inoculation under natural conditions was found to be between 0300 and 0400 hours (Shah, unpublished). The best and easiest method of inoculation was to collect conidia in the field at 0200-0400 hours and spray the suspension in the whorl with a knapsack sprayer. However, the inoculum suspension should not be held in the container for more than an hour after collection because a gradual decline in infection rate was found to occur in storage beyond that time period (Shah, unpublished). In a date of sowing study the highest infection (76.3%) was found in maize sown on 16 June when precipitation was 24.7 cm, average temperature was 28.3°C and the relative humidity (RH) was 83.2%. The lowest DM severity (2.5%) was recorded in plantings made between 1 and 15 May. The disease did not develop in the crop sown after August nor prior to May (13). In the Philippines the severity of the disease was highest in the crops sown in July, November and December. The rainfall, temperature and RH prevailing in these 3 months were 13.5, 40.5 and 13.2 cm; 27.5, 27 and 26.3 C; and 88, 88, 88.4%, respectively (6). The degree of susceptibility of maize was found to be influenced by plant age under a definite spore density. Highest infection was recorded in the youngest plants (1 week old) and infection rate decreased with an increase in plant age. Similar results have been obtained in Taiwan and Thailand (14, 12).

In host nutritional studies, disease severity was lowest (21.2%) when 160 kg/ha of nitrogen was applied and highest (52 and 53%) at 0 and 60 kg/ha. No significant different was obtained when nitrogen levels were increased from 180 to 240 kg/ha (Table 1). Phosphate application (0-60 kg/ha) did not appreciably change the incidence of disease (45.7 to 53.7%; Table 2) nor did the application of lime (0-2000 kg/ha) to the soil (Table 3).

Attempts to control DM by spraying various chemicals on 12 day-old plants at weekly intervals gave insignificant results (13). However, seed treatment with the systemic fungicides, Demosan and Benlate, prevented the disease for upto 13 days (Shah & Tuladhar, unpublished). Prevention of secondary disease spread was reported in Bihar, India by spraying 5:5:50 Bordeaux mixture (8). In the Philippines, alternate spray of Dithane M-22 or M-45 and Duter a number of times in the initial growth period of the crop (4) and a combination of seed treatment and foliar spray with Demosan (10) was reported effective.

Gaps in Knowledge

No systematic work on the DM diseases of maize has been done in Nepal for many reasons and information on various important aspects are lacking. Some of the areas where information is needed urgently are listed.

Perpetuation and source of primary inoculum. — How the pathogen survives during the long dry periods in absence of collateral hosts reported from other countries and in absence of the perfect stage is not known. The role of Kans in perpetuation and spread of the pathogen has to be determined.

Combined effect of different factors. Information on the effect of temperature, light and humidity on conidial production, germination and infection are available. Similarly, data on spore production under controlled conditions, spore density and maturity are available. However, when this information is applied to creating artificial epiphytotics, especially in places which are not "hot spots", results are erratic. Since all of these factors are operative at one time in nature, it would be worthwhile to study the combined effects for initiating infection since we do not know how one factor modifies other factors. In late blight of potato and DM of tobacco the minimum, maximum and optimum levels of each factor (spore density, duration of wetness and

Table 1. Effect of soil nitrogen on the incidence of Philippine downy mildew of maize. Rampur 1969/70*

N (Kg/ha)	Percent downy mildew replication					Yield (Kg/ha)
	1	2	3	4	Av.	
0	51	62	48	49	52	176
60	49	50	62	51	53	298
120	30	28	24	35	29	365
180	22	28	21	14	21	283
240	28	30	27	21	26	343

*Trial damaged by heavy storm after cob formation causing serious lodging; plot size = $15M^2$; uniform application of 80 P_2O_5 and 60 K_2O made.

Table 2. Effect of soil phosphate on the incidence of Philippine corn downy mildew. Rampur 1971/72*

Fertilizer level (Kg/ha)		Percent downy mildew replication					Yield (Kg/ha)
P_2O_5	K_2O	1	2	3	4	Av.	
0	60	45	52	49	65	53	119
40	60	49	48	71	47	54	174
80	60	24	49	62	48	46	187
120	60	61	52	43	44	50	227
160	60	49	52	49	61	53	171

*Trial severely attacked by bacterial stalk rot and had heavy lodging; plot size = 15^2; 120 kg/ha N uniformily applied.

Table 3. The effect on lime cum fertilizer on the incidence of Philippine downy mildew of maize (J_1 var.). Rampur 1971-72.

Treatments (kg/ha)				Percent downy mildew replication					Grain yield (Kg/ha)
N	P_2O_5	K_2O	Lime	1	2	3	4	Av.	
0	0	0	0	30	25	20	32	27	1539
120	80	60	0	13	12	14	11	12	2820
0	0	0	1000	28	32	26	34	32	1801
0	0	0	1500	30	45	45	30	37	1870
0	0	0	2000	30	48	46	44	42	1775
120	80	60	1000	14	15	10	13	13	2634
120	80	60	1500	18	12	14	15	15	2495
120	80	60	2000	11	12	14	18	14	2710

L.S.D. at 5% = 12.27

temperature) have been found to be dependent on the other two factors.

Virulence of the pathogen. — The severity of the disease differs from region to region. It is said that the pathogen is most virulent in the Philippines. Whether this reported virulence can be attributed to continuous cropping in the Philippines, which assures high inoculum density, to the existence of physiologic races or biotypes, or to other factors is not known.

Assessment of loss. — No definite data on the assessment of loss are available under Nepal conditions.

Effect of nutrition. — The data available on these effects are limited and confusing.

Effect of chemicals. — The few chemicals tried so far under our conditions have not proved to be effective even though good results have been reported from the Philippines.

Dissemination of the pathogen. — How the pathogen was introduced into the distant place of Trisuli, which is surrounded by mountains, is not known. Similarly, in Rapti and Nabalpur, it is not known how long range dispersal of the pathogen takes place in absence of the host. Sometimes fields near the sources of infection do not become infected while other fields in the same direction become seriously infected.

Constraints To Research

Inaccessible geographic areas. — The disease is prevalent in areas having very poor means of communication during the maize growing period. There, facilities are meager for handling the pathogen under controlled conditions. However, with the transfer of the National Maize Improvement headquarter to the Rampur Agricultural Station an attempt is being made to provide facilities for pathological research.

Shortage of technical personnel. — Disease problems of maize are numerous and exist in the different agroclimatic zones of the country. There are few trained pathologist and the work in this discipline used to be controlled from Kathmandu. However, pathologists are being stationed at Rampur and will be assisted by the center.

Research in Progress and Planned in the Future

Downy mildew of maize is a comparatively new disease to Nepal, although the reported epidemics have clearly demonstrated its importance. Moreover, the danger of the spread of this disease to other districts having congenial climatic conditions for its rapid development cannot be neglected. Little attempt has been made so far to study the pathogen in a systematic way. Our main emphasis for the time being directed towards is being the introduction of resistant materials, screening them and combining certain characters needed for our conditions before their release to the farmers. With the establishment of the Rampur facility the following research are being plannedfor thefuture:

1) Identify, map distribution and assess damage caused of the different DMs reported.
2) Study spore production, germination and storage of inoculum.
3) Collect and test local germplasm for reaction to DM.
4) Search for the sources of primary infection and the role of collateral hosts.
5) Study spore dispersal.
6) Study cultural, nutritional and chemical means of control.

Control Practices

Time of sowing large areas. — The disease usually develops after the onset of rain. The majority of the farmers plant maize before that, which enables the crop to escape infection.

Drainage. — The disease severity has been found to be usually high in poorly drained soils. Therefore, the farmers are advised to maintain good drainage.

Fertilizer. — A balanced fertilizer of 120:80:60 is being recommended to the farmers.

Roguing. — The disease is called 'Sete' and the farmers of the affected areas are quite familiar with the disease. Roguing of the few affected plants at the initial stage of infection has been recommended.

Resistant varieties. — Two resistant varieties namely Rampur Composite and Sarlahi Seto were released last year, although seeds were distributed to farmers before their official release. Last season, enough certified seeds was distributed to farmers to sow 300 hectares. Certified seeds for 6000 hectares of land will be supplied for the coming season and additional seed will be exchanged among farmers. It is planned to distribute certified seeds of the resistant materials to farmers both in the DM affected areas and adjoining areas where DM may possibly spread.

Cooperation Suggested

1) Development of resistant materials and distribute them widely through the International DM Nursery.

2) Uniform testing of promising chemicals.

3) Exchange of current knowledge on the DMs.

4) Supply of DMR germplasm to countries.

Laboratories

Most of the information needed on the unsolved problems of the pathogens need to be conducted under control conditions. Apparently facilities are available at Los Banos (Philippines), Mysore (India), Maryland (USA) and Texas (USA) and should be utilized for studies of taxonomic clarification, host-parasite relationships, physiologic races, and the combined effects of different factors on the infection process.

Literature Cited

1. ACEDO, G. N. and O. R. EXCONDE. 1967. Oospores of *Sclerospora philippinensis* Weston from corn leaf tissue. Phil. Agric. 51 : 279-282.

2. BARREDO, F. C. and O. R. EXCONDE. 1973. The Philippines experience on the incidence of corn downy mildew as affected by inoculum suscept and environment. Proc. IX IACP Workshop, Kuala Lumpur, Malaysia. 28-29 p.

3. CHONA, B. L. and D. SURYANARAYANA. 1955. The occurrence of *Sclerospora philippinensis* Weston on Kans *(Saccharum spontaneum* L.*)* in India. Indian Phytopathol. 8: 209-210.

4. DALMACIO, S. C. and O. R. EXCONDE. 1971. Chemical control of downy mildew. The use of protectant fungicides. Proc. VII IACP Workshop. Los Banos, Philippines. 108-110 p.

5. EXCONDE, O. R., J. V. ELEC and B. A. ADVINCULA. 1968. Host range of *Sclerospora philippinensis* Weston in the Philippines. Phil. Agric. 52: 175-188.

6. EXCONDE, O. R., J. Q. ADVERSARIO and B.A. ADVINCULA. 1968. Effect of dates of planting corn on infection by *Sclerospora philippinensis* Proc. V IACP Workshop, Bangkok, Thailand. 166-172 p.

7. EXCONDE, O. R., J. Q. ADVERSARIO and B. A. Advincula. 1968. Incidence of corn downy mildew in relation to planting date and metereological factors. Phil. Agric. 52 : 189-199.

8. GATTANI, M. L. 1950. Control of secondary infection of downy mildew of maize. Curr. Sci. 19 : 90.

9. PAYAK, M. M. 1974. Epidemiology of maize downy mildews with special reference to those occurring in Asia. Trop. Agric. Res. (Jpn.) Series 8 : 81-91.

10. SCHULTZ, O. E. 1971. Evaluation of seed treatment with chloroneb for control of Philippine downy mildew of corn. Proc. VII IACP Workshop, Los Banos, Philippines. 104-107 p.

11. SHAH, S. M. 1966. Annual report. Nepal Department of Agriculture, 1966.

12. SHAH, S. M. 1973. A study of some epidemiological factors affecting sorghum downy

mildew epiphytotics in Thailand. Proc. IX IACP Workshop, Kuala Lumpur, Malaysia. 14-27 p.

13. SHAH, S. M. and K. L. TULADHAR. 1971. Downy mildew disease of maize in Nepal. Proc. VII IACP Workshop, Los Banos, Philippines. 88-94 p.

14. SUN, M. H., S. C. CHANG and N. C. CHEN. 1966. Mature plant resistance in corn to downy mildew. Proc. III IACP Workshop, New Delhi, India. 57-61 p.

15. WESTON, W. H., JR. 1923. Production and dispersal of conidia in the Philippine Sclerosporas of maize. J. Agric. Res. 23: 239-278.