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CORN PATHOLOGY RESEARCH OF PIONEER IN THE PHILIPPINES

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ABSTRACT

Basic studies relating to *Diplodia macrospora*, downy mildew, bacterial rot and banded leaf disease have been conducted at Pioneer.

Inoculation experiments proved that *D. macrospora* was the cause of leaf blight, ear rot and stalk rot of corn. The leaf blight phase appears to be initiated first, followed by either the ear rot or stalk rot phase, depending upon the location of the leaf blight phase. Symptoms of the three phases of infection are described. This study constitutes the first report on the occurrence of the ear and stalk rot phases of *D. macrospora* and the destructive potential of the disease in the Philippines.

Studies on metalaxyl fungicide showed that the chemical was capable of eradicating established downy mildew infection on corn. The implications of this result in DM resistance breeding and other research areas are given. Studies also showed that metalaxyl fungicide gave complete control of downy mildew at rates as low as 0.2 g a. i./kg seed. On the other hand, the recommended rate of 2 g a. i./kg showed some detrimental effect on seed germination.

Using a stalk inoculator for bacterial rot screening, we have identified good sources of resistance to the disease among existing Pioneer corn inbreds. On the other hand, presently grown commercial corn hybrids showed inadequate resistance to bacterial rot with infection ranging from 53 to 85%. Yield losses from these infection levels ranged from 36 to 82%. There was good correlation (r = 0.83) between percent infection and yield loss. Results of a study on the comparative virulence of three isolates of *Erwinia carotovora* pv *chrysanthemi* showed isolate IPB 24 as the most virulent and isolate R8, (an isolate from rice) as the least virulent.

Among the eight methods tried for inoculating corn with *Rhizoctonia solani*, the whorl inoculation using sclerotial bodies showed the highest percent infection (98%), followed by leafsheath inoculation using infested sorghum grains (92%) and whorl inoculation using infested sorghum grains (67%). Of these three, leafsheath inoculation method was adopted as the standard method in screening for resistance to banded leaf disease because it simulates natural infection pattern by the fungus. Results of the most recent trial showed great variation in all parameters measured. Thus, lesion length ranged from 35 to 71 cm, ear rotting from 28 to 100%, visual rating from 1 to 8 and ear height (measured from the point of inoculation to the base of the ear) ranged from 5 to 65 cm. Correlation analyses involving these parameters showed that the extent of ear rotting, which reflects resistance to banded leaf disease, was more closely correlated with ear height than lesion length. Close correlation between visual rating at 20 days after inoculation and ear rotting also suggests that visual rating can be used in evaluating resistance to banded leaf disease, thus, eliminating the tedious job of counting infected ears at harvest or measuring lesion length.

Introduction

Diseases constitute a great hazard to corn production particularly in tropical areas where staggered planting over one or more cropping seasons is practiced. Pioneer realized this between 1974 and 1976 when it introduced to the Philippines corn hybrids developed in Jamaica. Though these hybrids showed high yield, they all proved highly susceptible to downy mildew, long considered the most destructive disease of corn in the Philippines. Breeding for high-yielding corn hybrids with acceptable resistance to corn diseases, primarily downy mildew, therefore, became the main thrust of Pioneer research when it establish a research station in General Santos City, South Cotabato in 1976. Within three years, the first downy mildew resistant hybrid, X076, was released to the farmers. This hybrid was replaced by Pioneer 6181 the following year (1980) and became so popular among many farmers because of its yield stability that despite competition from other Pioneer and competitor hybrids, it is still in the market. The development of Pioneer 6181 coupled with the discovery of metalaxyl fungicide highly effective against downy mildew led to the adoption of corn hybrid technology by many corn farmers. However, this also gave rise to other disease problems like stalk and ear rots, several foliar diseases and viral diseases which may have long been overshadowed by downy mildew. Realizing the need for hybrids with multiple disease resistance trait to attain high-yielding potential, Pioneer intensified its corn pathology research starting 1985. The ultimate goal is to minimize losses due to diseases, primarily through disease resistance breeding and secondarily, through other disease control measures. This paper aims to present research accomplishments of Pioneer on corn pathology in the Philippines.

Materials and Methods

Diplodia macrospora

In 1985, *D. macrospora* was found associated with severe incidence of ear rot and leaf blight. Since then, these two phases of the pathogen have been regularly encountered in most farmers' fields in South Cotabato and at our research stations in General Santos City and Cabuyao, Laguna. To understand some aspects of the fungus' biology, pathogenicity tests were conducted. Three types of inoculum were used, namely: infected leaf tissues, artificially infested sorghum grains and spore suspension from naturally produced pycnidia. Infected leaf tissues and infested sorghum grains were introduced to the whorl of 40- to 50-day old plants while spore suspension was injected into the second internode of stalk of 70- to 80-day old corn plants. Inoculated plants were regularly observed for the appearance of initial and the development of the typical symptoms. Moreover, field observations on the natural incidence of the disease were also made to relate results of artificial inoculation.

Downy mildew

Severe incidences of downy mildew were encountered in some isolated areas in Isabela and Northern Mindanao in 1985 on supposedly DM-resistant materials. Considering that this could be a case of 'breakdown' of DM resistance, studies on metalaxyl fungicide, long considered as the most effective chemical against DM, were conducted. To study the eradicative effect of metalaxyl on DM infection, seeds of a DM-susceptible corn were planted in seedboxes. One week after planting, seedlings were artificially inoculated with DM fungus, *Peronosclerospora philippinensis*, using spore suspension. Seedboxes were then divided into groups. In one experiment, seedlings were sprayed with Ridomil MZ at various times after inoculation, viz. one, three, five or seven days after inoculation. In another experiment, the seed dressing (Apron 35 SD = 35% metalaxyl) and the sprayable (Ridomil MZ = 10% metalaxyl) formulations were sprayed on seedlings one week after inoculation. In both experiments, inoculated seedlings but not sprayed with metalaxyl were provided to serve as check. Seedboxes were placed on benches outside the greenhouse and seedlings were observed for DM infection. Final DM count was taken 25 days after inoculation.

To determine if metalaxyl can cure plants showing more advanced stages of infection, surviving plants left after final count was taken were sprayed with Apron 35SD. Plants were then observed for disappearance of DM symptoms until flowering.

To study the effect of varying rates of metalaxyl on seed germination and DM control, seeds of Pioneer hybrids were treated with Apron 35SD ranging from 0.2 g a. i. to 6.0 g a. i./kg seed. Treated seeds were tested for seed germination at different intervals using the ragdoll method. Efficacy of Apron 35SD against DM was determined by planting the treated seeds in the DM nursery using three to five replications. Untreated seeds were also planted as check.

Bacterial rot

Bacterial rot occurs at all stages of crop growth, causing top rot, stalk rot and ear rot, depending upon the tissue or organ affected. Field observations made since 1985 suggest that it is causing substantial damage on corn, hence, given considerable attention. Main emphasis of Pioneer research concerning this disease include evaluation of resistance and pathogen variation. To evaluate for resistance to the disease, test materials were planted in two-row plots, 5 m long. Plants were inoculated at different growth stages with the bacterial suspension applied through the whorl or through the stalk using an inoculator. Number of dead plants was taken 10 to 15 days after inoculation and percent mortality computed. Yield loss due to the disease was also determined on hybrids by comparing the yield of inoculated and uninoculated rows. Correlation coefficient between percent infection and loss was also determined.

Banded leaf disease

This disease, which is caused by *Rhizoctonia solani*, is prevalent in almost all corn growing areas during periods of high precipitation. The fungus is soil-borne and initiates infection from the base spreading upwards. Substantial losses occurs when ears become infected. At Pioneer, various inoculation methods were compared to determine the best method to use in screening for resistance to the disease. Eight methods of inoculation were initially compared, as described below:

T1 = soil inoculation using 20 artificially infested sorghum grains per hill at planting time

T2 = leafsheath inoculation by inserting 20 infested sorghum grains between leafsheath and stem, two to three nodes above the ground

T3 = whorl inoculation using 20 infested sorghum grains

T4 = whorl inoculation using mycelium suspension

T5 = whorl inoculation using chopped infected leaf materials

T6 = band application of chopped infected leaf materials

T7 = whorl inoculation using five naturally infected corn kernels

T8 = whorl inoculation using sclerotial bodies

T9 = no inoculation

Except for T1, all inoculations were made 35 DAP using a Pioneer corn inbred known to be susceptible to the disease. Efficiency of methods was determined based on percentage infected plants.

Using the most appropriate inoculation method, germplasm materials of Pioneer were evaluated for resistance to BLSD. Plants were grown in two-row plots, five meters long in two replications. Inoculation was done about 40 days after planting by placing 5-10 infected sorghum grains at the axil of the third leaf from the ground. Lesion length, measured from the point of inoculation upwards, ear height and visual rating were taken at 20 days after inoculation while number of rotten ears was taken at harvest time. Correlation coefficients were determined among ear height, lesion length, visual rating and percent ear rot.

Results and Discussion

Diplodia macrospora

All pathogenicity tests showed positive results, clearly indicating that *D. macrospora* is the cause of leaf blight, ear rot and stalk rot. The prevalence and the nature of *D. macrospora* infection also indicate the destructive potential of the fungus on corn production in the country.

Based on field observations and inoculation experiments, the description of symptoms for the different phases of infection are given as follows. On the leaf, infection starts as a small, circular to oval chlorotic spot which later enlarge and become necrotic with distinct gray center and brown margin. Lesions continue to enlarge lengthwise reaching a length of 10-15 cm. Mature lesions resemble those of Stewart's wilt (caused by *Erwinia stewarti*) and Northern leaf blight (caused by *Helminthosporium turcicum*). However, leaf blight caused by *D. macrospora* is distinguishable by the presence of small, black, globose structures (pycnidia) scattered over the central portions of the lesion. On the ear, small, circular lesions start usually at the base of the outer husks, which later spread outward and into the inner husks. Husks of infected ears dry up prematurely and become pasted together by the fungus mycelium. On severely infected ear, fungus mycelium ramifies over the kernels and on the cob between the kernel rows. Kernels of affected ear assume pale and shrivelled appearance and become soft. Pycnidia of the fungus appear on the husks, kernel surface and on the cob. Infection on the stem usually starts at the nodal portion where the leaves are attached. Stem become discolored, starting from the nodal region and later spread both upward and downward. At a later advanced stage, leaves at and above the affected node wilt and dry up.

In many instances under natural conditions, several lesions were observed to occur at a common origin, which suggests that infection is initiated in the whorl when there is free moisture to allow spore germination and infection. This was confirmed by artificial inoculation through the whorl. In almost all cases, leaf infection precedes both ear and stalk infections. It appears that spores of the fungus produced on the leaves are washed down to the ear and/or leaf axils subsequently causing ear and stalk infection. This implies that controlling the leaf blight phase would substantially reduce ear and stalk infection. Screening for resistance to the leaf blight would therefore be more appropriate in *D. macrospora* resistance breeding. Nevertheless, correlation of resistance among the three phases of infection needs to be established.

Although *D. macrospora* is known to cause the three phases of infection in other countries, this is the first documented report on the occurrence of the ear and stalk rot phases in the Philippines. This also constitutes the first report on the destructive potential of the disease in the country. The paper by Stevens and Celino in 1931 was the first and only report that we are aware of on *D. macrospora* as causing leaf blight in the Philippines.

Downy mildew

On the eradicative effect of metalaxyl in the first experiment, all plants sprayed with metalaxyl (Ridomil MZ) within five days after inoculation did not show systemic infection while 16.5% of plants sprayed with metalaxyl seven days after inoculation showed systemic infection. Such systemic infection, however, disappeared within one week; infected plants resumed normal growth thereafter. Plants that were not sprayed with metalaxyl showed 59.5% infection. In the second experiment, all plants except those used as check were sprayed with either Apron 35SD or Ridomil MZ at six days after inoculation. Plants sprayed with Apron showed 0.7% infection while those sprayed with Ridomil showed 9.1% infection. These infected plants, however, completely recovered from DM infection within one week. Unsprayed plants showed 97.6% infection. At the time of assessment which was 15 days after inoculation, infected plants in two seedboxes of control treatment were each sprayed with Apron 35SD and Ridomil MZ; infected plants in the remaining seedbox were left unsprayed. Observations made 15 days later showed all sprayed plants to have completely recovered from DM infection. At this time, only four out of 28 infected plants in the remaining control treatment were surviving but showing complete chlorosis and spindly growth. When these were sprayed with Ridomil, all plants recovered their normal green color and were able to produce tassel and ear shoot when the experiment was terminated.

Results presented above clearly demonstrate the eradicative effect of metalaxyl on DM infection. While these results tend to disagree with the findings of Exconde (1982), eradicative action of metalaxyl is expected because of the systemic nature of the fungicide. Results also indicate high biological activity of metalaxyl considering that symplastic movement in foliar treatment is usually not more than 1-2% of the applied metalaxyl (Zaki *et al.*, 1981). This high biological activity is confirmed by our recent study where complete control of DM was obtained with seed treatment at the rate of 0.2 g a. i./kg, which is only 10% of the recommended rate. Likewise, Odvody and Frederiksen (1984) obtained 100% control of *P. sorghi* in corn and sorghum at seed treatment rates as low as 0.05 g a. i./kg seed. Results also indicate that both the foliar spray (Ridomil) and the seed treatment (Apron) formulations are equally effective when sprayed to infected plants. However, Apron would be more economical to use because of its more concentrated form and the absence of another active ingredient present in the spray formulation. The appearance of systemic infection on some plants sprayed with either Apron or Ridomil at six to seven days after inoculation may be explained by the delayed action of fungicide on the fungus that has already become established in the shoot apex. The normal incubation period for systemic symptom expression on plants inoculated one week after planting is about one week (Dalmacio and Exconde, 1969). In terms of DM control, the seed treatment approach is undoubtedly preferred over foliar treatment, however, spraying has important implications in DM resistance breeding. Under too much DM pressure, important breeding lines may be saved from complete elimination by DM through foliar spraying. We are also presently utilizing foliar application to determine the stability of DM resistance under DM and DM-free conditions for parent seed production. Foliar spraying may also be utilized in studying the inheritance of DM resistance by allowing crosses between truly susceptible (infected plant of a susceptible inbred) and resistant (uninfected plant of a resistant inbred) plants.

Results of study on the effect of metalaxyl on seed germination are presented in Tables 1 and 2. Results showed that seed germination was affected by both metalaxyl and length of storage. The effect of storage on seed germination may be attributed to seed moisture resulting from the water used in the slurry treatment. Perhaps, the initial moisture of the seed used was already high that the addition of water even at the rate of 0.5% activated physiological processes of the seed leading to decreased seed vigor. Comparison of the seed germination of treated and untreated seeds within a given storage period, however, clearly indicate the detri-

Table 1. Effect of Apron 35SD rate and length of storage period on corn seed germination of two Pioneer corn hybrids

Length of storage (days)	*Apron 25 SD Rate (g a.i./kg)*			
	0	*2*	*4*	*Mean*
0	95.45[a/]	91.80	82.8	90.02
7	86.65	66.15	31.66	61.49
14	71.30	38.30	25.00	44.87
Mean	84.47	65.41	46.49	65.46

[a/] Average of 300 seeds tested

Table 2. Effect of Apron 35SD rate and length of storage on corn seed germination of two Pioneer hybrids (2nd experiment)

Length of storage (days)	*Apron 35 SD Rate (g a.i./kg)*					
	0	*0.5*	*1.0*	*1.5*	*2.0*	*Mean*
0	95.5[a/]	92.5	90.0	86.5	77.0	88.3
7	93.0	86.5	82.7	78.0	70.5	82.1
14	90.0	84.2	76.2	71.2	62.0	76.7
30	89.2	85.5	80.2	67.0	61.5	76.7
60	78.5	74.7	71.7	66.5	60.2	70.3
90	62.2	51.7	45.2	33.5	20.5	42.6
Mean	84.7	79.2	74.3	67.1	58.6	72.8

[a/] Average of 400 seeds of two hybrids subjected to ordinary and cold storage conditions.

mental effect of metalaxyl on seed germination. The lowest rate of metalaxyl used (0.5 g a.i./kg) showed the least effect on seed germination. According to Hairston (1986, personal communication with Alex Paez of Pioneer), the effect on seed germination is associated with seed vigor, rate of application, storage conditions and use of other seed treatment, e.g. herbicide safeners. On sorghum, he cited reports of reduction in germination on seed stored for 5-6 months treated at 0.6 g a. i/kg seed, storage temperature and duration. However, water used in the slurry in excess of 10 ml/kg seed affected germination of both treated and untreated seed. In view of the conflicting data reported in the Philippines, further study using freshly harvested seeds and constant monitoring of seed moisture before and after seed treatment and during storage need to be conducted.

Tables 3 and 4 show the results of the study on the effect of different rates of metalaxyl on DM infection. In the first trial, DM infection was quite low, averaging only 26% infection in the untreated materials. Nevertheless, no infection was observed in the most DM-susceptible hybrid (untreated seed gave 71% infection) even at the rate of 0.5 g a. i./kg. In the second experiment where there was tremendous DM pressure (90% infection on a fairly resistant hybrid), no infection was observed even at the rate of 0.2 g a. i./kg, which is only 10% of the recommended rate of 2.0 g a. i./kg. Results of these experiments clearly demonstrate the effectiveness of metalaxyl against DM as has been reported by a number of investigators. Results also show that lower rates can be safely used thus, minimizing detrimental effect of metalaxyl on seed germination as well as reducing the cost of corn production. At the present price of ₱1,450.00 per kg of Apron 35SD, cost of the chemical good for 20 kg seed per ha amounts to only ₱16.60 compared to ₱166.00 per ha using the recommended rate of 2.0 g a.i./kg seed.

Table 3. Effect of varying rates of metalaxyl on downy mildew infection (1st experiment)

Rate (g a. i./kg)		Hybrid		
	3228	6181	X306B	Mean
0	3.4	4.0	71.0	26.0
0.5	0	0	0	0
1.0	0	0	0	0
1.5	0	0	0	0
2.0	0	0	0	0

a/ Percent downy mildew infection; mean of 5 replications of about 42 plants per replication.

Bacterial rot

With the breakthrough in DM control, bacterial rot now appears to be the most important disease of corn in the Philippines. As much as 40% incidence of the

Table 4. Effect of varying rates of metalaxyl on downy mildew infection (2nd experiment).

Rate (g a.i./kg)	Replication 1	2	3	Mean
0	96.0	91.0	83.0	90.0
0.2	0	0	0	0
0.4	0	0	0	0
0.6	0	0	0	0

[a] Percent downy mildew infection based on 100 seeds planted per replication.

disease was observed in South Cotabato in a 3-hectare field in 1981 (IPB, 1981). In 1985, about 20% incidence was again observed in the same area. We have also observed as much as 80% infection on some breeding materials at our research stations in General Santos City and Cabuyao, Laguna.

Inbreds developed by Pioneer stations in the Philippines and other Asian countries are being screened for bacterial rot resistance since 1985. Results of a recent trial are presented in Table 5. Infection ranged from 0-100% which indicates good disease pressure. Out of 107 inbreds evaluated, 25 showed good resistance (less than 10% infection). Some of these inbreds have consistently shown resistance in previous trials and may now be considered for utilization in bacterial rot resistance breeding.

Table 5. Reactions of Asian inbreds to bacterial rot at Cabuyao station during the 1986-87 season

Inbred No.	Replication I	II	Total Plt.	%BSR
001	5.6	0	38	2.8
002	0	60.0	37	30.0
003	30.4	22.7	45	26.5
004	0	0	15	0
005	0	4.5	38	2.3
006	25.0	30.8	29	27.9
007	0	18.2	24	9.1
008	45.5	57.1	43	51.3
009	79.2	57.2	45	68.2
010	38.1	61.9	42	50.0
011	11.1	18.2	40	14.7
012	13.6	45.5	44	29.6
013	78.9	100.0	42	89.5
014	27.3	0	42	13.7
015	82.6	95.5	45	89.1

Table 5. (Continuation)

Inbred No.	Replication I	Replication II	Total Plt.	%BSR
016	14.3	0	34	7.2
017	68.8	85.7	37	77.3
018	36.8	30.4	42	33.6
019	65.0	72.2	38	68.6
020	58.8	50.0	31	54.4
021	40.0	50.0	40	45.0
022	100.0	85.7	25	92.9
023	66.7	89.5	37	78.1
024	56.0	72.7	47	64.4
025	33.3	75.0	11	54.2
026	0	33.3	13	16.7
027	17.6	11.8	13	14.7
028	100.0	33.3	10	66.7
029	80.0	93.3	25	86.7
030	82.4	76.2	38	79.3
031	9.5	10.5	40	10
032	0	23.8	43	11.9
033	5.6	0	42	2.8
034	75.0	26.3	31	50.7
035	27.3	9.1	33	18.1
036	51.7	47.8	52	49.8
037	23.8	89.5	40	56.7
038	38.1	90.9	43	64.5
039	77.8	73.9	41	75.9
040	0	0	6	0
041	21.4	8.3	26	14.9
042	5.3	36.4	30	20.9
043	81.8	89.5	41	85.7
044	0	41.2	34	20.6
045	0	0	13	0
046	40.9	53.3	34	38.1
047	84.6	60.0	28	72.3
048	63.6	84.2	30	73.9
049	86.7	89.5	34	88.1
050	100.0	100.0	29	100.0
051	100.0	46.2	17	73.1
052	38.9	58.8	35	48.9
053	42.9	66.7	19	54.8
054	85.7	47.6	28	66.7
055	72.7	50.0	42	38.9
056	100.0	94.1	23	97.1
057	100.0	100.0	10	100.0
058	60.0	41.7	22	50.9

	Replication				Total	
	I	*II*	*III*	*IV*	*Plt.*	*%BSR*
059	0	0	6.3	0	65	1.6
060	16.7	63.0	9.5	22.7	80	28.0
061	75.0	83.3	84.2	88.2	52	82.7
062	26.1	13.6	31.8	37.5	91	27.3
063	33.3	14.3	16.7	18.2	40	20.6
064	25.0	0	0	7.7	38	8.2
065	84.2	64.7	68.8	90.5	73	77.1
066	34.8	52.4	88.9	24.0	87	50.0
067	5.3	26.1	23.8	31.8	85	21.8
068	70.0	50.0	84.2	77.8	77	70.5
069	42.1	71.4	82.4	65.0	70	65.2
070	5.9	0	5.3	15.8	65	6.8
071	0	4.3	5.3	10.0	83	4.9
072	50.0	100.0	42.9	78.3	83	67.8
073	0	15.4	6.3	4.8	70	6.6
074	100.0	0	25.0	50.0	20	43.8
075	94.7	100.0	95.2	100.0	80	97.5
076	91.7	90.0	61.1	36.4	84	72.3
077	27.3	71.4	33.3	0	25	33.0
078	100.0	80.9	79.2	87.5	89	89.2
079	59.1	22.7	37.5	22.7	90	35.5
080	44.4	8.9	22.2	31.8	81	26.8
081	75.0	81.3	7.7	50.0	47	36.0
082	9.1	4.3	9.5	36.8	85	14.9
083	0	0	0	0	54	0
084	0	0	0	0	81	0
085	50.0	33.3	85.7	58.3	51	56.8
086	43.8	70.6	38.1	52.4	75	51.2
087	0	0	4.8	0	76	1.2
088	89.5	84.4	89.5	86.4	79	87.5
089	0	4.3	9.5	0	73	3.5
090	0	0	28.6	0	30	7.2
091	14.3	15.8	5.0	0	86	8.8
092	0	10.0	13.3	0	67	5.8
093	70.0	50.0	57.1	91.7	69	67.2
094	20.0	25.0	6.3	0	56	12.8
095	45.0	33.3	–	70.0	55	49.4
096	100.0	78.3	90.5	88.9	88	89.4
097	86.7	90.0	91.7	90.5	68	89.7
098	52.6	65.0	66.7	60	85	61.1
099	0	0	31.6	20.8	84	13.1
100	100.0	92.3	100.0	81.2	78	93.4
101	10.0	1.7	0	4.5	67	4.1
102	90.0	90.2	72.2	86.4	81	84.8
103	95.0	78.9	77.8	68.2	79	80.0
104	90.9	90.9	72	73.9	92	81.9
105	94.7	100.0	90.0	94.1	80	94.5
106	92.3	86.7	100.0	92.9	55	90.0
107	0	0	–	0	44	0

Results of inoculation on precommercial and commercial hybrids of Pioneer and two commercial hybrids of a competitor company are shown in Table 6. Infection ranged from 53-85% with yield loss ranging from 36-82%. Correlation analysis between infection and yield loss gave an r value of 0.83, which indicate good correlation. However, this is expected from the experiment since plants were inoculated after flowering and yield of infected plants could not be compensated by neighboring healthy plants.

Table 6. Mean percent bacterial rot infection, yields of inoculated and uninoculated plots and percent yield loss due to bacterial rot on nine precommercial and commercial hybrids

	Percent	*Yield*	*(kg/plot)* [b]	*Percent*
Hybrid	*rot* [a]	*Inoculated*	*Uninoculated*	*Loss*
3208	71.2	0.8	2.0	66.7
3224	84.8	0.4	2.2	81.8
3228	53.0	1.1	2.3	52.2
3274	78.0	0.8	1.8	55.6
XCG51	58.6	1.6	2.5	36.0
YCG55	58.7	1.2	2.3	47.8
YCH55	78.8	0.8	2.5	68.0
Competitor 1	75.8	0.8	2.2	63.6
Competitor 2	84.0	0.6	2.2	72.7

[a]Average of 4 replications.

[b]Average of 3 replications of paired rows of inoculated and uninoculated plots.

Results indicate that corn hybrids presently grown in the Philippines do not possess adequate resistance to bacterial rot and are highly vulnerable to the disease under conditions favorable for disease development like those during periods of heavy precipitation. Apparent absence of resistance to bacterial rot among presently grown hybrids and varieties may be attributed to inadequate effort in bacterial rot resistance breeding.

Various screening techniques have been tried and these include whorl application with bacterial suspension, injection of bacterial suspension into the stalk and pricking of stalk with sharp nail previously dipped in bacterial suspension. For screening of germplasm materials, Karganilla and Exconde (1973) recommended pricking method. On the other hand, researchers at the Institute of Plant Breeding (IPB) are using whorl inoculation. At Pioneer, we have tried both methods and found these to be slow. We also found pricking method as unreliable because of contamination of inoculum during dipping of inoculating instrument after every pricking of stalk. We found the use of an inoculator (designed and fabricated in the U.S. for inoculating corn stalks with fungal pathogens) as the most convenient with equally reliable results. As many as 600 plants can be inoculated per hour per person. What remains to be determined, however, is the inoculum concentration most appropriate in inoculating plants in the breeding nursery. Too high concentration may completely wipe out a population while too low concentration may result to more escapes that would make selection for resistance ineffective. Other factors to be considered should include the type of isolate and age of the plant.

Banded leaf disease

Results presented in Table 7 showed infection ranging from 2 to 98%. Among the eight methods tried, whorl inoculation with sclerotial bodies and leafsheath inoculation with infested sorghum grains gave 98% and 92% infection, respectively. While whorl inoculation using either sclerotial bodies or infested sorghum grains is more efficient, it does not simulate natural infection in the field. *Rhizoctonia solani* is soil-borne which initiates infection from the base and spreads upwards to the ear where it causes ear rot. Hence, whorl inoculation would not be the appropriate screening method. The best alternative appears to be the leafsheath inoculation using either sclerotial bodies or infected sorghum grains. It is quite slow but each plant is assured of being inoculated, thus, minimizing, if not eliminating, escapes.

Using the leafsheath inoculation method, we have screened Pioneer materials for banded leaf disease (BLSD) for the past three seasons. Results of our most recent trial are presented in Table 8. Lesion length varied from 35 to 71 cm, visual rating from 1-8%, ear rot from 28-100% and ear height (measured from point of inoculation) from 5-65 cm. Based on the BLSD resistance criteria used, there exist

Table 7. Effect of various inoculation methods on percent infection by *Rhizoctonia solani* on corn

	Replication				
Treatment	*1*	*2*	*3*	*4*	*Mean*
T1	31	22	43	28	31 a
T2	93	95	92	90	92 b
T3	56	68	62	82	67 c
T4	10	19	8	16	13 d
T5	37	17	32	52	34 a
T6	8	10	32	18	17 d
T7	43	5	33	49	32 a
T8	100	90	100	98	98 b
T9	2	0	0	7	2 c

Note: Means followed by the same letter are not significantly different of 0.05 level using LSD. Treatment descriptions are given in the text.

variation in BLSD resistance among the inbreds. However, no inbred appears highly resistant based on lesion length. This is to be expected for diseases caused by a pathogen with very broad host range.

To understand what factors contribute to the degree of ear rotting, correlation analyses were made among lesion length, ear height, visual rating and % ear rot. Results showed that both ear height and visual rating were highly correlated with percent ear rot with r values of –0.68 and –0.59, respectively. Likewise, there was high correlation between ear height and visual rating (r = 0.76). On the other hand, no correlation was found between lesion length and percent ear rot (r = –0.05) and between lesion length and visual rating (r = 0.10). Results imply that resistance to BLSD is more of the function of ear height rather than lesion length, despite observed differences in lesion length among inbreds. Resistance to BLSD in corn has been reported in India (Singh and Sharma, 1976, Ahuja and Payak, 1978), however, in such studies nothing was mentioned about the effect of ear height on resistance. But assuming that inbreds with different ear height are infected with the fungus at the same rate, it is quite obvious that the inbred with lower ear placement would be affected more than the inbred with higher ear placement. And since variation in ear height (σn = 12.32) is greater than variation in lesion length (σ n = 6.71), it could be expected that ear height would influence the incidence of ear rot more than lesion length.

Table 8. Incidence of *Rhizoctonia* ear rot and visual disease rating of corn inbreds as influenced by ear height and lesion length (PA, 1986)

Inbred No.	*Ear height (cm[a])*	*Lesion length (cm)*	*Visual rating*	*% Ear rot*
1	30	55	1	86
2	23	53	1	100
3	31	57	1	95
4	39	60	2	92
5	42	53	3	49
6	36	53	3	94
7	33	56	3	33
8	33	52	3	78
9	32	57	3	100
10	26	45	1	100
11	12	53	1	100
12	34	55	1	38
13	38	58	2	47
14	19	53	1	100
15	31	53	1	83
16	26	42	1	76
17	30	51	1	69
18	14	77	1	100

Table 8. (Continuation)

Inbred No.	Ear height (cm[a])	Lesion length (cm)	Visual rating	& % Ear rot
19	25	58	1	79
20	51	55	6	29
21	43	56	5	74
22	45	71	2	85
23	37	59	4	72
24	49	46	6	33
25	30	51	4	63
26	26	58	2	94
27	46	61	4	44
28	20	57	1	100
29	47	50	5	37
30	36	66	3	37
31	41	55	3	40
32	35	56	3	87
33	31	54	1	86
34	41	50	5	74
35	47	49	2	65
36	32	53	1	95
37	48	53	5	28
38	48	51	7	28
39	24	51	1	90
40	65	56	5	31
41	23	55	1	76
42	7	41	1	100
43	18	54	1	87
44	57	56	8	61
45	48	67	3	66
46	35	56	1	93
47	28	53	2	97
48	28	59	1	100
49	30	56	2	88
50	5	47	1	100
51	11	48	1	95
52	27	47	1	91
53	15	46	1	97
54	36	57	2	81
55	45	35	8	87
56	18	44	1	59
57	36	57	2	86
58	20	54	1	93

[a]Ear height measured from point of inoculation.

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