REACTIONS OF THREE HUNDRED CORN FAMILIES TO PATHOGENIC FUNGI AT DIFFERENT LOCATIONS IN KANSAS AND MEXICO

by

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INTRODUCTION

Corn (Zea mays L.) is among the important cereal food crops grown in many countries of the world. It is cultivated in many areas where it is used as feed for livestock, or as basic food for low income families (7).

In most of these corn-producing areas, the average corn yields are usually low, sometimes less than 1000 kg/hectare.

A number of factors contribute to low yields. However, these may be difficult to generalize, for production problems vary from one country to another, and from one area to the other, even in the same country. But for yields to be increased, the limiting factors must be investigated in each ecological environment.

Diseases cause considerable damage and reduction in yield in most of the corn-growing regions, especially in the tropics where the absence of a cold season permits a continuous growth of the crop and multiplication of pathogens. Disease control through resistant cultivars seems to be very promising and chemical control also may be useful during disease epidemics.

There is no doubt that increases in corn yields and production will help ease the acute food problems of the world. In order to increase yields, the results of applied corn research conducted under local conditions must be passed on to the farmer. "Unless knowledge developed from scientific agricultural research is applied to areas of human welfare where it is needed, it becomes merely a sterile science" (8).

In this project, the reactions of 300 corn families to plant pathogenic fungi were measured at three different locations in an attempt to develop disease resistant synthetics that might be used in these areas and also to measure grain yields after one cycle of selection.

LITERATURE REVIEW

Common corn smut.—The common corn smut, caused by *Ustilago maydis* (DC.) Cda., has been known for a long time (1, 6).

Yield losses caused by this disease may vary from one area to the other and from year to year, depending on environmental conditions.

Immer and Christensen (13) showed that yield losses due to smut may be as high as 50% depending on the size and location of the smut galls. Johnson and Christensen (14) arrived at the same conclusion.

Generally, a single smut gall on the plant may reduce grain yield about 25%, or may even cause barrenness of the plant (6). However, yield losses in resistant varieties rarely exceed 2% (1).

Marked differences in susceptibility to smut among open-pollinated corn cultivars have been reported by some investigators (6). This suggests varietal resistance as a means of disease control.

Although resistant cultivars exist, little is known regarding the basic nature of resistance of corn to smut. Resistant corn cultivars may be selected on the basis of their ability to withstand natural infection in the field.

Stalk rot.—Stalk rot of corn is a very destructive disease common in all corn growing areas. It is a disease complex caused by several species of fungi (1, 3, 5).

The severity of disease may be influenced by many factors (1, 2, 5, 9, 19, 20, 22).

Corn stalk rot may cause direct yield losses in the form of premature plant death, and poorly finished ears which are usually light in weight (1, 5).

Severe yield losses attributed to corn stalk rot have been reported by several workers. Wysong and Kerr (26) reported losses due to stalk and root rot averaged at 35%. Hooker and Britton (12) reported 18% yield loss from rotted but standing stalks and a 27% yield loss from plants both lodged and rotted. Wilcoxson (25) obtained as much as 17% reduction in yield after artificial inoculation of corn hybrids with *Diplodia zeae* and *Fusarium graminearum*.

Fusarium moniliforme Sheldon is a common incitant of corn stalk rot (1, 5, 15). Corn hybrids and inbred lines vary in susceptibility to the stalk-rotting pathogens.

Selection for resistance to *F. moniliforme* may provide a general measure of resistance to stalk rot in corn cultivars although resistance to one pathogen does not necessarily imply resistance to other stalk-rotting organisms. Hooker (11) stated that corn hybrids resistant to one stalk rot pathogen tend also to be resistant to other pathogens that attack the plant at a similar time and in a similar manner.

Southern corn leaf blight.—Southern corn leaf blight, incited by *Helminthosporium maydis* Nisikado & Miyake (*Cochliobolus heterostrophus* Drechsler), is perhaps one of the most common and widely spread diseases of corn. Mercado and Lantican (16) first reported the susceptibility of corn hybrids possessing the "Texas male-sterile cytoplasm" to *H. maydis* in the Philippines. Ullstrup and Miles (23) pointed out that southern corn leaf blight may cause severe yield losses in susceptible corn varieties in the United States.

However, southern corn leaf blight was not considered to be of any major importance in the United States until recently. The epiphytotics of the disease in the United States in 1970, reported to have been influenced by favorable environmental conditions (18), caused severe losses in corn (24).

A virulent strain of *H. maydis*, identified as Race T, was isolated from corn containing Texas male-sterile cytoplasm (21). Corn lines with cytoplasmic male sterility are more susceptible to *H. maydis* than their normal counterparts.

Resistant varieties have been an effective means of control of this disease (10). Miller *et al.* (17) have suggested a forecast method to keep southern corn leaf blight in check. A similar forecast method has been developed for *H. turcicum* (4).

MATERIALS AND METHODS

Source of corn.—Three genetically variable corn populations, each consisting of 100 families, were used in this study. Families were groups of plants from single ears of corn and consisted of both half- and full-sib progenies.

These populations were Kansas Drought Synthetic (KDS), Mexican-Mixture (Mex-Mix), and Amarillo Bajio (Amar. Baj.). The KDS is a synthetic of ten inbred lines selected for drought resistance in Kansas. Mex-Mix is a composite consisting of nearly 6000 world collections. This composite was made in Mexico and sent to Cornell University for testing. The late maturing cultuvars at Cornell were killed by frost; thus Mex-Mix is essentially the early cultivars that survived the frost. Amarillo Bajio is a cross between United States corn belt germplasm and tropical cultivars. The crosses were made at Bajio in Mexico and the offspring called Amarillo because of the yellow color of the kernels.

Inoculum and source.—Stalk rot was artificially induced with isolates of *Fusarium moniliforme* at one location in Kansas and a combination of *F. moniliforme* and *Cephalosporium* species at another location in Mexico. Isolates were collected from Kansas, Illinois, Nebraska, and Mexico. There were no artificial inoculations with the fungi causing common smut and southern corn leaf blight.

Fungus isolation from seed.—Five infected kernels from each sample were surface sterilized by immersing them for one minute in a solution of 70% ethyl alcohol and for one minute in 2% sodium hypochlorite. The kernels were then rinsed in sterile distilled water before plating in petri dishes containing potato dextrose agar (PDA) acidified to pH 5 with 25% lactic acid. Kernels were plated at the rate of one per petri dish.

Any *Fusarium* species that grew out was picked up with a flame-sterilized needle, and transferred aseptically to other petri dishes containing PDA. Cultures of *F. moniliforme* were incubated in the laboratory at 25 C and were ready for toothpick inoculation after 10 days.

Preparation of toothpicks.—Toothpicks were prepared as described by Young (27) and were inoculated with either *F. moniliforme* isolates or with isolates of *F. moniliforme* and *Cephalosporium* species. The toothpicks were ready for stalk inoculations in 15 days.

Inoculation procedure.—Plants were inoculated two weeks after silking by inserting an infested toothpick into a hole made with a battery operated electric drill in the middle of the first elongated internode above the brace. Ten plants per plot were inoculated and disease ratings were taken four weeks after inoculation.

Disease index.—Ten plants per plot were rated for stalk rot severity on a 1-5 scale shown below. A disease index was calculated for each family and any family with an index of 2.5 or less was regarded as resistant, and susceptible if above 2.5.

Rating		Description
1	:	Less than 25% infection of internode
2	:	26 - 50% infection of internode
3	:	51 - 75% infection of internode
4	:	76 - 100% infection of internode
5	:	Infection extending into adjacent internodes.

A similar 1-5 scale shown below was used for leaf blight infection, and all 20 plants in a row were rated for disease incidence. A disease index was calculated as for stalk rot.

Rating		Description
1	:	Slight infection; lower leaves with few scattered lesions.
2	:	Light infection; lower leaves with moderate number of lesions.
3	:	Moderate infection; many lesions on lower leaves, few on middle leaves.
4	:	Heavy infection; many lesions on lower and middle leaves extending to upper leaves.
5	:	Very heavy infection; abundant lesions on all the leaves.

Smut infection was rated on a percentage basis on all plants in the plot. Any plant with one or more smut galls was counted as infected irrespective of size, position and number of galls.

Field plan.—Experiments at all locations were laid out in a randomized complete block design and replicated twice. A plot consisted of two rows, each 7.0 m long and 0.75 m apart. Planting was at the rate of two seeds per hill, with hills 0.25 m apart. Plants were later thinned to one per hill.

Testing.—Synthetics for smut resistance and stalk rot resistance were tested with original synthetics and synthetics developed for grain yield in 1975 following stalk inoculation with *Fusarium moniliforme* isolates. Experiments were carried out at two locations in a split-plot design with main plots arranged in a randomized complete block.

EXPERIMENTAL RESULTS

The 100 families from each of the three corn populations varied in reactions to pathogenic fungi at each location (Tables 1, 2, 3).

The families showed significant differences in reactions to common smut (Table 4, Fig. 1). The average smut reading on percentage basis for Kansas Drought Synthetic was 0.9, with a range of 0.0 to 5.5% (Table 1). For the Mexican-Mixture families, the average smut reading was 6.5%, with a range of 1.0 to 18.0% (Table 2). Amarillo Bajio population showed an average reading of 3.4% smut infection, with a range of 0.0 to 8.5% (Table 3).

At Manhattan, Kansas (USA), there were significant differences among Mexican-Mixture families in reactions to stalk rot (Table 4, Fig. 2). The 100 families of Kansas Drought Synthetic averaged 3.8 on a scale of 1-5 for stalk rot, with a range of 2.9 to 4.5 (Table 1). The 100 families of Mexican-Mixture showed an average stalk rot index of 3.5, with a range of 2.1 to 4.4 (Table 2), while the 100 families of Amarillo Bajio showed an average stalk rot index of 3.5, with a range of 2.4 to 4.4 (Table 3). At Tlaltizapan, Mexico, where both _F. moniliforme_ isolates and _Cephalosporium_ species were used for inoculations, all 300 families showed increased susceptibility to stalk rot. There were no significant differences in reaction (Table 4, Fig. 3).

The reactions to southern corn leaf blight at Poza Rica, Mexico, varied significantly among the 300 families (Table 4, Fig. 4). On a 1-5 scale, Kansas Drought Synthetic showed an average reading of 3.6, with a range of 2.4 to 4.4 (Table 1), while the average leaf blight index for Mexican-Mixture

Table 1. Means of disease ratings for Kansas Drought Synthetic families to pathogens at three different locations, 1974

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
1	0.5	4.1	4.7	4.1
2	0.0	3.6	4.4	4.4
3	1.0	4.0	4.8	3.7
4	0.0	4.1	4.4	4.1
5	1.0	3.2	4.7	3.6
6	1.0	4.3	4.9	3.4
7	0.5	3.4	4.9	3.4
8	1.0	4.0	5.0	4.0
9	1.5	4.1	5.0	3.8
10	3.0	3.9	5.0	4.1
11	0.0	3.3	4.9	3.3
12	0.5	3.7	4.9	3.9
13	0.0	3.9	4.8	3.0
14	1.5	4.3	5.0	2.8
15	2.0	3.7	4.7	3.1
16	1.0	4.1	4.9	3.4
17	0.5	3.9	5.0	3.3
18	0.0	3.6	5.0	3.2
19	2.0	3.6	5.0	4.0
20	0.5	2.9	4.6	3.6

Table 1. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
21	0.0	4.2	5.0	3.7
22	1.5	3.2	5.0	4.1
23	0.0	3.8	4.9	3.6
24	0.5	3.6	4.9	3.8
25	1.0	4.0	4.9	3.8
26	0.0	3.7	4.7	3.4
27	1.0	4.1	4.6	3.6
28	0.0	3.7	4.8	3.1
29	0.5	4.0	4.9	3.2
30	0.0	3.8	4.9	3.1
31	1.0	3.6	5.0	3.6
32	0.5	3.6	5.0	3.6
33	1.0	3.4	4.9	3.5
34	0.0	3.4	5.0	3.9
35	1.0	3.4	5.0	3.7
36	0.0	3.7	5.0	3.7
37	1.0	3.7	4.7	3.9
38	5.0	3.7	5.0	4.2
39	3.0	3.6	5.0	3.6
40	0.5	4.3	4.5	4.0

Table 1. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
41	0.5	3.8	4.9	4.0
42	0.0	3.4	5.0	3.2
43	0.0	3.6	5.0	3.7
44	1.0	4.1	4.9	3.5
45	1.0	4.2	4.7	3.4
46	1.0	3.8	4.7	3.1
47	0.0	3.8	5.0	4.1
48	2.5	3.7	4.9	3.0
49	0.5	4.2	5.0	4.1
50	2.5	3.9	4.7	3.1
51	0.0	4.2	4.6	3.5
52	3.5	3.8	5.0	3.7
53	5.5	4.1	4.6	2.4
54	0.5	3.5	4.7	2.7
55	0.0	3.2	4.8	3.3
56	1.5	4.1	4.9	3.2
57	1.0	3.8	5.0	3.8
58	0.0	3.8	4.8	3.6
59	1.0	3.4	5.0	3.7
60	0.5	3.7	5.0	3.3

Table 1. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
61	1.0	3.5	5.0	3.9
62	0.5	3.2	4.6	3.1
63	1.0	4.2	4.6	3.2
64	0.5	4.1	4.9	4.1
65	0.0	3.9	4.6	3.1
66	0.0	3.6	4.7	3.6
67	1.5	3.6	5.0	3.4
68	0.5	3.4	4.8	3.9
69	0.0	3.4	4.9	3.9
70	0.0	3.1	4.9	4.0
71	1.5	4.2	5.0	3.7
72	0.5	4.1	5.0	3.4
73	0.5	3.9	4.9	4.1
74	0.0	4.1	5.0	3.9
75	1.0	3.4	5.0	3.9
76	0.0	3.7	4.7	3.1
77	1.5	4.1	5.0	3.5
78	0.0	3.9	5.0	4.0
79	0.0	3.5	4.7	3.4
80	0.0	3.5	5.0	4.1

Table 1. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
81	1.5	4.1	5.0	4.3
82	0.0	3.7	4.7	3.7
83	2.0	3.5	4.9	3.2
84	1.0	3.8	4.7	2.8
85	0.0	4.2	4.8	3.7
86	1.0	3.9	4.8	3.5
87	0.0	3.6	5.0	3.5
88	2.0	3.5	4.7	4.2
89	0.5	4.0	5.0	3.8
90	1.5	3.7	4.9	2.8
91	1.0	4.5	5.0	3.6
92	1.0	3.8	5.0	4.1
93	0.0	3.7	5.0	4.1
94	2.0	3.4	4.8	3.4
95	0.0	3.8	5.0	3.3
96	0.5	3.4	5.0	4.1
97	0.5	3.6	5.0	3.7
98	0.0	4.2	4.9	3.3
99	0.0	3.4	4.9	3.1
100	2.0	3.9	4.8	3.6
Average	0.9	3.8	4.9	3.6
$LSD_{0.05}$	1.78	NS	NS	0.79

Table 2. Means of disease ratings for Mexican-Mixture families to pathogens at three different locations, 1974

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
1	2.0	4.0	4.8	3.2
2	14.5	3.8	4.8	4.3
3	5.0	3.2	4.8	2.4
4	10.0	4.2	4.8	2.3
5	5.0	3.1	4.7	2.7
6	6.0	3.3	4.8	2.4
7	4.5	3.9	4.8	2.6
8	9.5	3.4	4.7	2.5
9	7.5	3.8	4.6	2.5
10	2.5	3.6	4.8	2.5
11	5.0	3.4	4.6	2.5
12	4.5	4.0	4.6	2.4
13	10.5	3.4	4.7	2.6
14	6.0	4.1	4.7	2.6
15	4.5	4.2	4.6	2.5
16	3.5	2.3	4.6	2.7
17	4.5	3.6	4.8	2.4
18	9.0	3.7	4.5	2.5
19	10.5	3.7	4.8	2.4
20	5.5	2.8	4.7	2.7

Table 2. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
21	12.0	4.0	4.9	2.9
22	3.0	3.3	5.0	2.8
23	3.5	3.7	4.8	2.5
24	6.5	3.1	4.8	2.4
25	10.0	3.7	4.5	2.6
26	4.5	4.0	5.0	2.5
27	7.5	3.4	4.9	2.5
28	1.5	3.6	5.0	2.4
29	4.5	2.5	4.6	2.4
30	6.0	2.1	4.3	2.8
31	6.0	3.5	4.7	2.4
32	4.5	2.5	4.8	2.9
33	9.0	3.9	5.0	2.7
34	6.0	4.0	4.7	2.4
35	10.0	3.6	4.5	2.6
36	9.5	3.4	4.9	2.6
37	4.0	3.4	4.6	2.4
38	4.0	3.3	4.8	2.5
39	4.0	3.3	4.7	2.4
40	1.0	3.3	4.9	2.6

Table 2. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
41	5.5	4.3	4.7	2.8
42	12.0	3.0	4.8	2.0
43	4.0	3.5	4.9	2.5
44	3.0	3.9	4.8	2.4
45	6.0	3.5	4.7	2.2
46	8.0	3.4	4.6	2.6
47	3.0	3.3	4.6	2.4
48	17.5	4.4	4.6	2.5
49	5.0	4.1	4.7	2.4
50	4.5	3.2	4.7	2.5
51	7.0	3.2	4.4	3.3
52	9.5	3.9	4.8	2.3
53	7.5	3.6	4.7	2.6
54	7.0	3.4	4.9	3.9
55	7.5	3.8	4.6	2.6
56	2.0	3.4	4.8	2.2
57	8.5	3.6	4.8	2.3
58	7.5	3.8	4.4	3.1
59	5.0	3.4	4.9	3.6
60	7.0	3.2	4.9	2.2

Table 2. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
61	4.0	3.9	4.9	2.1
62	3.0	3.4	4.9	3.9
63	6.5	3.8	5.0	2.3
64	5.0	2.4	4.9	2.6
65	11.0	3.8	4.8	4.1
66	3.0	3.4	4.7	2.5
67	11.5	3.8	4.7	2.8
68	4.0	2.9	5.0	2.5
69	5.5	2.9	4.8	2.7
70	2.5	3.6	4.8	2.5
71	2.5	4.2	4.7	2.6
72	4.0	3.6	4.7	2.6
73	12.5	2.8	4.5	2.3
74	9.0	3.4	5.0	2.3
75	14.0	3.1	4.8	2.5
76	4.0	3.1	4.9	2.3
77	4.5	3.1	5.0	2.4
78	7.0	4.3	4.4	2.4
79	9.5	4.0	4.6	2.7
80	10.5	3.6	4.9	2.6

Table 2. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
81	3.5	3.5	4.9	2.4
82	5.0	3.7	4.6	2.5
83	4.5	3.6	4.8	2.8
84	18.0	3.7	4.9	2.8
85	5.5	3.4	5.0	2.3
86	3.0	4.0	4.7	2.5
87	10.0	4.2	4.8	2.3
88	7.5	3.7	4.9	2.6
89	6.0	3.8	4.8	2.4
90	2.5	3.5	5.0	2.6
91	4.5	3.3	4.6	3.0
92	10.5	3.3	4.9	2.6
93	4.0	3.0	4.8	2.8
94	2.5	3.6	4.6	2.3
95	6.5	3.9	4.7	2.4
96	7.0	3.6	5.0	2.7
97	7.0	3.3	4.7	2.3
98	10.5	3.9	4.8	2.7
99	6.0	3.1	4.9	2.9
100	7.0	4.3	4.8	3.3
Average	6.5	3.5	4.8	2.6
$LSD_{0.05}$	6.72	1.03	NS	0.57

Table 3. Means of disease ratings for Amarillo Bajio families to pathogens at three different locations, 1974

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
1	5.0	2.4	4.9	2.7
2	2.5	3.6	4.7	4.2
3	4.5	3.7	4.8	2.5
4	2.0	3.3	4.9	2.8
5	1.0	3.6	4.8	3.1
6	5.0	3.0	5.0	2.2
7	1.0	3.6	4.8	4.4
8	2.0	3.1	5.0	4.3
9	2.0	4.1	4.9	2.8
10	4.0	3.7	4.8	2.6
11	2.0	2.8	4.8	2.8
12	3.0	2.6	5.0	3.8
13	3.0	3.7	5.0	4.1
14	6.0	3.2	5.0	4.0
15	3.0	4.0	5.0	4.5
16	5.5	3.7	4.8	2.5
17	2.5	3.4	4.7	2.5
18	2.5	3.3	4.9	2.7
19	3.5	3.0	4.6	2.8
20	2.5	3.2	4.9	2.7

Table 3. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
21	4.0	3.6	4.9	2.5
22	2.0	4.0	4.9	2.5
23	4.0	3.0	4.6	2.5
24	5.0	3.9	5.0	3.0
25	5.0	3.5	5.0	2.6
26	2.0	4.1	4.5	3.2
27	3.0	3.4	5.0	2.8
28	2.0	2.9	4.8	4.8
29	3.5	3.3	4.8	4.6
30	3.0	3.2	4.9	4.5
31	5.0	3.9	4.9	3.7
32	6.0	3.3	4.9	4.0
33	0.5	3.1	4.9	4.7
34	3.5	3.7	5.0	3.8
35	8.0	4.4	4.7	4.5
36	5.5	4.1	5.0	4.1
37	2.5	2.9	4.6	4.3
38	3.0	3.4	4.8	2.5
39	1.5	4.0	4.9	2.3
40	5.5	3.4	4.9	3.4

Table 3. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
41	2.0	2.7	4.6	2.9
42	1.5	3.4	4.7	2.5
43	4.0	3.2	4.9	2.5
44	4.5	2.9	4.9	2.9
45	3.5	3.5	4.9	2.9
46	2.5	3.4	4.9	2.6
47	5.0	3.7	4.9	4.4
48	0.0	3.6	5.0	4.5
49	5.0	3.6	4.9	4.6
50	4.0	3.8	4.9	2.9
51	1.5	3.6	5.0	2.7
52	2.0	3.4	4.7	3.1
53	3.5	3.3	5.0	4.2
54	2.5	2.4	4.9	4.7
55	5.0	3.6	5.0	2.2
56	2.5	3.5	5.0	2.7
57	2.0	3.0	5.0	3.2
58	3.0	3.5	5.0	3.0
59	1.0	3.6	4.9	4.2
60	3.5	3.4	4.9	4.5

Table 3. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
61	3.5	3.7	5.0	2.5
62	3.0	3.3	4.8	2.9
63	5.5	3.1	4.6	2.8
64	5.0	3.4	5.0	2.4
65	4.0	4.0	4.8	4.0
66	1.5	3.2	5.0	2.5
67	3.0	3.5	5.0	3.2
68	3.5	3.3	5.0	4.3
69	1.5	3.3	4.8	2.5
70	3.5	4.0	4.9	2.4
71	2.5	3.5	4.8	3.5
72	5.0	3.3	5.0	2.5
73	3.0	3.4	4.9	3.0
74	7.0	3.5	5.0	2.7
75	3.5	3.1	4.6	3.1
76	3.0	4.4	5.0	2.9
77	3.0	3.1	4.8	2.6
78	8.5	3.4	5.0	4.5
79	4.0	3.3	4.8	2.6
80	2.5	3.0	4.7	2.5

Table 3. (Continued)

Family number (KSU 74)	Manhattan, Kansas		Tlaltizapan, Mexico	Poza Rica, Mexico
	Smut %	Stalk rot 1-5 Scale	Stalk rot 1-5 Scale	Leaf blight 1-5 Scale
81	2.5	4.2	4.8	3.4
82	3.0	3.4	4.7	2.5
83	3.0	3.5	4.8	4.8
84	3.5	4.2	5.0	4.5
85	5.0	3.5	4.7	3.8
86	4.5	3.9	4.8	2.4
87	3.0	3.5	4.7	2.8
88	4.0	4.0	4.8	2.6
89	1.0	3.7	5.0	2.3
90	3.0	3.9	4.9	4.5
91	3.0	3.7	5.0	2.3
92	2.5	3.7	5.0	4.6
93	1.5	3.8	4.9	2.6
94	2.5	3.2	4.9	2.9
95	3.0	2.6	5.0	2.9
96	2.5	3.6	4.9	2.5
97	2.5	2.9	5.0	2.7
98	3.5	3.3	5.0	2.4
99	3.5	3.1	4.9	2.4
100	5.5	3.5	4.8	2.4
Average	3.4	3.5	4.9	3.2
$LSD_{0.05}$	3.13	NS	NS	0.63

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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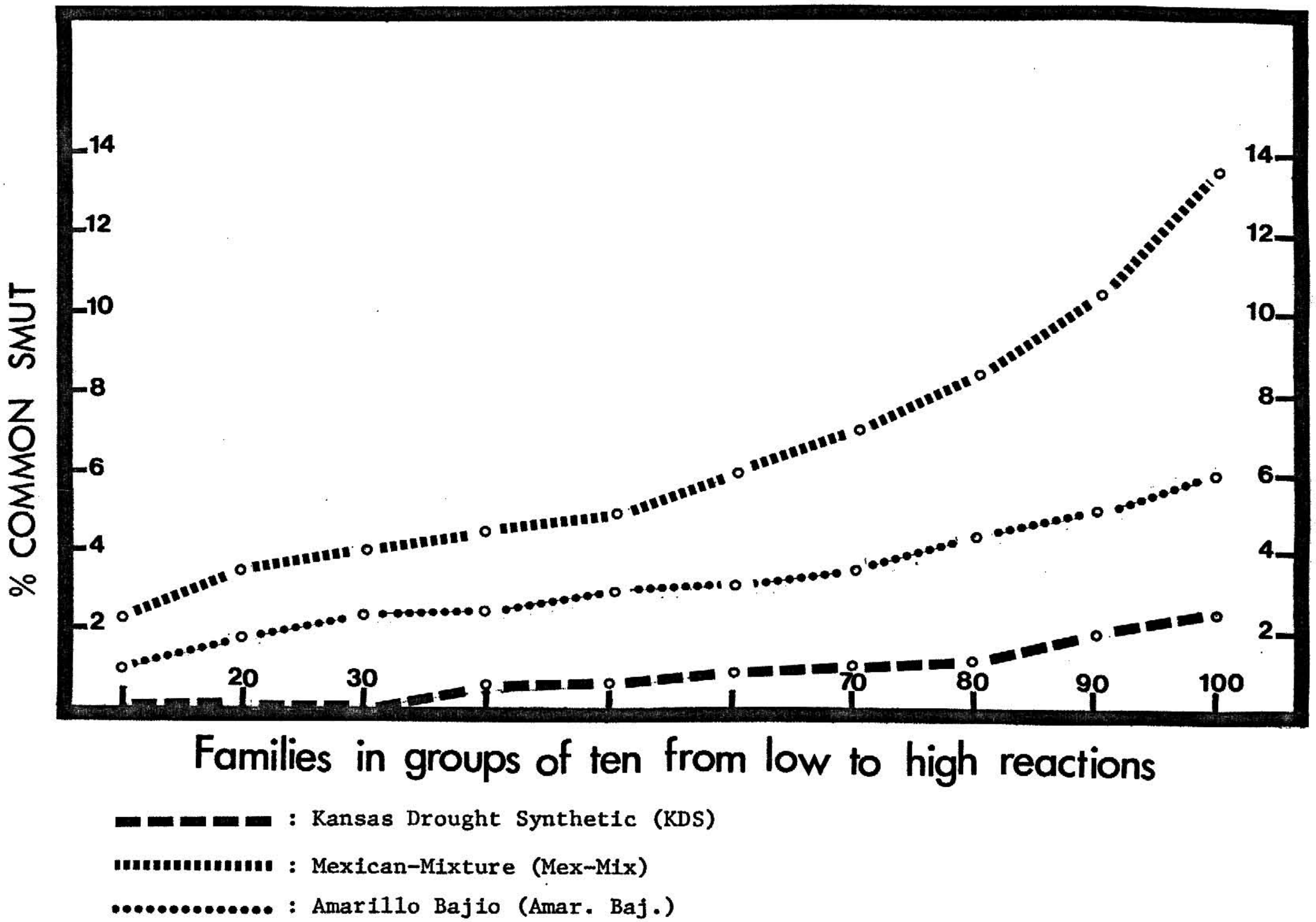

Fig. 1. Reactions of KDS, Mex-Mix, and Amar. Baj. corn families to Ustilago maydis (common smut) at Manhattan, Kansas (USA)

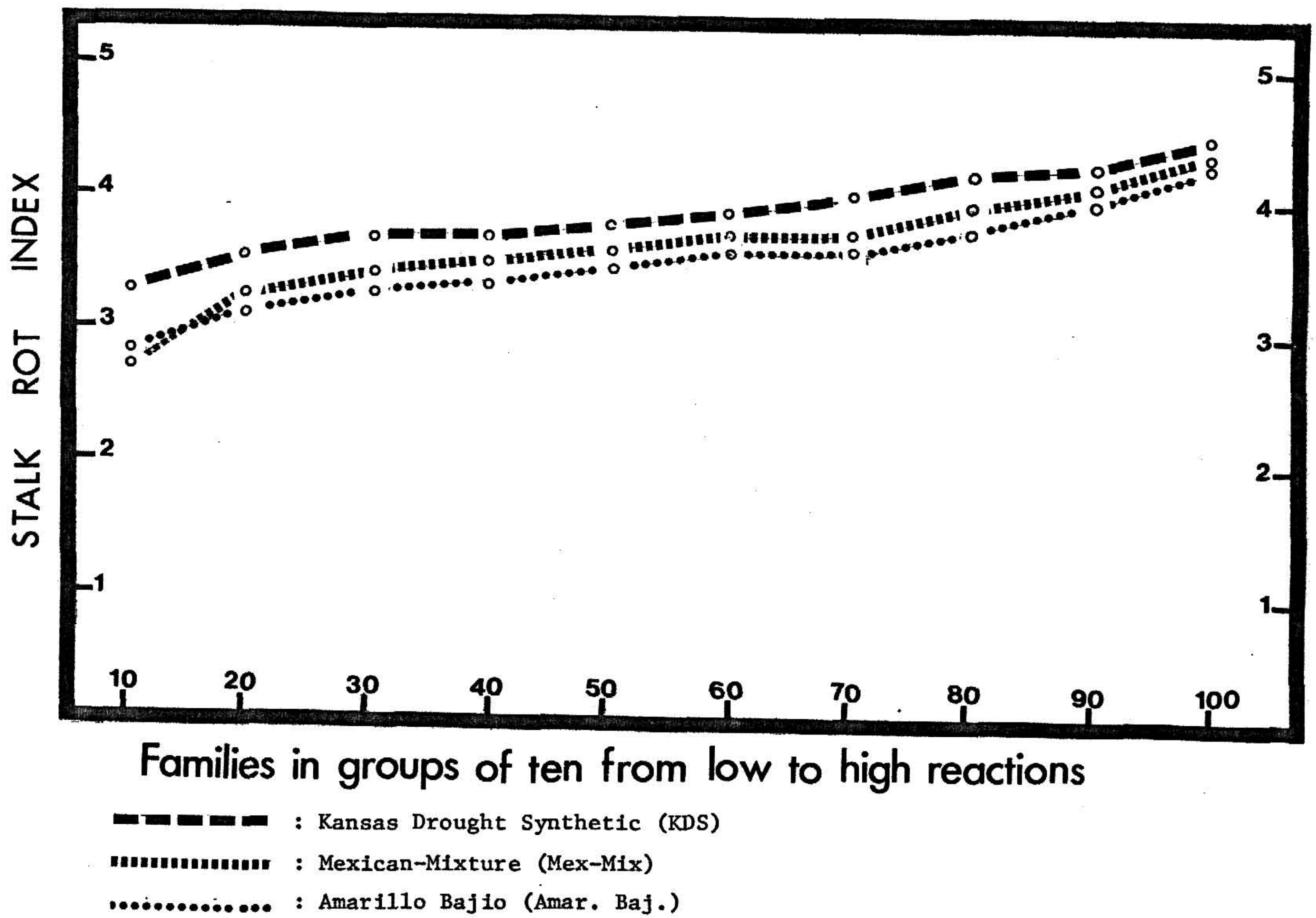

Fig. 2. Reactions of KDS, Mex-Mix, and Amar. Baj. corn families to isolates of *Fusarium moniliforme* (stalk rot) at Manhattan, Kansas (USA)

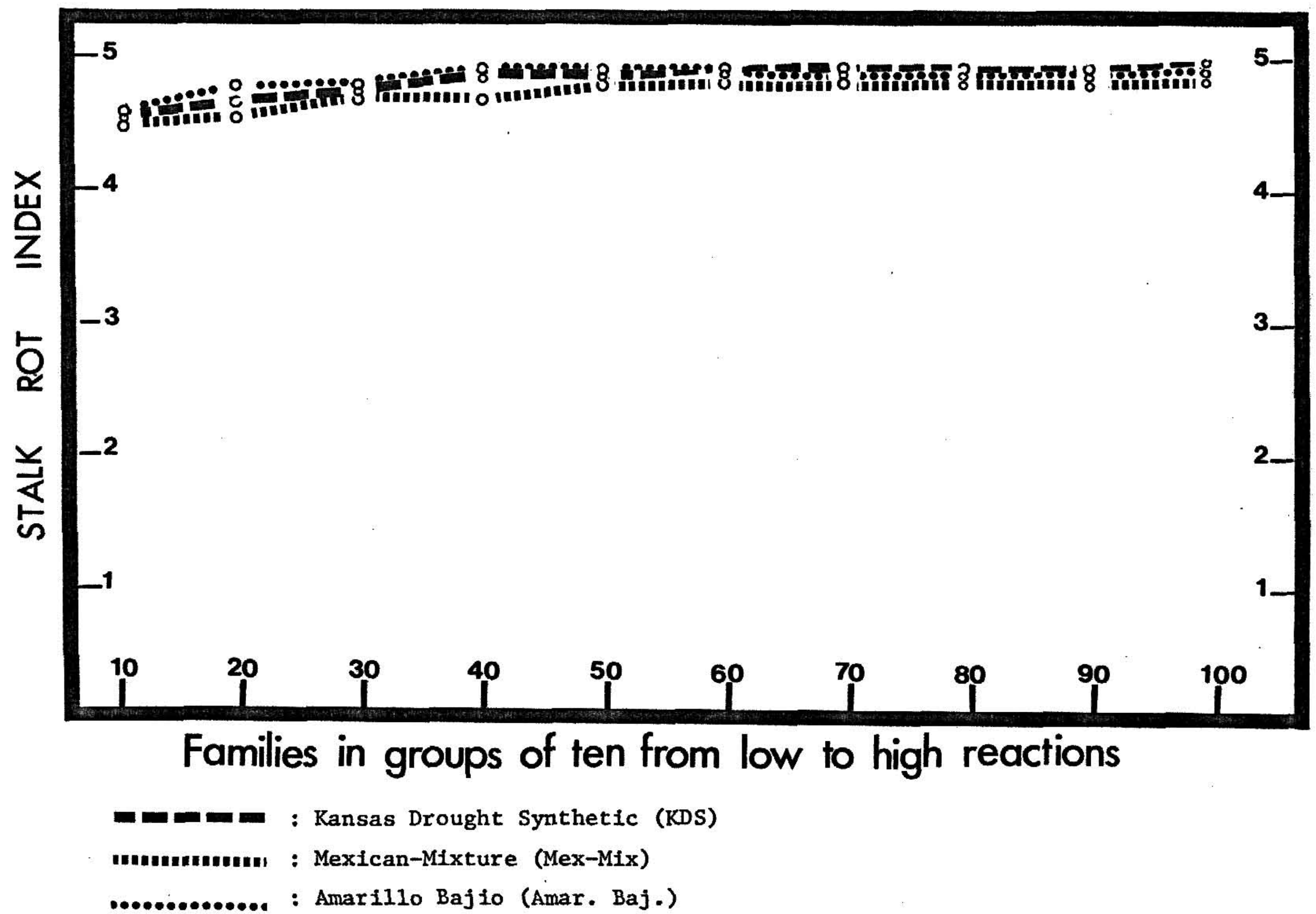

Fig. 3. Reactions of KDS, Mex-Mix, and Amar. Baj. corn families to Fusarium moniliforme and Cephalosporium species (stalk rot) at Tlaltizapan, Mexico

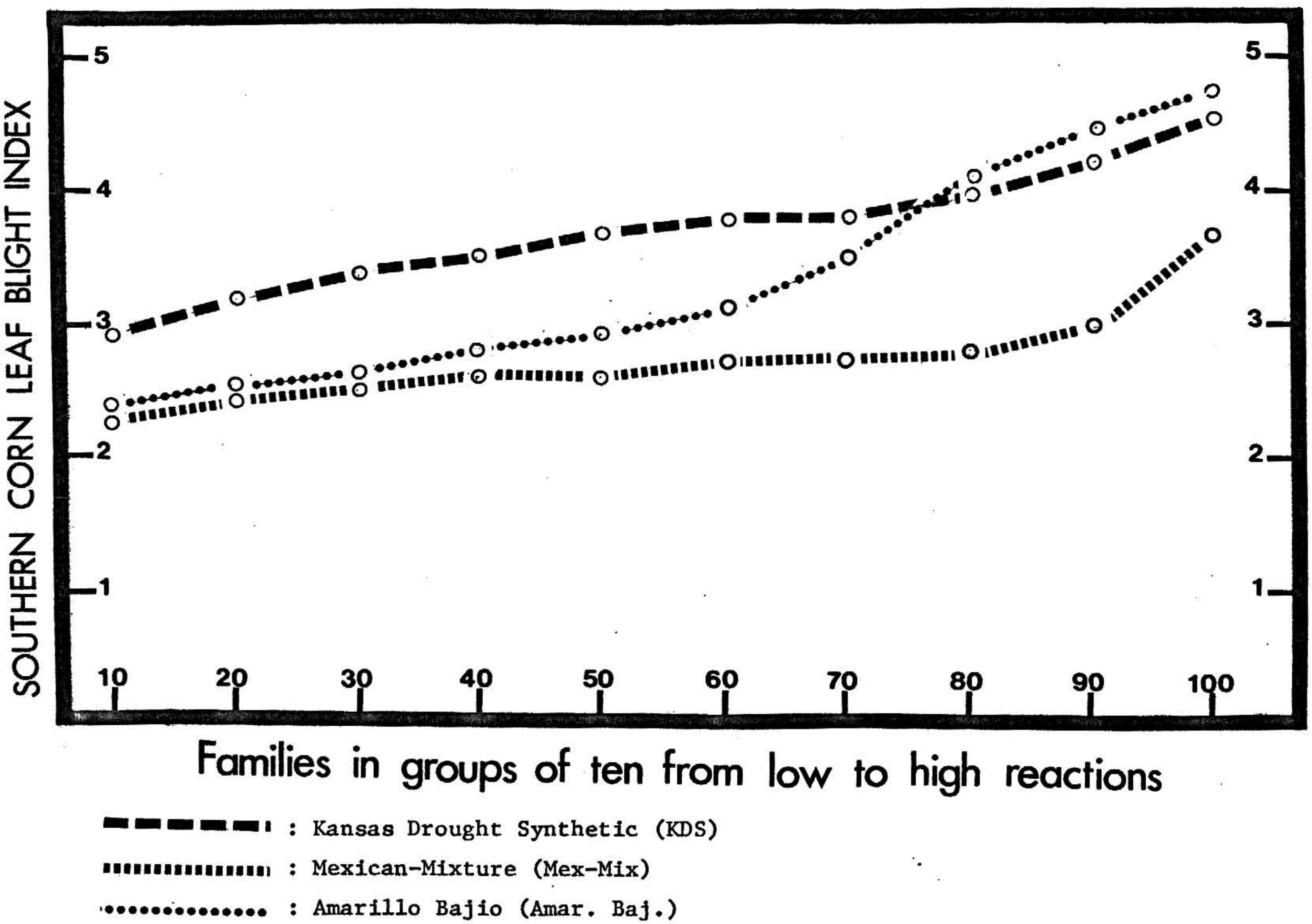

Fig. 4. Reactions of KDS, Mex-Mix, and Amar. Baj. corn families to <u>Helminthosporium maydis</u> (southern corn leaf blight) at Poza Rica, Mexico

Table 4. Analysis of variance for F tests on reactions to *U. maydis*, *F. moniliforme* and *Cephalosporium* species, and *H. maydis*, 1974 (see appendix)

	KDS 100 families	Mex-Mix 100 families	Amar. Baj. 100 families
Common smut (*U. maydis*) at Manhattan	2.49**	1.95**	1.85**
Stalk rot (*Fusarium moniliforme* isolates) at Manhattan	0.79^{ns}	1.50*	1.03^{ns}
Stalk rot (*F. moniliforme* isolates and *Cephalosporium* species) at Tlaltizapan	0.87^{ns}	0.83^{ns}	1.09^{ns}
Southern corn leaf blight (*H. maydis*) at Poza Rica	2.02**	3.64**	13.15**

ns: no significant difference

* : significant difference at 5% level

**: significant difference at 1% level

was 2.6, with a range of 2.1 to 4.3 (Table 2). Amarillo Bajio showed an average leaf blight index of 3.2, with a range of 2.2 to 4.8 (Table 3).

The data indicate that most families resistant to common smut were also susceptible to either stalk rot or southern corn leaf blight, or both, and vice versa. No family showed resistance to all diseases at all locations.

Common smut, and southern corn leaf blight occurred naturally in the field at Manhattan, Kansas (USA), and Poza Rica, Mexico, respectively. In some cases, young plants were killed by the severe smut epidemic about seven weeks after planting.

In general, Kansas Drought Synthetic families showed the lowest level of reaction to smut. Mexican-Mixture families were relatively more resistant to stalk rot at Manhattan than Kansas Drought Synthetic and Amarillo Bajio. Amarillo Bajio showed moderate susceptibility to smut and some families with high resistance to southern corn leaf blight.

There were significant differences in grain yield among the Mexican-Mixture synthetics developed for smut resistance, stalk rot resistance, and high yield, at Manhattan and St. John, Kansas (Table 5). However, there were no significant differences between the control and synthetics inoculated with isolates of _F. moniliforme_ (Table 6).

There were no significant differences in grain yield among Amarillo Bajio synthetics (Table 7), and between the control and inoculated synthetics (Table 8).

Table 5. Grain yields[a] (metric tons/hectare) of four Mexican-Mixture synthetics, 1975

Synthetic	Yield (metric tons/hectare) Manhattan	St. John
M_0 (original)	4.27	4.17
M_1 (high yield)	5.60	5.56
M_8 (stalk rot resistant)	4.67	4.86
M_9 (smut resistant)	5.64	5.28
Analysis of variance for F test	4.73*	11.41**
$LSD_{0.05}$	1.42	0.81

Table 6. Grain yields[a] (metric tons/hectare) of four Mexican-Mixture synthetics inoculated with isolates of _F. moniliforme_ at two locations, 1975

	Manhattan		St. John	
Synthetic	Control	Inoculated	Control	Inoculated
M_0 (original)	4.30	4.24	4.42	3.91
M_1 (high yield)	5.81	5.38	5.70	5.43
M_8 (stalk rot resistant)	4.73	4.61	4.95	4.78
M_9 (smut resistant)	5.63	5.65	5.35	5.22
Analysis of variance for F test	0.08[ns]		1.49[ns]	

a : average weight of four replicates

ns: no significant difference

* : significant difference at 5% level

**: significant difference at 1% level

Table 7. Grain yields[a] (metric tons/hectare) of three Amarillo Bajio synthetics, 1975

	Yield (metric tons/hectare)	
Synthetic	Manhattan	St. John
A_0 (original)	5.12	5.27
A_1 (high yield)	6.18	6.30
A_7 (stalk rot resistant)	6.22	5.70
Analysis of variance for F test	2.70^{ns}	1.77^{ns}

Table 8. Grain yields[a] (metric tons/hectare) of three Amarillo Bajio synthetics inoculated with isolates of _F. moniliforme_ at two locations, 1975

	Manhattan		St. John	
Synthetic	Control	Inoculated	Control	Inoculated
A_0 (original)	5.52	4.72	5.46	5.08
A_1 (high yield)	6.29	6.08	6.47	6.13
A_7 (stalk rot resistant)	6.42	6.02	6.14	5.65
Analysis of variance for F test	2.80^{ns}		0.60^{ns}	

a : average weight of four replicates

ns: no significant difference

DISCUSSION

In an open-pollinated population of corn genotypes plants from the same family differ genetically from each other and may react differently to various pathogens. However, a family with a high percentage of resistant plants may be regarded as relatively resistant to the pathogen causing infection. Differences in susceptibility among families indicates the possibility of selecting families for disease resistance from open-pollinated populations of corn, if variability represents genetic variation. Selected families may be developed into disease-resistant synthetics.

Resistance of a family to a disease may not imply resistance of that family to other diseases. In this investigation, no family was resistant to all three diseases, common smut, stalk rot, and southern corn leaf blight.

The environment plays an important role in plant disease development. Numerous climatic and edaphic factors may influence the severity of a disease. Hence, a family may react differently to the same pathogen at each different location because of variabilities in the environment.

Susceptibility to stalk rot at Tlaltizapan may be explained by inoculum potential. Inoculum at Tlaltizapan consisted of *Fusarium moniliforme* isolates and *Cephalosporium* species both of which are primary stalk rot pathogens in Mexico, each capable of inciting the disease. In this case, it is probable that genotypes resistant to *Fusarium* were susceptible to *Cephalosporium* species, and vice versa. Tests for resistance should be based on several isolates of a pathogen from different sources and not a combination of virulent pathogens.

Kansas Drought Synthetic is adapted to temperate environment whereas Mexican-Mixture and Amarillo Bajio each represents different combinations of tropical and temperate germplasm. In general, temperate sources tend to be more susceptible to disease organisms in the tropics than in temperate zones possibly because of environmental stress and lack of adaptation.

Stalk rot may not reduce grain yield significantly under normal conditions of plant growth but may reduce yield appreciably when plants are under stress. Severe yield loss from stalk rot frequently results from stalk breakage which exposes corn ears to infection by secondary pathogens, and makes harvesting more difficult. Infected ears may also be toxic to livestock.

Corn synthetics developed for stalk rot resistance were not significantly lower in grain yield than synthetics developed for high yield for both Mexican-Mixture and Amarillo Bajio at both Kansas locations. Therefore, resistance to stalk rot may not be correlated with low yield potential. Since yield may not be sacrificed for disease resistance, it is necessary to further investigate the relationship of stalk rot resistance and grain yield.

Reactions of cultivars to pathogenic fungi may vary from year to year because of the influence of environment on plant vigor. Corn families selected for disease resistance should be retested over different environments before synthetics for resistance are made.

Progress was made in increasing grain yields after one cycle of selection for disease resistance. In all cases, synthetics developed for disease resistance ranked higher in yield than the original populations.

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APPENDIX

A. Kansas Drought Synthetic (KDS), 1974

Appendix Table 1. Analysis of variance for F test on common smut at Manhattan

Source of variation	DF	Sum of squares	Mean square	F
Families	99	199.88	2.02	2.49**
Replication	1	0.72	0.72	0.89
Error	99	80.28	0.81	
Total	199	280.88		

$LSD_{0.05} = 1.78$

Appendix Table 2. Analysis of variance for F test on stalk rot at Manhattan

Source of variation	DF	Sum of squares	Mean square	F
Families	99	19.74	0.20	0.79^{ns}
Replication	1	2.88	2.88	11.37
Error	99	25.07	0.25	
Total	199	47.69		

Appendix Table 3. Analysis of variance for F test on stalk rot at Tlaltizapan

Source of variation	DF	Sum of squares	Mean square	F
Families	99	4.65	0.05	0.87^{ns}
Replication	1	0.00	0.00	0.03
Error	99	5.34	0.05	
Total	199	9.99		

Appendix Table 4. Analysis of variance for F test on southern corn leaf blight at Poza Rica

Source of variation	DF	Sum of squares	Mean square	F
Families	99	31.66	0.32	2.02**
Replication	1	0.05	0.05	0.33
Error	99	15.71	0.16	
Total	199	47.42		

$LSD_{0.05} = 0.79$

B. Mexican Mixture (Mex-Mix), 1974

Appendix Table 5. Analysis of variance for F test on common smut at Manhattan

Source of variation	DF	Sum of squares	Mean square	F
Families	99	2222.44	22.45	1.95**
Replication	1	616.00	616.00	53.43
Error	99	1141.49	11.53	
Total	199	3979.93		

$LSD_{0.05} = 6.72$

Appendix Table 6. Analysis of variance for F test on stalk rot at Manhattan

Source of variation	DF	Sum of squares	Mean square	F
Families	99	39.93	0.40	1.50*
Replication	1	0.19	0.19	0.71
Error	99	26.63	0.27	
Total	199	66.75		

$LSD_{0.05} = 1.03$

Appendix Table 7. Analysis of variance for F test on stalk rot at Tlaltizapan

Source of variation	DF	Sum of squares	Mean square	F
Families	99	4.72	0.05	0.83^{ns}
Replication	1	1.51	1.51	26.45
Error	99	5.67	0.06	
Total	199	11.90		

Appendix Table 8. Analysis of variance for F test on southern corn leaf blight at Poza Rica

Source of variation	DF	Sum of squares	Mean square	F
Families	99	30.25	0.31	3.64**
Replication	1	0.43	0.43	5.16
Error	99	8.32	0.08	
Total	199	39.00		

$LSD_{0.05} = 0.57$

C. Amarillo Bajio (Amar. Baj.), 1974

Appendix Table 9. Analysis of variance for F test on common smut at Manhattan

Source of variation	DF	Sum of squares	Mean square	F
Families	99	458.88	4.64	1.85**
Replication	1	32.00	32.00	12.77
Error	99	247.98	2.50	
Total	199	738.86		

$LSD_{0.05} = 3.13$

Appendix Table 10. Analysis of variance for F test on stalk rot at Manhattan

Source of variation	DF	Sum of squares	Mean square	F
Families	99	32.38	0.33	1.03^{ns}
Replication	1	0.29	0.29	0.91
Error	99	31.43	0.32	
Total	199	64.10		

Appendix Table 11. Analysis of variance for F test on stalk rot at Tlaltizapan

Source of variation	DF	Sum of squares	Mean square	F
Families	99	3.06	0.03	1.09^{ns}
Replication	1	0.16	0.16	5.54
Error	99	2.80	0.03	
Total	199	6.02		

Appendix Table 12. Analysis of variance for F test on southern corn leaf blight at Poza Rica

Source of variation	DF	Sum of squares	Mean square	F
Families	99	131.26	1.33	13.15**
Replication	1	0.36	0.36	3.58
Error	99	9.98	0.10	
Total	199	141.61		

$LSD_{0.05} = 0.63$

Appendix Table 13. Analysis of variance for F test on grain yield of Mex-Mix synthetics at Manhattan, 1975

Source of variation	DF	Sum of squares	Mean square	F
Populations	3	11.22	3.74	4.73*
Replications	3	5.28	1.76	2.23
Pop x Reps	9	7.14	0.79	6.04
Diseases	1	0.17	0.17	1.28
Pop x Disease	3	0.23	0.08	0.60^{ns}
Error	12	1.58	0.13	
Total	31	25.61		

$LSD_{0.05} = 1.01$

Appendix Table 14. Analysis of variance for F test on grain yield of Mex-Mix synthetics at St. John, 1975

Source of variation	DF	Sum of squares	Mean square	F
Populations	3	8.87	2.96	11.38**
Replications	3	1.51	0.50	1.92
Pop x Reps	9	2.33	0.26	6.64
Disease	1	0.59	0.59	15.14
Pop x Disease	3	0.17	0.06	1.49^{ns}
Error	12	0.47	0.04	
Total	31	13.95		

$LSD_{0.05} = 0.58$

Appendix Table 15. Analysis of variance for F test on grain yield of Amarillo Bajio synthetics at Manhattan, 1975

Source of variation	DF	Sum of squares	Mean square	F
Populations	2	6.28	3.14	2.71^{ns}
Replications	3	0.22	0.07	0.06
Pop x Reps	6	6.97	1.16	17.51
Disease	1	1.32	1.32	19.90
Pop x Disease	2	0.37	0.19	2.80^{ns}
Error	9	0.60	0.07	
Total	23	15.76		

Appendix Table 16. Analysis of variance for F test on grain yield of Amarillo Bajio synthetics at St. John, 1975

Source of variation	DF	Sum of squares	Mean square	F
Populations	2	4.28	2.14	1.77^{ns}
Replications	3	0.49	0.16	0.13
Pop x Reps	6	7.24	1.21	58.99
Disease	1	0.97	0.97	47.50
Pop x Disease	2	0.02	0.01	0.60^{ns}
Error	9	0.18	0.02	
Total	23	13.19		

ns: no significant difference

* : significant difference at 5% level

**: significant difference at 1% level

REACTIONS OF THREE HUNDRED CORN FAMILIES TO PATHOGENIC FUNGI AT DIFFERENT LOCATIONS IN KANSAS AND MEXICO

by

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

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MASTER OF SCIENCE

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Manhattan, Kansas

1976

ABSTRACT

Three populations of corn, each consisting of 100 families, showed varying degrees of susceptibility to various pathogens when tested at Manhattan, Kansas, and Tlaltizapan and Poza Rica, Mexico. Differences in reaction among families indicate a possibility of selection for disease resistance although plants in the same family differ genetically from each other.

The corn families were tested for their reactions to Ustilago maydis (DC.) Cda. causal agent of common corn smut, Fusarium moniliforme Sheldon and Cephalosporium species both stalk rot pathogens, and Helminthosporium maydis Nisikado and Miyake inciting southern corn leaf blight.

Heavy natural infections of smut and leaf blight occurred in the field at Manhattan and Poza Rica, respectively. These infections provided a measure for disease resistance. In some cases, plants in some families were killed about seven weeks after planting by the severe smut epidemic.

Stalk rot was artificially induced by the toothpick method. Families showed significant differences in reactions to pathogens at Manhattan where isolates of Fusarium moniliforme were used for inoculation. However, all families were susceptible to stalk rot at Tlaltizapan where inoculum consisted of Fusarium moniliforme isolates and Cephalosporium species. It is important that tests for resistance be based on many isolates of a virulent organism from different sources.

Kansas Drought Synthetic showed the lowest reaction to smut and moderate susceptibility to stalk rot and leaf blight. Mexican-Mixture showed the highest reaction to smut and moderate resistance to both leaf

blight and stalk rot. Several families of Amarillo Bajio showed resistance to leaf blight but the population as a whole was moderately susceptible to smut and stalk rot. However, retesting of selected families is necessary to eliminate disease escapes.

Synthetics developed from resistant families showed no significant decrease in yield when tested at two locations in Kansas.