Resistance to diplodia infection in inbred lines and hybrids of maize

Robert W. Jugenheimer
Iowa State College

Follow this and additional works at: http://lib.dr.iastate.edu/rtd

Part of the Genetics Commons, and the Plant Pathology Commons

Recommended Citation
Jugenheimer, Robert W., "Resistance to diplodia infection in inbred lines and hybrids of maize " (1940). Retrospective Theses and Dissertations. 14003.
http://lib.dr.iastate.edu/rtd/14003

This Dissertation is brought to you for free and open access by Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
NOTE TO USERS

This reproduction is the best copy available.
RESISTANCE TO DIPLODIA INFECTION IN INBRED
LINES AND HYBRIDS OF MAIZE

By

ROBERT WILLIAM JUGENHEIMER

A Thesis Submitted to the Graduate Faculty
for the Degree of
DOCTOR OF PHILOSOPHY
Major Subject Genetics

Iowa State College
1940
INFORMATION TO USERS

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleed-through, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

UMI

UMI Microform DP12796
Copyright 2005 by ProQuest Information and Learning Company.
All rights reserved. This microform edition is protected against unauthorized copying under Title 17, United States Code.

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>3</td>
</tr>
<tr>
<td>REVIEW OF LITERATURE</td>
<td>4</td>
</tr>
<tr>
<td>MATERIALS</td>
<td>9</td>
</tr>
<tr>
<td>METHODS</td>
<td>10</td>
</tr>
<tr>
<td>RESULTS</td>
<td>12</td>
</tr>
<tr>
<td>Determination of Resistance to Stalk Rot</td>
<td>12</td>
</tr>
<tr>
<td>Natural infection</td>
<td>12</td>
</tr>
<tr>
<td>Artificial infection</td>
<td>15</td>
</tr>
<tr>
<td>Inoculation technique</td>
<td>19</td>
</tr>
<tr>
<td>Stalk Rot Associations</td>
<td>25</td>
</tr>
<tr>
<td>Killing of stalks and leaves</td>
<td>25</td>
</tr>
<tr>
<td>Weight of ear</td>
<td>28</td>
</tr>
<tr>
<td>Lodged plants</td>
<td>28</td>
</tr>
<tr>
<td>Smut infection</td>
<td>31</td>
</tr>
<tr>
<td>Ear rotting</td>
<td>31</td>
</tr>
<tr>
<td>Nature of Resistance to Stalk Rot</td>
<td>32</td>
</tr>
<tr>
<td>Inheritance of Resistance to Stalk Rot</td>
<td>77</td>
</tr>
<tr>
<td>Resistance tends to be dominant</td>
<td>77</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>84</td>
</tr>
<tr>
<td>SUMMARY</td>
<td>88</td>
</tr>
<tr>
<td>LITERATURE CITED</td>
<td>91</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>94</td>
</tr>
</tbody>
</table>
INTRODUCTION

Resistance to lodging is one of the important requirements of a desirable strain of corn. Some strains lodge because of weak roots, others because of weak stalks. Stalk breaking often is associated with a complex of stalk disorders commonly referred to as stalk rot. Extremely stiff-stalked hybrids have been obtained by the utilization of inbred lines resistant to stalk rotting. In fact, this characteristic has been responsible for much of the popularity of hybrid corn.

*Diplodia zeae* (Schw.) Lev. was used in this investigation because it appears to be a primary parasite directly associated with stalk infection and breaking. Objectives were to study: (a) methods of determining resistance of corn strains to stalk rot, (b) stalk rot associations, (c) nature of resistance, and (d) inheritance of resistance.

Besides eliminating the factor of disease escape, a rapid, reliable inoculation technique would permit the use of smaller numbers of plants in studies on the nature and inheritance of resistance. Stalk rot associations need attention because little is known how stalk rotting affects stalk breaking, yield of grain, premature killing of stalks and leaves, ear rotting or smut infection. If inbred lines and hybrids differ in resistance to stalk rot, it is essential to determine the nature or cause of these differences. The corn breeder needs to know something about the inheritance of resistance if he is to utilize intelligently inbred lines, differing in resistance, in hybrid combinations.
REVIEW OF LITERATURE

*Diplodia zeae,* the causal organism of dry rot, was described by Schweinitz in 1834 but was not recognized as the cause of a serious disease of corn until Heald (1906) published his first note on Diplodia ear rot. The pathogenicity of this fungus on the corn plant was reported by Heald, Wilcox, and Pool (1909) in Nebraska, and Burrill and Barrett (1909) in Illinois. These workers contributed primarily to the ear rot phase of the problem.

Smith and Hedges (1919) believed that Diplodia infection was systemic and could extend from the roots up through the vascular bundles into the ear. Durrell (1923) succeeded in showing that infection was local instead of systemic. He concluded that the organism inhibited the development of the seedling by using its food supply instead of by direct invasion.

Holbert et al. (1934) reported that Diplodia migrated to the mesocotyl and roots to cause the characteristic lesions. McNew (1937) presented evidence to show that Diplodia spreads from the mesocotyl up into the crown. The mycelium spreads internally to a limited extent during the growing season and rapidly invades the entire crown and lower nodes at maturity. Raleigh (1930) found Diplodia lesions extending three inches above the crown and some plants were dead before the crop had passed out of the milk stage.

Malhus and Durrell (1922) suggested the germination test as the
most reliable way to cull diseased ears. Durrell (1923) and Clayton (1927) noted that Diplodia ear rot occurred as frequently on plants from disease-free seed as on plants from Diplodia-infected seed. Disinfection of infected seed was shown by Reddy and Holbert (1933) and by Melhus et al. (1933) to lessen the amount of seedling infection and increase the stand.

Hoppe (1933) reported the phenomenon of intraspecific aversion in Diplodia zea and D. macrospora, and interspecific aversion between these two species. He found that there were many strains of D. zea, and proved that certain strains inhibited other strains so that usually only one strain of the fungus could be reisolated from an ear. Strain 28 predominated over most of the other strains, and D. zea seemed to inhibit D. macrospora.

Jugenheimer and Bryan (1937) inoculated corn plants with spore suspensions of Diplodia and obtained very good infection and spread of the disease. Relative resistance and susceptibility of the lines was measured by the number of internodes traversed by the organism in the stalk pith and cortex. The lines differed statistically in resistance to Diplodia which, in general, was in accordance with their field records for resistance to stalk-breaking. The means for the three dates of inoculation used by these workers showed that the greatest infection was obtained on the first date and the least on the third date of inoculation. Smith, Hoppe, and Holbert (1933) used 13 dent single crosses to compare the extent of stalk rot following artificial infection with the amount resulting from natural sources of infection. They concluded
that relative resistance to Diplodia stalk rot could be measured by means of artificial inoculation with the fungus.

McNew (1937) reported that inbred lines of corn had different reactions to crown infection by Diplodia under field conditions. Most of the lines showed a strikingly uniform reaction, although some showed distinct segregation. Crown infection of the 20 lines ranged from 20 to 93 percent.

Hoppe and Holbert (1936) found that percentage of rotted ears was inaccurate for determining differences in resistance to ear rot and recommended the kernel separation method. After making kernel rot determinations on samples of various sizes, they found 200-gram samples to be most satisfactory. Semaniuk et al. (1939) inoculated corn ears on August 8 and September 8 with a suspension of Diplodia spores and with Diplodia-infected kernels placed between the husks and the ear. No agreement in infection by these two methods was obtained with the eight inbred lines tested.

Smith et al. (1938) reported the following correlations as a basis for judging the efficiency of artificial Diplodia inoculation in measuring resistance: pith spread and cortical spread, 0.948; natural infection and broken stalks, 0.909; pith spread and natural infection, 0.855; pith spread and broken stalks, 0.821; cortical spread and natural infection, 0.878; cortical spread and broken stalks, 0.899.

Holbert, Hoppe and Smith (1935) reported observations on factors affecting the infection and spread of Diplodia. In each case cited, increased susceptibility of the stalks to the fungus was associated with conditions causing a reduction of the carbohydrate reserves of
the plants. Jugenheimer and Bryan (1938) studied the nature of resistance of corn to Diplodia by inoculating normal, barren, and clipped plants varying in carbohydrate content with a spore suspension of the fungus. In general the pith rotting of the barren plants was greater than that of the normal or clipped plants. Differences between lines and between treatments were highly significant statistically. The barren plants tended to remain green the longest, while the clipped plants died first. Clipping the leaves materially lowered the yield of the lines. Deturk et al. (1939) made a complete chemical analysis of the carbohydrates of a resistant single cross, R4 x Hx, and another cross, Lan x H315, which was susceptible to Diplodia stalk rot and to low temperatures in the fall. They concluded that the resistance of R4 x Hx to low temperature and Diplodia was associated with high total active carbohydrates and total sugars, whereas the susceptibility of Lan x H315 was associated with low carbohydrate concentrations.

Studies on the nature of resistance of corn to Diplodia were made by Davis et al. (1938) by growing the fungus on stalk meal obtained from several inbred lines and observing the difference in the size of the colonies. Their results indicated a possible positive correlation between growth of the organism on the ground stalk meal and the sucrose reserve in the cornstalk.

Melhus (1936, 1937, 1938) reported that extracts of Diplodia reduced mycelial growth and delayed early growth of corn seedlings. The inhibitor was found to be non-volatile and appeared to be a stable organic compound. Slight growth was obtained when the filtrate was con-
centrated. Kent (1938) believed that the inhibiting substance included one or more complex nitrogen-containing compounds. Semeniuk (1940) noted growth stimulation of Diplodia on various media by the additions of small amounts of water extracts of organic materials as potato, carrot, corn meal, oatmeal and pith of mature corn stalks.

Helen Johann (1935) outlined the development and microscopic anatomy of the caryopsis of dent corn. She was primarily concerned with the tissues that might have a bearing on Diplodia ear-rot resistance but found no striking anatomical differences that might be associated with resistance.
MATERIALS

These studies were a part of the corn investigations conducted cooperatively by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, with the Departments of Agronomy at the Iowa and Kansas Agricultural Experiment Stations. All material in 1934, 1935, 1936, and 1937 was grown at Ames, Iowa, and that in 1938 at Manhattan, Kansas.

Inbred lines used in these studies resulted from selections among self-fertilized strains of corn. Most of the lines had been inbred for at least eight generations and should have been relatively homozygous for most agronomic characteristics. The crosses studied were combinations of these lines.

Inoculations were made with a spore suspension of Diplodia strain 26. The inoculum was generously provided by Mr. Paul Hoppe, U. S. Department of Agriculture pathologist stationed at the University of Wisconsin.
METHODS

These investigations were made during the five-year period, 1934 to 1938 inclusive. With exception of preliminary observations on inbred lines in 1934 and 1935, the experiments were arranged for statistical analysis using randomized blocks. Correlation coefficients were computed according to methods suggested by Wallace and Snedecor (1931) and analyses of variance methods as outlined by Snedecor (1934).

Diplodia infection was obtained both by natural and artificial means. The suspension used for artificial inoculations was of sufficient concentration to allow several spores to be seen under the low power of a microscope. A few drops of this inoculum were placed in the stalk internode about six inches above the soil with a hypodermic needle. Inoculations were generally made about one week after completion of pollination.

Leaf-clipping treatment consisted of removing the tip one-third of each leaf. This removal of about 25 percent of the leaf area was usually done at the time of inoculation. Enforced barrenness was obtained by covering the ear shoots with parchment bags before the silks appeared.

The extent of stalk rot infection was determined in several ways. In preliminary studies, the stalks were split at harvest and the amount of shredding and discoloration of the pith recorded as a grade ranging from "1", representing the least infection, to "5", representing the
highest infection. In later studies, relative resistance and susceptibility was measured in three ways: (a) number of internodes rotted by fungus in the stalk pith, (b) number of internodes rotted by fungus in the stalk cortex, and (c) horizontal spread of the rotting in the stalk cortex.

Any variation from the above methods is explained with the results from each experiment.
RESULTS

Determination of Resistance to Stalk Rot

Natural infection

One phase of the corn improvement project at Ames, Iowa, in 1934 and 1935 was an observation block comprising 120 inbred lines. Ten stalks of each line were split and the amount of shredding and discoloration in the pith was recorded as a grade. Differences in resistance to natural stalk rot infection are shown in table 1. In 1934 the stalk rot grade ranged from 1.0 (very resistant) to 4.9 (very susceptible) with a mean of 2.72 and a standard deviation of 1.02 grades, and in 1935 from 1.3 to 4.5, mean 3.10 and standard deviation 0.81 grades. The material was grown primarily for observational purposes and was not replicated. An analysis of variance in stalk rot grades was calculated by using "years" in place of ordinary replication. This analysis, shown in table 1, indicates highly significant differences between "lines" and between "years". Differences in grade of 1.6 are significant. An interannual positive correlation of 0.17 was obtained between the stalk rot grades of the two years.

The data in table 1 indicated that inbred lines differ in resistance to natural stalk rot infection. These figures were means of ten plants. Individual plants, however, varied considerably in grade.
Table 1. Differences in resistance to natural stalk rot infection of 120 inbred lines of corn at Ames, Iowa, in 1934 and 1935.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Stalk rot grade</th>
<th>Inbred line</th>
<th>Stalk rot grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1934</td>
<td>1935</td>
<td>Mean</td>
</tr>
<tr>
<td>15</td>
<td>2.5</td>
<td>2.2</td>
<td>2.4</td>
</tr>
<tr>
<td>27</td>
<td>2.6</td>
<td>3.9</td>
<td>3.2</td>
</tr>
<tr>
<td>30</td>
<td>3.9</td>
<td>3.8</td>
<td>3.8</td>
</tr>
<tr>
<td>51</td>
<td>2.9</td>
<td>3.5</td>
<td>3.2</td>
</tr>
<tr>
<td>42</td>
<td>3.0</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>46</td>
<td>3.0</td>
<td>3.7</td>
<td>3.4</td>
</tr>
<tr>
<td>47</td>
<td>1.9</td>
<td>5.8</td>
<td>2.8</td>
</tr>
<tr>
<td>63</td>
<td>2.9</td>
<td>3.3</td>
<td>3.1</td>
</tr>
<tr>
<td>63ALL1</td>
<td>2.4</td>
<td>2.8</td>
<td>2.6</td>
</tr>
<tr>
<td>63A2</td>
<td>3.4</td>
<td>3.5</td>
<td>3.4</td>
</tr>
<tr>
<td>69</td>
<td>2.2</td>
<td>3.6</td>
<td>2.9</td>
</tr>
<tr>
<td>82</td>
<td>2.2</td>
<td>2.6</td>
<td>2.4</td>
</tr>
<tr>
<td>87</td>
<td>3.8</td>
<td>2.8</td>
<td>3.3</td>
</tr>
<tr>
<td>95</td>
<td>2.9</td>
<td>2.3</td>
<td>2.8</td>
</tr>
<tr>
<td>101R1</td>
<td>3.1</td>
<td>2.9</td>
<td>3.0</td>
</tr>
<tr>
<td>102</td>
<td>3.2</td>
<td>1.4</td>
<td>2.3</td>
</tr>
<tr>
<td>111</td>
<td>3.7</td>
<td>3.5</td>
<td>3.6</td>
</tr>
<tr>
<td>111A1R1</td>
<td>2.9</td>
<td>2.9</td>
<td>2.9</td>
</tr>
<tr>
<td>128</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>153</td>
<td>4.1</td>
<td>4.2</td>
<td>4.2</td>
</tr>
<tr>
<td>153R1</td>
<td>4.2</td>
<td>3.6</td>
<td>3.9</td>
</tr>
<tr>
<td>154A</td>
<td>1.0</td>
<td>4.5</td>
<td>2.8</td>
</tr>
<tr>
<td>159</td>
<td>3.4</td>
<td>4.0</td>
<td>3.7</td>
</tr>
<tr>
<td>163</td>
<td>2.6</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>197</td>
<td>3.0</td>
<td>4.0</td>
<td>3.5</td>
</tr>
<tr>
<td>197R1</td>
<td>2.1</td>
<td>3.7</td>
<td>2.9</td>
</tr>
<tr>
<td>197A2L1</td>
<td>3.2</td>
<td>3.7</td>
<td>3.6</td>
</tr>
<tr>
<td>198</td>
<td>2.1</td>
<td>3.7</td>
<td>2.9</td>
</tr>
<tr>
<td>205A1</td>
<td>1.5</td>
<td>2.6</td>
<td>2.0</td>
</tr>
<tr>
<td>205A2L1</td>
<td>1.2</td>
<td>3.0</td>
<td>2.1</td>
</tr>
<tr>
<td>211</td>
<td>2.1</td>
<td>3.3</td>
<td>2.7</td>
</tr>
<tr>
<td>219</td>
<td>1.8</td>
<td>2.3</td>
<td>2.0</td>
</tr>
<tr>
<td>222</td>
<td>1.6</td>
<td>3.2</td>
<td>2.4</td>
</tr>
<tr>
<td>224A2</td>
<td>1.6</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>224A2L1</td>
<td>1.6</td>
<td>1.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>
### Table 1. (Continued)

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Stalk rot grade 1934</th>
<th>Stalk rot grade 1935</th>
<th>Mean</th>
<th>Inbred line</th>
<th>Stalk rot grade 1934</th>
<th>Stalk rot grade 1935</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>401</td>
<td>2.0</td>
<td>2.7</td>
<td>2.4</td>
<td>679</td>
<td>2.7</td>
<td>4.5</td>
<td>3.5</td>
</tr>
<tr>
<td>415</td>
<td>1.1</td>
<td>4.1</td>
<td>2.6</td>
<td>682</td>
<td>2.5</td>
<td>3.7</td>
<td>3.1</td>
</tr>
<tr>
<td>42022</td>
<td>4.0</td>
<td>2.5</td>
<td>3.2</td>
<td>683</td>
<td>3.9</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>425</td>
<td>4.1</td>
<td>2.1</td>
<td>3.1</td>
<td>701</td>
<td>4.2</td>
<td>5.6</td>
<td>4.9</td>
</tr>
<tr>
<td>445</td>
<td>2.9</td>
<td>2.3</td>
<td>2.6</td>
<td>731</td>
<td>1.0</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>447</td>
<td>4.0</td>
<td>2.8</td>
<td>3.4</td>
<td>743</td>
<td>4.0</td>
<td>3.1</td>
<td>3.6</td>
</tr>
<tr>
<td>456</td>
<td>2.8</td>
<td>3.4</td>
<td>3.1</td>
<td>744</td>
<td>1.5</td>
<td>3.7</td>
<td>2.6</td>
</tr>
<tr>
<td>497</td>
<td>1.5</td>
<td>3.1</td>
<td>2.2</td>
<td>745</td>
<td>5.2</td>
<td>3.3</td>
<td>4.3</td>
</tr>
<tr>
<td>625</td>
<td>3.0</td>
<td>3.1</td>
<td>3.1</td>
<td>794</td>
<td>3.0</td>
<td>4.2</td>
<td>3.8</td>
</tr>
<tr>
<td>630A</td>
<td>2.8</td>
<td>2.2</td>
<td>2.5</td>
<td>801</td>
<td>1.5</td>
<td>3.7</td>
<td>2.7</td>
</tr>
<tr>
<td>6409</td>
<td>2.3</td>
<td>1.9</td>
<td>2.1</td>
<td>803</td>
<td>3.6</td>
<td>3.3</td>
<td>3.6</td>
</tr>
<tr>
<td>643</td>
<td>2.1</td>
<td>1.6</td>
<td>1.9</td>
<td>804</td>
<td>4.2</td>
<td>3.4</td>
<td>3.8</td>
</tr>
<tr>
<td>645</td>
<td>3.5</td>
<td>1.9</td>
<td>2.9</td>
<td>806</td>
<td>4.9</td>
<td>3.6</td>
<td>4.3</td>
</tr>
<tr>
<td>646A</td>
<td>2.9</td>
<td>2.9</td>
<td>2.9</td>
<td>808</td>
<td>2.9</td>
<td>4.1</td>
<td>3.5</td>
</tr>
<tr>
<td>648</td>
<td>3.3</td>
<td>2.0</td>
<td>3.2</td>
<td>814</td>
<td>4.8</td>
<td>3.3</td>
<td>4.2</td>
</tr>
<tr>
<td>652</td>
<td>1.4</td>
<td>2.5</td>
<td>2.0</td>
<td>817</td>
<td>4.0</td>
<td>2.9</td>
<td>3.5</td>
</tr>
<tr>
<td>655</td>
<td>1.7</td>
<td>2.3</td>
<td>2.0</td>
<td>819</td>
<td>4.2</td>
<td>3.4</td>
<td>3.8</td>
</tr>
<tr>
<td>657</td>
<td>1.5</td>
<td>2.3</td>
<td>1.8</td>
<td>824</td>
<td>4.5</td>
<td>2.7</td>
<td>3.6</td>
</tr>
<tr>
<td>660</td>
<td>1.0</td>
<td>1.9</td>
<td>1.9</td>
<td>823</td>
<td>1.8</td>
<td>3.8</td>
<td>2.8</td>
</tr>
<tr>
<td>662</td>
<td>1.4</td>
<td>3.9</td>
<td>2.7</td>
<td>823</td>
<td>2.0</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>663</td>
<td>1.5</td>
<td>2.9</td>
<td>2.2</td>
<td>864</td>
<td>3.5</td>
<td>3.4</td>
<td>3.4</td>
</tr>
<tr>
<td>665</td>
<td>4.1</td>
<td>4.5</td>
<td>4.3</td>
<td>865</td>
<td>1.1</td>
<td>3.3</td>
<td>2.8</td>
</tr>
<tr>
<td>669</td>
<td>2.2</td>
<td>3.9</td>
<td>3.1</td>
<td>866</td>
<td>2.6</td>
<td>4.4</td>
<td>3.5</td>
</tr>
<tr>
<td>671</td>
<td>3.6</td>
<td>3.4</td>
<td>3.5</td>
<td>869</td>
<td>3.4</td>
<td>2.7</td>
<td>3.1</td>
</tr>
<tr>
<td>673</td>
<td>2.7</td>
<td>4.3</td>
<td>3.5</td>
<td>869</td>
<td>4.3</td>
<td>3.4</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Interannual correlation **+0.17**  
Mean 2.72  3.10
One percent level 0.23  \$ 1.02  0.61

### Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
<th>Significant diff. (grades)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>119</td>
<td>0.9595</td>
<td>1.41**</td>
<td>1.21</td>
<td>1.6</td>
</tr>
<tr>
<td>Years</td>
<td>1</td>
<td>6.8100</td>
<td>12.94**</td>
<td>3.92</td>
<td></td>
</tr>
<tr>
<td>Experimental error</td>
<td>119</td>
<td>0.6808</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>229</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference**
Typical variation is shown in table 2 by the frequency distribution of stalk rot grades of 12 inbred lines under natural infection. Line 205, which produces very stiff-stalked hybrids, appeared to be the most resistant. Lines 289, 401, and 447 were the most susceptible. Most of the plants of lines 159, 239, 317, and 426 were in one class, while 234 and 349 had plants in all five grade-classes.

The frequency distributions of stalk rot grades under natural infection of 28 single crosses involving the lines in table 2 are given in table 3. The crosses ranged from 1.4 to 4.4 grades. In general, the plants varied more within the crosses than within the inbred lines. An extreme example is cross 205 x 289 where the plants were distributed almost equally in all five classes.

Stalks of the crosses rotted less than did those of the parent inbred lines. The mean grade of the crosses was 2.9 whereas the mean grade of the lines was 3.6. A positive correlation of 0.32 was obtained between the rot grade of the $F_1$ and the mean of the parents. The five percent level of significance is 0.37.

**Artificial infection**

Artificial inoculation studies, started in 1935, consisted of inoculating plants with a spore suspension of Diplodia when the ears were partly dented. Other plants in each of the same rows were left uninoculated. At harvest the stalks were split and the amount of shredding in the pith was recorded as a grade. Differences in resistance to stalk rot of 50 inbred lines inoculated with Diplodia are given in table 4. Lines
Table 2. Frequency distribution of stalk rot grades on 12 inbred lines at Ames, Iowa, 1934 (natural infection).

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Stalk rot grade</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>159</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>205</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>224</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>234</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>289</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>317</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>345</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>349</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>401</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>420</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>426</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>447</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

1/ Standard errors.
Table 5. Frequency distribution of stalk rot grades on 26 single crosses at Ames, Iowa, in 1934 (natural infection).

<table>
<thead>
<tr>
<th>Cross</th>
<th>Stalk rot grade</th>
<th>Number of stalks</th>
<th>Mean (C)</th>
<th>Parent lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>159 x 224</td>
<td>1 10 4 49 212</td>
<td>273</td>
<td>2.7±0.07</td>
<td>3.6</td>
</tr>
<tr>
<td>x 229</td>
<td>0 2 4 10 6</td>
<td>22</td>
<td>3.9±0.20</td>
<td>4.1</td>
</tr>
<tr>
<td>x 345</td>
<td>0 16 18 13 3</td>
<td>50</td>
<td>3.1±0.13</td>
<td>3.4</td>
</tr>
<tr>
<td>x 401</td>
<td>0 2 6 2 0</td>
<td>10</td>
<td>3.0±0.21</td>
<td>4.1</td>
</tr>
<tr>
<td>205 x 224</td>
<td>4 3 0 0 0</td>
<td>7</td>
<td>1.4±0.20</td>
<td>2.8</td>
</tr>
<tr>
<td>x 234</td>
<td>0 2 5 2 1</td>
<td>10</td>
<td>3.2±0.29</td>
<td>2.8</td>
</tr>
<tr>
<td>x 289</td>
<td>12 10 10 12 6</td>
<td>50</td>
<td>2.8±0.19</td>
<td>3.4</td>
</tr>
<tr>
<td>x 317</td>
<td>1 3 4 15 7</td>
<td>30</td>
<td>3.8±0.19</td>
<td>3.3</td>
</tr>
<tr>
<td>x 345</td>
<td>5 5 2 6 2</td>
<td>20</td>
<td>2.7±0.17</td>
<td>2.7</td>
</tr>
<tr>
<td>x 349</td>
<td>3 3 2 0 2</td>
<td>10</td>
<td>2.5±0.48</td>
<td>2.9</td>
</tr>
<tr>
<td>x 401</td>
<td>3 3 0 2 7</td>
<td>15</td>
<td>3.5±0.45</td>
<td>3.4</td>
</tr>
<tr>
<td>x 420</td>
<td>4 11 10 5 1</td>
<td>31</td>
<td>2.6±0.18</td>
<td>3.5</td>
</tr>
<tr>
<td>x 426</td>
<td>3 5 0 7 4</td>
<td>19</td>
<td>3.2±0.54</td>
<td>3.2</td>
</tr>
<tr>
<td>224 x 317</td>
<td>3 11 3 3 10</td>
<td>30</td>
<td>3.2±0.27</td>
<td>3.6</td>
</tr>
<tr>
<td>x 345</td>
<td>5 5 2 4 1</td>
<td>15</td>
<td>2.5±0.36</td>
<td>3.0</td>
</tr>
<tr>
<td>x 401</td>
<td>0 2 0 0 1</td>
<td>3</td>
<td>3.0±0.00</td>
<td>3.6</td>
</tr>
<tr>
<td>234 x 289</td>
<td>0 6 3 1 0</td>
<td>10</td>
<td>2.5±0.22</td>
<td>3.6</td>
</tr>
<tr>
<td>289 x 317</td>
<td>0 26 21 8 5</td>
<td>60</td>
<td>2.9±0.11</td>
<td>4.2</td>
</tr>
<tr>
<td>x 345</td>
<td>0 2 0 1 0</td>
<td>3</td>
<td>2.7±0.07</td>
<td>3.6</td>
</tr>
<tr>
<td>x 349</td>
<td>4 12 7 7 0</td>
<td>30</td>
<td>2.6±0.18</td>
<td>3.8</td>
</tr>
<tr>
<td>x 401</td>
<td>3 23 10 9 5</td>
<td>50</td>
<td>2.8±0.16</td>
<td>4.2</td>
</tr>
<tr>
<td>x 420</td>
<td>4 38 58 42 22</td>
<td>173</td>
<td>3.2±0.08</td>
<td>4.2</td>
</tr>
<tr>
<td>317 x 349</td>
<td>0 3 7 16 4</td>
<td>30</td>
<td>3.7±0.15</td>
<td>3.7</td>
</tr>
<tr>
<td>345 x 349</td>
<td>5 11 2 2 0</td>
<td>30</td>
<td>2.0±0.20</td>
<td>3.1</td>
</tr>
<tr>
<td>x 401</td>
<td>0 0 2 2 6</td>
<td>10</td>
<td>4.4±0.27</td>
<td>3.6</td>
</tr>
<tr>
<td>349 x 401</td>
<td>9 15 5 1 0</td>
<td>30</td>
<td>1.9±0.14</td>
<td>2.8</td>
</tr>
<tr>
<td>x 426</td>
<td>0 1 5 2 2</td>
<td>10</td>
<td>3.5±0.31</td>
<td>3.6</td>
</tr>
<tr>
<td>420 x 426</td>
<td>2 4 6 13 0</td>
<td>30</td>
<td>3.3±0.18</td>
<td>4.0</td>
</tr>
</tbody>
</table>

1/ Standard errors.
Table 4. Differences in resistance to stalk rot of 50 inbred lines inoculated with Diplodia zeae at Ames, Iowa, in 1935.

| Inbred line | Stalk rot grade | Inoculated | Check | | Inbred line | Stalk rot grade | Inoculated | Check |
|-------------|-----------------|------------|-------||-------------|-----------------|------------|-------|
| 159         | 3.7             | 4.0        |       | | 339         | 3.8             | 2.6        |       |
| 197         | 4.2             | 4.0        |       | | 345         | 3.9             | 3.4        |       |
| 205         | 2.9             | 2.6        |       | | 345R1       | 3.6             | 3.5        |       |
| 205A1       | 3.7             | 3.2        |       | | 345C        | 4.1             | 3.9        |       |
| 207         | 3.2             | 2.6        |       | | 349         | 4.2             | 4.1        |       |
| 222         | 2.9             | 3.2        |       | | 351A1       | 4.2             | 3.6        |       |
| 224A1       | 2.0             | 1.8        |       | | 356         | 2.8             | 2.6        |       |
| 224A2       | 1.9             | 1.3        |       | | 356R1       | 2.9             | 2.8        |       |
| 224A2A1     | 2.1             | 1.3        |       | | 356RE        | 3.6             | 3.0        |       |
| 233         | 1.9             | 1.5        |       | | 354         | 3.4             | 4.1        |       |
| 234         | 2.4             | 2.0        |       | | 397R1       | 4.2             | 3.4        |       |
| 244         | 3.0             | 3.0        |       | | 397L1       | 3.8             | 5.1        |       |
| 244A        | 1.4             | 1.1        |       | | 398L1       | 3.6             | 2.7        |       |
| 244A1       | 2.2             | 2.3        |       | | 401         | 2.8             | 2.7        |       |
| 257         | 2.4             | 2.1        |       | | 401R1       | 2.9             | 2.3        |       |
| 276         | 2.8             | 2.7        |       | | 415         | 4.4             | 4.1        |       |
| 276A1       | 2.4             | 2.1        |       | | 420         | 3.0             | 2.5        |       |
| 289         | 2.3             | 1.9        |       | | 420R1       | 3.1             | 2.9        |       |
| 293         | 2.1             | 2.3        |       | | 420R2       | 3.5             | 2.5        |       |
| 304A        | 2.3             | 2.3        |       | | 426         | 2.3             | 2.1        |       |
| 304B        | 3.5             | 3.1        |       | | 426R1       | 3.1             | 2.3        |       |
| 317         | 4.2             | 5.9        |       | | 426R2       | 2.0             | 1.3        |       |
| 317B2       | 3.3             | 3.0        |       | | 447         | 3.6             | 2.8        |       |
| 317C        | 3.9             | 2.8        |       | | 456         | 3.6             | 3.4        |       |
| 324         | 3.7             | 2.9        |       | | 497         | 3.4             | 3.1        |       |

Interinfection correlation: 0.88
One per cent level 0.35
Mean 3.12 2.75
σ 0.77 0.79
ranged from 1.4 to 4.4 grades. The mean grade of the inoculated plants was 3.12, while that of the check plants was 2.75. Later studies have usually shown larger differences than these. The standard deviations were 0.77 grade for inoculated and 0.79 grade for check plants. Using the data in table 4, a highly significant correlation of +0.88 was obtained between the inoculated and check plants.

Thirty top crosses of lines with Krug variety and two entries of Drug were also inoculated with Diplodia in 1935. The experiment was planted on farms of two different levels of fertility. Two replications of each entry were planted on each farm and each kind of corn was distributed at random within each replication. Plots consisted of two rows, each five hills long, with rows and hills spaced 40 inches apart. In order to obtain a uniform stand, four seeds were planted per hill and seedlings later thinned to three plants per hill. Data were recorded separately for the right and left row of each plot. The crosses ranged from 1.9 grades to 2.5. Statistically significant differences occurred between crosses and between fields (table 5).

In 1936, 25 plants of each of 48 single crosses involving 16 inbred lines were inoculated with Diplodia. In general the lines ranked the same in pith and cortex rotting (table 6).

Inoculation technique

The 1935 results had demonstrated that studies in technique were necessary to obtain best results from Diplodia inoculation. Questions constantly arose as to the best method and time of inoculation and of reading infection.
Table 5. Analysis of variance in 30 Krug top crosses and two entries of Krug variety inoculated with Diplodia zeae, Ames, Iowa, 1935.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crosses</td>
<td>31</td>
<td>0.21</td>
<td>1.50</td>
<td>1.83</td>
</tr>
<tr>
<td>Fields</td>
<td>1</td>
<td>11.77</td>
<td>84.07**</td>
<td>6.81</td>
</tr>
<tr>
<td>Replications</td>
<td>1</td>
<td>3.49</td>
<td>24.93**</td>
<td>6.81</td>
</tr>
<tr>
<td>Plots</td>
<td>1</td>
<td>0.01</td>
<td>0.07</td>
<td>6.81</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C x F</td>
<td>31</td>
<td>0.20</td>
<td>1.43</td>
<td>1.83</td>
</tr>
<tr>
<td>C x P</td>
<td>31</td>
<td>0.07</td>
<td>0.50</td>
<td>1.83</td>
</tr>
<tr>
<td>F x P</td>
<td>1</td>
<td>0.40</td>
<td>2.86</td>
<td>6.81</td>
</tr>
<tr>
<td>Experimental error</td>
<td>158</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>255</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference**

<table>
<thead>
<tr>
<th>Cross</th>
<th>224</th>
<th>227</th>
<th>233</th>
<th>229</th>
<th>235</th>
<th>249</th>
<th>251</th>
<th>257</th>
<th>401</th>
<th>420</th>
<th>456</th>
<th>665</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>205</td>
<td>1.1</td>
<td>1.1</td>
<td>1.9</td>
<td>1.3</td>
<td>1.3</td>
<td>1.2</td>
<td>1.5</td>
<td>1.7</td>
<td>1.3</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>317</td>
<td>1.2</td>
<td>1.4</td>
<td>1.3</td>
<td>1.3</td>
<td>1.1</td>
<td>1.4</td>
<td>1.4</td>
<td>1.3</td>
<td>1.5</td>
<td>1.3</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>345</td>
<td>1.0</td>
<td>1.1</td>
<td>1.3</td>
<td>1.2</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>701</td>
<td>1.2</td>
<td>1.2</td>
<td>1.7</td>
<td>1.5</td>
<td>1.2</td>
<td>1.2</td>
<td>1.6</td>
<td>1.4</td>
<td>1.1</td>
<td>1.2</td>
<td>1.6</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Mean</td>
<td>1.1</td>
<td>1.2</td>
<td>1.6</td>
<td>1.2</td>
<td>1.3</td>
<td>1.2</td>
<td>1.3</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cross</th>
<th>205</th>
<th>317</th>
<th>345</th>
<th>701</th>
</tr>
</thead>
<tbody>
<tr>
<td>205</td>
<td>1.2</td>
<td>1.1</td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>317</td>
<td>1.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>345</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>701</td>
<td>1.1</td>
<td>1.1</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Mean</td>
<td>1.1</td>
<td>1.2</td>
<td>1.5</td>
<td>1.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cross</th>
<th>205</th>
<th>317</th>
<th>345</th>
<th>701</th>
</tr>
</thead>
<tbody>
<tr>
<td>205</td>
<td>1.2</td>
<td>1.1</td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>317</td>
<td>1.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>345</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>701</td>
<td>1.1</td>
<td>1.1</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Mean</td>
<td>1.1</td>
<td>1.2</td>
<td>1.5</td>
<td>1.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cross</th>
<th>205</th>
<th>317</th>
<th>345</th>
<th>701</th>
</tr>
</thead>
<tbody>
<tr>
<td>205</td>
<td>1.2</td>
<td>1.1</td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>317</td>
<td>1.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>345</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>701</td>
<td>1.1</td>
<td>1.1</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Mean</td>
<td>1.1</td>
<td>1.2</td>
<td>1.5</td>
<td>1.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cross</th>
<th>205</th>
<th>317</th>
<th>345</th>
<th>701</th>
</tr>
</thead>
<tbody>
<tr>
<td>205</td>
<td>1.2</td>
<td>1.1</td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>317</td>
<td>1.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>345</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>701</td>
<td>1.1</td>
<td>1.1</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Mean</td>
<td>1.1</td>
<td>1.2</td>
<td>1.5</td>
<td>1.3</td>
</tr>
</tbody>
</table>

**Horizontal spread of the fungus in cortex (grade)**

<table>
<thead>
<tr>
<th>Cross</th>
<th>205</th>
<th>317</th>
<th>345</th>
<th>701</th>
</tr>
</thead>
<tbody>
<tr>
<td>205</td>
<td>2.6</td>
<td>1.5</td>
<td>2.8</td>
<td>1.9</td>
</tr>
<tr>
<td>317</td>
<td>3.9</td>
<td>2.0</td>
<td>3.1</td>
<td>2.0</td>
</tr>
<tr>
<td>345</td>
<td>2.2</td>
<td>1.4</td>
<td>1.7</td>
<td>2.0</td>
</tr>
<tr>
<td>701</td>
<td>2.7</td>
<td>1.9</td>
<td>2.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Mean</td>
<td>2.8</td>
<td>1.7</td>
<td>2.4</td>
<td>1.8</td>
</tr>
</tbody>
</table>

1/ Grade: 1 = Fungus spread less than 30% of distance around stalk.  
2 = Fungus spread between 30 and 40% of distance around stalk.  
3 = Fungus spread between 41 and 60% of distance around stalk.  
4 = Fungus spread between 61 and 80% of distance around stalk.  
5 = Fungus spread between 81 and 100% of distance around stalk.
Fifteen inbred lines of corn were included in an experiment in 1936 to determine the best time to inoculate plants with a spore suspension of Diplodia. Three lines, differing in resistance to stalk rotting, were obtained from each of the following five states: Wisconsin, Iowa, Illinois, Indiana, and Ohio. Each kind was distributed at random within each of five replications. Plots consisted of five-plant rows spaced 40 inches apart with the plants 13 inches apart in the row. Three dates of inoculation were compared with uninoculated checks, and inoculations were made on August 20, August 31, and September 10. Readings were made at harvest by counting the number of internodes traversed by the organism in the pith and cortex of the corn stalk. As shown in table 7, highly significant differences occurred between the lines. The means for the three dates of inoculation show that the greatest amount of disease was obtained on the first date and the least on the third date of inoculation.

Date of inoculation studies were continued in 1937. Eight Iowa inbred lines, replicated five times, were planted on May 19. Each replication consisted of ten plants. The first inoculations were made with spore suspensions on August 16 and the second ten days later. Comparable uninoculated plants were left as checks. Stalks were split and notes taken on September 30 (table 8). In the pith, highly significant differences occurred between lines. Although the inoculation on August 16 produced the most rotting, it is interesting to note how consistently the lines ranked from resistant to susceptible for the two dates of inocu-
Table 7. Disease development in stalk internodes of 15 inbred lines inoculated with Diplodia zeae on three dates, Ames, Iowa, 1936. Means of five replications.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Number of internodes rotted by fungus</th>
<th>Pith</th>
<th>Cortex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>8/20</td>
<td>8/31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8/20</td>
<td>8/31</td>
</tr>
<tr>
<td>Ind. Tr.</td>
<td>1.2 1.2 1.2 0.2 1.0</td>
<td>1.2 1.2 1.2 0.2 1.0</td>
<td></td>
</tr>
<tr>
<td>Ind. WF 9</td>
<td>1.3 1.2 1.1 0.5 1.0</td>
<td>1.3 1.2 1.1 0.2 1.0</td>
<td></td>
</tr>
<tr>
<td>Oh. 56</td>
<td>1.7 1.3 2.0 0.2 1.3</td>
<td>1.9 1.5 2.0 0.3 1.4</td>
<td></td>
</tr>
<tr>
<td>Ind. 38-11</td>
<td>2.0 1.4 1.1 0.3 1.2</td>
<td>1.0 1.0 1.0 0.2 0.8</td>
<td></td>
</tr>
<tr>
<td>Ill. Hy</td>
<td>2.0 1.2 1.2 0.0 1.1</td>
<td>2.2 1.4 1.2 0.0 1.2</td>
<td></td>
</tr>
<tr>
<td>Ia. 224</td>
<td>2.5 2.4 2.1 0.7 1.9</td>
<td>1.8 2.1 1.9 0.4 1.6</td>
<td></td>
</tr>
<tr>
<td>Oh. 10</td>
<td>2.3 2.1 1.0 0.0 1.4</td>
<td>2.3 1.9 1.0 0.0 1.3</td>
<td></td>
</tr>
<tr>
<td>Ia. 317</td>
<td>2.4 1.6 1.4 0.3 1.4</td>
<td>1.6 1.4 1.1 0.0 1.0</td>
<td></td>
</tr>
<tr>
<td>Ind. L 9</td>
<td>2.4 1.9 2.0 0.3 1.6</td>
<td>2.9 1.8 1.9 0.3 1.7</td>
<td></td>
</tr>
<tr>
<td>Wis. 26</td>
<td>2.5 2.5 2.2 1.0 2.0</td>
<td>2.0 2.7 1.9 1.0 1.9</td>
<td></td>
</tr>
<tr>
<td>Oh. 732</td>
<td>2.3 1.7 1.7 0.0 1.5</td>
<td>2.1 1.6 1.4 0.2 1.3</td>
<td></td>
</tr>
<tr>
<td>Wis. 23</td>
<td>3.1 3.3 1.9 0.8 2.3</td>
<td>2.8 3.1 1.7 0.2 2.0</td>
<td></td>
</tr>
<tr>
<td>Ia. 289</td>
<td>3.8 3.3 1.7 0.9 2.4</td>
<td>3.4 2.9 2.1 1.1 2.4</td>
<td></td>
</tr>
<tr>
<td>Ill. Lan</td>
<td>4.0 4.2 3.2 3.4 3.7</td>
<td>4.1 4.3 3.2 3.8 3.8</td>
<td></td>
</tr>
<tr>
<td>Wis. 6</td>
<td>4.6 3.0 2.2 1.0 2.7</td>
<td>4.3 3.3 2.7 2.8 2.8</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.5 2.2 1.7 0.6 2.3 2.1 1.7 0.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Analyses of Variance**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Number of internodes rotted</th>
<th>Pith</th>
<th>Cortex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>Mean</td>
<td>Y</td>
</tr>
<tr>
<td>Lines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inoculation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L x I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental error</td>
<td>176</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>224</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
1/Check not included
Table 6. Disease development in stalk internodes of eight inbred lines inoculated with Diplodia zeae on two dates, Ames, Iowa, 1937. Means of five replications.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Number of internodes rotted by fungus</th>
<th>Pith</th>
<th>Cortex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inoculation</td>
<td>8/16</td>
<td>8/26</td>
</tr>
<tr>
<td>349</td>
<td></td>
<td>1.3</td>
<td>0.9</td>
</tr>
<tr>
<td>205</td>
<td></td>
<td>1.5</td>
<td>0.9</td>
</tr>
<tr>
<td>345</td>
<td></td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>426</td>
<td></td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>401</td>
<td></td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>420</td>
<td></td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>234</td>
<td></td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>317</td>
<td></td>
<td>3.7</td>
<td>3.6</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>1.9</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Number of internodes rotted</th>
<th>Pith</th>
<th>Cortex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F squares</td>
<td>Mean</td>
<td>F</td>
</tr>
<tr>
<td>Lines</td>
<td>1/</td>
<td>7</td>
<td>652.00</td>
</tr>
<tr>
<td>Inoculations</td>
<td>1/</td>
<td>1</td>
<td>107.42</td>
</tr>
<tr>
<td>Replications</td>
<td>4/</td>
<td>4</td>
<td>95.89</td>
</tr>
<tr>
<td>Interactions</td>
<td>1/</td>
<td>7</td>
<td>22.21</td>
</tr>
<tr>
<td>Experimental error60</td>
<td>4/</td>
<td>47.49</td>
<td>60</td>
</tr>
</tbody>
</table>

*Significant difference **Highly significant difference

†/ Check not included
lation.

Very little cortex rotting occurred in the uninoculated plants, and notes were not taken. The analysis of the variance in cortex rotting between the two dates of inoculation indicates non-significant differences.

Table 9 shows the horizontal spread of Diplodia rotting in the stalk cortex. The lines differed significantly in resistance to Diplodia, but time of inoculation did not appear to affect materially the spread of the rotting.

A highly significant correlation of +0.92 was obtained between the average number of internodes rotted in the pith and in the cortex of the stalks of 15 inbred lines inoculated August 16, 1936 with Diplodia indicating that both methods of reading infection give similar results. The correlation between the number of internodes rotted in the stalk pith and in the cortex of eight inbred lines inoculated with Diplodia in 1937 was +0.30. Although this correlation was positive it was not statistically significant.

Stalk Rot Associations

Killing of stalks and leaves

In order to obtain an indication of the effect of Diplodia infection on premature killing of stalks and leaves, notes were taken shortly before harvest on stalk and leaf color (table 10). Grade "1" indicates green stalks or leaves, "2", medium and "3", dead stalks or
Table 9. Disease development in stalk cortex and smut infection of eight inbred lines inoculated with Diplodia zeae on two dates, Ames, Iowa. Means of five replications.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Horizontal spread of fungus (grade)</th>
<th>Smut infection (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inoculation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8/16</td>
<td>8/26</td>
</tr>
<tr>
<td>349</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>205</td>
<td>2.8</td>
<td>1.5</td>
</tr>
<tr>
<td>345</td>
<td>2.8</td>
<td>1.9</td>
</tr>
<tr>
<td>426</td>
<td>3.1</td>
<td>4.7</td>
</tr>
<tr>
<td>401</td>
<td>2.6</td>
<td>3.1</td>
</tr>
<tr>
<td>420</td>
<td>3.4</td>
<td>4.1</td>
</tr>
<tr>
<td>234</td>
<td>4.1</td>
<td>3.8</td>
</tr>
<tr>
<td>317</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Mean</td>
<td>2.9</td>
<td>2.9</td>
</tr>
</tbody>
</table>

1/ Grade: 1 = Fungus spread less than 20% of distance around stalk
2 = Fungus spread between 20% and 40% of distance around stalk
3 = Fungus spread between 41% and 60% of distance around stalk
4 = Fungus spread between 61% and 80% of distance around stalk
5 = Fungus spread between 81% and 100% of distance around stalk

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Horizontal spread of fungus</th>
<th>Smut infection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F squares</td>
<td>F value</td>
</tr>
<tr>
<td>Lines</td>
<td>7</td>
<td>737.5</td>
</tr>
<tr>
<td>Inoculations</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Replications</td>
<td>4</td>
<td>187.3</td>
</tr>
<tr>
<td>Interactions</td>
<td>L x I</td>
<td>239.2</td>
</tr>
<tr>
<td>Experimental error</td>
<td>60</td>
<td>64.18</td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Table 10. Premature dying of stalks and leaves of eight inbred lines inoculated with Diplodia zeae on two dates, Ames, Iowa, 1937. Means of five replications.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Stalk color (grade) 1/</th>
<th>Leaf color (grade) 1/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inoculation</td>
<td>Check</td>
</tr>
<tr>
<td></td>
<td>8/16</td>
<td>8/26</td>
</tr>
<tr>
<td>349</td>
<td>1.7</td>
<td>2.1</td>
</tr>
<tr>
<td>205</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>345</td>
<td>2.2</td>
<td>2.3</td>
</tr>
<tr>
<td>426</td>
<td>2.9</td>
<td>3.0</td>
</tr>
<tr>
<td>401</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>420</td>
<td>2.1</td>
<td>2.3</td>
</tr>
<tr>
<td>334</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>317</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Mean</td>
<td>2.2</td>
<td>2.3</td>
</tr>
</tbody>
</table>

1/ Grade: 1= Green plants or leaves  
2= Medium plants or leaves  
3= Dead plants or leaves

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Stalk color</th>
<th>Leaf color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>Mean squares</td>
</tr>
<tr>
<td>Lines</td>
<td>7</td>
<td>184.22</td>
</tr>
<tr>
<td>Inoculations</td>
<td>2</td>
<td>3.60</td>
</tr>
<tr>
<td>Replications</td>
<td>4</td>
<td>10.01</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L x I</td>
<td>14</td>
<td>5.06</td>
</tr>
<tr>
<td>Experimental error</td>
<td>92</td>
<td>3.70</td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
leaves. Highly significant differences in maturity occurred between lines. Inoculation with Diplodia did not appear to cause or affect premature dying of either stalks or leaves.

Weight of ear

Table 8 shows that the average number of internodes rotted in the pith of the lines inoculated August 16 was 1.9. This was nearly four times that of the check plants. The mean ear weight of the plants with a heavy Diplodia infection was 126 grams compared to 141 grams for the plants with only a slight infection or a decrease of 11 percent (table 11). Differences in ear weight between lines and between inoculated versus uninoculated plants were highly significant statistically. Although not statistically significant, a correlation of -0.42 between stalk pith rotting and mean ear weight of eight lines in 1937 indicates that lines resistant to Diplodia pith rotting tend to produce the heavier ears. Little relation occurred between resistance to cortex rotting and weight of ear.

Lodged plants

Short rows of 212 inbred lines were grown in 1934. Ten plants of each line were graded for lodged plants and these stalks were later split and the amount of shredding and discoloration recorded. Stalks differing in resistance to Diplodia are shown in figure 1. The correlation between stalk rotting under natural infection and lodged plants was +0.20. Since the one percent point for significance is 0.18, it
Table 11. Ear weight and ear rot of eight inbred lines inoculated with Diplodia zeae on two days, Ames, Iowa, 1937. Means of five replications.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Ear weight (grams)</th>
<th>Ear rot (grade)</th>
<th>Inoculation</th>
<th>Check</th>
<th>Mean</th>
<th>Inoculation</th>
<th>Check</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inoculation 8/16</td>
<td>8/26</td>
<td>Check</td>
<td>Mean</td>
<td>Inoculation 8/16</td>
<td>8/26</td>
<td>Check</td>
<td>Mean</td>
</tr>
<tr>
<td>349</td>
<td>148</td>
<td>156</td>
<td>161</td>
<td>155</td>
<td>2.7</td>
<td>2.8</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>205</td>
<td>147</td>
<td>162</td>
<td>158</td>
<td>156</td>
<td>2.6</td>
<td>2.4</td>
<td>2.4</td>
<td>2.5</td>
</tr>
<tr>
<td>345</td>
<td>135</td>
<td>111</td>
<td>141</td>
<td>129</td>
<td>2.9</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>426</td>
<td>126</td>
<td>118</td>
<td>142</td>
<td>128</td>
<td>2.2</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>401</td>
<td>82</td>
<td>93</td>
<td>99</td>
<td>91</td>
<td>2.7</td>
<td>2.4</td>
<td>2.7</td>
<td>2.6</td>
</tr>
<tr>
<td>420</td>
<td>175</td>
<td>171</td>
<td>183</td>
<td>178</td>
<td>2.2</td>
<td>2.1</td>
<td>2.4</td>
<td>2.2</td>
</tr>
<tr>
<td>234</td>
<td>96</td>
<td>102</td>
<td>107</td>
<td>101</td>
<td>2.4</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>317</td>
<td>96</td>
<td>109</td>
<td>130</td>
<td>112</td>
<td>1.7</td>
<td>1.6</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Mean</td>
<td>126</td>
<td>127</td>
<td>141</td>
<td>131</td>
<td>2.4</td>
<td>2.3</td>
<td>2.4</td>
<td>2.4</td>
</tr>
</tbody>
</table>

1/ Grade: 1 = 1% to 20% rotted kernels
2 = 21% to 40% rotted kernels
3 = 41% to 60% rotted kernels

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Ear weight</th>
<th>Ear rot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F Mean squares</td>
<td>F Value</td>
</tr>
<tr>
<td>Lines</td>
<td>7 1329025</td>
<td>58.62**</td>
</tr>
<tr>
<td>Inoculations</td>
<td>2 274375</td>
<td>12.12**</td>
</tr>
<tr>
<td>Replications</td>
<td>4 122006</td>
<td>5.38**</td>
</tr>
<tr>
<td>Interactions</td>
<td>L x I 14</td>
<td>31889</td>
</tr>
<tr>
<td>Experimental error</td>
<td>92 22670</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference
**Highly significant difference
Figure 1. Representative stalks of an inbred line susceptible to Diplodia zeae (A) and from a resistant inbred line (B). There is a marked correlation between susceptibility to Diplodia infection and the breaking of stalks.
is concluded that stalk rotting and stalk lodging are associated.

**Smut infection**

The "time of inoculation" experiments gave an opportunity to determine how stalk rotting affected smut infection. Table 9 shows that the eight inbred lines differed very greatly in resistance to smut (*Ustilago zeae*). None of the plants of line 234 were infected with smut, while 55 percent of the plants of line 349 were smutted. Inoculation and differential Diplodia infection, however, did not have a significant effect upon smut infection.

**Ear rotting**

Table 8 shows pith stalk rotting and table 11 the ear rot grade of eight inbred lines of corn. The lines differed significantly in amount of stalk and ear rotting. Inoculation of the stalks with Diplodia did not appear to affect rotting of the ears. The correlation between stalk and ear rot was -0.35, which is above the one percent point of 0.33. These data, based on only eight lines, indicate that lines which are resistant to pith stalk rot tend to be susceptible to ear rot and vice versa. Earlier data on 185 lines, infected naturally under field conditions, gave a correlation of 40.06, which was not significant, probably because of disease escape.
Nature of Resistance to Stalk Rot

In 1956, 15 inbred lines, 30 top crosses and two entries of Krug yellow dent were included in an experiment consisting of four replications. About ten days after pollination, each 60-plant plot was divided into four equal parts and each part given one of the following treatments: (a) leaves clipped, stalks inoculated, (b) leaves clipped, stalks not inoculated, (c) leaves normal, stalks inoculated, and (d) leaves normal, stalks not inoculated. Stalks were split and readings made the first week in October. The development of Diplodia in stalk pith of the inbred lines is shown in table 12. Lines given no treatment ranged from 0 to 1.63 internodes rotted. These same inbreds when inoculated varied in susceptibility from 1.44 to 3.50 internodes. As shown by the analysis of variance, highly significant differences occurred between inbred lines and between inoculated and not inoculated plants. Clipping of leaves did not appear to affect the relative resistance and susceptibility of the inbred lines. The 1936 season at Ames was unusually hot and dry. Many of the corn leaves were dead and dry at the time of clipping. Removing part of these leaves, therefore, probably had very little effect upon the photosynthetic and translocation processes of the plants.

Development of Diplodia in the stalk internodes of the top crosses is shown in table 13. These results in general corroborate those of the inbred lines. Differences between crosses and between inoculated and check plants were highly significant. As with the inbred lines,
Table 12. Development of Diplodia zeae in stalk internodes of 15 inbred lines treated in various ways at Ames, Iowa, 1936.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Number of internodes rotted in pith</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
</tr>
<tr>
<td></td>
<td>Clipped leaves</td>
</tr>
<tr>
<td></td>
<td>Inoculated</td>
</tr>
<tr>
<td>163</td>
<td>2.92</td>
</tr>
<tr>
<td>205</td>
<td>3.50</td>
</tr>
<tr>
<td>224</td>
<td>1.69</td>
</tr>
<tr>
<td>234</td>
<td>2.06</td>
</tr>
<tr>
<td>289</td>
<td>2.70</td>
</tr>
<tr>
<td>317</td>
<td>2.81</td>
</tr>
<tr>
<td>345</td>
<td>2.38</td>
</tr>
<tr>
<td>349</td>
<td>2.58</td>
</tr>
<tr>
<td>364</td>
<td>3.46</td>
</tr>
<tr>
<td>397</td>
<td>2.76</td>
</tr>
<tr>
<td>401</td>
<td>1.31</td>
</tr>
<tr>
<td>420</td>
<td>2.97</td>
</tr>
<tr>
<td>426</td>
<td>2.16</td>
</tr>
<tr>
<td>447</td>
<td>2.58</td>
</tr>
<tr>
<td>743</td>
<td>3.24</td>
</tr>
<tr>
<td>Mean</td>
<td>2.62</td>
</tr>
</tbody>
</table>

Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>14</td>
<td>2.22</td>
<td>5.84**</td>
<td>2.23</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clipped and not clipped</td>
<td>1</td>
<td>0.05</td>
<td>0.13</td>
<td>6.84</td>
</tr>
<tr>
<td>Inoculated and not inoculated</td>
<td>1</td>
<td>199.24</td>
<td>521.68**</td>
<td>6.84</td>
</tr>
<tr>
<td>Interaction:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clipped x inoculated</td>
<td>1</td>
<td>0.00</td>
<td>0.00</td>
<td>6.84</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>1.47</td>
<td>3.87*</td>
<td>4.78</td>
</tr>
<tr>
<td>Interaction:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line x treatment</td>
<td>42</td>
<td>0.29</td>
<td>0.76</td>
<td>1.75</td>
</tr>
<tr>
<td>Experimental error</td>
<td>119</td>
<td>0.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>179</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference.  *Significant difference
Table 15. Development of Diplodia zeae in stalk internodes of 30 top crosses and 2 entries of Krug treated in various ways at Ames, Iowa, 1936.

<table>
<thead>
<tr>
<th>Krug and top crossed lines</th>
<th>Number of internodes rotted in pith</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clipped leaves</td>
<td>Uncipped leaves</td>
</tr>
<tr>
<td></td>
<td>Inoculated</td>
<td>Inoculated</td>
</tr>
<tr>
<td>Krug</td>
<td>2.88</td>
<td>2.73</td>
</tr>
<tr>
<td>Krug</td>
<td>2.65</td>
<td>2.55</td>
</tr>
<tr>
<td>159</td>
<td>2.20</td>
<td>2.50</td>
</tr>
<tr>
<td>163</td>
<td>2.33</td>
<td>2.70</td>
</tr>
<tr>
<td>184</td>
<td>2.43</td>
<td>2.40</td>
</tr>
<tr>
<td>198</td>
<td>1.83</td>
<td>1.70</td>
</tr>
<tr>
<td>205</td>
<td>2.40</td>
<td>2.73</td>
</tr>
<tr>
<td>224</td>
<td>1.95</td>
<td>2.10</td>
</tr>
<tr>
<td>233</td>
<td>2.40</td>
<td>2.50</td>
</tr>
<tr>
<td>234</td>
<td>2.53</td>
<td>2.40</td>
</tr>
<tr>
<td>287</td>
<td>2.40</td>
<td>2.50</td>
</tr>
<tr>
<td>289</td>
<td>2.50</td>
<td>2.35</td>
</tr>
<tr>
<td>304</td>
<td>2.25</td>
<td>2.13</td>
</tr>
<tr>
<td>311</td>
<td>2.33</td>
<td>2.50</td>
</tr>
<tr>
<td>317</td>
<td>2.83</td>
<td>3.03</td>
</tr>
<tr>
<td>339</td>
<td>2.18</td>
<td>2.35</td>
</tr>
<tr>
<td>345</td>
<td>3.00</td>
<td>2.48</td>
</tr>
<tr>
<td>349</td>
<td>3.20</td>
<td>2.58</td>
</tr>
<tr>
<td>364</td>
<td>2.35</td>
<td>2.58</td>
</tr>
<tr>
<td>397</td>
<td>2.18</td>
<td>2.25</td>
</tr>
<tr>
<td>401</td>
<td>2.30</td>
<td>2.63</td>
</tr>
<tr>
<td>420</td>
<td>2.40</td>
<td>2.60</td>
</tr>
<tr>
<td>426</td>
<td>2.20</td>
<td>2.50</td>
</tr>
<tr>
<td>447</td>
<td>3.00</td>
<td>2.65</td>
</tr>
<tr>
<td>456</td>
<td>2.73</td>
<td>2.58</td>
</tr>
<tr>
<td>665</td>
<td>2.65</td>
<td>2.60</td>
</tr>
<tr>
<td>701</td>
<td>2.60</td>
<td>2.55</td>
</tr>
<tr>
<td>737</td>
<td>2.58</td>
<td>3.18</td>
</tr>
<tr>
<td>743</td>
<td>2.18</td>
<td>2.18</td>
</tr>
<tr>
<td>R4</td>
<td>2.25</td>
<td>2.25</td>
</tr>
<tr>
<td>WF9</td>
<td>1.95</td>
<td>2.38</td>
</tr>
<tr>
<td>Tr</td>
<td>1.88</td>
<td>2.23</td>
</tr>
<tr>
<td>Mean</td>
<td>2.43</td>
<td>2.46</td>
</tr>
</tbody>
</table>
Table 13. (Continued)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross</td>
<td>31</td>
<td>.45</td>
<td>3.21**</td>
<td>1.74</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cliped and not cliped</td>
<td>1</td>
<td>.05</td>
<td>.36</td>
<td>6.70</td>
</tr>
<tr>
<td>Inoculated and not inoculated</td>
<td>1</td>
<td>533.62</td>
<td>3811.57*</td>
<td>6.70</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clipped x inoculated</td>
<td>1</td>
<td>.04</td>
<td>.28</td>
<td>6.70</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>4.00</td>
<td>28.57**</td>
<td>3.83</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross x treatment</td>
<td>93</td>
<td>.17</td>
<td>1.21</td>
<td>1.42</td>
</tr>
<tr>
<td>Experimental error</td>
<td>381</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>511</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference.
**Highly significant difference.
clipping the leaves did not affect the relative resistance of the
crosses to Diplodia. The range in resistance and susceptibility of the
top crosses was less than in the inbred lines. Krug variety was inter-
mediate in resistance. This open-pollinated variety, which contributed
half the heredity of all the top crosses, tended to lessen the differ-
ential in the material. In general, the top crosses were slightly more
resistant than were the inbred lines.

The studies to determine the effects of leaf clipping upon reac-
tions to stalk rot were enlarged in 1937. The material consisting of
inbred lines and single crosses was divided into four experiments.
Four single crosses were included in experiments A and B, and eight
inbred lines were used in experiments C and D. The material in ex-
periments A, B, and C was subjected to the three following treatments:
(a) normal (N), (b) enforced barrenness (B), and (c) leaf clipping (C).
Representative treated plants are shown in figures 2, 3, and 4. Leaves
were clipped about one week after pollination and stalk inoculations
were made one week later. The stalks were split and first readings
made about the middle of September. A second reading was made about
ten days later.

The effect of leaf clipping and prevention of pollination on pith
stalk rotting of eight inbred lines inoculated with Diplodia in 1937
is shown in table 14. Inbred lines 224, 456, 701, and 84 were the most
resistant to Diplodia stalk rot, while Tr, 397, and 743 were much more
susceptible. Under the abnormally hot, dry conditions of 1936, Tr was
resistant to Diplodia (table 7). Plants given the barren treatment
Figure 2. Normal plants.
Figure 3. Barren plants. Pollination was prevented by covering the ear shoots with parchment bags before the silks appeared.
Figure 4. Clipped plants. The tip one-third of each leaf, consisting of about 25 percent of the leaf area, was removed about one week after pollination.
Table 14. Effect of leaf clipping and prevention of pollination on number of internodes rotted by fungus in stalk pith of eight inbred lines inoculated with Diplodia zeae, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>First sampling</th>
<th>Second sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment 1/</td>
<td>Treatment 1/</td>
</tr>
<tr>
<td></td>
<td>N   B   C</td>
<td>N   B   C</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>224</td>
<td>0.8 0.9 0.7</td>
<td>0.8 0.9 1.1</td>
</tr>
<tr>
<td>701</td>
<td>0.9 1.1 1.0</td>
<td>1.0 1.0 1.2</td>
</tr>
<tr>
<td>456</td>
<td>1.0 1.0 0.9</td>
<td>0.9 1.0 1.4</td>
</tr>
<tr>
<td>124</td>
<td>0.9 1.6 0.8</td>
<td>1.1 1.1 1.7</td>
</tr>
<tr>
<td>746</td>
<td>1.0 5.6 1.9</td>
<td>2.9 1.5 5.5</td>
</tr>
<tr>
<td>107-2</td>
<td>1.8 1.6 2.1</td>
<td>1.8 2.5 2.3</td>
</tr>
<tr>
<td>397</td>
<td>4.7 6.2 2.2</td>
<td>4.4 2.2 5.1</td>
</tr>
<tr>
<td>Tr</td>
<td>3.4 4.9 4.5</td>
<td>4.3 4.1 4.9</td>
</tr>
<tr>
<td>Mean</td>
<td>1.8 2.9 1.8</td>
<td>2.2 1.8 2.8</td>
</tr>
</tbody>
</table>

 Treatment: N = Normal plants, B = Barren plants, C = Clipped plants

Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>P point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>3,151,36</td>
<td>84.19**</td>
<td>2.82</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>68.48</td>
<td>1.83</td>
<td>4.82</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>1,812,70</td>
<td>48.43**</td>
<td>4.82</td>
</tr>
<tr>
<td>Samplings</td>
<td>1</td>
<td>1.65</td>
<td>0.04</td>
<td>6.90</td>
</tr>
<tr>
<td>L x T</td>
<td>14</td>
<td>544.21</td>
<td>14.54**</td>
<td>2.26</td>
</tr>
<tr>
<td>L x S</td>
<td>7</td>
<td>150.04</td>
<td>4.01**</td>
<td>2.82</td>
</tr>
<tr>
<td>T x S</td>
<td>2</td>
<td>2.30</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Experimental error</td>
<td>108</td>
<td>37.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
appeared to be the most susceptible to the spread of Diplodia. The analysis of variance in pith readings indicated highly significant differences between lines, between treatments, but not between readings made at the two different dates.

The effect of the three treatments on rotting in the stalk pith of eight single crosses is shown in table 15. Differences between crosses, between treatments, and between samplings are highly significant. Although individual crosses varied in response to the three treatments, the barren plants averaged much more susceptible than the clipped or normal plants.

Table 16 shows the results of leaf clipping and barrenness on cortex rotting of inbred lines, and table 17 the effect of treatment on single crosses. Differences between lines and between samplings in table 16 were highly significant. In table 17, differences in group A between crosses and between treatments were highly significant. In contrast to the results on pith rotting, barren single cross plants tended to be most resistant to cortex rotting.

The third measure of resistance was a grade indicating the horizontal spread of the fungus in the stalk cortex. A grade of 1 indicates fungus spread of less than 20 percent of the distance around the stalk and grade 5 a spread 81 to 100 percent of the distance around the stalk. Table 18 shows the effect of treatment on inbred lines, and table 19 on single crosses. Treatment did not appear to affect the horizontal rotting of the Diplodia in the cortex of the inbred lines. In the single crosses, barren plants were more resistant than normal or clipped plants. These differences were highly sig-
Table 15. Effect of leaf clipping and prevention of pollination on number of internodes rotted by fungus in stalk pith of eight single crosses inoculated with *Diplodia zeae*, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Number of internodes rotted in pith</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First sampling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment 1/</td>
<td>Mean</td>
<td>Treatment 1/</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>E</td>
<td>C</td>
<td>Mean</td>
<td>N</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>198 x Lan</td>
<td>1.1</td>
<td>1.4</td>
<td>1.6</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Tr x Lan</td>
<td>1.3</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.7</td>
</tr>
<tr>
<td>364 x Lan</td>
<td>1.7</td>
<td>1.0</td>
<td>2.2</td>
<td>1.6</td>
<td>1.9</td>
</tr>
<tr>
<td>198 x 38-11</td>
<td>1.5</td>
<td>3.8</td>
<td>1.1</td>
<td>2.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Mean</td>
<td>1.4</td>
<td>1.9</td>
<td>1.5</td>
<td>1.6</td>
<td>1.9</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td>Second sampling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment 1/</td>
<td>Mean</td>
<td>Treatment 1/</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>E</td>
<td>C</td>
<td>Mean</td>
<td>N</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>197 x 198</td>
<td>1.1</td>
<td>4.5</td>
<td>1.1</td>
<td>2.3</td>
<td>1.2</td>
</tr>
<tr>
<td>198 x 351</td>
<td>1.0</td>
<td>3.9</td>
<td>1.6</td>
<td>2.2</td>
<td>1.5</td>
</tr>
<tr>
<td>197 x 364</td>
<td>1.6</td>
<td>4.2</td>
<td>2.7</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td>351 x 364</td>
<td>1.3</td>
<td>2.5</td>
<td>1.4</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Mean</td>
<td>1.3</td>
<td>3.8</td>
<td>1.7</td>
<td>2.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Mean A &amp; B</td>
<td>1.3</td>
<td>2.8</td>
<td>1.6</td>
<td>1.9</td>
<td>1.6</td>
</tr>
</tbody>
</table>

1/ Treatment: N = Normal plants, B = Barren plants, C = Clipped plants

### Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean D/F squares F value 1% point</td>
<td>Mean D/F squares F value 1% point</td>
</tr>
<tr>
<td>Crosses</td>
<td>3 339.1 7.46** 4.08</td>
<td>3 111.4 6.71** 3.94</td>
</tr>
<tr>
<td>Replications</td>
<td>3 75.0 1.65 4.08</td>
<td>5 81.3 4.90** 3.17</td>
</tr>
<tr>
<td>Treatments</td>
<td>2 207.9 4.59* 4.92</td>
<td>2 3256.8 196.19** 4.78</td>
</tr>
<tr>
<td>Samplings</td>
<td>1 436.0 9.62** 7.01</td>
<td>1 122.3 7.36** 6.84</td>
</tr>
<tr>
<td>Interactions</td>
<td>6 54.8 1.21 3.07</td>
<td>6 106.7 6.43** 2.95</td>
</tr>
<tr>
<td>G x T</td>
<td>3 11.8 0.56 4.08</td>
<td>3 76.8 4.63** 3.94</td>
</tr>
<tr>
<td>G x S</td>
<td>2 6.2 0.14 4.92</td>
<td>2 88.4 5.33** 4.78</td>
</tr>
<tr>
<td>Experimental error</td>
<td>95 45.3</td>
<td>121 16.6</td>
</tr>
</tbody>
</table>

*Significant difference **Highly significant difference
Table 16. Effect of leaf clipping and prevention of pollination on number of internodes rotted in stalk cortex of eight inbred lines inoculated with Diplodia zeae, Ames, Iowa, 1957.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>First sampling</th>
<th>Second sampling</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment 1/</td>
<td>Treatment 1/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N  B  C</td>
<td>N  B  C</td>
<td></td>
</tr>
<tr>
<td>224</td>
<td>0.9 0.9 0.7</td>
<td>0.9 1.0 0.9</td>
<td>0.8 0.8</td>
</tr>
<tr>
<td>701</td>
<td>0.7 0.9 0.9</td>
<td>0.9 1.1 0.8</td>
<td>1.1 1.0</td>
</tr>
<tr>
<td>456</td>
<td>0.9 0.7 0.9</td>
<td>0.8 1.1 0.8</td>
<td>1.5 1.1 1.0</td>
</tr>
<tr>
<td>844</td>
<td>0.6 0.6 0.6</td>
<td>0.6 0.6 0.7</td>
<td>0.9 0.7 0.7</td>
</tr>
<tr>
<td>743</td>
<td>0.6 1.0 1.1</td>
<td>0.9 1.2 1.2</td>
<td>1.0 1.0 0.9</td>
</tr>
<tr>
<td>187-2</td>
<td>0.8 1.1 0.9</td>
<td>1.0 1.6 1.2</td>
<td>1.2 1.3 1.1</td>
</tr>
<tr>
<td>397</td>
<td>1.0 1.0 0.8</td>
<td>0.9 1.2 1.1</td>
<td>1.2 1.2 1.0</td>
</tr>
<tr>
<td>Tr</td>
<td>0.9 0.8 0.8</td>
<td>0.8 0.8 0.8</td>
<td>0.8 0.8 0.8</td>
</tr>
<tr>
<td>Mean</td>
<td>0.8 0.9 0.8</td>
<td>0.8 1.0 1.1</td>
<td>1.0 1.0 0.9</td>
</tr>
</tbody>
</table>

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants

Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>40.97</td>
<td>7.88**</td>
<td>2.82</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>6.14</td>
<td>1.18</td>
<td>4.82</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>4.85</td>
<td>0.93</td>
<td>4.82</td>
</tr>
<tr>
<td>Samplings</td>
<td>1</td>
<td>102.34</td>
<td>19.68**</td>
<td>6.90</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L x T</td>
<td>14</td>
<td>12.48</td>
<td>2.40**</td>
<td>2.26</td>
</tr>
<tr>
<td>L x S</td>
<td>7</td>
<td>9.89</td>
<td>1.90</td>
<td>2.82</td>
</tr>
<tr>
<td>T x S</td>
<td>2</td>
<td>10.72</td>
<td>2.06</td>
<td>4.82</td>
</tr>
<tr>
<td>Experimental error</td>
<td>108</td>
<td>5.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference
Table 17. Effect of leaf clipping and prevention of pollination on number of internodes rotted by fungus in stalk cortex of eight single crosses inoculated with Diplodia zeae, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Treatment 1/</th>
<th>Treatment 2/</th>
<th>Mean</th>
<th>Treatment 1/</th>
<th>Treatment 2/</th>
<th>Mean</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N  B  C</td>
<td>N  B  C</td>
<td></td>
<td>N  B  C</td>
<td>N  B  C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>198 x Lan</td>
<td>0.96 0.43 1.17</td>
<td>0.86 1.27 0.59</td>
<td>1.10</td>
<td>0.99 0.92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tr x Lan</td>
<td>1.11 0.77 0.64</td>
<td>0.84 1.38 0.99</td>
<td>1.07</td>
<td>1.14 0.99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>354 x Lan</td>
<td>1.43 0.57 1.73</td>
<td>1.25 1.14 0.96</td>
<td>0.90</td>
<td>1.00 1.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>198 x 38-11</td>
<td>0.63 0.68 0.48</td>
<td>0.60 1.08 0.97</td>
<td>0.92</td>
<td>0.99 0.80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.03 0.62 1.01</td>
<td>0.89 1.22 0.88</td>
<td>1.00</td>
<td>1.03 0.96</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Group A

Group B

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>F value</td>
</tr>
<tr>
<td>Crosses</td>
<td>3 45.09</td>
<td>4.47** 4.08</td>
</tr>
<tr>
<td>Replications</td>
<td>3 37.67</td>
<td>3.73* 4.08</td>
</tr>
<tr>
<td>Treatments</td>
<td>2 119.54</td>
<td>11.87** 4.92</td>
</tr>
<tr>
<td>Samplings</td>
<td>1 51.52</td>
<td>5.12* 7.01</td>
</tr>
<tr>
<td>Interactions C x T</td>
<td>6 33.93</td>
<td>3.37** 3.07</td>
</tr>
<tr>
<td>C x S</td>
<td>3 47.65</td>
<td>4.73** 4.08</td>
</tr>
<tr>
<td>T x S</td>
<td>2 15.76</td>
<td>1.57  4.92</td>
</tr>
<tr>
<td>Experimental Error?</td>
<td>10.08</td>
<td>4.49</td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Table 18. Effect of leaf clipping and prevention of pollination on horizontal spread of the fungus in stalk cortex of eight inbred lines inoculated with <i>Diplodia sese</i>, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Horizontal spread of fungus in cortex (Grade)²/</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First sampling</td>
<td>Second sampling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment ¹/</td>
<td>Mean</td>
<td>Treatment ¹/</td>
<td>Mean</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>B</td>
<td>C</td>
<td></td>
<td>N</td>
<td>B</td>
</tr>
<tr>
<td>224</td>
<td>1.7</td>
<td>1.4</td>
<td>1.1</td>
<td>1.4</td>
<td>1.6</td>
<td>2.5</td>
</tr>
<tr>
<td>701</td>
<td>1.1</td>
<td>1.4</td>
<td>1.3</td>
<td>1.3</td>
<td>2.3</td>
<td>2.4</td>
</tr>
<tr>
<td>456</td>
<td>2.4</td>
<td>1.2</td>
<td>1.9</td>
<td>1.8</td>
<td>3.0</td>
<td>2.2</td>
</tr>
<tr>
<td>R4</td>
<td>1.7</td>
<td>1.2</td>
<td>1.2</td>
<td>1.4</td>
<td>1.2</td>
<td>2.0</td>
</tr>
<tr>
<td>743</td>
<td>1.6</td>
<td>1.5</td>
<td>2.8</td>
<td>2.0</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>187-2</td>
<td>1.5</td>
<td>2.2</td>
<td>2.3</td>
<td>2.0</td>
<td>4.2</td>
<td>4.3</td>
</tr>
<tr>
<td>397</td>
<td>2.1</td>
<td>1.5</td>
<td>1.5</td>
<td>1.7</td>
<td>2.8</td>
<td>2.3</td>
</tr>
<tr>
<td>Tr</td>
<td>1.7</td>
<td>1.1</td>
<td>1.6</td>
<td>1.5</td>
<td>1.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Mean</td>
<td>1.7</td>
<td>1.4</td>
<td>1.7</td>
<td>1.6</td>
<td>2.3</td>
<td>2.6</td>
</tr>
</tbody>
</table>

¹/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants

²/ Grade: 1=Fungus spread less than 20% distance around stalk
2=Fungus spread between 20 and 40% distance around stalk
3=Fungus spread between 41 and 60% distance around stalk
4=Fungus spread between 61 and 80% distance around stalk
5=Fungus spread between 81 and 100% distance around stalk

Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>574.36</td>
<td>13.18**</td>
<td>2.82</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>63.34</td>
<td>1.45</td>
<td>4.82</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>108.46</td>
<td>2.49</td>
<td>4.82</td>
</tr>
<tr>
<td>Samplings</td>
<td>1</td>
<td>3,173.44</td>
<td>72.80**</td>
<td>6.90</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L x T</td>
<td>14</td>
<td>91.20</td>
<td>2.09*</td>
<td>2.26</td>
</tr>
<tr>
<td>L x S</td>
<td>7</td>
<td>257.87</td>
<td>5.92**</td>
<td>2.82</td>
</tr>
<tr>
<td>T x S</td>
<td>2</td>
<td>101.26</td>
<td>2.32</td>
<td>4.82</td>
</tr>
<tr>
<td>Experimental error</td>
<td>108</td>
<td>43.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Table 19. Effect of leaf clipping and prevention of pollination on horizontal spread of the fungus in stalk cortex of eight single crosses inoculated with Diplodia zeae, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Horizontal spread of the fungus in cortex (grade)</th>
<th>First sampling</th>
<th>Second sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment 1/ Mean Treatment 1/ Mean Treatment 1/ Mean</td>
<td>N B C</td>
<td>N B C</td>
</tr>
<tr>
<td>198 x Lan</td>
<td>2.3 1.1 3.3 2.2 3.4 1.4 2.6 2.5 2.4</td>
<td>Group A</td>
<td></td>
</tr>
<tr>
<td>Tr x Lan</td>
<td>2.4 1.8 1.9 2.0 2.9 2.1 3.0 2.7 2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>364 x Lan</td>
<td>3.7 1.6 3.8 3.0 2.7 2.5 2.9 2.7 2.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>198 x 38-11</td>
<td>1.4 1.7 1.5 1.5 2.5 2.6 2.8 2.6 2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.5 1.5 2.6 2.2 2.9 2.2 2.8 2.6 2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>197 x 198</td>
<td>2.0 1.1 2.7 2.0 2.8 1.4 2.7 2.3 2.1</td>
<td>Group B</td>
<td></td>
</tr>
<tr>
<td>198 x 351</td>
<td>2.1 1.5 3.4 2.3 3.3 3.0 2.7 3.0 2.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>197 x 364</td>
<td>3.0 1.5 3.4 2.6 3.1 1.7 2.5 2.4 2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>351 x 364</td>
<td>2.8 1.5 3.1 2.5 3.8 1.9 2.6 2.8 2.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.5 1.4 3.1 2.3 3.2 2.0 2.6 2.6 2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean A &amp; B</td>
<td>2.5 1.4 2.8 2.2 3.0 2.1 2.7 2.6 2.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants

2/ Grade: 1=Fungus spread less than 20% distance around stalk
          2=Fungus spread between 20 and 40% of distance around stalk
          3=Fungus spread between 41 and 60% of distance around stalk
          4=Fungus spread between 61 and 80% of distance around stalk
          5=Fungus spread between 81 and 100% of distance around stalk

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean squares</td>
<td>F value</td>
</tr>
<tr>
<td>D/F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crosses</td>
<td>3 269.0</td>
<td>5.35**</td>
</tr>
<tr>
<td>Replications</td>
<td>3 588.1</td>
<td>11.69**</td>
</tr>
<tr>
<td>Treatments</td>
<td>2 745.1</td>
<td>14.81**</td>
</tr>
<tr>
<td>Samplings</td>
<td>1 425.0</td>
<td>8.45**</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C x T</td>
<td>6 154.3</td>
<td>3.07**</td>
</tr>
<tr>
<td>C x S</td>
<td>3 234.2</td>
<td>4.65**</td>
</tr>
<tr>
<td>T x S</td>
<td>2 45.3</td>
<td>0.90</td>
</tr>
<tr>
<td>Experimental error</td>
<td>75 50.3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference **Highly significant difference
In order to obtain an indication of the effect of treatment on premature dying of the plant, notes were taken on the stalks and leaves. A grade of 1 indicates green plants or leaves, 2 medium, and 3 dead plants or leaves. As shown in tables 20 and 21, and in figure 5, barren stalks tended to remain green the longest, while the clipped plants died prematurely. These differences are highly significant. The effect of treatment on premature killing of the leaves is shown in tables 20 and 22. The leaves of the clipped, single cross plants died before the leaves of the normal or barren plants.

The effects of leaf clipping and prevention of pollination on percentage of smutted inbred and single cross plants inoculated with Diplodia are given in tables 23 and 24. Smut infection was materially increased by the barren treatment. The mean percent smutted plants of all eight crosses was 10.3 for the normal, 10.6 for the clipped and 15.2 for the barren plants. These differences are highly significant statistically.

Clipping the leaves lowered the yield of corn. The ear weight of the normal plants was 141 grams for the inbred lines and 337 grams for the single crosses. Clipping the leaves resulted in an ear weight of 102 grams for the inbreds and 306 grams for the single crosses. In other words, clipping the leaves resulted in decreasing the yield 23 percent for the inbred lines and 21 percent for the single crosses. As shown in tables 23 and 25 these differences are highly significant.

The effect of leaf clipping on amount of ear rot of inbred lines
Table 20. Effect of leaf clipping and prevention of pollination on premature killing by fungus of stalks and leaves of eight inbred lines inoculated with Diplodia zeae, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Stalk</th>
<th>Color (Grade)</th>
<th>Leaf</th>
<th>Color (Grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>B</td>
<td>C</td>
<td>Mean</td>
</tr>
<tr>
<td>224</td>
<td>2.4</td>
<td>2.0</td>
<td>2.9</td>
<td>2.4</td>
</tr>
<tr>
<td>701</td>
<td>1.7</td>
<td>2.0</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>456</td>
<td>1.5</td>
<td>1.8</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>84</td>
<td>3.0</td>
<td>2.0</td>
<td>3.0</td>
<td>2.7</td>
</tr>
<tr>
<td>743</td>
<td>2.7</td>
<td>1.7</td>
<td>2.7</td>
<td>2.3</td>
</tr>
<tr>
<td>187-2</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>397</td>
<td>2.4</td>
<td>2.1</td>
<td>2.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Tr</td>
<td>1.3</td>
<td>2.0</td>
<td>2.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Mean</td>
<td>2.0</td>
<td>1.8</td>
<td>2.3</td>
<td>2.0</td>
</tr>
</tbody>
</table>

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants
2/ Grade: 1=Green stalks or leaves
         2=Medium stalks or leaves
         3=Dead stalks or leaves

Analyses of Variance

| Source of variation | Color of stalk | | Color of leaf | |
|---------------------|---------------|----------------------|----------------------|
|                     | D/F | Mean squares | F value | 1% point | D/F | Mean squares | F value | 1% point |
| Lines               | 7   | 248.53       | 31.22** | 3.05     | 7   | 214.32       | 30.19** | 3.05     |
| Replications        | 2   | 0.52         | 0.07    | 5.10     | 2   | 0.60         | 0.08    | 5.10     |
| Treatments          | 2   | 127.10       | 15.97** | 5.10     | 2   | 48.39        | 6.82**  | 5.10     |
| Interactions        |     |              |         |          |     |              |         |          |
| L x T               | 14  | 38.14        | 4.79**  | 2.50     | 14  | 28.36        | 3.99**  | 2.50     |
| Experimental error  | 46  | 7.96         | 7.96    | 46       | 7.10 | 7.10         | 7.10    | 7.10     |
| Total               | 71  |              |         |          |     |              |         |          |

**Highly significant difference
Table 21. Effect of leaf clipping and prevention of pollination on premature killing by fungus of stalks of eight single crosses inoculated with Diplodia zeae, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Treatment 1/</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>B</td>
</tr>
<tr>
<td><strong>Group A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>198 x Lan</td>
<td>1.7</td>
<td>1.0</td>
</tr>
<tr>
<td>Tr x Lan</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>364 x Lan</td>
<td>2.2</td>
<td>1.3</td>
</tr>
<tr>
<td>198 x 38-11</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Mean</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Group B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>197 x 198</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>198 x 351</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>197 x 364</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>351 x 364</td>
<td>2.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Mean</td>
<td>1.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Mean A and B</td>
<td>1.4</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants
2/ Grade: 1=Green stalks, 2=Medium stalks, 3=Dead stalks

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>F value</td>
</tr>
<tr>
<td>Crosses</td>
<td>3</td>
<td>304.3</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>13.2</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>285.2</td>
</tr>
<tr>
<td>Interactions</td>
<td>C x T</td>
<td>6</td>
</tr>
<tr>
<td>Experimental error</td>
<td>33</td>
<td>5.6</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>71</td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Figure 5. A typical example of premature dying of clipped plants inoculated with *Diplodia zeae*.
Table 22. Effect of leaf clipping and prevention of pollination on premature killing by fungus of leaves of eight single crosses inoculated with Diplodia zeae, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Leaf color (grade)</th>
<th>Treatment 1/</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td><strong>Group A</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>198 x Lan</td>
<td>1.8</td>
<td>1.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Tr x Lan</td>
<td>1.1</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>364 x Lan</td>
<td>2.3</td>
<td>2.0</td>
<td>2.6</td>
</tr>
<tr>
<td>198 x 38-11</td>
<td>1.0</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Mean</td>
<td>1.5</td>
<td>1.3</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Group B</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>197 x 198</td>
<td>1.2</td>
<td>1.8</td>
<td>2.5</td>
</tr>
<tr>
<td>198 x 351</td>
<td>1.3</td>
<td>1.1</td>
<td>2.6</td>
</tr>
<tr>
<td>197 x 364</td>
<td>1.4</td>
<td>2.9</td>
<td>2.5</td>
</tr>
<tr>
<td>351 x 364</td>
<td>2.0</td>
<td>3.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Mean</td>
<td>1.5</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Mean A and B</td>
<td>1.5</td>
<td>1.7</td>
<td>2.2</td>
</tr>
</tbody>
</table>

1/ Treatment: N = Normal plants, B = Barren plants, C = Clipped Plants
2/ Grade: 1 = Green leaves, 2 = Medium leaves, 3 = Dead leaves

<table>
<thead>
<tr>
<th>Analyses of Variance</th>
<th>Group A</th>
<th></th>
<th>Group B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>F</td>
<td>1% point</td>
<td>Mean</td>
</tr>
<tr>
<td>Source of Variation</td>
<td>D/F squares</td>
<td></td>
<td></td>
<td>D/F squares</td>
</tr>
<tr>
<td>Crosses</td>
<td>3</td>
<td>383.4</td>
<td>73.73**</td>
<td>3</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>22.6</td>
<td>4.35*</td>
<td>5</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>181.0</td>
<td>34.81**</td>
<td>2</td>
</tr>
<tr>
<td>Interaction</td>
<td>C x T</td>
<td>6</td>
<td>68.6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>13.19**</td>
<td>3.42</td>
<td>6</td>
</tr>
<tr>
<td>Experimental errorE3</td>
<td>5.2</td>
<td>55</td>
<td>5.5</td>
<td>55</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>71</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Table 23. Effect of leaf clipping and prevention of pollination on smut infection, ear weight and ear rot of eight inbred lines inoculated with *Diplodia zeae*, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Smutted plants (per cent)</th>
<th>Ear weight (grams)</th>
<th>Ear rot (grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment 1/</td>
<td>Treatment 1/</td>
<td>Treatment 1/</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>224</td>
<td>0</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>701</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>456</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>R4</td>
<td>10</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>743</td>
<td>38</td>
<td>40</td>
<td>17</td>
</tr>
<tr>
<td>187-2</td>
<td>23</td>
<td>27</td>
<td>37</td>
</tr>
<tr>
<td>397</td>
<td>10</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Tr</td>
<td>27</td>
<td>47</td>
<td>23</td>
</tr>
<tr>
<td>Mean</td>
<td>13</td>
<td>19</td>
<td>12</td>
</tr>
</tbody>
</table>

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants
2/ Grade: 1=1 to 20% rotted kernels
3=21 to 40% rotted kernels
5=41 to 60% rotted kernels
Table 23. (continued)

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Smutted plants</th>
<th>Ear weight</th>
<th>Ear rot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>Mean squares</td>
<td>F value</td>
</tr>
<tr>
<td>Lines</td>
<td>7</td>
<td>15.62</td>
<td>14.46**</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>0.16</td>
<td>0.15</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>3.16</td>
<td>2.93</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L x T</td>
<td>14</td>
<td>1.60</td>
<td>1.48</td>
</tr>
<tr>
<td>Experimental error</td>
<td>46</td>
<td>1.08</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>71</td>
<td>47</td>
<td>47</td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Table 24. Effect of leaf clipping and prevention of pollination on percentage of smutted plants of eight single crosses inoculated with Diplodia zeae, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Per cent smutted plants</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment 1/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>B</td>
</tr>
<tr>
<td>198 x Lan</td>
<td>0.0</td>
<td>82.5</td>
</tr>
<tr>
<td>Tr x Lan</td>
<td>12.5</td>
<td>35.0</td>
</tr>
<tr>
<td>364 x Lan</td>
<td>10.0</td>
<td>70.0</td>
</tr>
<tr>
<td>198 x 28</td>
<td>20.0</td>
<td>87.5</td>
</tr>
<tr>
<td>Mean</td>
<td>10.6</td>
<td>68.8</td>
</tr>
<tr>
<td>Group A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>197 x 198</td>
<td>4.8</td>
<td>47.6</td>
</tr>
<tr>
<td>198 x 361</td>
<td>0.0</td>
<td>50.0</td>
</tr>
<tr>
<td>197 x 364</td>
<td>21.4</td>
<td>35.7</td>
</tr>
<tr>
<td>351 x 364</td>
<td>14.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Mean</td>
<td>10.1</td>
<td>41.7</td>
</tr>
<tr>
<td>Mean A and B</td>
<td>10.3</td>
<td>55.2</td>
</tr>
</tbody>
</table>

1/ Treatment: N = Normal plants, B = Barren plants, C = Clipped plants

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean squares</td>
<td>F value</td>
</tr>
<tr>
<td>Crosses</td>
<td>3 12.2</td>
<td>6.73**</td>
</tr>
<tr>
<td>Replications</td>
<td>3 4.7</td>
<td>2.72</td>
</tr>
<tr>
<td>Treatments</td>
<td>2 186.2</td>
<td>103.44**</td>
</tr>
<tr>
<td>Interactions</td>
<td>6 8.5</td>
<td>4.72**</td>
</tr>
<tr>
<td>Experimental error</td>
<td>33 1.8</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47 71</td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference **Highly significant difference
Table 25. Effect of leaf clipping on ear weight of eight single crosses inoculated with Diplodia zeae, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Weight of ear in grams</th>
<th>Treatment 1/</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>127 x 198</td>
<td>329.66</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>198 x 351</td>
<td>364.64</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>197 x 364</td>
<td>328.45</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>351 x 364</td>
<td>323.61</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean</td>
<td>341.66</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean A and B</td>
<td>338.96</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1/ Treatment: N = Normal plants, B = Barren plants, C = Clipped plants

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>Mean squares</td>
</tr>
<tr>
<td>Crosses</td>
<td>3</td>
<td>696653</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>309986</td>
</tr>
<tr>
<td>Treatments</td>
<td>1</td>
<td>1986028</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C x T</td>
<td>3</td>
<td>544137</td>
</tr>
<tr>
<td>Experimental error</td>
<td>21</td>
<td>99694</td>
</tr>
</tbody>
</table>

*Significant difference **Highly significant difference
and single crosses inoculated with Diplodia is shown in tables 23 and 26 respectively. Although the lines and crosses differed significantly in resistance to ear rot, no consistent differences due to treatment were noted. In general, single cross ears had less rotting of kernels than did ears from the inbred lines.

Experiment D in 1937 was arranged in a factorial design. Factorial experiments include all combinations of several different sets of treatments. Three factors, barren, clipped, and inoculated plants, were included. In a $2 \times 2 \times 2$ experiment of this type, the following eight treatment combinations were possible:

- Barren, Clipped, Inoculated
- Barren, Clipped, Normal
- Barren, Normal, Inoculated
- Barren, Normal, Normal
- Normal, Clipped, Inoculated
- Normal, Clipped, Normal
- Normal, Normal, Inoculated
- Normal, Normal, Normal

The experiment consisted of four replications. Within each replication, the eight treatments were distributed at random and the eight inbred lines were randomized within each treatment. Leaves were clipped August 10 and Diplodia inoculations made on August 16. Data were taken on September 20.

Table 27 shows the differential disease development in the stalk pith of the lines. The lines ranged in resistance to Diplodia from 0.7 to 2.2 internodes. Examples of various degrees of resistance are shown
Table 26. Effect of leaf clipping on amount of ear rot of eight single crosses inoculated with Diplodia senea, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Treatment 1/</th>
<th>Mean</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>B</td>
<td>C</td>
<td>N</td>
</tr>
<tr>
<td>198 x Lan</td>
<td>1.3</td>
<td>-</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Tr x Lan</td>
<td>1.9</td>
<td>-</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>364 x Lan</td>
<td>1.5</td>
<td>-</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>198 x 38-11</td>
<td>2.1</td>
<td>-</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Mean</td>
<td>1.7</td>
<td>-</td>
<td>1.6</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Group B

<table>
<thead>
<tr>
<th>Cross</th>
<th>Treatment 1/</th>
<th>Mean</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>B</td>
<td>C</td>
<td>N</td>
</tr>
<tr>
<td>197 x 198</td>
<td>1.6</td>
<td>-</td>
<td>1.7</td>
<td>1.6</td>
</tr>
<tr>
<td>198 x 351</td>
<td>1.6</td>
<td>-</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>197 x 364</td>
<td>1.5</td>
<td>-</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>351 x 364</td>
<td>1.5</td>
<td>-</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Mean</td>
<td>1.5</td>
<td>-</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Mean A and B</td>
<td>1.6</td>
<td>-</td>
<td>1.6</td>
<td>1.6</td>
</tr>
</tbody>
</table>

1/ Treatment: N = Normal plants, B = Barren plants, C = Clipped plants

2/ Grade: 1 = 1 to 20% rotted kernels
2 = 21 to 40% rotted kernels
3 = 41 to 60% rotted kernels

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>Mean squares</td>
</tr>
<tr>
<td>Crosses</td>
<td>3</td>
<td>72.21</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>70.21</td>
</tr>
<tr>
<td>Treatments</td>
<td>1</td>
<td>6.13</td>
</tr>
<tr>
<td>Interactions C x T</td>
<td>3</td>
<td>6.37</td>
</tr>
<tr>
<td>Experimental error</td>
<td>21</td>
<td>7.63</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>7.63</td>
</tr>
</tbody>
</table>

*Significant difference
**Highly significant difference
Table 27. Effect of various treatments on number of internodes rotted by Diplodia zea in stalk pith of eight inbred lines of corn, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>401</td>
<td>0.0</td>
<td>1.7</td>
<td>0.0</td>
<td>1.7</td>
<td>0.2</td>
<td>1.7</td>
<td>0.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Hy</td>
<td>0.1</td>
<td>1.5</td>
<td>0.0</td>
<td>1.1</td>
<td>0.2</td>
<td>1.9</td>
<td>0.3</td>
<td>1.6</td>
</tr>
<tr>
<td>289</td>
<td>0.1</td>
<td>1.1</td>
<td>0.1</td>
<td>1.3</td>
<td>0.0</td>
<td>1.5</td>
<td>0.0</td>
<td>1.5</td>
</tr>
<tr>
<td>205</td>
<td>0.2</td>
<td>1.1</td>
<td>0.0</td>
<td>1.1</td>
<td>1.4</td>
<td>2.2</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>197</td>
<td>0.5</td>
<td>2.6</td>
<td>0.2</td>
<td>1.5</td>
<td>1.2</td>
<td>1.7</td>
<td>0.7</td>
<td>2.8</td>
</tr>
<tr>
<td>169</td>
<td>0.7</td>
<td>2.1</td>
<td>0.3</td>
<td>0.9</td>
<td>1.5</td>
<td>2.0</td>
<td>1.0</td>
<td>2.3</td>
</tr>
<tr>
<td>198</td>
<td>0.7</td>
<td>2.1</td>
<td>0.5</td>
<td>2.4</td>
<td>3.4</td>
<td>2.9</td>
<td>3.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Mean</td>
<td>0.4</td>
<td>1.9</td>
<td>0.4</td>
<td>1.3</td>
<td>1.1</td>
<td>2.0</td>
<td>0.9</td>
<td>2.2</td>
</tr>
</tbody>
</table>

**Analysis of Variance**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>7.59</td>
<td>12.44**</td>
<td>2.73</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>3.51</td>
<td>5.75**</td>
<td>3.88</td>
</tr>
<tr>
<td>Treatments</td>
<td>7</td>
<td>17.37</td>
<td>28.48**</td>
<td>2.73</td>
</tr>
<tr>
<td>Interaction L x T</td>
<td>49</td>
<td>0.82</td>
<td>1.33</td>
<td>1.62</td>
</tr>
<tr>
<td>Experimental error</td>
<td>189</td>
<td>.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>255</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference

**Highly significant difference
in figure 6. Inoculation materially increased stalk rotting. The barren plants tended to be most susceptible to Diplodia, the normal plants were intermediate, and the clipped plants were most resistant. Differences between lines and between treatments were highly significant statistically.

The spread of the Diplodia fungus in the stalk cortex is shown in tables 23 and 29. Differences in resistance between lines were highly significant. Treatment did not appear to affect vertical spread of the fungus in the stalk cortex. The clipped plants, however, had more horizontal spread of the rotting around the stalk than did the barren plants. These results indicate that pith rotting is increased in barren plants and that cortex rotting is increased in clipped plants.

Only two percent of the plants of line Hy were infected with smut while 63 percent of line 159 plants had smut galls. As shown in table 50, these differences were highly significant.

Highly significant differences occurred in stalk and leaf color between lines and between treatments. Tables 31 and 32 show that clipping the leaves hastened maturity of the stalks, but delayed maturity of the leaves.

Data in table 33 give an indication of the effect of Diplodia inoculation and leaf clipping upon ear weight. The plants given the clipped treatment consistently yielded less than did the inoculated plants. Inoculated plants yielded 13 percent less grain than did normal plants, but the clipped plants yielded 36 percent less grain. Differences between lines and between treatments were highly significant.
Figure 6. Examples of various degrees of resistance to Diplodia zeeae.
Table 28. Effect of various treatments on number of internodes rotted by *Diploida zeae* in stalk cortex of eight inbred lines of corn, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>401</td>
<td>1.1</td>
<td>1.0</td>
<td>1.1</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>By</td>
<td>1.0</td>
<td>1.1</td>
<td>1.2</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>289</td>
<td>1.0</td>
<td>1.0</td>
<td>1.2</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>205</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>197</td>
<td>0.9</td>
<td>0.9</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Len</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>198</td>
<td>0.8</td>
<td>1.0</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>159</td>
<td>0.8</td>
<td>1.0</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Mean</td>
<td>0.9</td>
<td>1.0</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>0.18</td>
<td>3.60**</td>
<td>2.82</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>0.03</td>
<td>.60</td>
<td>3.98</td>
</tr>
<tr>
<td>Treatments</td>
<td>3</td>
<td>0.02</td>
<td>.40</td>
<td>3.98</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
<td>.80</td>
<td>2.06</td>
</tr>
<tr>
<td>L x T</td>
<td>21</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental error</td>
<td>93</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>127</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference**
Table 29. Effect of various treatments on horizontal spread of Diplodia zeae in stalk cortex of eight inbred lines of corn, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Horizontal spread of fungus in cortex (Grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment</td>
</tr>
<tr>
<td>401</td>
<td>3.2</td>
</tr>
<tr>
<td>Hy</td>
<td>2.7</td>
</tr>
<tr>
<td>205</td>
<td>1.8</td>
</tr>
<tr>
<td>197</td>
<td>1.8</td>
</tr>
<tr>
<td>Len</td>
<td>2.9</td>
</tr>
<tr>
<td>198</td>
<td>2.3</td>
</tr>
<tr>
<td>159</td>
<td>1.4</td>
</tr>
<tr>
<td>Mean</td>
<td>2.3</td>
</tr>
</tbody>
</table>

1/ Grade: 1=Fungus spread less than 20% distance around stalk
2=Fungus spread between 20 and 40% distance around stalk
3=Fungus spread between 41 and 60% distance around stalk
4=Fungus spread between 61 and 80% distance around stalk
5=Fungus spread between 81 and 100% distance around stalk

Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>9.31</td>
<td>22.17**</td>
<td>2.82</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>1.01</td>
<td>2.40</td>
<td>3.98</td>
</tr>
<tr>
<td>Treatments</td>
<td>3</td>
<td>3.54</td>
<td>8.43**</td>
<td>3.98</td>
</tr>
<tr>
<td>Interaction</td>
<td>L x T</td>
<td>21</td>
<td>0.85</td>
<td>2.02*</td>
</tr>
<tr>
<td>Experimental error</td>
<td>33</td>
<td>0.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>127</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Table 50. Effect of various treatments on smut infection of eight inbred lines of corn, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>401</td>
<td>8</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>22</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Hy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>239</td>
<td>4</td>
<td>27</td>
<td>58</td>
<td>9</td>
<td>22</td>
<td>38</td>
<td>45</td>
<td>8</td>
</tr>
<tr>
<td>205</td>
<td>5</td>
<td>8</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>197</td>
<td>29</td>
<td>30</td>
<td>35</td>
<td>48</td>
<td>27</td>
<td>52</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>Lan</td>
<td>0</td>
<td>45</td>
<td>6</td>
<td>0</td>
<td>67</td>
<td>21</td>
<td>55</td>
<td>54</td>
</tr>
<tr>
<td>198</td>
<td>12</td>
<td>19</td>
<td>14</td>
<td>0</td>
<td>30</td>
<td>50</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>159</td>
<td>66</td>
<td>60</td>
<td>60</td>
<td>62</td>
<td>75</td>
<td>69</td>
<td>53</td>
<td>42</td>
</tr>
<tr>
<td>Mean</td>
<td>18</td>
<td>25</td>
<td>23</td>
<td>16</td>
<td>23</td>
<td>32</td>
<td>30</td>
<td>27</td>
</tr>
</tbody>
</table>

Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>0.3029</td>
<td>14.02**</td>
<td>2.89</td>
</tr>
<tr>
<td>Treatments</td>
<td>7</td>
<td>0.0262</td>
<td>1.21</td>
<td>2.69</td>
</tr>
<tr>
<td>Experimental error</td>
<td>49</td>
<td>0.0216</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference
Table 31. Effect of various treatments on premature killing by Diplodia zeae of stalks of eight inbred lines of corn, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Inbred</th>
<th>Color of stalk (Grade)</th>
<th>Treatment</th>
<th>Normal</th>
<th>Inoc.</th>
<th>Clipped</th>
<th>Barren</th>
<th>Barren</th>
<th>Barren</th>
<th>Barren</th>
<th>Clipped</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>401</td>
<td>1.0</td>
<td>1.7</td>
<td>1.2</td>
<td>1.0</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.0</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Hy</td>
<td>1.0</td>
<td>1.2</td>
<td>1.2</td>
<td>1.5</td>
<td>1.2</td>
<td>1.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>269</td>
<td>2.7</td>
<td>3.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>205</td>
<td>1.0</td>
<td>1.2</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>197</td>
<td>1.0</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Lan</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2.0</td>
<td>1.7</td>
<td>2.6</td>
<td>1.5</td>
<td>1.5</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>128</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
<td>1.2</td>
<td>1.2</td>
<td>1.0</td>
<td>1.5</td>
<td>1.5</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>159</td>
<td>1.2</td>
<td>1.0</td>
<td>1.0</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Mean</td>
<td>1.5</td>
<td>1.6</td>
<td>1.8</td>
<td>1.6</td>
<td>1.4</td>
<td>1.3</td>
<td>1.5</td>
<td>1.3</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

1/ Grade: 1 = Green stalks  
2 = Medium stalks  
3 = Dead stalks

Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>10.96</td>
<td>60.89**</td>
<td>2.73</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>0.93</td>
<td>5.06**</td>
<td>3.88</td>
</tr>
<tr>
<td>Treatments</td>
<td>7</td>
<td>0.97</td>
<td>5.39**</td>
<td>2.73</td>
</tr>
<tr>
<td>Interaction L x T</td>
<td>49</td>
<td>0.41</td>
<td>2.28**</td>
<td>1.62</td>
</tr>
<tr>
<td>Experimental Error</td>
<td>189</td>
<td>0.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>255</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Table 32. Effect of various treatments on premature killing by Diplodia zeae of leaves of eight inbred lines of corn, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>401</td>
<td>1.5</td>
<td>2.2</td>
<td>2.0</td>
<td>1.7</td>
<td>2.7</td>
<td>2.5</td>
<td>2.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Hy</td>
<td>1.0</td>
<td>1.5</td>
<td>1.2</td>
<td>1.0</td>
<td>2.7</td>
<td>3.0</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>269</td>
<td>2.7</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>205</td>
<td>1.0</td>
<td>1.2</td>
<td>1.2</td>
<td>1.0</td>
<td>2.5</td>
<td>2.7</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>197</td>
<td>1.5</td>
<td>2.2</td>
<td>1.2</td>
<td>1.5</td>
<td>2.5</td>
<td>2.7</td>
<td>2.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Lan</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>198</td>
<td>2.0</td>
<td>2.0</td>
<td>2.7</td>
<td>2.5</td>
<td>2.2</td>
<td>2.5</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td>159</td>
<td>1.2</td>
<td>2.0</td>
<td>1.2</td>
<td>1.2</td>
<td>2.2</td>
<td>2.7</td>
<td>2.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Mean</td>
<td>1.7</td>
<td>2.2</td>
<td>2.0</td>
<td>1.9</td>
<td>2.6</td>
<td>2.8</td>
<td>2.3</td>
<td>2.3</td>
</tr>
</tbody>
</table>

1/ Grade: 1=Green leaves  
2=Medium leaves  
3=Dead leaves

---

**Analysis of Variance**

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>7.33</td>
<td>26.18**</td>
<td>2.73</td>
</tr>
<tr>
<td>Replications</td>
<td>3</td>
<td>0.97</td>
<td>3.46*</td>
<td>3.88</td>
</tr>
<tr>
<td>Treatments</td>
<td>7</td>
<td>4.60</td>
<td>16.43**</td>
<td>2.73</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L X t</td>
<td>49</td>
<td>0.62</td>
<td>2.21**</td>
<td>1.62</td>
</tr>
<tr>
<td>Experimental error</td>
<td>189</td>
<td>0.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>255</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference  * Significant difference**
Table 33. Effect of various treatments on ear weight of eight inbred lines of corn, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Inbred line</th>
<th>Ear weight (grams)</th>
<th>Treatment</th>
<th>Normal</th>
<th>Inoc.</th>
<th>Clipped</th>
<th>Clipped Inoc.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>491</td>
<td>82</td>
<td></td>
<td>65</td>
<td>7</td>
<td>50</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>229</td>
<td>227</td>
<td></td>
<td>156</td>
<td>107</td>
<td>138</td>
<td>132</td>
<td></td>
</tr>
<tr>
<td>396</td>
<td>169</td>
<td></td>
<td>181</td>
<td>144</td>
<td>136</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>197</td>
<td>113</td>
<td></td>
<td>114</td>
<td>82</td>
<td>114</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>186</td>
<td>120</td>
<td></td>
<td>120</td>
<td>110</td>
<td>101</td>
<td>129</td>
<td></td>
</tr>
<tr>
<td>198</td>
<td>252</td>
<td></td>
<td>244</td>
<td>159</td>
<td>162</td>
<td>205</td>
<td></td>
</tr>
<tr>
<td>159</td>
<td>86</td>
<td></td>
<td>97</td>
<td>33</td>
<td>62</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>160</td>
<td></td>
<td>139</td>
<td>103</td>
<td>114</td>
<td>139</td>
<td></td>
</tr>
</tbody>
</table>

### Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>10,922.73</td>
<td>35.47**</td>
<td>3.51</td>
</tr>
<tr>
<td>Treatments</td>
<td>3</td>
<td>5,200.73</td>
<td>13.22**</td>
<td>4.87</td>
</tr>
<tr>
<td>Experimental error</td>
<td>21</td>
<td>393.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference**
Table 34 shows the effect of the various treatments on ear rot. Although they were highly significant, differences between treatments are difficult to interpret.

The Diplodia studies in 1938 were made at Manhattan, Kansas and included six inbred lines and nine single crosses involving the six lines. The material, replicated three times, was subjected to the normal, barren, and clipped treatment previously described. Stalk inoculations with a water suspension of Diplodia spores were made on August 5 (two days after clipping the leaves). Stalks were split and readings made September 24 and 26. Relative resistance of the material was measured by the number of internodes rotted by the fungus in stalk pith and cortex and the horizontal spread of the rotting around the stalks.

The effect of the three treatments on pith stalk rotting of inbred lines and crosses inoculated with Diplodia in 1938 is shown in Table 35. The analysis of variance in the inbred lines shows that there were statistically highly significant differences between lines, treatments, and replications. The differences between crosses were also highly significant. In practically all cases, the barren treatment resulted in increasing the Diplodia rotting in the stalk pith. Clipping the plants, which lowered the amount of carbohydrates in the stalk, resulted in decreased spread. In the inbred lines the fungus spread 6.1 internodes for the barren plants and 4.4 internodes for the normal and clipped plants. The barren single cross plants were also the most susceptible to pith rotting. In general, the crosses were considerably
Table 34. Effect of various treatments on ear rot of eight inbred lines of corn, Ames, Iowa, 1937.

<table>
<thead>
<tr>
<th>Immred line</th>
<th>Ear rot (Grade)</th>
<th>Treatment</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Inoc</td>
<td>Clipped</td>
</tr>
<tr>
<td>401</td>
<td>2.2</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>By</td>
<td>2.2</td>
<td>1.7</td>
<td>1.9</td>
</tr>
<tr>
<td>289</td>
<td>1.9</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>205</td>
<td>2.0</td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>197</td>
<td>2.6</td>
<td>1.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Lan</td>
<td>1.7</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>199</td>
<td>1.9</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>149</td>
<td>2.0</td>
<td>1.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Mean</td>
<td>2.1</td>
<td>1.7</td>
<td>1.9</td>
</tr>
</tbody>
</table>

1/Grade: 1=1 to 20% rotted kernels
2=21 to 40% rotted kernels
3=41 to 60% rotted kernels

Analysis of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>7</td>
<td>.14</td>
<td>2.33</td>
<td>3.81</td>
</tr>
<tr>
<td>Treatments</td>
<td>3</td>
<td>.68</td>
<td>11.35**</td>
<td>4.87</td>
</tr>
<tr>
<td>Experimental error</td>
<td>21</td>
<td>.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference
Table 35. Effect of leaf clipping and prevention of pollination on number of internodes rotted in stalk pith of inbred lines and crosses inoculated with *Diplodia zeae*, Manhattan, Kansas, 1938. Means of three replications.

<table>
<thead>
<tr>
<th>Number of internodes rotted in pith of stalk</th>
<th>Inbred lines</th>
<th>Single crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line</td>
<td>Treatment 1/</td>
<td>Cross</td>
</tr>
<tr>
<td>N</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>205</td>
<td>3.1</td>
<td>5.5</td>
</tr>
<tr>
<td>224</td>
<td>2.7</td>
<td>3.6</td>
</tr>
<tr>
<td>349</td>
<td>6.0</td>
<td>8.5</td>
</tr>
<tr>
<td>289</td>
<td>3.3</td>
<td>3.9</td>
</tr>
<tr>
<td>317</td>
<td>7.5</td>
<td>7.6</td>
</tr>
<tr>
<td>364</td>
<td>3.2</td>
<td>7.3</td>
</tr>
</tbody>
</table>

Mean   4.4 | 6.1 | 4.4 | 4.9 | Mean   3.5 | 5.0 | 3.0 | 3.8

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Inbred lines</th>
<th>Single crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>Mean squares</td>
</tr>
<tr>
<td>Strains</td>
<td>5</td>
<td>26.15</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>17.82</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>20.14</td>
</tr>
<tr>
<td>S x T</td>
<td>10</td>
<td>2.28</td>
</tr>
<tr>
<td>Experimental error</td>
<td>34</td>
<td>3.32</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>3.32</td>
</tr>
</tbody>
</table>

**Highly significant difference**
more resistant than the inbreds.

Table 36 shows the effect of leaf clipping and prevention of pollination on the spread of the fungus in the stalk cortex. In general, these results substantiate those on pith rotting. Differences between lines, crosses, and treatments were highly significant.

The third measure of resistance was the horizontal spread of the Diplodia organism around the stalk. There were highly significant differences in resistance of the material. Only in the crosses did treatment appear to have an effect (table 37).

Notes were taken on the effect of treatment on other characteristics. Table 38 shows that the barren, crossed plants tended to remain green the longest, while the clipped plants died prematurely.

The effect of treatment on amount of leaf firing is shown in table 39. A grade of 1 indicates no fired leaves, while plants with 1 to 25 percent of fired leaf surface were given a grade of 2. In the inbred lines, highly significant differences were observed between lines and between treatments. The barren plants were most susceptible to leaf firing.

Clipping the leaves lowered yield of grain. The mean yield of the inbred lines was eight bushels per acre and that of the crosses was 43 bushels per acre. As shown in table 40 the differences between strains and between treatments were statistically significant.

Table 41 shows the effect of treatment on amount of ear rot. Although treatment had no effect, highly significant differences were observed between strains.
Table 36. Effect of leaf clipping and prevention of pollination on number of internodes rotted in stalk cortex of inbred lines and crosses inoculated with Diplodia zeae, Manhattan, Kansas, 1938. Means of three replications.

<table>
<thead>
<tr>
<th>Line</th>
<th>Treatment 1/</th>
<th>Mean</th>
<th>Cross</th>
<th>Treatment 1/</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>B</td>
<td>C</td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>205</td>
<td>2.9</td>
<td>5.3</td>
<td>3.4</td>
<td>3.8</td>
<td>205 x 224</td>
</tr>
<tr>
<td>224</td>
<td>2.6</td>
<td>3.4</td>
<td>2.5</td>
<td>2.8</td>
<td>205 x 349</td>
</tr>
<tr>
<td>349</td>
<td>5.3</td>
<td>7.4</td>
<td>4.8</td>
<td>5.8</td>
<td>224 x 349</td>
</tr>
<tr>
<td>289</td>
<td>3.0</td>
<td>3.6</td>
<td>3.5</td>
<td>3.4</td>
<td>289 x 317</td>
</tr>
<tr>
<td>317</td>
<td>6.6</td>
<td>6.7</td>
<td>6.5</td>
<td>6.6</td>
<td>289 x 364</td>
</tr>
<tr>
<td>364</td>
<td>2.8</td>
<td>6.4</td>
<td>3.5</td>
<td>4.2</td>
<td>317 x 364</td>
</tr>
</tbody>
</table>

Mean 3.8 5.5 4.0 4.5 Mean 3.5 4.5 2.8 3.6

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Inbred lines</th>
<th>Single crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>Mean squares</td>
</tr>
<tr>
<td>Strains</td>
<td>5</td>
<td>18.92</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>14.17</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>20.18</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S x T</td>
<td>10</td>
<td>1.75</td>
</tr>
<tr>
<td>Experimental error</td>
<td>34</td>
<td>2.75</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>2.75</td>
</tr>
</tbody>
</table>

*Highly significant difference
Table 37. Effect of leaf clipping and prevention of pollination on horizontal spread of fungus in stalk cortex of inbred lines and crosses inoculated with Diplodia zeae, Manhattan, Kansas, 1938. Means of three replications.

<table>
<thead>
<tr>
<th>Line</th>
<th>Inbred lines</th>
<th>Single crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment 1/</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td>N  B  C</td>
<td></td>
</tr>
<tr>
<td>205</td>
<td>4.5  4.1  4.6</td>
<td>4.4</td>
</tr>
<tr>
<td>224</td>
<td>4.8  4.7  4.6</td>
<td>4.7</td>
</tr>
<tr>
<td>349</td>
<td>4.9  5.0  4.9</td>
<td>4.9</td>
</tr>
<tr>
<td>289</td>
<td>4.4  4.7  4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>317</td>
<td>4.9  4.8  4.9</td>
<td>4.8</td>
</tr>
<tr>
<td>364</td>
<td>4.3  4.7  4.7</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>205 x 317</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>289 x 349</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Mean 4.6  4.7  4.7  4.7  Mean 4.8  4.6  4.5  4.6

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants
2/ Grade: 1=Fungus spread less than 20% distance around stalk
         2=Fungus spread between 20 and 40% of distance around stalk
         3=Fungus spread between 41 and 60% of distance around stalk
         4=Fungus spread between 61 and 80% of distance around stalk
         5=Fungus spread between 81 and 100% of distance around stalk

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Inbred lines</th>
<th>Single crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>Mean squares</td>
</tr>
<tr>
<td>Strains</td>
<td>5</td>
<td>0.36 4.50**</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>0.05 0.50</td>
</tr>
<tr>
<td>Replications</td>
<td>30</td>
<td>1.09 13.62**</td>
</tr>
<tr>
<td>Interaction S x T</td>
<td>10</td>
<td>0.10 1.25</td>
</tr>
<tr>
<td>Experimental error</td>
<td>34</td>
<td>0.08 2.50</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Table 33. Effect of leaf clipping and prevention of pollination on premature killing by fungus of stalks of inbred lines and crosses inoculated with Diplodia zaeae, Manhattan, Kansas, 1938. Means of three replications.

<table>
<thead>
<tr>
<th>Line</th>
<th>Treatment 1/</th>
<th>Mean</th>
<th>Cross</th>
<th>Treatment 1/</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>B</td>
<td>C</td>
<td>F</td>
<td>B</td>
</tr>
<tr>
<td>205</td>
<td>1.0</td>
<td>1.3</td>
<td>1.0</td>
<td>1.1</td>
<td>205 x 224</td>
</tr>
<tr>
<td>224</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>205 x 349</td>
</tr>
<tr>
<td>349</td>
<td>2.0</td>
<td>1.7</td>
<td>2.0</td>
<td>1.9</td>
<td>224 x 349</td>
</tr>
<tr>
<td>289</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>289 x 317</td>
</tr>
<tr>
<td>317</td>
<td>1.7</td>
<td>1.7</td>
<td>2.7</td>
<td>2.0</td>
<td>289 x 364</td>
</tr>
<tr>
<td>364</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>317 x 364</td>
</tr>
<tr>
<td>Mean</td>
<td>2.2</td>
<td>2.2</td>
<td>2.4</td>
<td>2.3</td>
<td>Mean</td>
</tr>
</tbody>
</table>

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants
2/ Grade: 1=Green stalks, 2=Medium stalks, 3=Dead stalks

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Inbred lines</th>
<th>Single crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F Mean squares</td>
<td>F value 1% point</td>
</tr>
<tr>
<td>Strains</td>
<td>5</td>
<td>3.01</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>0.16</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>0.06</td>
</tr>
<tr>
<td>Interactions S x T</td>
<td>10</td>
<td>0.21</td>
</tr>
<tr>
<td>Experimental error</td>
<td>34</td>
<td>0.15</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>80</td>
</tr>
</tbody>
</table>

*aSignificant difference  **Highly significant difference
Table 39. Effect of leaf clipping and prevention of pollination on amount of leaf firing of inbred lines and crosses inoculated with *Diplodia zeae*, Manhattan, Kansas, 1938. Means of three replications.

<table>
<thead>
<tr>
<th>Line</th>
<th>Treatment 1/</th>
<th>Mean</th>
<th>Cross</th>
<th>Treatment 1/</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N  B  C</td>
<td></td>
<td></td>
<td>N  B  C</td>
<td></td>
</tr>
<tr>
<td>205</td>
<td>1.3 2.0 1.3</td>
<td>1.6</td>
<td>205 x 224</td>
<td>1.0 1.0 1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>224</td>
<td>1.0 1.0 1.0</td>
<td>1.0</td>
<td>205 x 349</td>
<td>1.0 1.0 1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>349</td>
<td>1.3 1.7 1.0</td>
<td>1.3</td>
<td>224 x 349</td>
<td>1.0 1.3 1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>289</td>
<td>2.3 2.0 2.0</td>
<td>2.1</td>
<td>289 x 317</td>
<td>1.0 1.0 1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>317</td>
<td>1.0 1.3 1.0</td>
<td>1.1</td>
<td>289 x 364</td>
<td>1.0 1.0 1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>364</td>
<td>1.7 4.6 1.3</td>
<td>2.6</td>
<td>317 x 364</td>
<td>1.0 1.7 1.0</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td></td>
<td>1.4 2.1 1.3</td>
<td>1.6</td>
</tr>
</tbody>
</table>

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants
2/ Grade; 1=No fired leaves, 2=1 to 25% of leaf surface fired

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Inbred lines</th>
<th>Single crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D/F</td>
<td>Mean squares</td>
</tr>
<tr>
<td>Strains</td>
<td>5</td>
<td>3.32</td>
</tr>
<tr>
<td>Treatments</td>
<td>2</td>
<td>3.50</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 x T</td>
<td>10</td>
<td>1.52</td>
</tr>
<tr>
<td>Experimental error</td>
<td>34</td>
<td>0.21</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td></td>
</tr>
</tbody>
</table>

**Highly significant difference
Table 40. Effect of leaf clipping on yield of grain of inbred lines and crosses inoculated with Diplodia zeae, Manhattan, Kansas, 1938. Means of three replications.

<table>
<thead>
<tr>
<th>Line</th>
<th>Treatment 1/</th>
<th>Mean</th>
<th>Cross</th>
<th>Treatment 1/</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>C</td>
<td>N</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>205</td>
<td>9.9</td>
<td>9.9</td>
<td>9.9</td>
<td>205 x 224</td>
<td>47.3</td>
</tr>
<tr>
<td>224</td>
<td>9.3</td>
<td>9.1</td>
<td>9.2</td>
<td>205 x 349</td>
<td>52.2</td>
</tr>
<tr>
<td>349</td>
<td>7.9</td>
<td>4.8</td>
<td>6.3</td>
<td>224 x 349</td>
<td>43.0</td>
</tr>
<tr>
<td>289</td>
<td>10.2</td>
<td>8.9</td>
<td>9.6</td>
<td>289 x 317</td>
<td>59.0</td>
</tr>
<tr>
<td>317</td>
<td>0.3</td>
<td>0.2</td>
<td>0.3</td>
<td>289 x 364</td>
<td>54.6</td>
</tr>
<tr>
<td>364</td>
<td>14.3</td>
<td>10.6</td>
<td>12.6</td>
<td>317 x 364</td>
<td>61.2</td>
</tr>
<tr>
<td>Mean</td>
<td>8.6</td>
<td>7.3</td>
<td>8.0</td>
<td>Mean</td>
<td>49.4</td>
</tr>
</tbody>
</table>

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants

Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
<th>D/F</th>
<th>Mean squares</th>
<th>F value</th>
<th>1% point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strains</td>
<td>5</td>
<td>108.44</td>
<td>27.11**</td>
<td>3.39</td>
<td>8</td>
<td>278.69</td>
<td>17.89**</td>
<td>3.08</td>
</tr>
<tr>
<td>Treatments</td>
<td>1</td>
<td>17.50</td>
<td>4.33*</td>
<td>7.94</td>
<td>1</td>
<td>2289.31</td>
<td>146.84**</td>
<td>7.44</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>25.85</td>
<td>6.46**</td>
<td>5.72</td>
<td>2</td>
<td>13.57</td>
<td>0.87</td>
<td>5.29</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S x T</td>
<td>5</td>
<td>3.94</td>
<td>0.99</td>
<td>3.99</td>
<td>6</td>
<td>40.14</td>
<td>2.57*</td>
<td>3.03</td>
</tr>
<tr>
<td>Experimental error</td>
<td>22</td>
<td>4.00</td>
<td></td>
<td></td>
<td>34</td>
<td>15.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td></td>
<td>53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant difference  **Highly significant difference
Table 41. Effect of leaf clipping on amount of ear rot of inbred lines and crosses inoculated with *Diplodia zeae*, Manhattan, Kansas, 1938. Means of three replications.

<table>
<thead>
<tr>
<th>Line</th>
<th>Treatment 1</th>
<th>Mean</th>
<th>Cross</th>
<th>Treatment 1</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>C</td>
<td></td>
<td>N</td>
<td>C</td>
</tr>
<tr>
<td>205</td>
<td>2.0</td>
<td>2.3</td>
<td>2.2</td>
<td>205 x 224</td>
<td>1.0</td>
</tr>
<tr>
<td>224</td>
<td>1.5</td>
<td>1.0</td>
<td>1.2</td>
<td>205 x 349</td>
<td>2.3</td>
</tr>
<tr>
<td>349</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>224 x 349</td>
<td>1.3</td>
</tr>
<tr>
<td>289</td>
<td>1.7</td>
<td>2.3</td>
<td>2.0</td>
<td>289 x 317</td>
<td>1.0</td>
</tr>
<tr>
<td>317</td>
<td></td>
<td></td>
<td></td>
<td>289 x 364</td>
<td>1.0</td>
</tr>
<tr>
<td>364</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>317 x 364</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Mean       1.9  2.0  1.9

1/ Treatment: N=Normal plants, B=Barren plants, C=Clipped plants

2/ Grade: 1=1 to 20% rotted kernels, 2=21 to 40% rotted kernels

---

### Analyses of Variance

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Inbred lines</th>
<th>Single crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td>D/F</td>
<td>Mean squares</td>
<td>F value</td>
</tr>
<tr>
<td>Strains</td>
<td>4</td>
<td>1.88</td>
</tr>
<tr>
<td>Treatments</td>
<td>1</td>
<td>0.14</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>0.54</td>
</tr>
<tr>
<td>Interactions</td>
<td>4</td>
<td>0.22</td>
</tr>
<tr>
<td>S x T</td>
<td>4</td>
<td>0.24</td>
</tr>
<tr>
<td>Experimental error</td>
<td>8</td>
<td>0.24</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>2.24</td>
</tr>
</tbody>
</table>

**Highly significant difference**
Inheritance of Resistance to Stalk Rot

Since breeding for resistance offers the most practical means of controlling Diplodia dry rot, information is needed on the inheritance of this characteristic. The availability of many different, highly stable inbred lines of maize offers unusual opportunities for investigation of the problem.

Resistance tends to be dominant

Disease development resulting from natural infection in the stalk pith of 28 single crosses and the parent inbred lines in 1934 is shown in table 42. The lines were grouped into three classes. Data are given on the lines and crosses involving resistant parents, susceptible parents, and resistant x susceptible parents. Six crosses of resistant parental inbreds averaged 2.4 internodes rotted. One set of resistant inbred lines averaged 2.6 and the other 3.1 internodes. Thus it may be seen that the single crosses averaged slightly more resistant than the parent lines. Six crosses of susceptible lines averaged 3.2 internodes rotted compared to 2.4 for the resistant crosses. Single crosses between the susceptible lines were about one grade more resistant than the parent lines. This might be attributed to supplementary action of resistance factors. Sixteen crosses between resistant and susceptible lines averaged 3.1 internodes rotted, compared with 2.9 internodes for the resistant and 4.1 internodes for the susceptible parent lines.
Table 42. Comparison of disease development in inbred lines and hybrids, Ames, Iowa, 1934. (Natural infection)

<table>
<thead>
<tr>
<th>Single cross</th>
<th>Number of internodes rotted in pith</th>
<th></th>
<th></th>
<th>Single cross</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inbred lines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>205 x 345</td>
<td>2.5</td>
<td>2.9</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>x 224</td>
<td>2.5</td>
<td>3.1</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>x 234</td>
<td>2.5</td>
<td>3.1</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>x 349</td>
<td>2.5</td>
<td>3.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>345 x 224</td>
<td>2.9</td>
<td>3.1</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>x 349</td>
<td>2.9</td>
<td>3.3</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.6</td>
<td>3.1</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>159 x 289</td>
<td>4.0</td>
<td>4.2</td>
<td>3.9</td>
<td></td>
</tr>
<tr>
<td>x 401</td>
<td>4.0</td>
<td>4.2</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>420 x 220</td>
<td>4.0</td>
<td>4.1</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td>420 x 289</td>
<td>4.1</td>
<td>4.2</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>317 x 289</td>
<td>4.1</td>
<td>4.2</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>289 x 401</td>
<td>4.2</td>
<td>4.2</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.1</td>
<td>4.2</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resistant</td>
<td></td>
<td></td>
<td>Susceptible</td>
</tr>
<tr>
<td>205 x 426</td>
<td>2.5</td>
<td>4.0</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>x 420</td>
<td>2.5</td>
<td>4.1</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>x 317</td>
<td>2.5</td>
<td>4.1</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>x 289</td>
<td>2.5</td>
<td>4.2</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>x 401</td>
<td>2.5</td>
<td>4.2</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>345 x 159</td>
<td>2.9</td>
<td>4.0</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>x 289</td>
<td>2.9</td>
<td>4.2</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>x 401</td>
<td>2.9</td>
<td>4.2</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>224 x 159</td>
<td>3.1</td>
<td>4.0</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>x 317</td>
<td>3.1</td>
<td>4.1</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>x 401</td>
<td>3.1</td>
<td>4.2</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>234 x 289</td>
<td>3.1</td>
<td>4.2</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>349 x 426</td>
<td>3.3</td>
<td>4.0</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>x 317</td>
<td>3.3</td>
<td>4.1</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>x 289</td>
<td>3.3</td>
<td>4.2</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>x 401</td>
<td>3.3</td>
<td>4.2</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.9</td>
<td>4.1</td>
<td>3.1</td>
<td></td>
</tr>
</tbody>
</table>
Resistance appears to be at least partially dominant.

Inheritance studies since 1934 have included inoculation of the stalks with a water suspension of Diplodia spores. In 1935, the experiment consisted of 24 inbred lines and the same lines top crossed with Krug variety (table 43). With one exception, the top crosses were more resistant to pith rotting than the parent lines. The 24 top crosses averaged 2.2 internodes rotted, whereas the lines averaged 3.2 internodes. Unfortunately the Krug variety itself was as resistant as the average top cross. Since Krug contributed one-half of the heredity of the top crosses, the effect on resistance of heterosis cannot be separated from possible dominance of resistance. The selection of a susceptible variety for top crossing would have been more desirable.

Inheritance studies at Manhattan, Kansas, in 1938 included six inbred lines and nine single crosses involving these six lines. A comparison of disease development in the stalk pith of this material is shown in table 44. The resistant lines averaged 3.0 internodes rotted, while the susceptible lines averaged 5.6 internodes rotted. The crosses between resistant and susceptible lines averaged 3.5 internodes rotted, a figure approaching that of the resistant parents.

Disease development in stalk cortex of six inbred lines and nine single crosses is given in table 45. As with the pith rotting, the performance of the single crosses approached that of the resistant parent line.

In progress are studies attempting to determine the number of
Table 42. Comparison of disease development in inbred lines and top crosses inoculated with Diplodia zea, Ames, Iowa, 1933.

<table>
<thead>
<tr>
<th>Top cross</th>
<th>Number of internodes rotted in pith</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inbred line</td>
</tr>
<tr>
<td>244 x Krug</td>
<td>3.0</td>
</tr>
<tr>
<td>207A1 x Krug</td>
<td>3.2</td>
</tr>
<tr>
<td>436 x Krug</td>
<td>2.5</td>
</tr>
<tr>
<td>222A1 x Krug</td>
<td>2.9</td>
</tr>
<tr>
<td>224A2 x Krug</td>
<td>1.9</td>
</tr>
<tr>
<td>234 x Krug</td>
<td>2.4</td>
</tr>
<tr>
<td>456A2 x Krug</td>
<td>3.6</td>
</tr>
<tr>
<td>239A2 x Krug</td>
<td>2.5</td>
</tr>
<tr>
<td>461 x Krug</td>
<td>2.8</td>
</tr>
<tr>
<td>197A2 x Krug</td>
<td>4.2</td>
</tr>
<tr>
<td>267A3 x Krug</td>
<td>2.4</td>
</tr>
<tr>
<td>266B x Krug</td>
<td>3.9</td>
</tr>
<tr>
<td>204B x Krug</td>
<td>3.5</td>
</tr>
<tr>
<td>355 x Krug</td>
<td>2.8</td>
</tr>
<tr>
<td>205A1 x Krug</td>
<td>2.9</td>
</tr>
<tr>
<td>276A x Krug</td>
<td>2.8</td>
</tr>
<tr>
<td>480C2 x Krug</td>
<td>3.0</td>
</tr>
<tr>
<td>270A1 x Krug</td>
<td>3.2</td>
</tr>
<tr>
<td>354 x Krug</td>
<td>3.4</td>
</tr>
<tr>
<td>415 x Krug</td>
<td>4.4</td>
</tr>
<tr>
<td>324 x Krug</td>
<td>3.7</td>
</tr>
<tr>
<td>317B2 x Krug</td>
<td>4.2</td>
</tr>
<tr>
<td>349A x Krug</td>
<td>4.2</td>
</tr>
<tr>
<td>159 x Krug</td>
<td>3.7</td>
</tr>
<tr>
<td>Mean</td>
<td>3.2</td>
</tr>
<tr>
<td>Krug</td>
<td></td>
</tr>
<tr>
<td>Score</td>
<td>Single</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>5.5</td>
<td>4.0</td>
</tr>
<tr>
<td>5.6</td>
<td>3.7</td>
</tr>
<tr>
<td>5.0</td>
<td>3.1</td>
</tr>
<tr>
<td>6.2</td>
<td>0.0</td>
</tr>
<tr>
<td>6.5</td>
<td>0.0</td>
</tr>
<tr>
<td>6.1</td>
<td>2.7</td>
</tr>
<tr>
<td>2.2</td>
<td>2.7</td>
</tr>
</tbody>
</table>

*Hours; 1956.*

Intermed Types and Hybrids Crossed with Hybrid Type S63, Harbison.

Table 44: Comparison of chromosome development in single pitch of

81
Table 45. Comparison of disease development in stalk cortex of inbred lines and hybrids inoculated with Diplodia zeae, Manhattan, Kansas, 1936.

<table>
<thead>
<tr>
<th>Single cross</th>
<th>Number of internodes rotted in cortex</th>
<th>Inbred line</th>
<th>Single cross</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Resistant</td>
<td>Susceptible</td>
</tr>
<tr>
<td>224 x 205</td>
<td>2.6</td>
<td>2.9</td>
<td>3.4</td>
</tr>
<tr>
<td>224 x 364</td>
<td>2.6</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>224 x 349</td>
<td>2.5</td>
<td>5.3</td>
<td>2.6</td>
</tr>
<tr>
<td>205 x 349</td>
<td>2.9</td>
<td>5.3</td>
<td>3.5</td>
</tr>
<tr>
<td>205 x 317</td>
<td>2.9</td>
<td>6.6</td>
<td>3.6</td>
</tr>
<tr>
<td>364 x 289</td>
<td>2.8</td>
<td>3.0</td>
<td>4.1</td>
</tr>
<tr>
<td>364 x 317</td>
<td>2.8</td>
<td>6.6</td>
<td>3.6</td>
</tr>
<tr>
<td>289 x 317</td>
<td>3.0</td>
<td>6.6</td>
<td>5.6</td>
</tr>
<tr>
<td>289 x 349</td>
<td>3.0</td>
<td>5.3</td>
<td>5.5</td>
</tr>
<tr>
<td>Mean</td>
<td>2.8</td>
<td>4.9</td>
<td>5.4</td>
</tr>
</tbody>
</table>
factors responsible for resistance and to find what specific chromosomes are associated with resistance to Diplodia.
DISCUSSION

It is difficult to recognize disease resistant strains in seasons when little stalk rotting occurs. The use of a reliable inoculation technique would furnish a means of testing the lines or hybrids independently of natural infection, thus materially hastening the process of selection. By eliminating disease escape, artificial inoculation should permit the use of smaller numbers of plants in breeding experiments and in fundamental studies on the nature and inheritance of resistance.

The 412 inbred lines, 93 single crosses and 53 top crosses studied in 2248 plots ranged from extreme resistance to stalk rot to extreme susceptibility. A highly significant correlation of +0.83 between inoculated and check plants indicated that inoculation with Diplodia was a satisfactory means of differentiating between corn strains resistant and susceptible to stalk rotting.

Although artificial Diplodia inoculation is far superior to dependence upon natural infection in the selection of corn strains, several precautions are necessary in its use. For instance, environment appears to affect the expression of stalk rotting. Some limited data in 1935 showed significant differences between fields differing in soil fertility. A significant cross x field interaction was interpreted to mean that stalk rotting of various strains is not influenced to the same degree by different levels of soil fertility.
Large, healthy plants with a high moisture content grown under irrigation were over twice as susceptible to Diplodia stalk rot as plants of the same crosses grown under dry-land conditions. The relative order of ranking the strains for resistance was similar under both environments. Inoculations made at the time of pollination produced heavier stalk rotting than at later dates although the lines ranked similarly in resistance at all dates. Stage of maturity at the time of inoculation is important. Apparently the earlier maturing lines are more susceptible than the later lines. Although it may be inaccurate to compare directly the relative resistance of lines differing in maturity, striking differences remain among lines of equal maturity. Readings should preferably be made while normal stalk tissues remain green. Differential damage between strains from chinch bugs, grasshoppers, drought, etc. may cause abnormal carbohydrate relationships or premature dying and thus affect normal spread of Diplodia. If these various disturbing factors are recognized and the data interpreted intelligently, the Diplodia inoculation technique can be used even under adverse conditions.

Holbert, Hoppe and Smith (1935) reported that increased susceptibility of corn stalks to Diplodia was associated with conditions causing a reduction of the carbohydrate reserves of the plants. If this were true, the highest-yielding corn strains would tend to have lowest concentrations of carbohydrates in the stalks and consequently would be susceptible to stalk rot. Strains resistant to stalk rot theoretically would be inefficient translocators of carbohydrates and thus would be lower-yielding. As a result, some corn breeders are
averse to using the newly-developed inoculation technique.

Sayre, Morris and Richey (1931) found that preventing pollination was associated with a gradual accumulation of total sugars. Reduction in leaf area was associated with a reduction in the total sugar content of the stalk. The changes in total sugar content were due to changes in the sucrose content of the tissue and not to free reducing sugars.

Studies were made during 1936, 1937 and 1938 to determine the effect of leaf clipping and enforced barrenness on resistance of corn to Diplodia. Although individual lines and crosses varied in response, the barren plants were most susceptible to pith rotting. The barren, single cross plants were more resistant to cortex rotting than clipped hybrids, but the effect of treatment on cortex rotting of inbred lines was inconclusive. These data indicate that selecting stalk-rot resistant inbreds need not result in lower yielding hybrid combinations. In fact a correlation of -0.42 indicates that lines resistant to pith rotting tend to produce the heavier ears. Inbred plants with a heavy Diplodia infection yielded 11 percent less grain than plants of the same heredity grown side by side but having only a slight Diplodia infection. Obviously a susceptible line must have about an 11 percent yield advantage to compete with a line resistant to Diplodia. Little relation occurred between cortex rotting and ear weight. This might indicate that notes on pith rotting are more important than those on cortex rotting.

Resistance to corn smut appeared to be closely associated with
sugar accumulation. Enforced barrenness stimulated smut infection while leaf clipping retarded it. Corn smut appears to be most prevalent in seasons and sections of low rainfall and high temperature. Under such conditions, poor pollination of the corn plant occurs. Lack of translocation to the ear results in an accumulation of sugars in the stalk and increased axillary bud growth which in turn stimulates growth of the relatively dormant smut fungus.
SUMMARY

Objectives of these investigations, made during 1934 to 1938 inclusive, were to study: (a) reliable methods of determining resistance of corn strains to stalk rot, (b) stalk rot associations, (c) nature of resistance, and (d) inheritance of resistance.

With the exception of preliminary observations on inbred lines in 1934 and 1935, the experiments, containing 412 inbred lines, 93 single crosses and 63 top crosses in 2248 plots, were arranged for statistical analysis.

In preliminary studies, stalks were split at harvest and the amount of shredding and discoloration recorded as a grade. In later studies, relative resistance was measured by the number of internodes rotted in stalk pith and cortex and horizontal spread around the stalk. A highly significant correlation of +0.92 between pith and cortex readings showed that both methods of reading infection give similar results.

Depending upon natural means of infection, inbreds and hybrids differed significantly in resistance to stalk rot. A positive interannular correlation indicated that resistance is a strain characteristic and is inherited.

Artificial inoculations were utilized to eliminate disease escape. Inoculations with Diplodia zeae strain 26 were made about one week after the completion of pollination with a water suspension of spores. A highly significant positive correlation between inoculated and check plants showed that artificial inoculation was satisfactory for differ-
entiating between strains differing in resistance to stalk rotting organisms.

Although artificial Diplodia inoculation was far superior to dependence upon natural infection, certain precautions are necessary in its use. Strains cannot be compared directly if differing greatly in maturity, if grown on different levels of soil fertility, or suffering differential damage from drought, chinch bugs, grasshoppers, etc. Stalk inoculations made at the time of pollination produced more rotting than at later dates although the ranking of the lines for resistance was similar at all dates. Readings should be made while normal stalk tissue remains green.

Stalk inoculation with Diplodia caused a 11 percent decreased yield and considerable stalk breaking but did not affect smut infection, ear rotting, or premature dying of stalks or leaves.

Studies were made in 1936, 1937 and 1938 to determine the effect of leaf clipping and enforced barrenness on resistance of corn to Diplodia. Leaf clipping consisted of removing the tip one-third of each leaf at the time of inoculation. Enforced barrenness was obtained by covering the ear shoots with parchment bags before the silks appeared. Barren single cross plants were more resistant to cortex rotting than clipped plants but the effect of treatment on cortex rotting of inbred lines was inconclusive. Barren inbred and single cross plants averaged most susceptible to pith rotting. Theoretically, it might be reasoned that susceptible plants are inefficient translocators of sugars to the ear, and thus tend to be lower yielding than resistant plants. Obviously
food utilized by fungus cannot be stored in the ear. Although not statistically significant, a correlation indicated that lines resistant to pith rot tend to produce heavier ears. Little relation occurred between resistance to cortex rotting and ear weight.

Some clipped, inoculated plants died prematurely, preventing normal spread of Diplodia. Neither leaf clipping or enforced barrenness appeared to affect ear rotting. Leaf clipping caused a 36 percent decreased yield. Resistance to smut appeared to be closely associated with sugar accumulation in the stalks.

In general, data obtained during several years indicate that crosses between resistant and susceptible lines approach the resistant parent in resistance. The effects of heterosis and at least partial dominance of resistance appear to be factors. Some evidence of supplementary action of resistance factors was obtained when crosses between certain susceptible lines were more resistant than either parent. Crosses between very resistant lines sometimes were less resistant than the parent lines. Individual crosses varied somewhat in performance. Resistance appears to be complex and due to many factors.
LITERATURE CITED

Burrill, T. J., and Barrett, J. T.

Clayton, E. E.


DeTurk, E. E., Earley, E. B., and Holbert, J. R.

Durrall, L. W.

Heald, F. D.

Wilcox, E. W., and Pool, V. W.

Holbert, J. R., Burlison, W. L., Koehler, B., Woodworth, C. M., and Dungan, G. H.

Hoppe, P. E., and Smith, A. L.
1935. Some factors affecting infection with and spread of Diplodia zeae in the host tissue. Phytopath. 25:1113-1114.

Hoppe, P. E.
and Holbert, J. R.

Johann, Helen.

Jugenheimer, R. W., and Bryan, A. A.

Jugenehimer, R. W., and Bryan, A. A.

Kent, G. C.

McNew, George L.

Melhus, I. E.

Melhus, I. E.

Melhus, I. E.

Melhus, I. E., and Durrell, L. W.

Reddy, C. S., Raleigh, W. P., and Burnett, L. C.

Raleigh, W. P.

Reddy, C. S., and Holbert, J. R.
Sayre, J. D., Morris, V. H., and Richey, F. D.

Semeniuk, G.

---

Smith, N. F., and Hedges, F.

Smith, A. L., Hoppe, P. E., and Holbert, J. R.

Snedecor, G. W.

Wallace, H. A., and Snedecor, G. W.
ACKNOWLEDGMENTS

The writer wishes to express his appreciation to the late Dr. A. A. Bryan for advice on statistical phases of the problem, to Mr. Paul E. Hoppe for supplying the Diplodia inoculum, and to Dr. E. W. Lindstrom, Dr. I. E. Melhus, and Dr. I. J. Johnson for valued suggestions.