

LARS Information Note No. 083170
Purdue University
August 31, 1970

SOUTHERN CORN LEAF BLIGHT

(A status report by

Laboratory for Applications of Remote Sensing Staff)

Southern corn leaf blight, a fungal disease, has been observed in corn fields throughout the central corn belt and the South. The need for information on possible yield losses from the disease has prompted interest in the detection of the disease by remote sensing techniques.

Background Information. The Appendix A includes background information on the disease and its significance.

Research Objectives. During the week of August 17, 1970 a research project was initiated by Purdue University's Laboratory for Applications of Remote Sensing with the objective of investigating the feasibility of identifying the various stages of the disease infestation using remote sensing techniques. It is hoped that ancillary studies will relate the degree of infestation at a specific stage of plant maturity to yield reduction.

Six stages of southern corn leaf blight infestation can be described:

- (0) No infection - no lesions present;
- (1) very mild - a few, scattered lesions appearing mostly on the lower leaves, with less than 10% of the lower leaf surface affected;

- (2) mild - many lesions appearing on the lower leaves and a few scattered lesions on the upper half of the plant, 10 to 30 % of the lower leaf surfaces and less than 10% of the upper leaf surfaces are affected;
- (3) moderately severe - lesions on the lower leaves to the extent that large areas of the leaves are non-functional with scattered lesions on upper leaves, 30 to 60% of lower and 10 to 30% of upper leaf surfaces affected;
- (4) severe - lower leaves mostly killed with the upper leaves beginning to die, 60 to 90% of lower and 30 to 60% of upper leaf surfaces affected;
- (5) very severe - nearly all leaves have become non-functional, more than 90% of total leaf surface affected.

Investigations are being conducted to determine the ability to identify these stages of infestation from photography with different film-filter combinations and from multispectral scanner measurements. Photographic data are to be analyzed with standard photo interpretive techniques and digitized multiband photography are to be subjected to computer analysis using pattern recognition techniques. Multispectral measurements are to be analyzed using these same pattern recognition techniques.

Data are to be collected over the test site on three occasions at 7 to 10 day intervals. This will permit investigation of the temporal characteristics of blight infected plants.

Test Site. A flightline following highways U.S. 421, Ind. 43, U.S. 231, and Ind. 57 was established as a representative test site in Indiana. The flightline proceeds in a north-south direction from near Michigan City in northern Indiana to near Evansville at the southern end of the state. (See attached map.) High altitude photography is being collected over the flightline by an RB-57 aircraft from NASA's MSC facilities.

Within the total flightline, six segments were chosen for flights by the University of Michigan plane equipped with an optical scanner. Each of the segments is 8 to 12 miles long and approximately one mile wide. There are 30 to 60 corn fields in each segment where ground truth information is being collected. The attached map shows the location of these six segments.

An area southwest of West Lafayette (South River Road) which has fields exhibiting several stages of blight has been used as a control area.

Status of Flights. To date the following flights have been made for data collection.

<u>Plane/Date</u>	<u>Area</u>	<u>Measurement</u>
Purdue Univ. - Beechcraft		
August 19	S. River Road	35mm Color & Color IR
August 21	S. River Road and segments south of Lafayette	70mm Color and 35mm Color & Color IR
August 24	S. River Road and segments north of Lafayette	70mm Color and 35mm Color & Color IR

<u>Plane/Date</u>	<u>Area</u>	<u>Measurement</u>
Univ. of Michigan		
August 24	Two flights at 3000 feet	multispectral scanner
	over the six sample areas	and photographic data
NASA RB-57F		
August 26	flew at 60,000 feet in	Color & Color IR
	both directions over	from RC-8
	the entire flightline	Color IR in Zeiss
		Film-filter combinations
		in six Haselblads
Air Force C-131		
(Rome AFB)		
August 27	Entire flightline at	9 lenses, 70mm format
	20,000 feet	

Additional flights by the same aircraft are scheduled for September 1 to 18.

Ground Truth Data. The corn fields in each of the six sample areas are to be visited near the time of each flight. Area crop extension agents and Purdue staff members are assisting in collecting the data. Each corn field is being rated for the degree of southern corn leaf blight infestation. Data is being collected for the following items: leaf damage, ear and stalk lesions, ear and stalk rot, and plant maturity stage. Additional comments on such factors as fertility deficiencies and drought damage are also being used in the analysis. The categories and descriptions of the various factors are shown in the Appendix.

Results. Aerial observation indicates that in most cases the infestation of blight is quite uniform within a given corn field. This is particularly true of the moderate to severe stages of infestation.

At this time a key is being made for interpreting the aerial photography. Preliminary results, however, indicate that possibly three levels of blight infestation are identifiable on the photography.

Problems are being encountered in analysis of the multispectral data due to the marginal weather conditions at the time the data was collected.

Several complicating factors in the identification of southern corn leaf blight by remote sensing have come to our attention. These include: (1) the approach of normal maturity and senescence of some early varieties of corn, (2) drought damage, (3) fertility deficiencies of nitrogen and potassium, and (4) the presence of northern and yellow corn leaf blights in some areas.

Rating and Description for S. Corn Leaf Blight

Leaf Damage

0. no infection - healthy, no lessions present
1. V. Mild - few scattered lessions, mostly on the lower leaves
2. Mild - lower leaves have many lessions, only a few scattered lessions on upper half of plant.
3. Mod. severe - Many lessions to the degree where dead or dry areas appear on leaves of lower half of the plant, scattered lessions on upper half.
4. Severe - lower leaves mostly dead, upper leaves are beginning to dry up.
5. V. severe - nearly all leaves are dead (brown) or dry.

Ear & Stalk Lessions

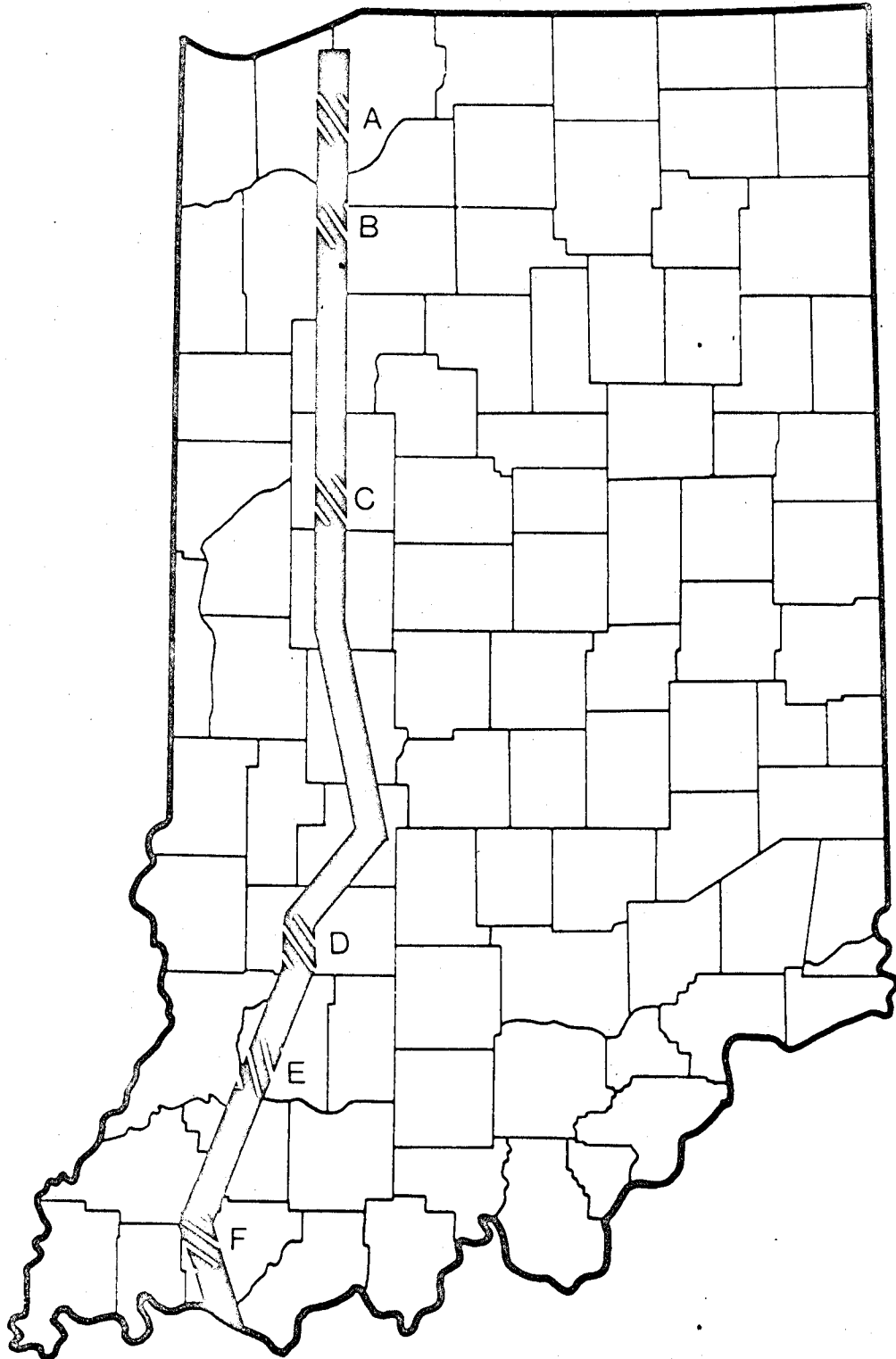
0. None
1. Few - less than 25% of surface affected
2. Many - more than 25% of surface affected

Ear & Stalk Rot

0. None present
1. Mild - less than 25% of ears or stalks infected
2. Severe - more than 25% of ear or stalks infected

Plant Maturity

1. Tasseling
2. Pollenation
3. Blister
4. Milk
5. Dough
6. Dent
7. Mature
8. Ready to harvest



Southern Corn Leaf Blight Flightline in Indiana flown in August, 1970 for the Laboratory for Applications of Remote Sensing (LARS) at Purdue University. Cross-hatched regions are intensive study areas.

The invasion of the Southern Corn Leaf Blight into Indiana during recent weeks has caused great concern. Here follows background information that may help you assess the situation.

-- Herbert H. Kramer
Director, Purdue Agricultural Experiment Station

I. Pathology

This disease is caused by the fungus pathogen, Helminthosporium maydis. It seems evident that this species is composed of two physiologic races, which are morphologically similar, if not identical, in this respect. That is, the size, shape, number of cross walls and color of the spores are the same in both races. A distinguishing feature of these two races is the unusually high virulence of one of them on corn containing "Texas male-sterile" cytoplasm. This is characteristic of the new race, designated the "T" race. It is only mildly pathogenic on "normal" cytoplasm; usually so benign as to cause only small, hardly recognizable lesions.

The old race, designated the "O" race, has been extant for many years, probably coincident with corn culture down through the centuries. This race attacks both "Texas male-sterile" corn and that bearing "normal" cytoplasm with equal facility. But, it has rarely caused any serious problem. Only occasionally has this "O" race incited heavy infection, and this in localized fields on very susceptible inbred lines.

Both the "O" race and the "T" race are favored by warm wet weather. Heavy dews are especially conducive to rapid multiplication of both races. The "T" race appears to be a prolific spore producer. That is, it produces an abundance of inoculum in a warm, wet environment.

The time elapsing from penetration of the leaf until production of spores on the dead tissue of the lesions may be as little as 7 days under ideal conditions. And in this respect, it is more prolific than the "O" race. It is so exceedingly productive of spores only on corn containing "Texas male-sterile" cytoplasm.

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The symptoms incited by the race are characterized by tan to brown elliptical lesions that are generally spindle-shaped and range in size up to about 1 x 0.5 inches. Usually these lesions appear first on the lower leaves. Eventually, more lesions are produced from successive infections on the upper leaves. Lesions are also formed on the husks, and from there the fungus penetrates through the successive shucks into the ear and on and within the kernels.

Early infection on the kernels may appear as a light-gray mold which, with time becomes dark gray to black.

Lesions incited by the "O" race are tan to brown and tend to be parallel-sided rather than spindle-shaped. Ears are rarely attacked by the "O" race.

The first recognition of the "T" race in the United States was in 1969 when some corn with "Texas male-sterile" cytoplasm succumbed to the disease in southern Iowa. The disease was also present in southern Indiana and Illinois.

The reduction of functional leaves by the disease predisposes the corn plant to stalk rot not only by H. maydis, but also by other fungi of less aggressive capabilities. Such secondary invaders may also grow on and within kernels infected with H. maydis.

Both the "O" race and the "T" race are present, but the latter is by far predominant. In 1970 the disease first appeared in southern Florida, where seedsmen were growing a winter crop of foundation stocks. From here it spread to Alabama and Mississippi.

The disease fanned out from here in a northerly direction, and week by week its progress was plotted to the Corn Belt. It has been recognized from Texas, eastward to the Atlantic Coast and northward through Iowa, Minnesota, Wisconsin, Michigan, Ohio and southern Ontario. The spores can be wind-borne and the northerly progression has been in a stepwise manner. The pathogen may also be seed-borne; this is another way in which it can be disseminated. Seed treatment would probably have little or no effect for control of the disease, since the fungus can be within the seed as well as on the surface.

Three major factors are of cardinal importance in the development of any plant disease, and these must act coordinately to bring about disease establishment. These factors are (1) virulent pathogen, (2) a favorable environment for reproduction of the pathogen and (3) a susceptible host. These three requisites have been operative in the production of southern corn leaf blight in 1970 in that a new virulent race of the pathogen has been widespread, weather conditions in the Gulf States and on up through the eastern half of the United States have been conducive to rapid growth and development of this race of H. maydis and, lastly, a very susceptible host corn with "Texas male-sterile" cytoplasm has been widely planted.

-- A. J. Ullstrup,
Plant Pathologist

II. Current Situation and Recommendations

Recent reports from southern corn producing states indicate serious losses from southern corn leaf blight in these areas.

In Indiana, southern corn leaf blight was first observed and positively identified in early July. Since that time, the disease has developed rapidly and has now been reported in varying degrees of severity from most Indiana counties.

At the present time, it would appear that damage from southern leaf blight will be serious in southern Indiana. Significant losses are to be expected in south central Indiana. Losses will be less severe in central Indiana and probably greatly less in the northern section of the state.

Loss estimates at this time are difficult to assess, since the possibility of ear rot and stalk rots could change present estimates within the next two weeks.

It is important to recognize, however, that 35 to 40 per cent of Indiana corn production is in the area from Lafayette northward.

There may be as much as a ten per cent overall reduction from the normal corn crop in the state. It will be very likely more serious in the southern part of the state and less so in the north. But, this reduction may be modified, depending on the weather conditions which may prevail. Hot, dry conditions will decrease the damage, while continued heavy dews and rainfall will contribute to its increase.

Seed corn producers and some field corn producers have applied aerial and ground applications of carbamate fungicides to arrest the spread and development of southern leaf blight.

It is the general opinion that fungicide applications were started too late to be as effective as they might have been if they had been begun in mid-July. However, it is the opinion of most observers that fungicide applications did check the spread of southern leaf blight and were justified.

Fungicide applications now will not be effective, will be too late to prevent further spread of the disease and will not prevent stalk and ear rots now beginning to develop.

-- Eric G. Sharvelle,
Extension Plant Pathologist

III. Methods of Control Through Breeding

Control of this disease may be accomplished by several genetic mechanisms. As Dr. Ullstrup pointed out, most of the hybrids with the "T" race cytoplasm are susceptible to this new race, while hybrids with normal cytoplasm are quite resistant. Therefore, the most practical genetic method of control is to use normal cytoplasm requiring the rather costly and bothersome hand detasseling operation in hybrid seed corn production. However, this change cannot be accomplished by next year.

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Several generations will be required to increase seed stocks to produce hybrids with normal cytoplasm to avoid losses from this disease. I am confident that seed companies will make every effort through winter crops in Florida, Hawaii or South America to get this task accomplished as quickly as possible.

A number of the hybrids now being marketed do have normal cytoplasm and are resistant, even with sterile cytoplasm. Corn breeders will probably be able to develop more hybrids with this type of resistance.

A third method may involve the use of other types of cytoplasm that, based on limited observations, are resistant to this race of the disease. Whether they are genetically suited to eliminate the detasseling operation has yet to be determined. Also this is a relatively long range solution, since a number of generations will be required to evaluate and introduce the new cytoplasm into seed parent inbreds. Caution should be exercised in this approach, since a new virulent strain or other pathogens may appear and we could have a repeat of the present situation.

A suggestion has been made that it might be feasible to save advance generation or F₂ seed from hybrids grown this year with normal cytoplasm for planting next year. At present I would not recommend this as a control measure. In the absence of this disease, F₂ seed would give yields 20 to 30 per cent less than F₁ hybrids. At this time, we cannot predict that losses from this disease next year will be greater than this decrease from using F₂ seed. In fact, it is possible that weather conditions next year may not favor development of the disease to the extent we are observing in the current season.

Losses from this new "T" strain of southern leaf blight can be reduced, or probably even eliminated by efforts of corn breeders and plant pathologists, and changes in seed production methods. The required changes in breeding and production methods will cost money. However, once the initial shortage of resistant hybrids is alleviated the extra cost of seed will not be great.

-- Loyal F. Bauman,
Professor of Agronomy

IV. Economic Implications

The immediate consequence of the blight is the expected drop in production of the 1970 corn crop. This immediately has implications for current and future corn prices. Any assessment of the price situation depends upon the accuracy of crop damage estimates, the resultant loss in production and, to some extent, the reduction in the quality of the 1970 crop.

What has happened recently:

Corn prices strengthened in late summer as stocks reports and crop estimates fell below expected levels.

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July 1 corn stocks were seven per cent below July 1, 1969, and the August 1, 1970 crop report at 4,693 million bushels was three per cent below the July 1, 1970 report, even though it was three per cent above last year's production.

Prices strengthened on the basis of both of these reports.

Reports of blight damage began to be felt in the market during the week ending August 7. A first major price increase attributable to the blight came on Monday, August 10. Upward pressure on prices has intensified since that date, with futures prices now about 25 cents per bushel above August 1 levels.

Corn prices ahead:

With an expected 4.8 billion bushel corn crop, corn prices seemed destined to settle to the \$1.00-1.10 level at harvest. The change in crop prospects currently reflects a \$1.35-1.40 level. If damage to the crop in the Corn Belt approaches ten per cent, then even higher corn price levels may be expected.

Here are some recent price comparisons:

	<u>June 15</u>	<u>July 15</u>	<u>August 1</u>	<u>August 17</u>	<u>August 20</u>
Indiana farm price.	1.19	1.29	--	1.38 est.	--
Cash price	1.22	1.27	1.24	1.42	1.47
December futures	1.27	1.31	1.27	1.50	1.56
New corn	1.06	1.11	1.08	1.30	1.35

Projected corn supply and utilization, 1970-71:

	<u>Situation A</u> <u>1970 crop-3%</u> (million bu.)	<u>Situation B</u> <u>1970 crop-5%</u> (million bu.)
Carryover, Oct. 1, 1970	900	900
1970 crop	4552	4558
Total supply	5452	5358
Estimated total utilization	4700	4800
Total carryover (Oct. 1, 1971)	752	658

Note: The carryover figure must include 300-350 million bushels of "pipeline" supplies and government-owned or controlled stocks. Thus, these estimates leave "free" carryover at very low levels. October 1, 1969, "free" carryover was 377 million bushels.

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Influence of blight on grade:

Blight damage may affect both test weight and kernel damage. Blight damaged kernels will be graded as damaged kernels, just as any other disease damage.

Grade specifications are:

	<u>Test weight at least</u>	<u>Damage not over</u>
No. 1 corn	56	3
No. 2 corn	54	5
No. 3 corn	52	7
No. 4 corn	49	10
No. 5 corn	46	15

Price discounts for test weight are usually one cent for each pound under 54. Discounts for damage are usually one cent for each one per cent over five per cent. Musty, moldy or otherwise distinctly low quality corn will be sample grade and will take a negotiated market discount.

Influence of blight on hybrid corn seed prices:

The high incidence of the corn blight will have at least two major influences on seed corn availability and prices.

1. Corn seed production from the 1970 crop will obviously be reduced about in line with the overall crop reduction.
2. Farmers will be seeking seed supplies which are resistant to the blight. Such seed which could be placed on the market for 1971 plantings will probably bring premium prices.

Total seed supplies for 1971 plantings may be adequate, but choice of hybrids will probably be more restricted and prices generally are expected to be higher.

Impact of blight on the livestock industry:

The demand for livestock feed has, until recently, been projected on the basis of corn price at slightly above \$1.00 per bushel level. A reduced corn crop and higher corn prices will boost livestock feed prices and thus change the livestock feeding ratios and profitability accordingly.

The hog-corn ratio for Indiana was:

July 15, 1969	21.2
June 15, 1970	19.0
July 15, 1970	18.7
August 15, 1970	15.2 est.

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Prices of livestock which have been forecast as lower in winter and spring will probably respond upward with the prospect of higher feed costs. Short run livestock supplies are already available and the impact of the change in feed prices will not greatly affect near term supplies and prices.

Corn supplies are supplemented by supplies of other feed grains and total feed grain supplies will be down less than corn supplies.

However, based on longer range expectations for the hog industry, higher feed costs will slow the buildup in hog numbers and thus be a strengthening influence in prices next spring and summer.

Impact of blight on corn exports:

Prospects are that corn exports would be reduced slightly with higher prices and smaller supplies. However, demand around the world is still relatively high. EEC imports can be maintained by shifting the variable tariff, which can be done. Exports to Japan and other areas will probably not be greatly restricted. Quality may become a problem in corn exports and damaged corn may be heavily discounted. The caution exercised by foreign buyers because of the danger of importing the disease may be a factor in exports, but is as yet unassessed.

-- Wm. E. Farris,
Agricultural Economics

V. Handling and Feeding Infected Corn

The fungus, H. maydis, does produce a phyto-toxin (plant toxin). This means the toxin causes damage to plants but not necessarily to animals.

As the 1970 crop infection and damage became apparent, Mississippi agricultural scientists analyzed stored silage that had been harvested from heavily infected fields. In samplings 10 days after ensiling, no live H. maydis was found. The fermentation apparently killed the H. maydis, and it was concluded that the fungus could not live or grow under anaerobic conditions as found in a silo of fermenting corn. The same probably is true for properly stored high moisture corn. The organism can live on stored grain which is not sealed and on stalks in the field when moisture and temperature conditions are right.

A feeding trial involving 20 steers was started in early July, 1970, at the South Mississippi Branch Experiment Station. Ten steers were fed heavily infected corn (silage) and ten on noninfected corn (silage). To date, no toxic effect has been observed in these animals. Routine blood and tissue tests on these steers have shown no differences.

The Mississippi scientists are also feeding corn leaves heavily infected with H. maydis to guinea pigs. A control group receives noninfected leaves. To date, after four weeks of test, no symptoms have been observed that could be attributed to the infected corn.

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At Purdue, Dr. John Tuite, botany and plant pathology department, and Dr. W. Carlton, veterinary pathology, have tested the toxicity of blight infected corn grain in feeding trials with mice. No evidence of toxicity or problems with palatability were seen.

Feeding trials are planned at Purdue this fall in which blight infected corn grain will be fed to hogs. The results of these studies will be released upon completion of the trials.

On the basis of these limited studies, it would appear that heavily infected corn can be safely harvested and ensiled for livestock feed. It should be anticipated that the leaf moisture content at harvest might be quite low, but the moisture content of the stalk and grain and cob could partially compensate. Storage and packing techniques that work for low moisture (mature corn) silage should be satisfactory.

The following summary of work from Kentucky indicates losses that may be taken from early harvested silage:

Silage Yield vs. Harvest Date For Corn*

Components	Stages of development after silking			
	Silking	12 days	25 days	Mature
Silage weight (lbs./acre, 65% moisture)	15,000	24,000	33,000	39,000
Dry matter (lbs./acre)	5,400	8,300	11,700	13,600
Stalks and leaves (%)	93	72	53	37
Ears and husks (%)	7	28	47	63

* 1965 results with 15,700 stalks/acre and 100 lbs. nitrogen.

The feed value of the silage may be lower than that of undamaged corn, with the amount depending primarily on the maturity of the corn when the infection occurred, and its condition at harvest. If feeding value is critical, samples should be analyzed for nutritional value at a forage laboratory.

Addresses of two Indiana laboratories that supply this service are as follows:

Shuman Chemical Laboratory
Battle Ground, Indiana 47920

Farm Bureau
47 S. Pennsylvania Street
Indianapolis, Indiana 46204

The fungus H. maydis can infect the kernel and can be carried over in grain or seed. Low germination in seed corn can be one indication. No evidence exists that would suggest any problems from such infected, but otherwise sound, grain relative either to its storage or use as feed.

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It is very important to realize and emphasize that once the corn stalk, leaves, and ear are infected with H. maydis, the way is opened for infestation by many other organisms. Some of these organisms (such as other ear molds, for instance) could present animal feeding problems that would need to be considered. This would seem more probable if the grain and/or silage were in very bad condition when harvested and processed.

The main concern of secondary infection is the incidence of stalk rot and ear rot. Both will be increased markedly. Lodging will be severe in heavily infested fields. Ear shanks may rot, or be weakened so that any stalk movement during harvesting will drop the ear. Ear tip infection tends to seal or paste the husks to the grains, making husking, shelling, and separating more difficult. Cob rot reduces cob strength, presenting problems in shelling, separating, and cleaning.

Early harvest and artificial drying or ensiling appear to be workable solutions. All of the usual drying techniques should work satisfactorily. However, some of the corn may be immature and chaffey. This will generally give more kernel breakage in shelling, and this in turn will produce more fine material that may affect dryer and storage performance. Consideration should be given to cleaning grain going into the dryer, and especially before it goes into storage. Distribution of fines in storage filling is also important.

If grain is in generally poor condition, with numerous broken, rotted, or moldy kernels, drying to slightly lower moisture contents (12-13%) may be good insurance. Do not consider long term storage for poor quality or poor condition material. Observe and probe marginal grain in storage more frequently. Correct aeration design and operation will be even more important on marginal grain.

Look to AE-71, "Aeration for Safe Grain Storage" for guidelines on equipment and management. Look to AE-67, "Selecting a Grain Drying Method" and to MWPS-13, "Planning Grain-Feed Handling" for information on drying, handling and cleaning processes and equipment.

Wet shelled corn or corn and cob meal can be ensiled for livestock feed. For ruminant animals, the feeding value is usually superior to that of the same corn, dried. Whole shelled corn can be stored in a sealed (oxygen free) storage. For storage in non-sealed upright or horizontal silos, the material should be ground or cracked. The sidewalls for the latter should be in good repair. Storage moistures are recommended between 23 and 28%. Grinding will improve the packing to better exclude air.

The use of emergency horizontal silos is another possibility. In filling horizontal silos, most heating and damage to the corn occurs before it is covered with plastic. Fill the silo from one end and cover as quickly as possible. Quick covering seems to be more important to final quality than packing, but both can be used. Look to June, 1970, Prairie Farmer reprint (unnumbered) entitled "High Moisture Corn in Horizontal Solos." Look to MWPS-6 "Beef Housing and Equipment Handbook," and MWPS-7, "Dairy Equipment Plans and Housing Needs" for information on silos and construction.

--Bruce A. McKenzie,
Extension Agricultural Engineer

--B. J. Hankins
Extension Agronomist

--Martin Stob
Professor of Animal Sciences

Errata for page 4; delete paragraph 2. Add the following:

A number of hybrids now being marketed do have normal cytoplasm and are resistant. However, there will not be an adequate supply of these hybrids for planting in 1971.

A second method of control involves the fact that a few hybrids are relatively resistant, even with sterile cytoplasm. Corn breeders will probably be able to develop more hybrids with this type of resistance.