

STUDIES ON DISEASES OF MAIZE IV : VARIATION IN INCIDENCE OF DIFFERENT DISEASES AT DIFFERENT STAGES OF PLANT GROWTH

BY

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A study of variations of incidence of different diseases of maize at different stages of plant growth on a few selected varieties indicated the most susceptible stages of the host for different diseases. Such findings are necessary to take control measure against any specific disease or a group of diseases where multiple infections occur, besides they provide the basis of testing the varieties against specific diseases at appropriate stage.

Studies of variations of incidence were done on leaf blight due to *Helminthosporium turcicum*, *H. maydis*, Leaf spot incited by *Phaeosphaeria maydis*, *Physoderma maydis*, *Diplodia macrospora*; leaf and sheath blight caused by *Rhizoctonia zeae*, common smut caused by *Ustilago maydis*, downy mildew by *Sclerophthora rayssiae* var. *zeae*; ear rot due to *Rhizoctonia zeae*, *Diplodia zeae*, *Gibberella zeae*, *Fusarium moniliforme*, *Aspergillus* and *Penicillium* spp.; stalk rot caused by *Rhizoctonia zeae*, *Gibberella zeae*, *Diplodia zeae*, *Pythium aphanidermatum*, *Erwinia carotovora* f. sp. *zeae* (= *E. chrysanthemi*).

Most of the foliar diseases excepting *phaeosphaeria* leaf spot were found to appear just at or before tasseling of plants and continued upto a certain stage if weather conditions were favourable. A progressive increase of *turcicum* leaf blight were found upto 13 weeks of plant growth. Leaf and sheath blight showed an abrupt rise in disease intensity from 52 to 76 days of plant growth. *Diplodia* leaf spot and leaf blight incited by *H. maydis* appeared after tasseling and progressed till maturity. Downy mildew infection was observed from the seedling stage and was found to continue upto 1-2 weeks after silking. *Phaeosphaeria* leaf spot appeared 2-3 weeks after silking and continued till maturity.

Excepting *Rhizoctonia* stalk rot which are normally more virulent before silk, others were found to be most prevalent 2-3 weeks after silking. The same is also true in case of other ear rots excepting those caused by *Rhizoctonia zeae*.

INTRODUCTION

Different types of plant pathogens may attack the same host at different stages of plant growth. Before testing the same for resistance against specific diseases, it is necessary to have information on the most susceptible stages of the plant relating to specific diseases. An appearance of a disease in an early stage of plant growth may cause even total loss in yield, whereas late appearance of the same may harm the crop marginally. Leaf blight caused by *Helmin-*

thosporium turcicum, and leaf spot caused by *Phaeosphaeria maydis*, both might cause considerable damages of green leaves under a wet humid cooler Kalimpong condition, but due to late appearance of (2-3 weeks after silking) *Phaeosphaeria maydis*, damage is much less in comparison to leaf blight incited by *H. turcicum*.

Some pathogens may attack at different stages of plant and there is a variation of intensity of infection due to difference in stages in the growth of the host plant. For example, when *Rhizoctonia zeae* establishes infection on ear-primordial stage, there is complete rotting of infected ear, where as very late infections are only restricted to the husk-cover and does not cause any considerable damage of grain. Hence the study of variation of intensity of infection of pathogen on a host plant is crucial and accordingly it was taken up.

RESULTS AND DISCUSSION

Leaf and smut diseases

A comparative study of three leaf spot diseases in relation to different stages of growth on a few selected varieties are presented in Table 1. These varieties included both resistant and susceptible ones. In case of leaf blight caused by *Helm'niosporium turcicum*, appearance of disease was quite early in the season and there was progressive increase in infection with increase in age atleast upto third stage (13 weeks of growth) and complete field reaction to the disease was not evident until the plants were at least six to eight weeks old even in susceptible varieties (Jugenheimer, 1975). This gradual increase in severity of infection also pointed out the importance of the disease. In case of Physoderma brown spot, after appearance of the disease, comparatively early in plant growth intensity of infection remained more or less constant and did not show any increase with increasing age of the host plants.

Leaf and sheath blight caused by *Rhizoctonia zeae* showed an abrupt rise in disease intensity from 52 to 76 days of growth after which they remained more or less static. In a few cases, where disease was observed to be late in appearance, but increase in infection with age was not normally noticed.

Isolated pustules of common rust (*Puccinia sorghi*) might be observed on about one month old seedling, but full development of disease was not usually evident until 1-2 weeks after tasseling stage (Table 2). Though under green house condition full expression of disease symptoms with characteristics reactions might be evident after inoculation of plants at 2-4 weeks stage but in the field, even under condition of artificial inoculation, infection was evident in the later stages. Steps were taken to note the disease reaction under artificial condition of inoculation in the field. Inoculation was done on one

TABLE 1. Showing variation in intensity of disease incidence at different stages of plant growth

Sl. No.	Pedigree	Days to silk 75%	Helminthosporium turcicum (0-5)				Physoderma brown spot (0-5)				Leaf and sheath blight (0-5)			
			Plant age in days				Plant age in days				Plant age in days			
			52	76	94	116	52	76	94	116	52	76	94	116
1.	Khyber x Himala	65	1.00	2.10	2.50	2.60	—	—	—	—	0.30	1.00	1.00	1.00
2.	Khyber x Var. cross 80	68	0.45	1.40	1.45	1.50	0.11	0.33	0.33	0.33	0.15	1.20	1.30	1.30
3.	Khyber x Phil. DMR-1	66	0.12	0.25	0.30	0.30	—	—	—	—	—	0.50	0.75	0.75
4.	Khyber x Tuxpeno	71	0.68	1.70	1.85	1.85	—	—	—	—	—	1.00	1.20	1.20
5.	Himala x Var. cross 80	68	0.20	1.00	1.11	1.11	—	—	—	—	—	—	—	—
6.	Kalimpong white flint	71	0.10	0.32	0.32	0.33	0.05	0.05	0.05	0.05	—	—	—	—
7.	Himala x Phil. DMR-4	68	0.35	0.90	1.02	1.02	—	—	—	—	—	—	—	—
8.	Himala x Tuxpeno	71	0.40	0.62	0.70	0.70	0.20	0.25	0.25	0.25	—	—	—	—
9.	Var. cross 80 x Phil. DMR-4	74	0.37	1.15	1.90	1.95	—	—	—	—	—	0.50	0.55	0.55
10.	E. H. 2380	73	0.25	0.35	0.35	0.35	—	—	—	—	0.50	1.00	1.00	1.00
11.	Var. cross 80 x Tuxpeno	73	0.50	0.82	1.27	1.27	—	—	—	—	—	0.80	0.80	0.80
12.	Tuxpeno	75	0.10	0.27	0.37	0.37	0.10	0.25	0.40	0.40	0.20	0.80	1.00	1.00
13.	Phil. DMR-4 x Tuxpeno	67	—	0.07	0.10	0.10	—	—	—	—	0.30	1.00	1.25	1.25
14.	Vijay	74	—	0.80	0.90	0.90	0.05	0.05	0.10	0.10	0.25	0.68	0.68	0.68
15.	Khyber x Blanco Pakistan	73	0.70	2.00	2.15	2.15	—	—	—	—	—	—	—	—
Total			5.22	13.63	16.29	16.50	0.51	0.93	1.13	1.13	1.70	8.48	9.48	9.53
Average			0.35	0.90	1.08	1.10	0.03	0.06	0.07	0.07	0.11	0.56	0.60	0.64

TABLE 2. Showing the variation of incidence of ear rots and downy mildew and common rust at different stages of plant growth.

Sl. No.	Pedigree	Common rust (0-5)					B. S. downy mildew (%)				
		Plant age in days					Plant age in days				
		55	73	98	108	113	55	73	98	108	113
1	VLI x Karimnagar local	1.40	1.57	1.57	1.57	0.02	10.00	25.00	35.00	35.00	35.00
2	16 x Kulu local	1.32	1.65	1.65	1.65	0.10	—	—	—	—	—
3	American Early x Ant. Gr. II	1.55	2.40	2.40	2.40	0.10	—	—	—	—	—
4	Cuba II J ₁ (Arr 2) x J ₁ (Arr 2)	0.47	0.77	0.77	0.77	0.10	—	10.00	20.00	20.00	20.00
5	J 607 x J 305	0.80	0.89	0.89	0.89	—	5.00	25.00	27.77	27.77	27.77
6	J 607 x Mazela Amar Sel	0.77	1.10	1.10	1.10	—	5.00	10.00	10.00	10.00	10.00
7	J 24 x J 607	0.36	0.43	0.43	0.43	—	31.81	36.36	36.36	36.36	36.36
8	J 617 x TAD	0.75	1.05	1.05	1.05	0.30	4.16	10.00	10.00	10.00	10.00
9	Antigua 3D x St. Croix 4D	1.35	1.97	1.97	1.97	0.32	—	—	—	—	—
10	Sikkim 76-44	0.72	1.05	1.05	1.05	—	—	14.55	14.55	14.55	14.55
11	J 607 x EC 103838	1.27	1.40	1.40	1.40	0.02	—	12.50	40.00	40.00	40.00
12	J 607 x J 605	1.22	1.95	1.95	1.95	—	—	—	—	—	—
13	J 607 x Antigua Gr. I	0.75	0.95	0.95	0.95	—	—	5.00	5.00	5.00	5.00
14	Bodhipur yel x Ec 103338	1.30	1.52	1.52	1.52	—	—	16.66	16.66	16.66	16.66
15	Bodhipur yel x (PS) x EC 103838 (PS)	0.70	1.05	1.05	1.05	—	—	10.00	15.00	15.00	15.00
16	J 607 er 155 x J 603 er 247	1.62	2.32	2.32	2.32	0.11	—	—	—	—	—
17	Sikkim 76-35	1.02	1.42	1.42	1.42	—	—	—	—	—	—
18	Sikkim 76-34	0.72	0.87	0.87	0.87	—	3.5	10.00	10.00	10.00	10.00
19	NP 62 x Hunius	0.20	0.37	0.37	0.37	—	—	—	—	—	—
20	Na 104 x Hunius	0.62	0.90	0.90	0.90	—	—	5.00	10.00	10.00	10.00
21	Na 21 x Harius	1.15	1.60	1.60	1.60	—	—	—	—	—	—
22	Na 82 x Hunius	1.00	1.32	1.32	1.32	—	—	—	—	—	—
23	Golden Crystal x Hunius	0.95	1.22	1.22	1.22	—	—	10.00	15.00	15.00	15.00
24	Akber x Hunius	0.92	1.12	1.12	1.12	—	10.00	10.00	20.00	20.00	20.00
Total		22.93	30.89	30.89	30.89		69.47	210.07	284.84	287.57	287.57
Average		0.95	1.28	1.28	1.28		2.89	8.75	11.86	11.98	11.98

able 2. contd.

Sl. No.	Common Smut (%)				Gibberella ear rot (%)				Rhizoctonia ear rot (%)				Diplodia ear rot (%)			
	55	73	98	108	55	73	98	108	55	73	98	108	55	73	98	108
1.	—	—	—	—	—	—	10.00	10.00	—	—	—	—	—	—	5.00	5.00
2.	—	—	—	—	—	—	15.00	15.00	—	—	—	—	—	—	—	—
3.	—	—	5.00	5.00	—	—	—	—	—	—	—	—	—	—	—	—
4.	—	—	—	—	—	—	—	—	2.00	5.00	5.00	5.00	—	—	—	—
5.	—	—	—	—	—	—	—	13.33	—	—	—	—	—	—	—	—
6.	—	—	—	—	—	—	—	—	1.50	5.00	5.00	5.00	—	—	—	—
7.	—	—	—	—	—	—	—	3.84	1.00	4.54	4.54	4.54	—	—	—	—
8.	—	—	—	—	—	—	5.00	5.00	—	—	—	—	—	—	5.00	7.50
9.	—	—	—	—	—	—	2.94	2.94	—	—	—	—	—	—	—	—
10.	—	—	5.00	5.00	—	—	5.00	5.00	—	—	—	—	—	—	—	—
11.	—	—	—	—	—	—	5.00	10.00	—	—	5.50	5.50	—	—	—	—
12.	—	—	—	—	—	—	5.00	10.00	—	—	—	—	—	—	10.00	10.00
13.	—	—	—	—	—	—	—	5.00	—	—	—	—	—	—	—	—
14.	—	—	5.00	5.00	—	—	—	5.00	1.75	5.00	5.00	5.00	—	—	—	—
15.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16.	—	—	—	—	—	—	—	4.16	—	—	—	—	—	—	—	—
17.	—	—	5.00	5.00	—	—	9.44	13.33	—	—	5.00	5.00	—	—	10.00	10.00
18.	—	—	—	—	—	—	10.00	10.00	—	—	—	—	—	—	—	—
19.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20.	—	—	—	—	—	—	—	5.00	—	—	—	—	—	—	—	—
21.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23.	—	—	—	—	—	—	—	4.54	2.00	4.54	9.09	9.09	—	—	—	—
24.	—	—	—	—	—	—	—	—	2.50	5.00	10.00	10.00	—	—	5.00	5.00
Total	—	—	20.00	20.00	—	—	67.38	122.14	10.75	39.53	53.63	53.63	—	—	35.00	37.50
Average	—	—	0.83	0.83	—	—	2.80	5.08	0.44	1.64	2.23	2.23	—	—	1.45	1.56

N. B. Days to silk (75%) varied 60-70 days for all varieties.

month old seedling with brushing off fresh uredia on the young leaves. Symptoms of the disease began to appear within one week after inoculation, but full expression of the disease was noticed later.

Thus it may be stated that appearance of common rust was quite early and further progress of the disease would take place later upto a certain stage and after which there would be no further increase. Usually after 10 weeks of plant age, increase in disease intensity was not observed as shown in Table 2.

Downy mildew infection was observed from the seedling stage and was found to continue upto 1-2 weeks after silking, thereafter no further progress of infections was observed, though there might be cases of increase in intensity of disease upto 12 weeks of age (Table 2).

TABLE 3. Showing the variation in incidence of *Phaeosphaeria* leaf spot at different stage of plant growth

Sl. No.	Pedigree	Plant age in days		
		70	83	100
1.	HP 81	—	0.40	2.10
2.	HP 203	—	0.10	1.80
3.	HP 62	—	1.10	3.00
4.	HP 73	—	0.50	2.90
5.	HP 99	—	1.20	2.00
6.	Amarillo-de-cuba	—	0.25	1.00
7.	HP 123	—	0.80	3.00
8.	HP 132	—	0.70	2.80
9.	HP 75	—	1.28	2.57
10.	HP 95	—	1.40	3.90
11.	HP 74	—	0.50	2.50
12.	MZ 28	—	0.20	1.75
13.	Ganga 5	—	0.44	2.53
14.	Khalil	—	0.80	3.40
15.	Kisan	—	0.50	1.14
16.	A ₂ composite F ₅ 72 L	—	1.00	2.48
17.	MR 31	—	1.28	2.88
18.	Jawhar x Thai comp. 1.	—	0.30	2.30
19.	HP 34	—	1.00	3.75
20.	HP 119	—	0.10	1.12
21.	HP 43	—	1.00	3.12
22.	HP 66	—	0.20	1.44
23.	Suwan source 6	—	0.50	1.53
	Total	—	15.55	54.83
	Average	—	0.67	2.38

Leaf spot caused by *Phaeosphaeria maydis* was found to appear in the later stage of plant growth. A progressive increase in disease intensity was observed with increase in age of the plant till the plants remained green (Table 3). Generally disease appeared two to three weeks after silking.

Diplodia leaf spot was generally found after tasseling and the disease progressed gradually till the maturity of the plant. Infection was more evident towards declining phases of the growth and development of the plant (Table 4). It may be categorised as a mature plant disease.

TABLE 4. Showing the variation in incidence of Diplodia leaf spot at different stages of plant growth

Sl. No.	Pedigree	Plant age in days			
		55	73	91	117
1.	L ₃ (Limns)	—	0.30	0.57	0.73
2.	A 235 PL	—	0.26	0.36	0.36
3.	TIJ x P. Planta Baja	—	0.23	0.23	0.50
4.	Comp. shed 3	—	0.03	0.56	0.63
5.	Ganga-2	0.50	1.50	2.00	2.50
6.	Varietal cross 80	—	—	0.22	0.27
7.	H.P. 99	—	0.10	0.10	0.20
8.	Syn. Var. 108	—	—	0.71	0.71
9.	Vikram	0.10	0.38	0.38	0.38
10.	Syn. Var. 105	—	0.20	0.20	0.29
	Total	0.60	3.00	5.33	6.57
	Average	0.06	0.30	0.53	0.65

Leaf blight caused by *Helminthosporium maydis* was found usually on plants attaining maturity and the disease was not evident before silking of the plants under Kalimpong conditions to increase till the leaves remained green.

Smut galls caused by *Ustilago maydis* were observed to appear on the aerial parts of the plants from seedling stage to mature plants. Smut galls which were formed on ear and tassel appeared during flowering time. A progressive ear and tassel-break infection was observed at 98 days of growth stage under field conditions in the Kalimpong hills (Table 2), and thereafter no increase in disease incidence could be noticed.

Stalk rots

Rhizactonia stalk rot

Stalk rot caused by *Rhizoctonia zeae* was observed from the early stages of plant growth upto 2-3 weeks after silking. Normally the more susceptible stage was observed to be before silking. On the data presented in the Table 5,

it appeared that there was a gradual progress of disease with increase in susceptibility upto pre-silking stage after which disease intensity decreased as the plants approached maturity. Though infection took place much earlier, damage was noticed at a much later stage.

TABLE 5. Showing variation in incidence of *Rhizoctonia* stalk rot at difference stages of plant growth

Sl. No.	Pedigree	Plant age in days				
		35	50	65	80	100
1.	(CM 201 x CM 110) br	7	30	40	40	40
2.	(CM 113 x CM 100) br	7	25	37	40	40
3.	(CM 400 x CM 600) br	10	40	45	50	50
4.	(CM 113 x CM 110) br	1	5	8	10	10
5.	(CM 201 x CM 105) br	8	35	50	50	50
6.	(CM 202 x CM 201) (CM 103 x CM 113) br	5	30	40	40	40
7.	(CM 202 x CM 201) (CM 105 x CM 113) br	3	30	40	40	40
8.	(CM 202 x CM 201) (CM 112 x CM 105) br	4	25	35	40	40
9.	(CM 201 x CM 113) br	6	25	35	40	40
10.	D 745	5	25	40	50	50
11.	D 746	6	30	40	45	45
12.	E. H. 2420	3	20	25	30	31
13.	Tuxpeno	—	8	10	10	10
14.	Phil DMR-5	5	25	37	37	37
15.	3369 AMR	2	15	20	25	26
	Total	72	368	494	547	549
	Average	4.80	24.53	32.93	36.46	36.60

Pythium and *Erwinia* stalk rot

Both the diseases appeared at time of appearance of silking and continued 2-3 weeks thereafter provided the weather conditions remained favourable for development and spread of disease. Highest disease incidence was normally noticed 2-3 weeks after silking.

Diplodia and *Gibberella* stalk rot

Infection appeared late, 2-3 weeks after silking and damage was not serious and infection was found to be restricted. Both the stalk and ear rots caused by these two pathogens were found on mature plants.

Ear rots

As expected various ear rots caused by *Diplodia zeae*, *Gibberella zeae*, *Fusarium moniliforme*, *Penicillium* spp. and *Aspergillus* spp. excepting *Rhizoctonia* ear rot caused by *Rhizoctonia zeae* appeared very late almost towards maturity.

Even in those varieties which showed heavy infection, disease was usually observed between 98 to 114 days (Table 2). This was also true in case of kernel rot caused by *Fusarium moniliforme*.

Rhizoctonia ear rot caused by *Rhizoctonia zeae* could cause damage to the ears from primordial stage to almost maturity. Immature, soft, succulent ears were found to be more vulnerable to attack than mature ones. From the Table 2, it was evident that there was a gradual increase in incidence of the disease from 98 days to full maturity of the crop.

Ear rot caused by *Penicillium* and *Aspergillus* spp. was found to be more of post-harvest stage phenomenon. Infection was in almost at the mature stage and was linked with dying sheaths of cobs which become infected under highly moist and humid conditions.

REFERENCES

- Jugenheimer, R. W. (1975). Corn Improvement, Seed Production and Uses. John Wiley & Sons, New York/London/Sydney/Toronto.