4-1-1985

Proceedings: 1985 Short Course for Seedsmen (Full Document)

Proceedings
1985 SHORT COURSE
for
SEEDSMEN

Volume 27

April 15-17, 1985

SEED TECHNOLOGY LABORATORY

MISSISSIPPI STATE **MISSISSIPPI**

Sponsored By The Mississippi Seedmen's Association

PROCEEDINGS (VOLUME 27)

THIRTY-THIRD SHORT COURSE FOR SEEDSMEN

APRIL 15-17, 1985

SEED TECHNOLOGY LABORATORY

MISSISSIPPI STATE UNIVERSITY

MISSISSIPPI STATE, MISSISSIPPI 39762

TABLE OF CONTENTS

THE STAFF

(Seed Technology Laboratory)

James C. Delouche, In-Charge

C. Hunter Andrews
Charles C. Baskin
A. H. "Bill" Boyd
Joseph Cortes
Warren Couvillion
Howard C. Potts
Charles E. Vaughan
G. Burns Welch
Shirley C. Carter
Pat Childress
Curtis Reed
Sue Reed

(Foundation Seed)

Bennie Keith
Fabian Watts
Kenny Rivers
Randy Vaughan
Brenda S. Reed
Johnny Gazaway

AND STUDENTS

(Graduate)

Rozalvo Andrigueto
Arnaldo Bianchetti
Cleverson Borba
Edmundo Garcia
Michael Larinde
Udin Nugraha
Roduel Rodriquez
Quanchit Santipracha
Wullop Santipracha
Basilio Souza
Hasanah Tatang
Sirichai Unsrisong
Wade Abdul-Sattar
Abesinghe Armbage
Ernest Asiedu
Mahmuda Haroon
Thein Htoon
Samuel Izaguirre
Sam-ang Khaokham
Rumphan Koslanund
Mary McBroom
Phoebe Mtambo
Paulo Nogueira
Jesus Ortegon
Sakultala Panasampol
Jose Perdomo
Wirat Pianvithanya
Renan Pineda
Bambang Purnomohadi
Musti Purnomohadi
Loston Rowe
Chantima Sauagatrup
Alain Suisse-Guillaud
Mohamed Suliman
Weerachart Thongteera
Jose Trochez
Brent Turnipseed
Jose Yau

(Undergraduate)

Rebecca Alford
Ralph Allen
Luis Balladares
Pegase Banyankiye
William Butler
Kenneth Cauthen
Sam Garris
Boukary Hama
Steven Kelly
Ricardo Lardizabal
James Lawrence
Ibrihim Mahamodou
Christopher Muyonga
Wilfred Silwinba

MISSISSIPPI STATE UNIVERSITY ADMINISTRATION

James D. McComas, President, Mississippi State University
Louis Wise, Vice President, Agriculture and Forestry
R. Rodney Foil, Director, Miss. Agriculture & Forestry Expt. Station
Charles Lindley, Dean, College of Agriculture
H. D. Bunch, Director, International Programs in Agr. & Forestry
Jamie Carpenter, Director, Miss. Agricultural Extension Service
Roy G. Creech, Head, Department of Agronomy
William Fox, Head, Department of Agricultural & Biological Engineering
Verner Hurt, Head, Department of Agricultural Economics

CONTRIBUTORS

We gratefully acknowledge the contributions from the following organizations which added greatly to the success and enjoyment of this Short Course.

Bar-B-Que

Miss. Seed Improvement Association
W. W. Guerry, Exec. Secretary
P. O. Drawer MS
Miss. State, MS 39762

Miss. Seedsmen's Assoc.
Ted Cheshire, Secretary
P. O. Box 12408
Jackson, MS 39205

Refreshments

Mr. Murland Taylor, President
Taylor Products Co.
5300 Main
Parsons, KS 67357

Mr. Jack Snader, Vice President
Seedburo Equipment Co.
1022 West Jackson Boulevard
Chicago, IL 60607

Mr. Bill Belous
Triple S Dynamics
1031 Haskell Avenue
Dallas, TX 75223

Mr. Herschel Stults, Jr.
Stults Scientific Eng. Co.
3133 S. 66 Freeway
Springfield, IL 62703

Mr. T. Gilliam Austin
Dir. of Sales
Gustafson, Inc.
P. O. Box 220065
Dallas, TX 75222

Mr. Thomas Klein
Mercator Corp.
101 N. 5th Street
Berkshire Towers
P. O. Box 142
Reading, PA 19603

Mr. Robert Frevert, Pres.
Crippen Mfg. Co.
P. O. Box 350
Alma, MI 48801

Mr. Geoffrey Burney
Oliver Mfg. Co., Inc.
P. O. Box 512
Rocky Ford, CO 81067

Mr. Wm. H. Wallace
Product Manager
Blount/Ferrell-Ross
785 S. Decker Drive
Bluffton, IN 46714

Mr. Ben Manring
Manring Corporation
P. O. Box 1865
Bellevue, WA 98009

Mr. Stephen L. Cashman
Sales Manager
CEA Carter-Day Company
500-73rd Avenue, N.E.
Minneapolis, MN 55432

Mr. J. Van Pernis
Black Products Co.
13513 Calumet Ave.
Chicago, IL 60627

Door Prizes

Mr. Elmo Collum
MFC Services
P. O. Box 500
Madison, MS 39110

Mr. Richard Wax
The Wax Co.
P. O. Box 60
Amory, MS 38821

Mr. Boyd Eifling
Eifling Farms Seed Co.
Route 1, Box 285
Hollandale, MS 38748

Mr. Sam Latham, Sales Mgr.
Hollandale Seed & Delinting
P. O. Box 397
Hollandale, MS 38748

Mr. James E. Thompson, Gen. Mgr.
American Drying Systems, Inc.
1135 N.W. 159th Drive
Miami, FL 33169

Mr. Dick Flowers
Miss. Seed, Inc.
P. O. Box 686
Tunica, MS 38676

Mr. Walter Cook
Delta & Pine Land Co.
P. O. Box 157
Scott, MS 38772

Mr. Lester A. Shipley, Jr.
Shipley Grain Co.
P. O. Box 476
Greenwood, MS 38930

Mr. Bobby Horton
Big River Seed Co.
P. O. Box 867
Cleveland, MS 38732

Mr. Roy Armstrong
Mid America Grain Co.
Route 1, Box 278
Smithville, MS 38870

Mr. James Johnson
Rose Seed Co.
P. O. Box 849
Clarksdale, MS 38614

Mr. Marion Hawkins
Dir. of of Sales
Coker's Pedigreed Seed Co.
P. O. Box 340
Hartsville, SC 29550

Mr. Wm. W. Moore, II
Magnolia Grain Co., Inc.
P. O. Box 336
Cary, MS 39054

Mr. Jimmy Sanders
Sanders Seed Co.
P. O. Box 520
Cleveland, MS 387832

Publicity

Grain & Feed Journal
327 So. LaSalle St.
Chicago, IL 60604

Progressive Farmer
Suite 1630
White Station Tower
Memphis, TN 38157

Seed Trade News
7535 Office Ridge Circle
Eden Prairie, MN 55344

Seedsmen's Digest
10714 Manchester Rd.
Suite 202
St. Louis, MO 63122

Seed World Publications
380 Northwest Highway
Des Plains, IL 60016

REDUCING SEED HARVEST LOSSES[1]

John W. Hummel[2]

Although the grain-combine harvester has been used for soybeans since the mid-twenties, little progress was made in reducing soybean harvesting losses until about 1970. At that time the average combine operator, when using a rigid grain platform header, was leaving as much as 10 percent of the crop in the field. The introduction of attachments such as the floating cutterbar and pick-up reel made it possible to reduce harvesting losses to 7 or 8 percent.

More recently, combine headers specifically designed for soybeans have become available. Several combine manufacturing companies have introduced headers that have a built-in flexible cutterbar. A low-profile, row-crop header was introduced by John Deere and Company in 1974.[3] With these new headers, you can reduce harvest ing losses to about 4% of yield. An alert combine operator can reduce losses even further under some harvesting conditions.

To keep harvest losses to a minimum, you need to know what types of losses occur, how to measure those losses, and what equipment, adjustments, and practices will enable you to harvest soybeans most efficiently.

----

[1]Much of this article is taken from information presented in, "Illinois Growers Guide to Superior Soybean Production" Illinois Coop. Ext. Ser. Circular 1200, Urbana-Champaign, IL.

[2]Agricultural Engineer, USDA/ARS, Soil, Water and Plant Research, Univ. of IL., Urbana, IL.

[3]Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the University Illinois or the U.S. Department of Agriculture, and does not imply approval of the named product to the exclusion of other products that may be suitable.

Types of Soybean Losses

Some soybean losses result, not from the operation of the combine, but from natural causes before harvest. These preharvest losses are soybeans that have fallen to the ground by the time harvest begins. If soybeans that are ready for harvest are then subjected to several alternating periods of wet and dry weather, your preharvest losses could be as high as 25 percent. To avoid such high losses, you should plant varieties that are resistant to shattering and harvest early. You can usually keep preharvest losses low by harvesting soybeans shortly after their moisture content reaches 13% for the first time.

As long as you take these precautions, preharvest losses should account for a relatively small part of your total soybean losses. Your most important concern will be to reduce losses that occur during the gathering, threshing, separating, and cleaning operations at harvest.

Gathering

Gathering, or header, losses are soybeans that are not gathered into the combine. These losses are caused by the action of the cutterbar, reel, and auger. They account for more than 85 percent of the total soybean loss at harvest. There are four kinds of gathering losses. Shatter losses are shelled beans and detached bean pods that are shattered from stalks by the header and fall to the ground without going into the combine. Stubble losses are soybeans in pods remaining on the stubble. Stalk losses are soybeans remaining in pods attached to stalks that were cut but not delivered into the combine. Lodged losses are beans remaining in pods attached to stalks that were not cut or that were cut at heights greater than that of the stubble.

Threshing, Separating, and Cleaning

Soybeans are easy to thresh, separate, and clean. They can be rubbed out of the pod readily, and their size and shape are ideal for cleaning. Even so, small errors in the adjustment of the combine can result in disastrous losses during the threshing, separating, and cleaning operations. Threshing, or cylinder, losses occur when unthreshed beans remain in pods that pass through the combine and when beans are cracked by the cylinder. Separating, or straw walker, losses occur when shelled beans are carried out the back of the machine with the stalks (these losses are usually insignificant unless the combine is overloaded). Cleaning, or shoe, losses occur when shelled beans are carried over the chaffer, or top, sieve and out the back of the combine.

Measuring Soybean Losses

The easiest way to measure harvest losses is to enclose an area of approximately 10 square feet within a rectangular frame and count the beans remaining in that area after harvest. If you count 40 beans within the frame, your soybean loss is approximately 1 bushel per acre.

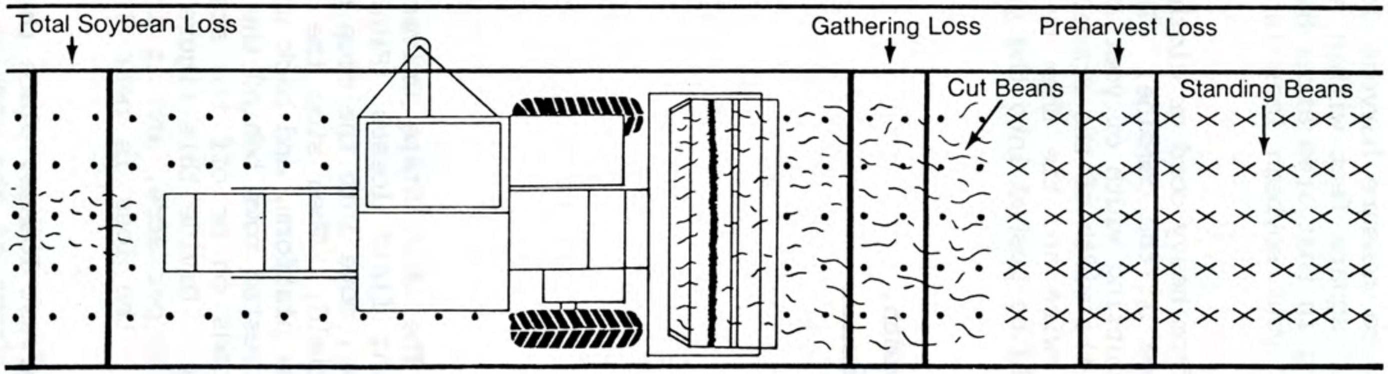
Make the frame from heavy cord or clothesline, so you can coil it and carry it with you on the combine. The length of the frame should be equal to the cutting width of your combine header. Use the list above to determine the width of the frame. Make four pins 3 to 4 inches long from No. 9 wire and tie them to the frame to mark the corners. The pins should be pushed into the ground to hold the frame tight.

Header width, feet	Frame width, inches
10	12
12	10
13	9 1/4
14	8 1/2
15	8
16	7 1/2
18	6 3/4
20	6
22	5 1/2
24	5

Researchers at The Ohio State University have developed a procedure for determining field losses (Figure 1). Operating the combine in the normal way, move into the crop until you are well away from the edge of the field. Then stop the combine, disengage the platform drive, raise the platform, and back up 15 to 20 feet. Place the frame across the harvested rows behind the combine, and count the loose beans, beans in pods on or off the stalks, and beans on the stubble inside the frame. Divide this figure by 40. The result is the total loss in bushels per acre, and it includes both preharvest and harvest losses. If the loss is near 3 percent of the yield, continue harvesting.

To measure preharvest losses, place the frame across the rows of standing soybeans in front of the combine, count the loose beans and the beans in pods on the ground, and divide by 40. To arrive at the total harvesting loss, subtract the preharvest loss from the total loss found behind the combine.

Figure 1



The shaded areas in the drawing above show where you should place a frame to measure your total soybean loss, preharvest loss, and gathering loss.

If your harvesting losses are too high, you should use the following procedure to determine where most of these losses are occurring. First, place the frame across the harvested rows in front of the combine just ahead of the drive-wheel tracks. Count all the beans inside the frame, subtract the number of beans found in the preharvest count, and divide by 40. The result is your gathering loss. When making this count, be sure to note how many of each of the four types of gathering losses there are, so you will know where to make adjustments in the machinery. You can find the cylinder and separating losses by subtracting the gathering losses from the total harvesting losses.

Reducing Soybean Losses

Header Design

In 1976, University of Illinois researchers conducted a large-plot experiment at Urbana to compare the effects of variety, narrow row spacing, and header design upon soybean losses during harvest. Corsoy, Amsoy-71, Beeson, and Williams varieties were grown in row spacings of 7 and 30 inches. The target population was about 170,000 plants per acre for the 7-inch rows and 125,000 for the 30-inch rows. The data in Table 1 show the effect of row width and variety upon preharvest loss and yield. In 7-inch rows, the yield of Corsoy increased 8 percent, that of Beeson 4 percent, and Amsoy-71 2 percent compared to their yields in 30-inch rows. Growing Williams in 7-inch rows did not increase its yield.

Table 2 compares the header losses that occurred when various types of headers were used in 30- and 7-inch soybean rows. Header loss with both types of platform headers was about 30 percent less in 7-inch than in 30-inch rows. In 30-inch rows, the row-crop header proved to be the most efficient type under the conditions of our experiment.

The data obtained during the 1976 season proved that a floating cutterbar header with air-jet guards reduces harvest losses by 45 percent, compared to a conventional floating cutterbar header. But the flexible floating cutterbar header, either with or without the air-jet guards, is even more efficient. In fact, the air-jet system is probably unnecessary because the addition of it did not significantly increase the harvesting efficiency of the flexible floating cutterbar. This type of header has several features that enable it to reduce soybean losses: its long dividing points help prevent problems that occur in lodged soybeans; its extended platform, and low profile reduce shatter and stalk losses; and its large-diameter auger rapidly moves plant material to the center and helps reduce stalk losses.

Table 1. Effect of row width and variety upon pre-harvest loss and yield of soybean.

	Preharvest loss, Percent	Yield, bushels per acre
Amsoy-71		
7-inch rows	1.8	45.8
30-inch rows	2.2	44.9
Beeson		
7-inch rows	5.1	38.9
30-inch rows	4.3	37.3
Corsoy		
7-inch rows	0.2	53.3
30-inch rows	0.2	49.3
Williams		
7-inch rows	1.1	37.2
30-inch rows	0.4	37.7

Table 2. Effect of header type and row width on header loss.

	Total header loss, percent	Reduction in loss, percent
Flexible floating cutterbar		
7-inch rows	2.4	37
30-inch rows	3.8	
Flexible floating cutterbar with air-jet guards		
7-inch rows	2.4	30
30-inch rows	3.4	
Floating cutterbar		
7-inch rows	6.3	28
30-inch rows	8.7	
Floating cutterbar with air-jet guards		
7-inch rows	3.3	33
30-inch rows	4.9	
Row-crop header		
30-inch rows	1.4	

To determine which header has the most potential for increasing profits, we analyzed the harvesting costs and crop yields with various combine header configurations in 7- and 30-inch row spacings. We used yield and loss data for Corsoy because this variety produced the highest yield in both row spacings. The study was conducted for an average central Illinois grain farm that had 250 acres of soybeans and 300 acres of corn.

By reducing harvest losses, the row-crop header, in spite of its higher cost, returned $5 per acre more than the flexible floating cutterbar in 30-inch rows. The flexible floating cutterbar, however, returned $25 per acre more in 7-inch rows than the row-crop header in 30-inch rows. The platform header in 7-inch rows proved more profitable because the yield was four bushels per acre higher at that row spacing, the purchase price of that header was lower, and because it held harvest loss to an acceptable level.

In this analysis we assumed that control of weeds was equal in both row spacings, but realized of course that mechanical cultivation is impossible in 7-inch rows. We also assumed that the row-crop header was operated at 5.0 miles per hour (mph) and the flexible cutterbar at 3.5 mph. We did not include a cost factor for the timeliness of harvest operations.

It is obvious from our analysis that under good production management solid-seeded soybeans can be profitably produced. Farm equipment manufacturers have made equipment available that, if used properly, can keep harvest losses below 4 percent, regardless of the row spacing.

Combine Adjustments

To take full advantage of the time available for harvesting, make all necessary repairs and major adjustments well before the harvest season. Using the operators manual as a guide, thoroughly repair, lubricate, and adjust the combine. Familiarize yourself with the adjustments in the manual and those described here, so that you can make adjustments easily and quickly in the field.

Studies conducted by researchers at The Ohio State University, the University of Illinois, and Iowa State University have proven that to make any major gains in harvesting efficiency, the header must be properly adjusted to reduce gathering losses, particularly shatter lodged and stalk losses. The header must cut close to the ground to avoid leaving soybeans on the stubble and shattering them from the stalks. To further reduce shatter losses, it must be able to handle the beans as gently as possible. Rough handling by the header's cross auger and by the slat conveyors in the feeder housing can thresh a substantial percentage of the soybeans before they reach the combine cylinder. These soybeans can be lost if the slope of the header's deck is improperly adjusted, the deck is not tight, or if the plant material is not fed uniformly into the combine cylinder.

Almost all gathering losses are caused by the action of the knife and reel. Keep the knife sharp and replace broken or badly worn sections. Adjust the wear plates to minimize knife vibration. Align the guards and adjust the knife vibration. Align the guards and adjust the knife clips, so the knife can move freely and cut efficiently.

Proper reel adjustments are particularly necessary to keep losses low. A pick-up reel can help reduce harvesting losses. The speed of the pick-up reel should be 50 percent greater than ground speed. A 42-inch reel should rotate at about 12 revolutions per minute (rpm) for each 1 mph of forward speed. The reel will shatter soybeans excessively if it turns too fast, but it may drop stalks or allow too many of them to be recut if it turns too slowly.

The reel axle should be 8 to 12 inches ahead of the sickle. Several manufacturers are now providing headers with a built-in flexible cutterbar. When harvesting short plant material, you may need to move the reel axle nearer the cutterbar.

To prevent excessive threshing and separating losses and still keep the soybeans clean, the threshing and separating mechanisms must be kept properly adjusted.

Probably the single most important item to check is the separator speed. In each combine a particular shaft serves as a starting point for checking the operating speed. In some machines this starting point is the cylinder-beater cross-shaft; in others it is the primary countershaft. Most combines are designed to operate at the proper speed when the speed control lever of the engine is in the maximum position. If the separator is not running at the proper speed with the control lever in this position, adjustment is needed.

If you are not certain of the procedure for adjusting engine speed, check the operators manual or have the work done by your local dealer. A small deviation from the correct engine speed can affect the operation of the cleaning and separating units, making it impossible to get soybeans clean and keep losses to a minimum.

Before taking the combine to the field, you should adjust, in addition to the cylinder speed, the cylinder-concave clearance, the sieve settings, and the speed and opening of the cleaning fan. If you follow the operators manual closely in making these adjustments, you should have to make only minor adjustments in the field.

For most conventional combines, the recommended cylinder-concave clearance for soybeans is 3/16 to 3/8 inch at the back and 3/8 to 1 inch at the front. The cylinder and fan speed must be adjusted to fit your threshing conditions. When the moisture content of the soybeans is above 13 percent, they are usually tough, so the cylinder speed may have to be increased to 600 to 650 rpm. As soybeans dry, lower the cylinder speed to reduce breakage; 450 to 500 rpm should be high enough for soybeans that are below 13 percent in moisture content.

Rotary Combines

One way to improve the quality of soybeans is to reduce the mechanical damage caused by the combine threshing mechanism during harvesting. Efforts to reduce threshing damage while increasing capacity have resulted in the development of rotary threshing equipment. Rotary combines have one or more rotors, instead of the conventional cylinder and straw walkers for threshing and separating grain from crop material. The crop material is swirled around the rotor and passes over concaves several times. The threshing action of the rotor is reported to be more gently than that of the cylinder.

New Holland was the first company to introduce the concept of rotary, or axial-flow, threshing with its TR-70 combine. International Harvester followed with its single-rotor, axial-flow combine. In 1978 Allis-Chalmers introduced its N-Series rotary combine, and in 1979 White introduced its Model 9700 axial-flow combine. It appears that the rotary combines are here to stay. But in spite of the popularity of these new combines, the conventional cylinder combines will probably be around for a long time.

A study was conducted at the University of Illinois in 1977 to determine the damage to soybeans caused by rotary and conventional threshing mechanisms. In this study an International 1460 Axial-Flow (single-rotor) combine, a Sperry New Holland TR-70 (double-rotor) combine, and John Deere 7700 (conventional rasp-bar-cylinder) combine were tested under field conditions. The quality of the harvested soybeans was evaluated, and the threshing and separating losses for each combine were determined. All three combines were equipped with 20-foot-wide, floating cutterbar headers.

The results of the study, which are summarized in the following paragraphs, pertain only to the particular combines and soybean variety (Amsoy-71) tested in this study and to the particular conditions under which the study was conducted.

The percentage of soybean splits was significantly higher for the conventional cylinder than for the single- or double-rotor threshing mechanisms at similar peripheral threshing speeds. However, when the mechanisms were operated within the range of cylinder or rotor speeds recommended by the respective manufacturers, the percentage of splits did not exceed the allowable 10 percent limit for U.S. No. 1 grade soybeans.

With all three mechanisms, the percentage of splits increased as the peripheral threshing speed of the cylinder or rotor was increased. The increase in splits was less with the rotary threshing mechanisms than with the conventional cylinder.

With all three mechanisms, threshing and separating losses decreased as the cylinder or rotor speed was increased. These losses ranged from 0.2 to 0.5 percent of yield. With the rotary combines they were significantly higher at the lowest rotor speed than at the higher speeds.

Increasing the concave clearance generally decreased the percentage of splits for all three combines, although this adjustment had less effect than changes in cylinder or rotor speed. The percentage of splits was not significantly affected by concave adjustment until after a minimum clearance was reached for the rotary combines.

The susceptibility of soybeans to breakage and the seed-coat crack percentage were not affected significantly by the type of threshing mechanism or the cylinder or rotor speed. Nor did these factors affect other criteria used in grain-inspection grading, such as test weight, percentage of damaged kernels, and percentage of foreign material.

We found that improvements were needed in the design of augers and elevators that convey soybeans from the clean-grain auger to the grain tank. The percentage of splits that occurred as soybeans were elevated from the clean-grain auger to the grain tank averaged 1.0 percent for the conventional cylinder, 0.6 percent for the single-rotor, and 1.4 percent for the double-rotor combines.

The results of studies at The Ohio State University and the University of Illinois indicate that adjustments to rotary combines may be less critical than those to conventional rasp-bar-cylinder combines. However, the results of these studies also indicate that during threshing and cleaning a properly adjusted conventional combine can keep soybean damage well below the level that leads to dockage.

Weeds

Although it has long been recognized that weeds are detrimental to soybean production, only in recent years has their effect on combine harvesting efficiency been studied. University of Illinois researchers conducted experiments at Urbana, Illinois, in 1968 and 1969 to determine the effect of controlled infestations of smooth pigweed and giant foxtail upon soybean yields and harvesting losses.

In these experiments the smooth pigweed infestation (one pigweed per foot of row) reduced the average yield 25 to 30 percent. The same degree of giant foxtail infestation reduced yield 13 percent. but the weeds did not cause significant losses at the header during harvest as long as the weeds were desiccated before harvest began. The results of the experiment also indicate that harvesting soybeans before frost has desiccated the weeds results in excessive threshing and separating losses unless the ground speed of the combine is reduced. In some pigweed infested plots, 4.4 percent of the crop was lost during threshing and separating when it was harvested at 3 mph. whereas only 0.7 percent was lost when ground speed was reduced to 1 mph. At both speeds about 1 percent of the crop was lost during threshing and separating when it was harvested after the pigweed had dried.

Soybean Harvesting Research

Improved productivity of the harvesting system is necessary for the agricultural producer. The conventional reciprocating cutterbar limits combine travel speed to 3.5 mph or less, holding soybean throughput of modern combines to levels that are considerably below the capacities of both the threshing and separating units. Combine headers specifically designed for soybeans can remove this limitation. The John Deere Row-Crop header permits higher travel speeds that result in increased throughput of modern combines to levels that are considerably below the capacities of both the threshing and separating units. Combine headers specifically designed for soybeans can remove this limitation. The John Deere Row-Crop header permits higher travel speeds that result in increased throughput while maintaining low loss levels. However, the current trend toward planting soybeans in narrower row spacings to maximize yield potential emphasizes the importance of maintaining the ability to harvest soybeans in a continuous swath.

Rotary impact cutting seems to offer the potential for high combine travel speeds and high throughput for soybeans. Investigations of impact cutting at the University of Illinois demonstrated that soybean harvest losses could be reduced to levels lower than those resulting from conventional cutterbar configurations. Rotary disk and rotary drum mowers and haybines have recently been introduced in the United States by farm equipment manufacturers, after receiving wide acceptance by European customers. These units provide high speed rotary impact cutting of a continuous swath and can function at relatively high travel speeds. If the losses produced by an adaptation of this cutting unit can be held to levels comparable to those obtained with existing commercial cutterbar systems, an improvement in soybean harvesting system productivity would be possible.

The objectives of this study were:

1. To collect and measure the harvest loss associated with rotary blade cutters.

2. To evaluate the effect of forward speed, row spacing, and disk design on harvest loss.

Three Vicon disks were mounted on a rotary disk mower frame and operated at 3000 rpm on a laboratory test stand (Figure 2). Vicon manufactures a "standard" disk, with a smooth disk contour, and a "wing" disk (Figure 3) with three small metal pieces welded to the regular disk at an upward angle. Both styles were tested to evaluate effects of blade design on harvest losses.

Wells-II variety soybean plants were gathered at harvest, stored, and prepared for testing. Narrow row soybean production was simulated by using three rows of soybeans for each test run. Both 7.5 in. and 10 in. row spacings were evaluated. The soybean rows were mounted on a carriage and driven through the cutterbar at travel speeds of 4.5, 6.75 and 9.0 mph. Harvest losses were gathered from the collection tray and weighed, and moisture content and net yield were determined. High speed movies were taken and the movies were used as an aid in determining the percentage of actual loss collected. Only beans that fell in front of the cutterbar were considered to be lost.

For both the standard and winged disks (Tables 3 and 4), loss levels observed at the 4.5 mph travel speed were significantly higher than those at 6.75 mph and 9.0 mph travel speeds for both 7.5 in. and 10 in. row spacings. The higher momentum of the soybean plants at higher relative travel velocities tended to carry shattered seeds along with the plant onto the header. However, no significant difference in loss levels was detected between the 6.75 mph and 9.0 mph speeds.

With the exception of one treatment (4.5 mph travel speed with 10 in. row spacing and standard disk cutterbar), all losses recorded were below one percent of the gross yield. Loss levels for the higher travel speeds (6.75 mph and 9.0 mph) were below 0.55 percent. These recorded loss levels were lower than the losses that actually occurred. Analysis of the film revealed that, on the average, approximately 60 percent of the beans shattered along the length of the collection tray were collected during the tests.

The losses encountered with the wing disk cutterbar configuration appear to be significantly lower than those encountered with the regular disks. All losses for the wing disk configuration were below 0.53 percent and losses at the higher relative travel velocities were below 0.20 percent. Vicon manufactures mowers and hay conditioners

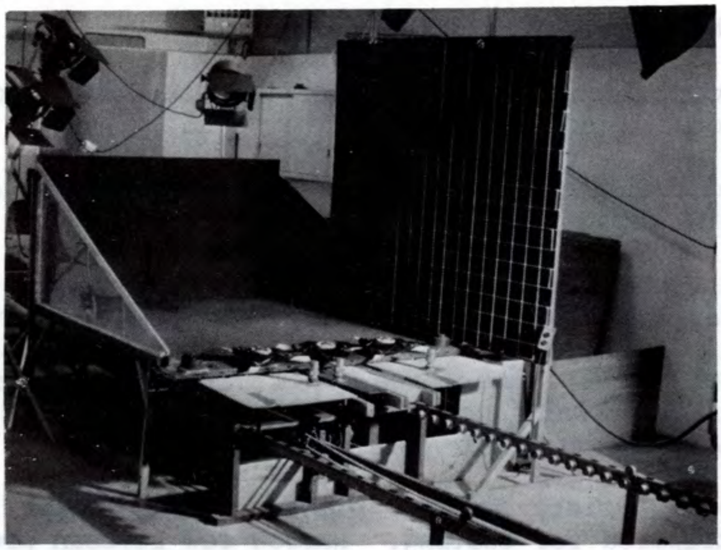


Figure 2. Laboratory test stand used to evaluate rotary disc mowers.

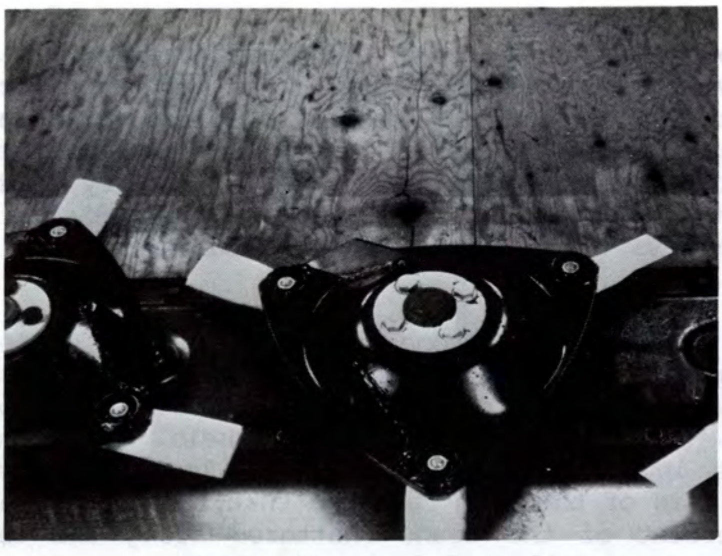


Figure 3. Close-up view of a modified Vicon wing disc.

Table 3. Soybean harvest loss and yield with the standard disk cutter configuration.

Row spacing, in.	Travel velocity, mph	Total harvest loss,[1]	Gross yield, bu/acre
7.5	4.5	0.85 a	70.2
	6.7	0.23 c	84.3
	9.0	0.28 bc	76.4
10.0	4.5	1.05 a	61.5
	6.7	0.54 b	61.7
	9.0	0.13 c	55.0

[1]Data are averages of three replications with Wells-II variety at 10.5 percent and moisture (W.B.). Numbers with the same letters do not differ significantly at the 5% level, based on Duncan's Multiple-Range Test.

Table 4. Soybean harvest loss and yield with the wing disk cutterbar configuration.

Row spacing, in.	Travel velocity, mph	Total harvest loss,[1]	Gross yield, bu/acre
7.5	4.5	0.50 a	88.6
	6.7	0.12 b	93.0
	9.0	0.18 b	91.0
10.0	4.5	0.52 a	64.2
	6.7	0.18 b	63.5
	9.0	0.15 b	66.4

[1]Data are averages of three replications with Wells-II variety at 10.5 percent seed moisture (W.B.). Numbers with the same letters do not differ significantly at the 5% level, based on Duncan's Multiple-Range Test.

which utilize the regular disks and wing disks respectively. The wing disks supposedly produce a greater upward air stream which helps carry the hay up into the crimper. The difference in airflow could account for the difference in loss levels as the greater airlift would suspend a shattered bean for a longer time and allow the seed more time to pass over the cutterbar and enter the header.

We concluded that soybean losses associated with a rotary disk mower can be expected to be below 2%, that soybean losses at the 4.5 mph forward speed were significantly higher than those at the 6.75 mph and 9.0 mph forward speeds, and that soybean losses using the regular disk cutterbar at 4.5 mph forward speed.

PRE-CONDITIONING CONSIDERATIONS

Howard C. Potts[1]

The title is very descriptive of the ideas to be conveyed. That is; "pre" - meaning before; "conditioning" - meaning those activities required to prepare a lot of seed for marketing and planting, and "considerations" - meaning, continuous and careful thought and activities based upon knowledge. Thus, a summary of this discussion can be made in a single sentence - Before conditioning each seed lot there are several facts that should be determined and decisions made based upon this knowledge.

There are many decisions that must be made concerning every bag or truck load of field run seed which arrives at a conditioning plant. Eight of the more important decisions; presented as questions, are:

1. Can the seed be cleaned to company quality standards?
2. Do the seed need drying or pre-conditioning?
3. What conditioning equipment will be used?
4. What is the best cleaning sequence?
5. How will the equipment be set-up initially?
6. What is the disposition of the clean-out and clean seed?
7. Are seed additives needed?
8. Are there special conditioning requirements?

These questions are answered actively or passively on every lot of seed. Professional seed conditioners answer them actively. Equipment operators answer them passively.

So much for theory; a conditioning manager must know the specific characteristics of every seed lot, before he/she starts the conditioning process, to most correctly answer the questions above (Figure 1). Further, the decisions should be made on the basis of knowledge and facts, not ignorance and guesses. In commercial seed

---

[1]Professor, Seed Technology Laboratory, MSU.

1. Seed kind

2. Moisture content

3. Flow characteristics

4. Frequency of contaminate contamination

5. Differences in physical characteristics.

6. Lot homogeneity

7. Amount of damaged seed

8. Quality potential

Figure 1. Physical characteristics of each seed lot that should be determined before the seed are cleaned.

businesses particularly, personnel are rewarded for their application of knowledge to a much greater degree than the attainment of knowledge, although, knowledge attainment necessarily comes before its application.

The remainder of this discussion is devoted to a more detailed consideration of the important characteristics of each seed lot and suggestions concerning how these characteristics can be determined. Formally, the determination of these characteristics is called a pre-conditioning diagnosis; practically its called a pre-cleaning exam (Figure 2). Regardless of how the characteristics are determined the information gained from an exam is of no immediate value unless it is used to make specific decisions about each seed lot!

There are eight characteristics of every seed lot that should be known before seed conditioning begins. These are: (a) seed kind,(b) seed moisture content, (c) flow characteristics of the seed-mass, (d) frequency of occurrence of contaminants, especially seed of restricted and prohibited noxious weeds, (e) differences in physical characteristics between the good seed and the undesired materials, (f) homogeneity of the seed lot, (g) the amount of damaged seed and (h) quality potential of the cleaned seed. No one of these characteristics is more important than all others for every seed lot!

Let us examine each of these factors in greater detail to emphasize their importance and the methods which can be used to make workable estimates of each factor.

Seed Kind: The kind of seed determines the general physical characteristics which can be used to make a separation, therefore, the machine(s) which can be used for conditioning. Often the variety can make a major difference in the specific adjustments made on the machines as well as the machines used. The number of people working in the seed industry who can not, on sight, identify some of the important crop and weed seeds is rather amazing. Some examples are wheat and rye: ryegrass and tall fescue; sweet sorghum and johnson grass, and dodder and arrowleaf clover. While it is possible to effectively condition seed without knowing the seed kind, it is difficult to believe that any seed conditioner will be effective in making the best decisions concerning the possibility of mechanical injury, the cleaning sequence, the need for drying, etc., if he doesn't know what kind of seed is to be cleaned.

Seed Moisture: Seed with moisture contents in the range of 14-18% are less subject to mechanical injury but will not flow through the equipment as rapidly as seed having 10-12% moisture. On the other hand, essentially all seed must be below 13% moisture for safe storage. The actual seed moisture content is not known on a majority of the agronomic crop seed at the time they are conditioned! The seed are simply assumed to be dry enough for conditioning and storage if

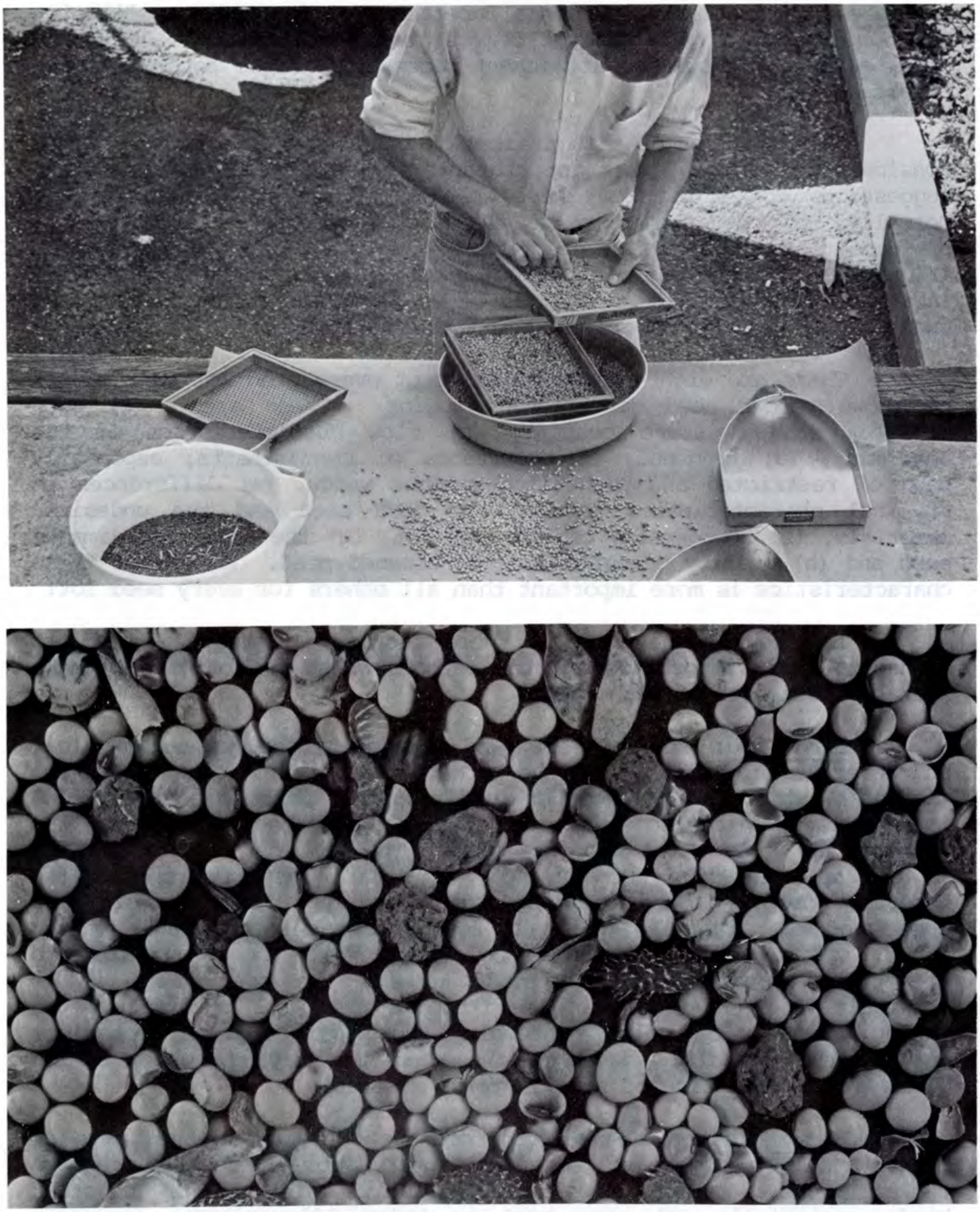


Figure 2. (Above) Performing a pre-cleaning examination; (below) a close-up view of combine run soybean seed used to determine the lot's characteristics.

they were dry enough to be harvested. While this assumption is probably valid 99% of the time, why make an assumption when exact knowledge can be obtained so easily? Among the array of moisture testers available, most are very easily operated and accurate for determining seed moistures within the range of 8 to 28%. Organizations which receive and/or condition seed at moisture contents above 25% or below 7% will need an air-oven to accurately determine seed moisture.

Flow Characteristics: The ease and uniformity with which the seed mass will flow, without mechanical force, is its flowability. A large sample of the entire lot must be used to determine flowability because compaction must be considered in addition to the presence of inert material and natural seed appendages. If flowability is based upon a sample, it should be drawn by hand because probes often exclude large pieces of inert materials which are most likely to cause problems.

Seed must flow uniformly through the elevating and cleaning equipment to make an effective separation. As a general rule, a lot of seed which has an angle of repose greater than 45° should be pre-cleaned or pre-conditioned before attempting separation by the air-screen or other conditioning machines. Anyone who has spent a day poking seed into an elevator or through a bin opening will testify for the need of predetermining the flowability of the seed lot.

Most seed lots which have been harvested and threshed mechanically will flow through a properly designed processing plant. However, an occasional lot of many seed kinds may lack the desired flow characteristics due to natural appendages on the seed, high quantities of stems or straw, high moisture content, or poor threshing. Such lots require pre-cleaning before attempting to separate the good seed. Scalping, drying, de-bearding, re-threshing or use of a hammermill may be required to obtain the desired flow characteristics of the seed mass.

Frequency of Occurrence of Contaminants: This refers to the ratio between the good seed of a lot and undesirable materials. When examining the seed to be cleaned, one may identify several undesirable contaminants, i.e., weed seed, other crop seed, or inert matter. Depending upon the quality standards to which the seed must be cleaned, certain contaminants can be ignored. All clean seed will contain a fractional percentage of inert matter. Many seed lots may contain small amounts of other crop seed or common weed seed after cleaning because the cost of removing these contaminants exceeds the value added by their removal.

Although a visual examination will provide an estimate of the frequency of contamination, a detailed purity analysis is useful for making this determination, particularly when a low frequency of noxious weed seed is involved. Identifying one johnsongrass seed in a pound of sudangrass is not likely when a quick visual examination of a handful of seed is the primary method of conducting a pre-cleaning examination.

As an example, if the pre-cleaning examination reveals the presence of an occasional oat seed in a lot of non-certified wheat seed, the occasional oat could be ignored. However, if the wheat seed are to be certified, it will be necessary to remove the oat seed. The presence of this oat seed would require the use of length grading equipment, therefore, increasing the cost of conditioning the certified seed. This same example is equally valid for common weed seed and inert matter. Generally the quality standards set by management or, in some cases, by regulation determine what contaminants must be removed from each seed lot.

Differences in Physical Characteristics: A mechanical separation of good seed from its contaminants is possible only when there is a mechanically distinguishable difference in one or more physical characteristics of the good seed and that of each contaminant (Figure 3). What is a mechanically distinguishable difference? The answer depends primarily upon the machines and adjustments available along with the operator's skill in running them. The effectiveness in achieving the desired separation is directly associated with the uniformity of the physical difference identified and the feed rate.

There are eight primary physical characteristics by which mechanical separations can be effected. These are: length, width, thickness, shape, surface texture, weight (density), color and electrical charge. Every seed and particle of contaminating material in a seed lot possesses these physical characteristics; therefore, separations are possible only when mechanically measurable, physical differences exist.

Contaminants which have physical characteristics similar to those of good seed are of greatest concern. When examining the seed lot, particular emphasis must be placed on determining the presence of contaminants such as noxious weed seed, nematode galls, etc., which could cause the seed to be unsalable even though the mechanical purity exceeds 99%. Noxious and common weed seed, seed of other crops or varieties, damaged seed, and inert matter having similar physical characteristics to those of the good seed are of descending importance in most seed lots.

Determination of the basic physical differences by which a particular separation can most effectively be made requires: a knowledge of the specific physical characteristics of the good seed and other contaminating materials. This means that at least a visual examination of a sample from each seed lot must be made.

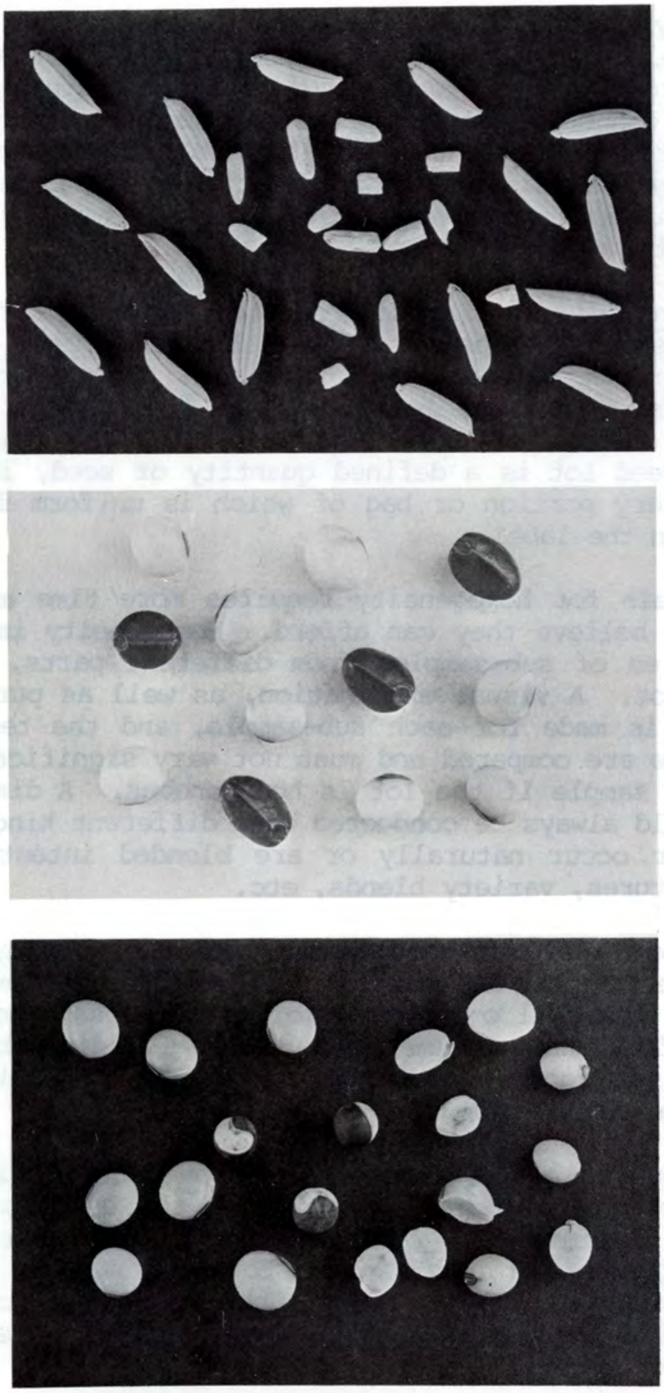


Figure 3. Commercial scale operations can easily separate whole grain and cross broken rice (above); with a lenght separator; separate soybean and giant morning glory (middle) with some difficulty due to differences in shape, but cannot separate soybean and balloon vine seed (below) because of insufficient physical differences.

Ideally, the conditioning manager will have an opportunity to "test" clean each lot of seed with hand screens and model equipment (Figure 4). This permits a precise diagnosis concerning what contaminants can and cannot be separated and an estimate of the clean seed loss required to remove the contaminating materials. The results of a standard purity analysis are desirable but do not provide the needed information for determining physical differences among the good seed and contaminants.

Homogeneity: Most conditioners do not test for lot homogeneity, rather they assume that seed lots harvested from the same field and cleaned through the same set of cleaning and/or grading machines are homogeneous. They are not. Lack of homogeneity is one of the most frequent causes of seed law violations at least for honest seedsmen. A seed lot is a defined quantity of seed, identified by a lot number, every portion or bag of which is uniform for the factors which appear on the label.

Diagnosis for homogeneity requires more time and effort than many companies believe they can afford. Homogeneity is determined by drawing a series of sub-samples from different parts, i.e., bags or bins, of the lot. A visual examination, as well as purity and germination tests, is made for each sub-sample, and the test results for each sub-sample are compared and must not vary significantly from that of a composite sample if the lot is homogeneous. A diagnosis for homogeneity should always be conducted when different kinds or varieties of seed either occur naturally or are blended intentionally, i.e., lawn grass mixtures, variety blends, etc.

The source of non-homogeneous lots can usually be traced to one of three errors on the part of the conditioning manager. These are: assuming that all or any two lots are the same (open end lots), ignoring the fact that contaminants rarely are distributed uniformly through a lot; or ignorance of the realities of blending non-uniform solid particles such as seed.

Just one rain shower or two combines can significantly alter the physical and biological properties of the seed harvested from a single field. Failure to recognize the natural variation brought about by conditions and events prior to the time the seed are first bulked often means trouble. It is much less costly to change a lot number when seed quality may have changed than it is to re-tag an entire lot after receiving a stop sale order.

A false assumption made by many seed conditioners is that the seed harvested from a single production field is uniform. Another false assumption is the belief that conveying the seed from combine to truck, truck to storage bin, storage bin to air-screen holding bin,

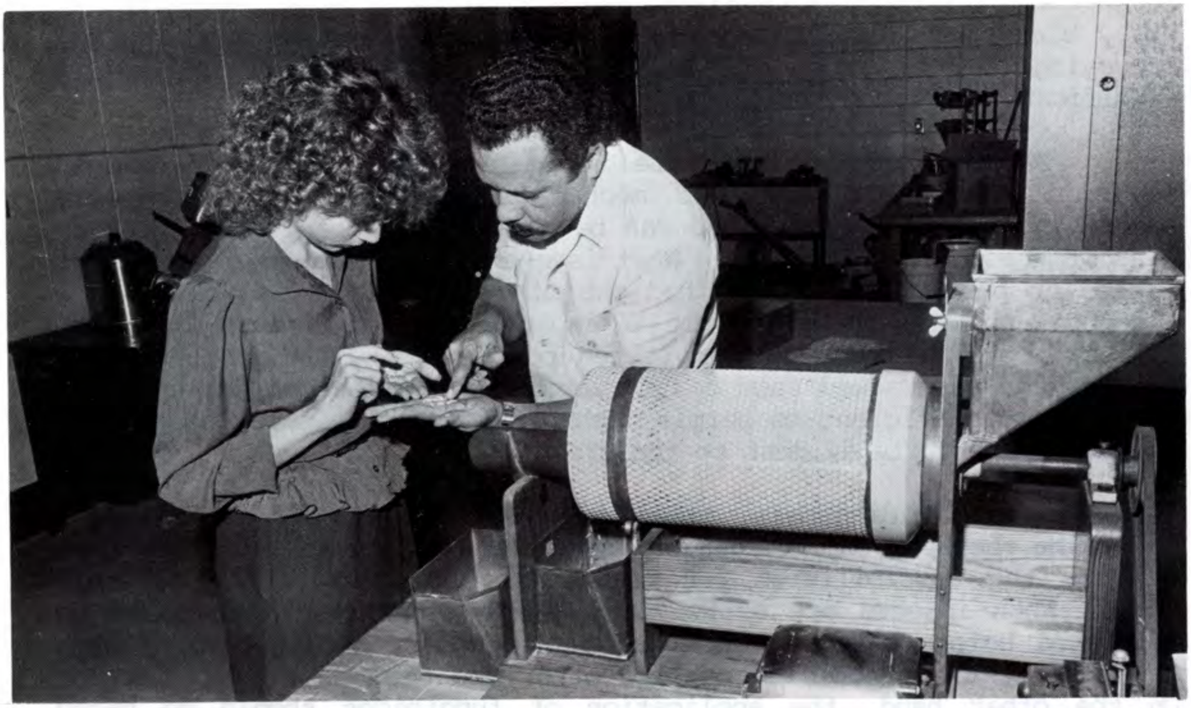


Figure 4. Test cleaning a seed lot permits more efficient cleaning operations.

etc., blends or mixes the seed to uniformity. Routine handling and conveying of most seed lots has not, does not and will not have a significant effect on their homogeneity.

Damaged Seed: There are three principal causes of damaged seed: insects, diseases and mechanical damage. Only the more severely damaged of these seed can be separated mechanically, regardless of the source of damage. What is a severely damaged seed? It is a seed or particle which has had one of its physical characteristics altered sufficiently to permit a separation; for example, soybean splits, weevil eaten wheat or rotten corn seed. On the other hand, damage such as cracked seed coats, abrasions, surface molds, etc., is usually not sufficient to permit mechanical separation, although, the damage may be quite evident to the eye.

A visual diagnosis, aided by magnification, may be needed to determine the need for fumigation and/or application of pesticides, as well as the possibilities for mechanical separation of the damaged seed. When insects are active in a sample, the seed lot should be fumigated before entering the conditioning plant and, depending upon the insect, an insecticide applied after the seed have been cleaned. On the other hand, the application of fungicides should be based solely upon the farmer's need for the protection provided. Seed which are so diseased that a fungicide is needed to protect them in storage should be rejected for commercial planting purposes. Pesticides protect seed; they will not bring them back to life.

Quality of the cleaned seed: "Seed of any quality can be sold if the price is right," is a time honored but business bankrupting philosophy of some seed companies. Today, most successful seed companies strive to attain their own or imposed seed quality standards. Specifically in terms of physical purity, seed conditioning personnel are responsible for meeting or exceeding the quality standards. Experienced seed conditioners can, based upon a pre-cleaning exam, judge the final physical quality level of a seed lot before it is cleaned.

Some seed lots can not be cleaned mechanically to the point of having no weed or other crop seed. The equipment available is not important. Weather damaged or discolored seed of good biological quality is unattractive to the potential buyer and may not meet company quality standards even though they meet state regulatory or certification quality standards. The seed conditioner cannot do much after the seed are cleaned and in the bag when these or related problems are encountered?

Does the conditioner have a responsibility to company management to identify and notify the appropriate persons before such seed lots are conditioned? If the cleaned seed will contain a small number of noxious weed or other crop seed, should they be packaged in company bags? Can sub-standard seed be sold without adversely affecting the company's reputation? Ideally the answers would be yes, no and no but only each conditioner knows the honest answers.

In summary, no two seed lots are exactly alike, indeed no two truck loads of the same lot are exactly the same. Thus, every truck load of seed brought to the conditioning plant should be subjected to a pre-cleaning exam before conditioning starts. One final consideration you should make before deciding whether or not to make a preconditioning exam - its your job on the line.

COMPLAINTS AND CIVIL SUITS: ARE YOU PREPARED?

Foy Campbell[1]

Introduction

The subject of this discussion: "Complaints and Civil Suits: Are You Prepared?", is one of increasing interest and importance to the seed industry. Not only do these problems add to the frustration of conducting business, but complaints and lawsuits can significantly add to the costs of doing business. It may be necessary for some of your most talented people to spend endless hours doing investigative work, involving costs for legal fees, Errors and Omissions insurance, and other expenditures.

No attempt is be made to catalog or document all the different types of complaints and problems in the seed industry which could lead to lawsuits. We're all familiar with various kinds of fines, violations of federal and state seed laws, suits arising from alleged violations involving interstate commerce, the Federal Seed Act, mislabeling, and numerous others. Space does not permit such a review.

Background Information

Because most people in attendance are involved in seed production, conditioning, plant operations, etc., you are no doubt well-versed in the agronomics of solving field problems. So, rather than go into this area of discussion, I offer a few suggestions on handling the problems to better serve customers, maintain better relations, and, hopefully, avoid lawsuits.

Over 30 years ago, when I first began investigating complaints and their causes, it was unusual to hear of a lawsuit in the seed industry. When we would discuss a problem or potential suit with the lawyers, they would simply tell us that no precedents existed on that topic. However, all of that has rapidly changed. Not only are complaints on the increase, but as an industry, we are experiencing a rising number of litigations.

----

[1]Manager, New Market Development and Product Development Agronomist, Funk Seeds International. Montgomery, Al

It is a reasonable assumption that the professional seedsmen assembled here do take the necessary steps to insure a high quality product getting into the bag for shipment to the seed trade. So, the causes are not always related to poor quality seed.

How do we avoid lawsuits; sometimes we can't! We do all that is humanly possible before there is even a chance for a customer complaint. Of course, we should follow the very best production practices: avoid mixtures or contamination from other varieties or species; carry on a good weed control program with proper tillage; be certain that isolation distances are more than adequate to insure varietal purity; do everything to produce a superior quality product that we can market with pride and absolute confidence. We need to harvest the seed with the proper machines, properly adjusted, at the right speed to minimize harvest damage. Then, in the final conditioning step--preparing the seed for packaging and shipping to the marketplace--again being sure we have proper equipment settings, near-perfect cleaning, removing any cracked or damaged seed, etc. In other words, all the good procedures that we know should be followed.

However, a word of caution--just doing all these things correctly may still not be enough to avoid a lawsuit. Remember, you can be as innocent as a lamb and still get sued. It is important to be thoroughly prepared to successfully defend yourself, if it becomes necessary to do so.

In dealing with a complaint we should always maintain a positive attitude. As purveyors of the seed, which may or may not be the cause of the problem, we are almost automatically put into an adversary or defendant role at the very beginning. We should neither assume this role, however, nor let it affect our attitude. It should be understood that when we investigate a complaint, our motive is not to cover up or seek some excuse, not to try to avoid responsibility but instead, quite the opposite. We should be ready to assume full responsibility for the products we have sold in good faith, and with good intentions. We should go, armed with all the facts and information we can get about the situation. We should maintain and open mind, a guilt-free conscience, and a sincere desire to be of genuine service. With all the knowledge we posses, we should demonstrate our desire to sincerely seek the truth about the causes of the problem which the customer has experienced.

The farmer customer is, perhaps, not aware of the many checks and balances, inspections and tests that are run, not only by the industry itself, but also by state and federal regulatory agencies, to help insure high quality. Knowing all that has been done to see that a high quality product reaches our customers, we can confidently approach a complaint with the expectation that the cause of the problem will be found somewhere other than with the seed. However, we should not rule out the possibility that something adverse may have happened after the seed left our control.

Do you have someone trained and experienced in your organization to deal with the problem? Or is it just whoever you can get to go look at the situation when it comes up?

A few observations to put the topic in perspective are: (1) When problems arise, in most cases it is the dealer or salesperson who first learns about it. So, in most instances, your dealer and field sales force are your first line of defense. The salesman is a most important link in conducting the initial investigation. But remember that good sales people are not always scientifically trained, nor psychologically prepared to deal with a serious problem and an irate customer. This is certainly no reflection on sales people. However, we should remember that the salesman's job, generally is filling wants and needs of the customer on a positive basis. He's experienced in selling the strong points--accentuating the positive, selling the sizzle, painting a picture of anticipation--not unlike the old time seed catalog with beautiful pictures of perfectly shaped fruits and vegetables with no sign of insect or disease damage. So, then, it may be very difficult for the salesman to deal with this problem which may end up in the courts. I've seen salesmen literally come "unglued" at the prospect of such a situation. It becomes even more difficult if an angry customer realizes that a prompt offer of pay is not going to be made for a crop he thinks he should have made.

Problem--Real Or Perceived

There is either a problem that is real, or certainly one that is perceived by the customer, or you would not have an unhappy situation on your hands. It should be dealt with promptly--the quicker the better. In some cases, it will help to cool the situation, just to make contact right away, letting the customer know you are concerned and want to work with him.

Now, to successfully solve this problem and avoid litigation requires knowledge, patience and perseverence, plus the ability to communicate the truth, if it can be discovered, in an acceptable manner, without argument or antagonism. That's a pretty tall order, especially if the customer is proved wrong. Is it any wonder, then, that oftentimes it appears that the best solution--certainly the easiest one--is to 'pay off' and hopefully rid yourself of this unpleasant situation.

Yet, that kind of solution is not fair to your company, nor to the seed industry, and actually does not serve the customer very well. Chances are, you will have spent a lot of money, lost a customer, and as a result of the payment, admitted guilt. This may bring the house down on you and your dealer from others who may fall in line and say "I knew all the time there was something wrong with that seed!"

One of my most important observations in this paper is that we should be aware that the doctrines of law, which now are being applied in agricultural suits, originated with "MANUFACTURED" or "ENGINEERED" products, rather than with products of nature or living organisms as in the past. This is one of the reasons behind the seed industry's insistence on using the term "conditioned seed" rather than "processed seed". The legal inference regarding a processed item is that it has had something done to it--it has been changed, thereby raising more legal questions. Whereas, a conditioned item has just been cleaned or put in a marketable form without any change to the item itself. It has not been altered genetically or had its bred-in ability to perform made different. It was not manufactured; yet legal actions will often use those very terms.

We are all familiar with the highly publicized recall procedures of the automobile industry. Manufactured products can be recalled, put on a rack and carefully examined. Parts can be changed, replaced or rightened. But, when seeds that are planted don't come up, or if they come up and die, or if some other malady attacks them, they cannot be recalled for such careful examination and analysis. Yet, this is the same legal doctrine often applied to the seed industry. I think we all have a responsibility to help draw these distinctions for the court's consideration. We need to become more knowledgeable and better equipped to deal effectively with complaints and the threats that often follow. Perhaps we should become less agreeable to settlements out of court as the easy or less expensive way out.

Following the unfortunate experience of the outbreak of the T-Race of <u>Helminthosporium</u> <u>maydis</u> in 1970, a new attitude emerged, leading to increased litigations against the seed industry. This may have been the real turning point. Experiences such as the southern corn leaf blight outbreak sensitized both customers and the legal profession to the possibility that more profitable solutions to agricultural problems might be found through the courts. There are several factors believed to have contributed to the increase in legal actions.

Economic conditions in recent years have threatened the stability of the agricultural community. It is a matter of record that all across the country, large numbers of farmers are insolvent. We have all heard of foreclosures in which the sale of property and equipment and everything the man owned would not pay off the indebtedness. Producers are becoming more aware of possible legal remedies as an alternative.

Although we all appreciate and respect the legal profession, it is a well-known fact that there are growing numbers of lawyers. They need to make a living, too. In the past few months, in a popular periodical, there was a feature article entitled, "American Lawyers: A Protested Profession Meets (Gasp!) Competition." This reference is certainly not intended as a criticism of the legal profession, but simply states a fact. This quote is from the article, "Much of today's trouble stems from one simple fact: There are too many lawyers chasing too few clients. The statistics are numbing. There were only 355,000 lawyers in the U.S. in 1970. There are 622,000 now, and there will be over 1 million by the middle of the next decade. The number of lawyers is growing much faster than the business available to support them. As a result, more people have found the promise of economic relief through lawyers who are willing to accept cases on a contingency basis, and who are competing for clients."

To further our exposure across the southern U.S., there are more natural hazards that affect crop production, such as high humidity and relatively mild temperatures, creating a greenhouse effect that is ideal for the development and spread of disease organisms. Also, insects can safely hibernate and multiply rapidly, while no-till farming has been on the increase.

Preventive Measures

It is important to remember that a complaint is usually registered before legal action is taken. This presents us with an opportunity to be of service to the customer, and to help him solve or recognize a problem that might be avoided in the future, thus contributing to his economic well-being. It can possibly help us to avoid a lawsuit and at the same time, save a valued customer. However, from the very outset you should prepare for defending your company. If all other efforts fail, you want to be prepared. This is hard and very demanding work.

You should have a fairly good understanding of state and federal seed laws and regulations. You need to have, as an absolute minimum, adequate records to comply with these laws and regulations. Good records are essential in a quality control program, and they may double in value in the case of a lawsuit.

At times I have been surprised to learn that not everyone is consistent in putting a record of the lot number on sales tickets and invoices. We should remember that knowing the lot number is the first step in tracing the history of that seed lot, and should be the first thing checked when a problem arises. The lot number is the official identification of the seed and everything that has happened to the seed is related to that particular lot number. Without this basic information as a part of your sales record, you will be in a weak position if a problem arises. Most of us are aware that when a lawsuit comes up, everybody in sight gets sued, which means that everybody who has had anything to do with the seed along the way can become a party to the suit.

Investigating A Complaint

At this point, we need to shift gears and stop referring to the problem as a "complaint" and think of it in terms of a "service call." In preparing for this service call, learn as much as you can about the problem before visiting the farm. Such information may come from the customer, the dealer, or some other source. Try to get the complete history of the particular lot of seed. Know as much as you can about the individual customer, his personality, temperament, etc. Does he have a history of complaining or experiencing problems, or filing lawsuits? This background information is very important in the initial stages. Whatever you do, don't arrive at the scene announcing how good the seed are, and denying everything before you've even been accused. On the other hand, don't admit fault before you've even checked into the matter.

The Service Call Report is a very basic document that should be kept as a part of your records. It is simply a form for recording all the facts we can learn about the problem. Perhaps most of you already have such a record form. If not, it would be well worth the trouble and expense of getting a lawyer to help you develop one to serve your purposes.

The following list includes a few fundamentals that I have found extremely important in making a service call:

1. Respond quickly. Don't put off calling on the customer. I am convinced that many lawsuits are caused, not by some weakness or failure of the product, but by the customer's finally feeling that legal action is the only way he can get attention.

2. Take a good camera with you--know how to use it. Good pictures can be very valuable in documenting the problem for seeking outside opinions later on if needed. Good photographs can be very helpful in case of litigation. It is remotely possible there won't be another chance to document with pictures.

3. Take something for digging. It is always a good idea to check all parts of the plants, with a look at the roots and root zone. Many times the ground is dry and hard, and this tool will help.

4. Have a good knife. Cutting into the plant stems and roots can help find the cause of trouble many times.

5. A hand lens can be helpful. Although not essential, a hand lens can improve our investigative ability by helping us see more than with the naked eye.

6. Have plastic bags with you. It is good to have several sizes of these bags, from large down to the small ones with zip-tops, for the collection of plant specimens. It is also good to take along cartons for soil samples, as well as paper bags.

7. Have bottles or jars with you. Small vials, bottles or jars can be used to collect insect specimens. If you do not have access to special type containers, small baby food jars are excellent for this purpose. A small, inexpensive tackle box makes a convenient storage and carrying case for these materials.

8. Have a good attitude--be friendly. Establish a sincere interest in the customer and his problem. Express appreciation for his business.

9. Have confidence; know your products. Know the production techniques of the crop. A good portion of the service call can be taken up with the customer's seeking advice concerning matters other than the complaint.

10. Listen and let the customer do the talking. Answer his questions with questions. Try to determine if a 'third party' should be involved to provide an expert opinion or analysis of the problem. Don't interrupt; make notes during the interview.

11. Ask questions. Listen some more, and make more notes.

12. Be prepared. Know the local conditions; know as much as you can about various problems that could possibly develop with a particular crop species. Maintain a library of reference books, experiment station and extension publications dealing with various crop production areas. By showing such information to the customer, you may bring in the help of a third party, without the intimidating effect of the third party's presence.

13. Take the dealer with you. If a dealer was involved, he will also want to establish with the customer the fact that he, too, is interested in the service aspect of the call. If you are the dealer, and don't have such a third

party to call on, then perhaps you should make the first visit alone. Depending on the nature, severity, and complexity of the problem, you might suggest that the customer invite the county agent to meet you at the farm to study the problem together. If it appears to be something out of the ordinary, you might suggest that the customer request the county agent to invite one of the state extension specialists, who will have more knowledge and experience in the field than either of you might have, to come and look at the problem.

14. Establish the fact that the customer has planted your product. We have enough to do without investigating someone else's problem. Information proving it was your seed should have been previously obtained from dealer records, samples, bags, tags, etc., all of which can be very important.

15. Be a good observer. Determine field conditions, such as soil type, drainage and topography, etc. See that a soil test is run, if it is likely to have an effect on the problem. If the problem occurred sometime ago, check the weather records to document conditions that might be crucial. Observe plants for disease, insect damage, chemical damage or poor management. (Be sure to photograph.) Observe adjacent fields and crops planted.

16. Fill out customer service call report. Ordinarily, it is advisable to fill out this report in the customer's presence. In developing such a form, provide a place for the customer to sign, after reviewing and agreeing that the facts are correctly stated. It is conceivable that presentation of such a form could agitate the customer. To overcome this you may simply explain that you are getting all the facts and details down to check over with him to be sure there are no errors and that you have everything clearly stated. If, for some remote reason, you do not fill out the form in his presence and review it with him then it should be done immediately afterwards; stating the facts and observations as accurately as you can.

17. Leave the farm and customer on a friendly note. Keep the door open. If the customer is in error, don't make an issue of it. Help the customer analyze the problems, and make suggestions on how to avoid future mistakes. If no solution has been reached, leave the customer with a definite plan of what future action you will take and be sure to FOLLOW THROUGH! Remember your objective: you are not there to win an argument but to avoid one if possible. You want to be of help and to be the customer's friend.

Conclusion

As we try to pull all of this together, still earnestly trying to be of sincere service to the customer, we, as seedsmen, see the problem as agronomic, pathological, chemical or entomological. Yet, to a lawyer who is not familiar with these disciplines, the problem is a potential case of negligence, misrepresentation, mislabeling, failure to warn, or even legal fraud under the statutes of your state. If an acceptable answer is not found among all of these disciplines, the lines may begin to rapidly converge, and you will then have a legal problem in addition to an agronomic or pathological one.

Although legal jargon is of little value out on the turn-row, and in fact, might be harmful to the satisfactory resolution of the problem, there comes a time when all the disciplines need to be welded together to form a new discipline. At that point, we need competent legal help. At the same time, counsel needs all the professional help we can provide. It is essential in dealing successfully with legal problems in agriculture, that we select a lawyer who will work with us and listen to us, and use the facts we have helped to accumulate to carry on our defense in a highly professional manner to assure the greatest degree of success; simply put: to win the lawsuit.

In closing, with all the natural hazards that affect seed emergence, plant growth, crop production, and the difficulty in explaining these problems to those who have had little or no exposure to the causes of such problems, we can take comfort in the fact that the seed industry's lawsuits have not been more numerous. However, as more and more customers are encouraged to seek legal remedies, we, in turn, must become more knowledgeable concerning all aspects of our business, especially in the technical area of problem-solving. We must be more responsive, alert and intentional in defending ourselves.

SEED TREATMENT UPDATE AND FORECAST

Kyle Rushing[1]

Seed treatment application relates to the placement of those products - fungicides, insecticides, minor elements, herbicides, herbicide safeners, dyes, plant growth regulators, etc., which are considered beneficial or necessary in maintaining or enhancing the, genetic yield potential of a crop. Those products being applied are termed "seed treatment(s)."

During the past two years, we have seen and become a part of a transitional period in the area of seed quality improvements which may be termed the "new era in seed treatment technology." Indeed, the practice of applying additives to seed is becoming an exact science which must be recognized by both the research and commercial communities.

The term "transitional period" has taken on a new definition during the past few months. Prior to recent guidelines published by the Environmental Protection Agency (EPA), this term identified the introduction of the new, highly systemic compounds which will provide increased activity and season long suppression of many diseases and insects, which until recent years had to be controlled by genetic resistance and/or in furrow or foliar applications of pesticides. The new guidelines of EPA will require all pre-1972 chemical registrations to be up-dated with a modern data base which meets the same requirements imposed on post-1972 chemicals. The costs of conducting these investigations in most cases will run into millions of dollars with no guarantees that the chemicals will meet the requirements. Many companies have some very important decisions to make in the immediate future, and their response could dramatically impact the seed treatment industry.

As we look at the list of the pre-1972 products -- Captan, Rhodamine Dye, Thiram, Maneb, Busan, Botran, Lindane, Terrazole, Lesan, Terrachlor (PCNB), Demosan, etc, one can quickly relate to the seriousness of these new guidelines. The effect will not be immediate but will affect each chemical as it comes under review by EPA over the next few years. Potential replacement products are presently available not in all areas. The chemicals in question are very broad spectrum in their ability to provide protection and the replacement

----

[1]Vice-president, Research and Development, Gutafson, Inc. Dallas, TX.

products are generally very specific and have a narrow spectrum of activity.

Therefore, we find ourselves potentially having several voids which will affect all cropping areas. During the past twenty-five years, both Captan and Thiram have established themselves as the basic standard seed treatment protectant fungicides because of their ability to provide protection against both seed-borne and soil-borne disease pathogens. The margin of safety to the seed, and to the environment, proved to be much greater than the mercury seed treatments which these products replaced. The non-volatile activity of both Captan and Thiram, as compared to the mercurial products, did encourage the development and introduction of systemic products, i.e., Vitavax®, Apron®, and Baytan®.

New Products

My discussion, to this point, has cast potential "black clouds" over seed treatment in the future, there are several new products which have or will soon receive federal registration for use in this area. These include fungicides, insecticides, and biological agents which will provide specific modes of activity for disease and insect control. A brief description of these will give you an introduction to the new seed treatments which you can use to enhance or maintain the quality of your present products. None of the chemicals discussed are a replacement for good seed quality or genetics, as these only enhance the products sold.

Gustafson APRON® FL is a systemic fungicide which was discovered by Ciba-Geigy Corp. This product is very specific in activity for the Phytophthora, and therefore, should be used with a broad spectrum fungicide when used commercially. This product is the first systemic fungicide to provide systemic activity against these diseases; therefore, there is a tremendous potential for this product in many cropping areas, i.e., alfalfa, cotton, sunflowers, sorghum, sugar beets, soybeans, edible beans, grasses, etc. Improved crop emergence, plant establishment and yield enhancement normally occur when Apron is used. The product is presently registered on several crops and during 1985 we expect additional uses to be approved by EPA. Apron is also registered for use on peas and sunflowers being exported to Europe.

Gustafson QUANTUM™ 4000 is a biological inoculant introduced into the U.S. peanut seed treatment market during 1984. This is a bacteria which can be incorporated directly with commercial fungicide seed treatments, which during the seed germination phase colonizes the developing root system, resulting in a healthier and highly productive root support system. Yield improvements averaging 9-10% have been reported during the 1983 and 1984 research periods. Quantum 4000 is being investigated on cotton, sugar beets, small grains, soybeans, potatoes, and peas. Selected strains will be developed for each of these new use areas.

Gustafson BAYTAN 30 FL is a systemic fungicide discovered by Bayer-Germany. This product is presently one of the leading wheat and barley seed treatments used in Europe. Baytan's direct and indirect activity extends well beyond the seed-seedling phase of the plant, thus, providing protection against many foliar and root diseases which limit yield. Because of the number of diseases, either suppressed or controlled by this product, yield improvements occur consistently and are normally significant. The activity against loose smut, covered smut, flag smut, barley stripe, Septoria, leaf rust, stem rust, take-all, powdery mildew and crown rust makes this product an excellent product for the high-tech management programs being introduced into the U.S. small grain production areas. Baytan represents the first chemical to be applied as a seed treatment which will substitute as a replacement for a foliar fungicide application. The cost of the seed treatment is approximately 20% of the cost of a foliar spray. A Federal EUP, or label, should be approved so that product will be available by the 1985 winter wheat planting season.

Gustafson RELDAN® insecticide is a grain protectant discovered by Dow Chemical Co. This product will be registered as a stored grain insecticide which will compete with products such as malathion and various fumigants. At a use rate of 6 ppm, grain will be protected against "all" insects for 9-12 months. Upon stored-grain registration approval, seed treatment uses will be applied for and, once granted by EPA, Reldan will compete with malathion, methoxychlor, and Dipel, which are presently the standards used as seed protectants. Reldan will significantly reduce the cost below that of the present protectants. Registration is expected during 1985.

Gustafson TOPS 2.5D®, a potato seed piece treatment, is a specific formulation of Topsin M® designed by Gustafson for use on cut potato seed pieces. The activity of TOPS 2.5D against Pythium, Fusarium, and Rhizoctonia places this product in a class by itself. No competitive products are as effective and broad spectrum in disease control potential.

Gustafson EPIC® 500 is a systemic fungicide from BASF-Germany. This product is broad spectrum in activity, but is highly systemic and active against Rhizoctonia in cotton. In 1983 and 1984 a Federal EUP was granted, and we are hopeful for full Federal clearance during 1985. This product, in combination with APRON, lead the National Cotton Seed Treatment Trials for the past two years.

MAGNUM® is a new systemic insecticide-nematicide candidate which has been evaluated by Gustafson during the past 18 months. This product has two characteristics which are extremely important: 1) excellent insect and nematode activity; and 2) a high margin of safety to seed, humans, and non-target pests. We will be evaluating this product against several insects on many crops during 1985. Some examples are: thrip; aphid; seed corn maggot; wireworm; cutworm; bean leaf beetle; flea beetle; stem weevil; greenbug; chinch bug; nematodes (soybean, cotton, wheat, corn); corn root worm; European corn borer; ants; etc.

In summary, there is one thing that you can be assured of in the very near future -- CHANGE. The seed treatment world is changing quite rapidly and will continue at an escalated rate. The standard treatments, with which we are familiar and with which many of us have grown up, are now very questionable products for the years ahead. We must continue, as an industry, to stay informed and work together as we strive to provide the grower the best varietal genetics and seed additives to maximize production.

RAPID METHODS FOR ESTIMATING GERMINABILITY

Charles E. Vaughan[1]

Seedsmen are showing enthusiastic interest in methods and techniques for rapidly determining seed viability. They see in these "quick-test" methods the tools for increasing operational efficiency and minimizing risks.

It is not an uncommon occurrence that a seedsman buys a lot of seed, runs the lot through expensive conditioning and cleaning operations only to find, several weeks later, when a seed analysis report arrives, that low germination renders the seed almost worthless. An alternative to the above procedure is to not condition the seed and wait for the germination report. A simple, fairly accurate method for rapidly estimating viability would provide a much better solution to this problem.

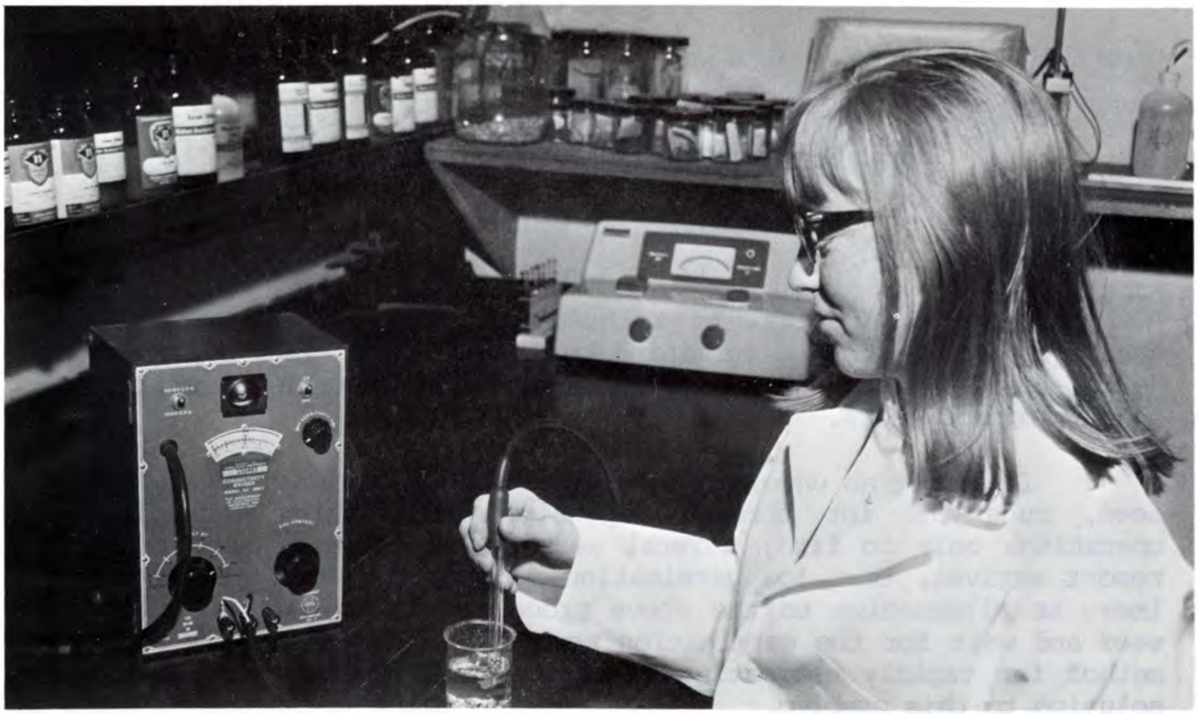
Attempts at rapidly estimating the viability of seeds goes back more than three quarters of a century. In 1901, Waller (10) reported on an electrical method for determining viability of seeds. He demonstrated that viable seeds when subjected to an electrical current gave so-called "blaze currents" which could be measured galvanometrically. Dead Seeds reacted differently to the treatment. Subsequent work on Waller's method showed that the technique was fairly reliable but very time consuming and required considerable technical competence.

The use of electrical methods for estimating seed viability took a somewhat different turn in the work of Hibbard and Miller (5). Their experiments were based upon the premise that non-viable seeds were more permeable than live seeds, hence, electrolytes leached out of dead or aged seed more rapidly. By soaking a quantity of seeds in water or a dilute solution of potassium permanganate and measuring the electrical resistance of the soaking solution, they were able to estimate germinative capacity of seeds with some accuracy (Figure 1A). Electrical resistance varied directly with viability.

Electrical conductivity techniques have shown considerable promise in rapidly estimating viability. Agro-Sciences, Inc., Ann Arbor, MI, developed an instrument (ASA-610) which has the capability of measuring the current flow in "soak" water of individual seeds (Figure 1B). In recent work at Mississippi State University (6), a

----

[1]Professor, Seed Technology Laboratory, MSU



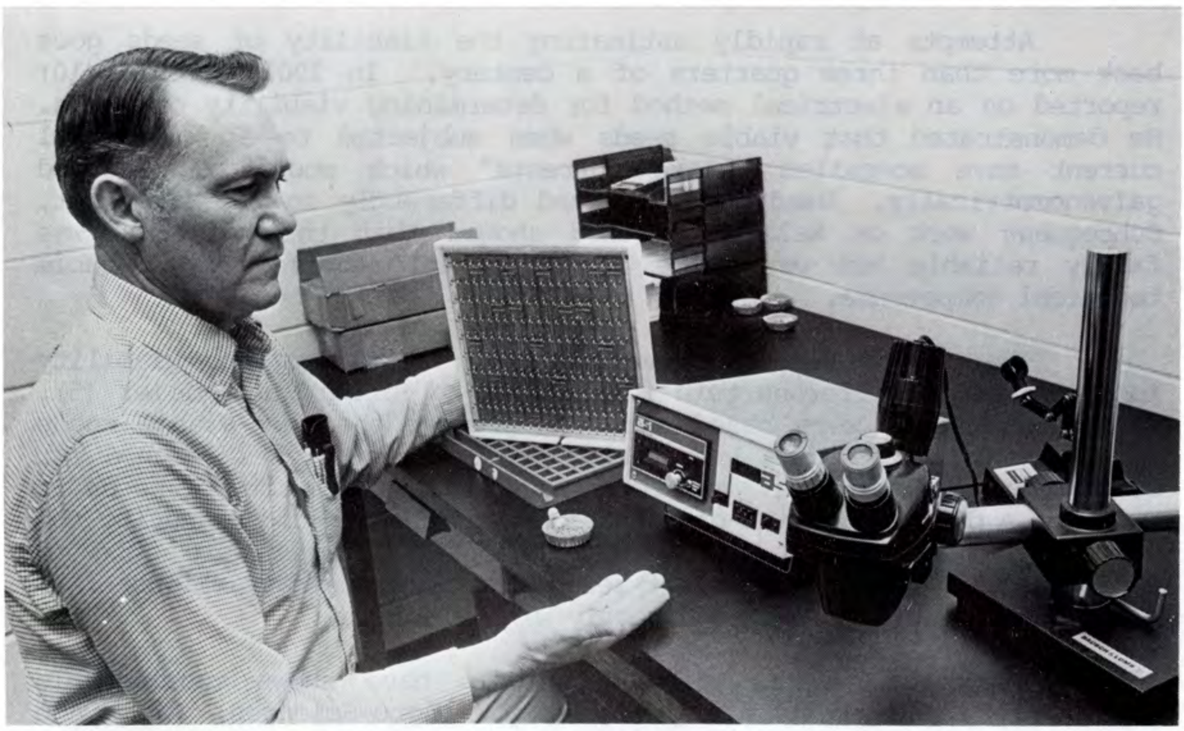


Figure 1. (Above) Measuring the electrical conductivity of the seep water from one seed lot. (Below) The ASA 610 apparatus permits determination of seep water conductivity of up to to 100 individual seed with each loading.

comparison of predicted germination and standard germination percentages was made for more than 100 lots of soybean seed. Predicted germination was within ± 10% of standard germination for slightly over 60% of the lots. Since over and under estimates of standard germination occurred with about equal frequency, use of the ASA-610 for assessing the quality of incoming soybean seed lots would result, on the average, in acceptance of lots of unacceptable quality, or discard of lots with acceptable quality in 4 out of every 10 cases.

Darsie et al. (3) based their approach to rapid viability testing on a phenomenon long known to physiologists, i.e., that germinating seeds liberated heat. They placed moist seeds in silvered Dewar flasks and measured heat production. Heat production was directly correlated with viability and vigor. For example, they found that the normal daily heat yield of 10g barley was 0.88°C and suggested that abnormally high heat yields resulted from contamination by fungi, that abnormally low heat yields were attributable to low viability and vigor.

It has long been known that temperature has great influence on the rapidity of germination. For most kinds of non-dormant seeds there is a temperature range over which final germination percentages are equivalent, however, within this range the higher temperatures promote more rapid germination.

Delouche (4) reported that germination tests of corn and soybeans carried out at 30°C could be terminated two or three days sooner than at the recommended 20°-30°C temperature and without reduction in accuracy. Also, reversing the temperature recommended for watermelons from 20°-30° to 30°-20°C (30° for 16 hours, 20° for 8 hours) allowed a four to five day reduction in test period.

Presoaking seeds in water prior to the germination test reduces, in some cases, the time required for the test (2). Moore (7) found that soaking cotton seed in a dilute soapy solution increased the rapidity of germination. Cotton seed germination can be determined in two to three days with fair accuracy by presoaking the seeds for several hours and germinating them at 30°C.

Seed buyers have traditionally based many of their decisions on the visual appearance of the seed under consideration. Certain characteristics affecting seed quality such as insect damage, mechanical damage, weathering, presence of weed seed and trash are easily evaluated by this method. It has also been determined, however, that more subtle characteristics are also related to or associated with seed quality, especially, seed viability. One of these characteristics is seed color. The possible use of seed color in red clover, white clover and crimson clover as an index of viability has been investigated. In general, dark colored (brown or rust) seeds of these crops were found to be low in germinability and vigor. The proportion of brown seeds in crimson clover was as high as 30%. Germination of the brown seeds was less than half that of the natural, straw colored seeds. These results indicate that with further development, seed color might serve as a rough index of seed viability.

Another test that provides a great deal of information about the viability of seed is the cutting test for cotton. When cotton seeds are split in half the embryo can be evaluated. The visual appearance or condition of the embryo provides a basis for judging the viability of individual seeds. The evaluation is based on the color of the embryo, the percentage of seed units completely filled and the number of immature seed found in the sample. The test is reliable and provides a lot of supplemental information.

Rate of seed swelling (water absorption) of small seeded legumes appears to be consistently and directly related to viability (8). It is also a very easily evaluated characteristic. Seeds are placed on moist blotters at 20^{0}C and the number of seeds swollen after various time intervals is determined. Seeds swollen at the end of one hour were generally dead. Seeds of white and red clover swollen by two hours were also very low in viability. With further refinement, rate of seed swelling has considerable potential as an index of viability even though it can probably never be applied with the precision of the tetrazolium test.

Several useful modifications of basic radiographic procedures have been developed for medical purposes. With little technical change, these procedures can be applied to seed research and to rapidly viability testing. They are, however, most useful in evaluating the difficult-to-germinate tree seeds. One such technique is tomography (9).

Tomography is a non-destructive X-ray technique for obtaining an image of any preselected plane with the specimen. Unlike a radiography, which is an image of all planes superimposed, a tomogram is an image of a single plane; it is similar to a photograph of a microtomed section. Tomography offers particular advantages to plant anatomists and physiologists because it is non-destructive. The same seed can be studied and then germinated.

Perhaps the tetrazolium test (Figure 2) is the most widely used and accurate method of rapidly estimating germinability. The test has been available since the mid-1940's and is relatively simple. The seeds are properly prepared, placed in a small beaker or other container, and covered with a solution of the chemical. After a period of time, they are removed and examined for the amount and pattern of staining. Proper interpretation of the color reaction provides a quick estimate of the viability of the seed.

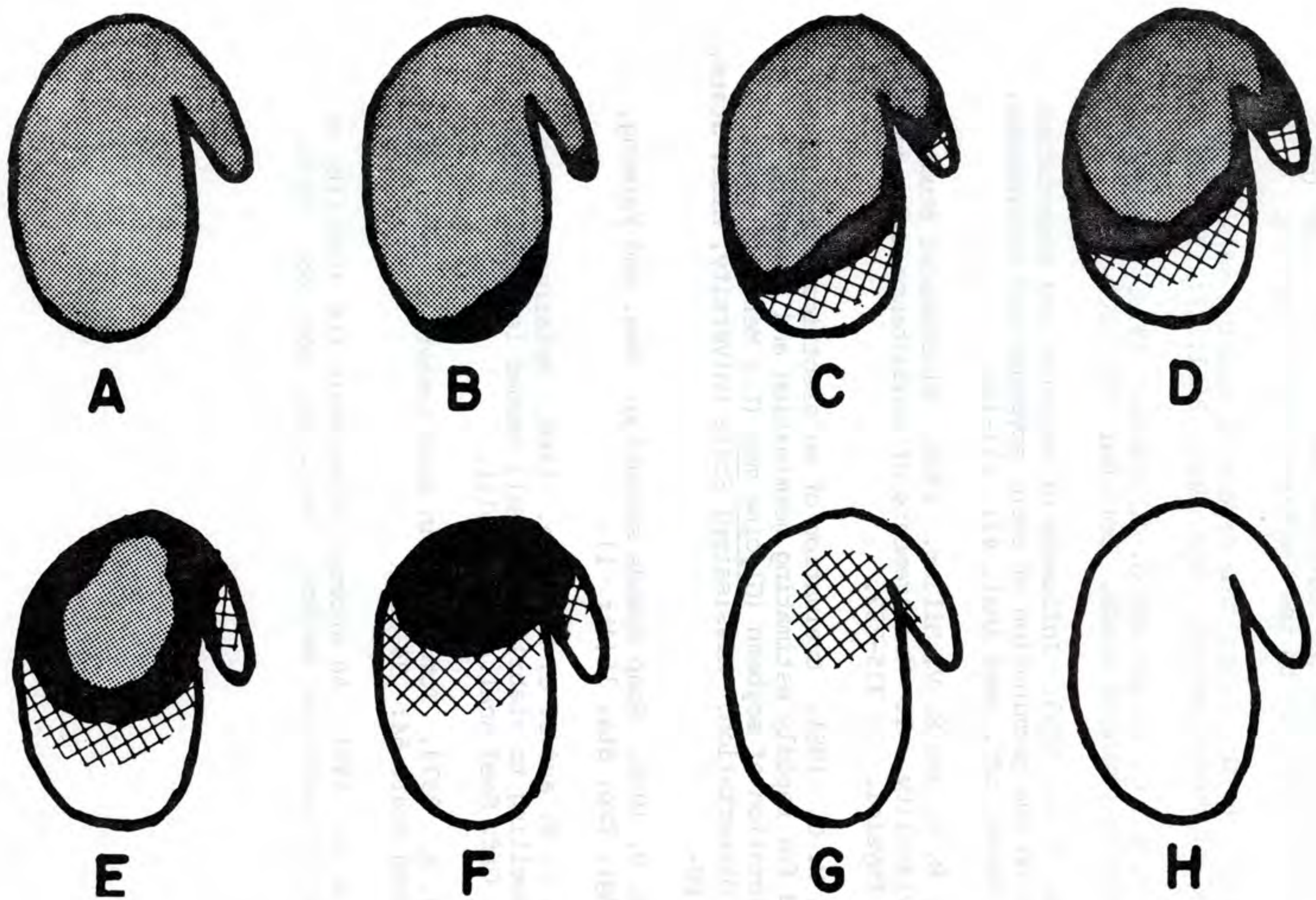


Figure 2. Pattern of deterioration in crimson clover seed as manifested in tetrazolium test reactions. Fine stippled areas represent normal, cherry red stains; black areas represent abnormal, dark purple stains; cross-hatched areas represent milky or cloudy red stains; white areas represent absence of stains.

References

1. Association of official Seed Analysts. 1970. Tetrazolium testing handbook for agricultural seeds. D.F. Grabe (ed.) contribution No. 29 to the Handbook on Seed Testing.

2. Chippendale, H. G. 1934. The effect of soaking in water on the "seeds" of some Graminae. Ann. Appl. Biol. 21: 225-232.

3. Darsie, M. L., C. Elliot and G. J. Pierce. 1914. A study of the germinating power of seeds. Bot. Gaz. 58: 101-136.

4. Delouche, J. C. 1953. Influence of moisture and temperature levels on the germination of corn, soybeans and watermelons. Proc. Assoc. off. Seed Anal. 43: 117-126.

5. Hibbard, R. P. and E. V. Miller. 1928. Biochemical studies on seed viability. 1. Measurements of conductance and reduction. Plant Physiol. 3: 335-352.

6. Miranda, M. C. 1981. Evaluation of an electrical conductivity method for rapidly estimating germination and assessing deterioration of soybean (Glycine max (L.) Merrill) seed. Ph.D. Dissertation. Mississippi State University, Miss. State, MS 96 pp.

7. Moore, R. P. 1958. Soap speeds sprouting. Res. and Farming. N.C. Agr. Exp. Sta. 16(4): 11.

8. Vaughan, C. E. and J. C. Delouche. 1960. Relation of rate of seed swelling to viability in small seeded legumes. Proc. Assoc. Off. Seed Anal. 50: 109-111.

9. Vozzo, J. A. 1974. Tomography in seed research. Proc. Assoc. Off. Seed Anal. 64: 94-96.

10. Waller, A. D. 1901. An attempt to estimate the viability of seed by an electrical method. Proc. Roy. Soc. 68: 79-92.

PHYSIOLOGICAL SEED QUALITY

James C. Delouche[1]

Seed quality is determined by attributes or traits that can be grouped into four categories: GENETIC factors - mainly, trueness-to-variety; PHYSICAL factors - attributes ranging from the traditional "purity" components to the incidence and severity of mechanical damage, to seed size; PATHOLOGICAL factors - type and incidence of seed borne diseases; PHYSIOLOGICAL factors - germinability, vigor. All of the categories of factors are important in the essential quality assurance "business" of a seed company and merit detailed discussion. Here, however, the emphasis will be given to PHYSIOLOGICAL SEED QUALITY.

What is Physiological Seed Quality?

The first and most crucial milestone in field and vegetable crop production is successful establishment of a uniform stand of vigorous plants. The degree to which this milestone is achieved has a great influence on the profitability of crop production. Crop stand establishment is mainly affected by two factors and their interactions: physiological quality or vigor of the seed planted and the microenvironmental complex of the seed bed.

Physiological Seed Quality

Physiological seed quality comprises those intrinsic attributes of seeds which determine their capacity to germinate and emerge rapidly and to produce a uniform stand of vigorous plants under the range of field conditions that can be encountered at planting time. Since the function of crop seed is propagation of the crop and fulfillment of this function requires that the seed perform in specific ways under greenhouse and field conditions that can vary over time and among locations during the planting season, physiological seed quality can, perhaps, be most easily conceptualized as the performance capabilities of seed.

The performance capabilities of seeds are maximum at the time they attain physiological maturity, which is usually some days before harvest. Thereafter, the performance capabilities of the seed--their physiological quality--are inexorably, irreversibly, and progressively

----

[1]Professor, Seed Technology Laboratory, MSU. Article based on paper published previously.

eroded by processes termed deterioration (also aging, degeneration) which are common in all living systems and culminate in death. While deteriorative processes in seed are inexorable, their rate is strongly influenced by the climatic conditions that prevail in the seed field before and during harvest and the specific practices used to harvest, condition, store and distribute seed for marketing to producers. Thus, the physiological quality of a seed lot at any given time is essentially determined by the extent to which the individual seeds in the lot have deteriorated.

Deterioration of seeds is progressive, and its consequences in terms of effects on seed performance capabilities are sequential and increasingly serious. The fundamental deteriorative changes occur at the cellular or sub-cellular levels and affect the integrity, functional capacity, and efficiency of nuclear materials, organelles, membranes, and biochemical mechanisms that control and "drive" the physiological processes required for seed performance. At the seed--or seed response--level the consequences of deterioration are manifested as a progressive reduction in performance capabilities.

The final and most serious consequence of deterioration is death, which for crop seed can be equated with loss of the capacity to germinate (Figure 1). Before this final state is reached, however, a sequence of lesser consequences arise during deterioration which impair other aspects of performance--other capabilities--that are important in crop stand establishment and production. The lesser consequences of seed deterioration will be considered later in this discussion.

Germination Percentage

Germination percentage is the most widely used and recognized index of physiological seed quality. It is determined by standardized tests developed and refined over the past 100 years. Yet, even at the beginning of organized seed testing, it was recognized that germination percentage had limitations as the index of the stand and plant-producing potential, or field value, of seed. These limitations have become increasingly clear and more serious with advances in crop production technology (and costs of production) and our knowledge of seed physiology.

The deficiencies of germination percentage as an index of the performance capabilities of a seed lot in crop production stem primarily from the test methodology that has been evolved to establish germination percentage, and the aspect of performance the test assesses. Germination tests are made under conditions that are rather "artificial" and highly optimal for the level of seed performance to be assessed, i.e., capability of the seed to germinate and develop into a "normal" seedling. The near ideal conditions of the test and

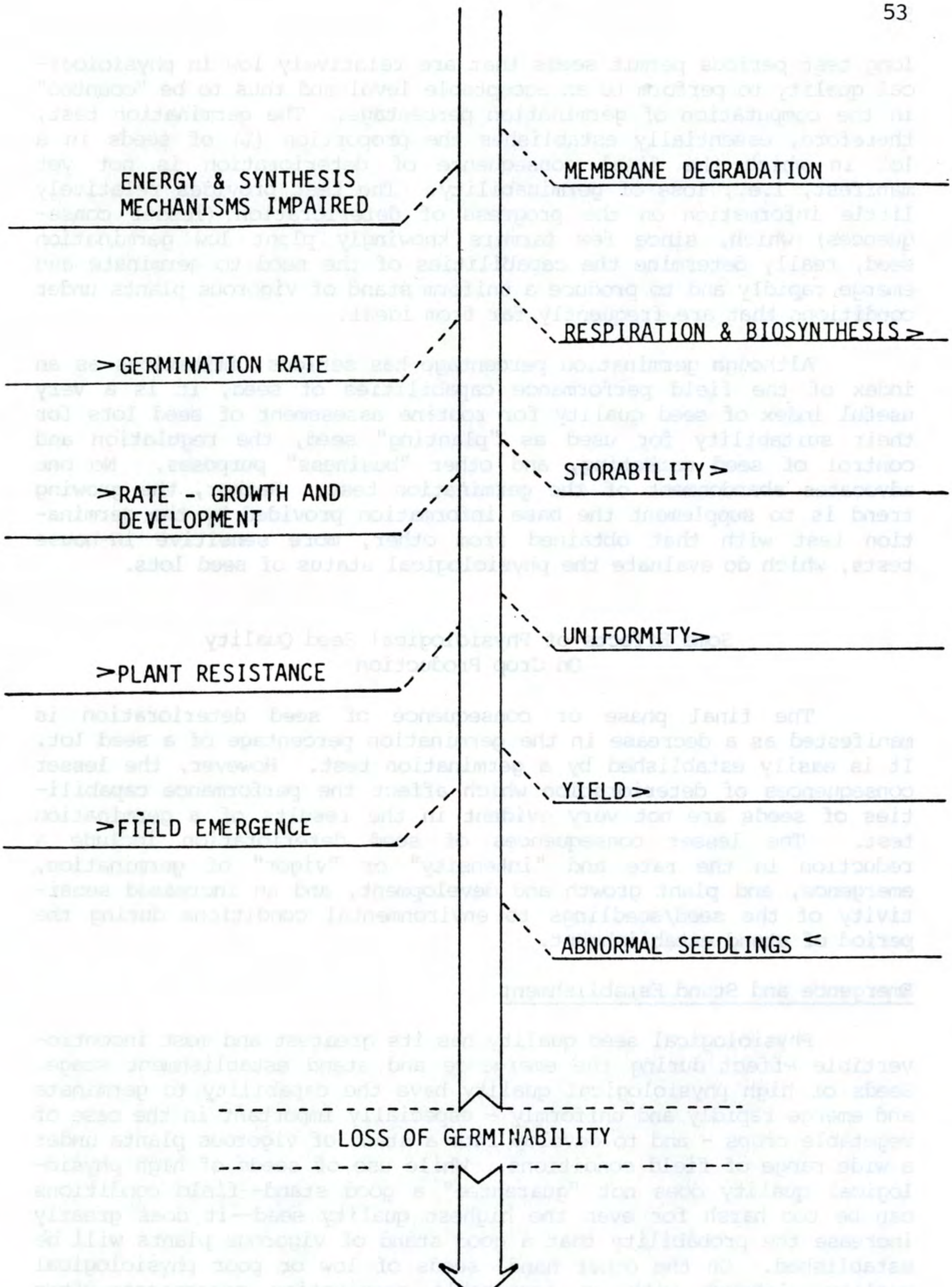


Figure 1. Possible sequence of changes in seed during deterioration.

long test periods permit seeds that are relatively low in physiological quality to perform to an acceptable level and thus to be "counted" in the computation of germination percentage. The germination test, therefore, essentially establishes the proportion (%) of seeds in a lot in which the final consequence of deterioration is not yet manifest, i.e., loss of germinability. The test provides relatively little information on the progress of deterioration (lesser consequences) which, since few farmers knowingly plant low germination seed, really determine the capabilities of the seed to germinate and emerge rapidly and to produce a uniform stand of vigorous plants under conditions that are frequently far from ideal.

Although germination percentage has serious limitations as an index of the field performance capabilities of seed, it is a very useful index of seed quality for routine assessment of seed lots for their suitability for used as "planting" seed, the regulation and control of seed marketing, and other "business" purposes. No one advocates abandonment of the germination test. Rather, the growing trend is to supplement the base information provided by the germination test with that obtained from other, more sensitive in-house tests, which do evaluate the physiological status of seed lots.

Some Effects of Physiological Seed Quality On Crop Production

The final phase or consequence of seed deterioration is manifested as a decrease in the germination percentage of a seed lot. It is easily established by a germination test. However, the lesser consequences of deterioration which affect the performance capabilities of seeds are not very evident in the results of a germination test. The lesser consequences of seed deterioration include a reduction in the rate and "intensity" or "vigor" of germination, emergence, and plant growth and development, and an increased sensitivity of the seed/seedlings to environmental conditions during the period of stand establishment.

Emergence and Stand Establishment

Physiological seed quality has its greatest and most incontrovertible effect during the emergence and stand establishment stage. Seeds of high physiological quality have the capability to germinate and emerge rapidly and uniformly - especially important in the case of vegetable crops - and to develop into a stand of vigorous plants under a wide range of field conditions. While use of seeds of high physiological quality does not "guarantee" a good stand--field conditions can be too harsh for even the highest quality seed--it does greatly increase the probability that a good stand of vigorous plants will be established. On the other hand, seeds of low or poor physiological quality--although with an acceptable germination percentage--often either fail to produce an acceptable stand or produce one that is less than satisfactory. A stand failure means additional costs for replanting and can mean loss of markets, and reduced yields. Less than satisfactory stands are often retained by farmers because of time and other constraints, even though they know that weed problems will be greater, produce quality will be poorer, and that there will probably be some short-fall in yield.

In terms of stand establishment, therefore, use of physiologically high quality seed is about the best "insurance" a farmer has against the adverse climatic conditions that often occur at or just after planting time (e.g., heavy rains, low soil temperatures).

Plant Growth and Development

There is no doubt that the reduced rates of germination and seedling growth associated with seeds of poor physiological quality "persist" during plant growth and development. Studies in our laboratory and elsewhere have shown that seedlings from poor quality seeds grow more slowly, develop less leaf area and flower somewhat later than those from seeds of high physiological quality. This reduction in rate of plant growth and development has been measured at both "normal" plant spacings and in individual plants isolated from competition from other plants. Slower plant growth and leaf area development delays the onset of the beneficial effects of shading and canopy closure in terms of weed control. In the case of root crops such as radish or turnips, slower growth means substantially less yield at harvest.

Yield

Yield studies conducted by our laboratory have indicated advantages for seed of high physiological quality. About half of studies have demonstrated reductions in yield of up to 10% attributable to poor physiological quality of the seed planted. It should be pointed out that in most of the studies referred to, reasonably good stands were produced for all treatments by adjusting plant rate on the basis of physiological quality of the seed. The other half of the studies indicated that while emergence and juvenile plant growth are reduced in plantings with seeds of poor physiological quality, the plants eventually "catch up" and yield is not reduced.

Measurements of Physiological Seed Quality

Reference has already been made to the increasing use of supplemental tests to evaluate the physiological quality or vigor of seed lots more accurately than is possible with the standard germination test. The supplemental tests used for this purpose are called "seed vigor tests."

The basic strategies followed in seed vigor testing are to establish the vigor level of a seed lot by direct measurement of the rate and/or status of some important seed property or process, or by evaluating the response/performance of seed lots under controlled conditions--usually "stress" conditions. These strategies are based on well-documented changes that occur in seed as they deteriorate.

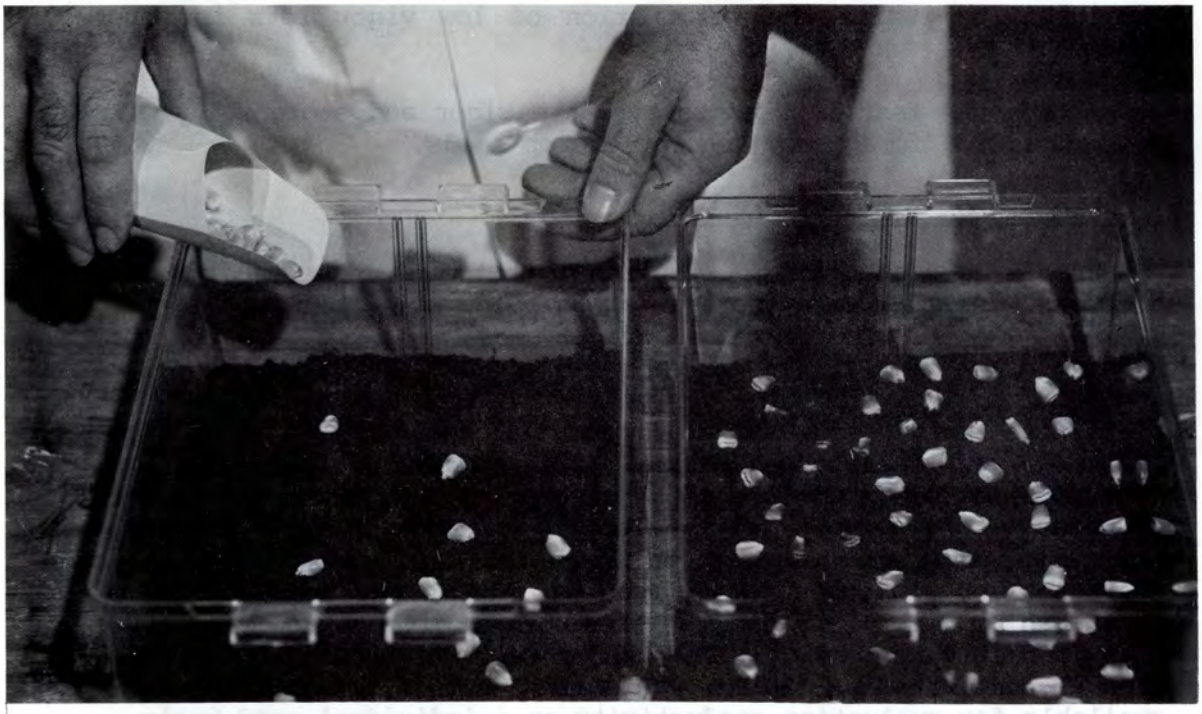
Direct measurement of the rate/status of seed properties and processes include measurements of the "cellular energy status" or "ATP pool", the rate of respiration, the activity of specific enzyme systems, the "leakiness" of the seed membranes, and the rate of germination and seedling growth. Seed vigor evaluations based on the response or performance of seeds under controlled "stressful" conditions include the well known and widely used cold (soil) test for corn and other seed kinds, the cool temperature germination test for cotton seed, and the accelerated aging test for a variety of seed kinds. The four most widely used vigor tests are discussed below.

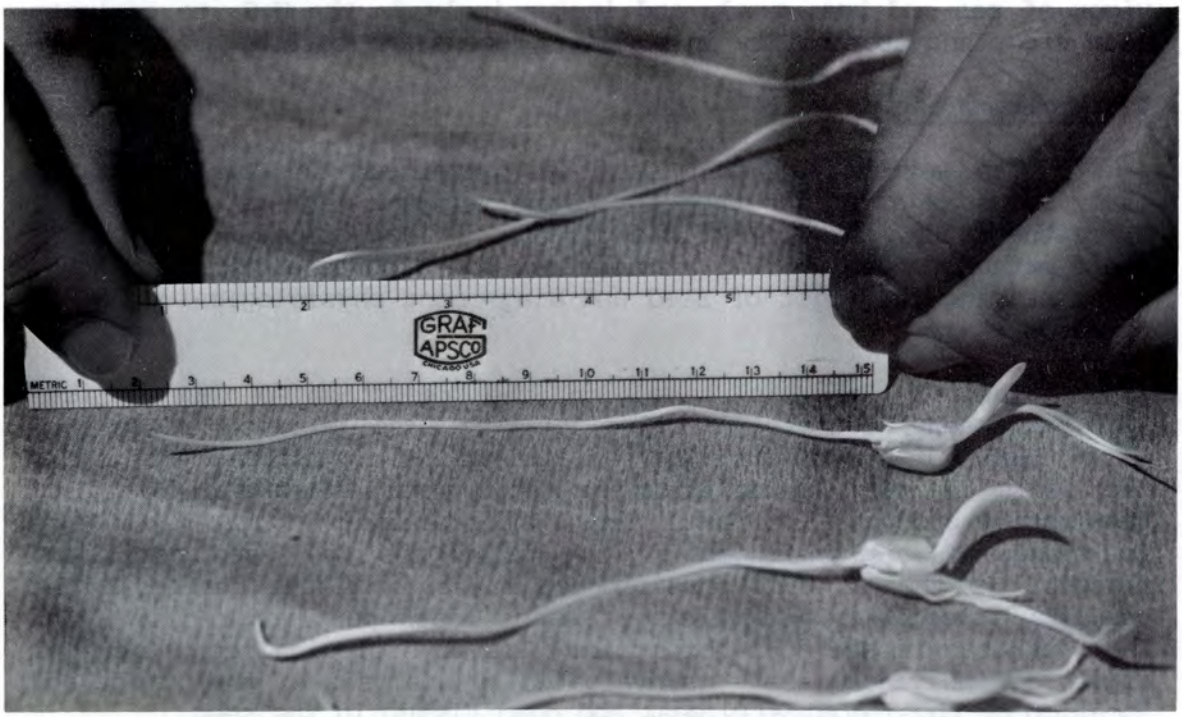
Cold Soil Test

The cold soil test was developed in the late 1930s to evaluate the germination and emergence capabilities of corn seed lots under laboratory conditions that stimulate the cold, wet field conditions that can occur at planting time. Corn seeds of the lots to be evaluated are planted in a mixture containing soil collected from a "cornfield" that is adjusted to a relatively high soil moisture level (fairly wet), and incubated at 50^{o} F for 5 to 7 days. The tests are then moved to a warm temperature (80^{0} to 86^{0} F) for emergence. Emergence of seeds of high vigor is only slightly reduced by the cold/wet soil stress, while emergence of low vigor seed is severely reduced. The cold test is also very useful for evaluating the efficacy of seed protectant fungicides applied to corn seeds. It also has been adapted for use for other kinds of seed, such as peas, soybeans, cotton. The correlation of cold test responses (emergence) and actual field emergence under cold and wet conditions is good.

Accelerated Aging Test

The accelerated aging (AA) test was originally developed to evaluate the storage potential of seed lots. However, since the storage potential of seed lots is a performance capability determined by the physiological quality or vigor of a seed lot, the AA test is also an excellent vigor test. Seeds of the lots to be tested are subjected to a high temperature (40 to 45C or 104 to 113F) at nearly 100% relative humidity for 3 to 6 days, depending on the kind of seed. At the end of the treatment, the seeds are planted for a standard germination test, and the germination percentage after AA is determined. The germination percentages of seed lots following accelerated aging are indicative of their vigor. High vigor seed lots retain their





Primary root growth is one expression of vigor.

germinability, while the germination of low vigor lots is severely reduced.

The AA test is used to evaluate vigor and storability of many kind of field, forage and vegetable crop seeds.

"Leakiness" or Conductivity Test

It has been well established that the permeability of seed membranes is impaired by deterioration - the seeds become "leaky" when placed in water. The leakiness of the seeds in a lot is determined by placing a specific number of seeds in a specific volume of deionized water for a period of time (usually 24 hours) and then measuring the electrical conductivity or resistance of the "steep" water with an electrode and resistance bridge. The materials that leak out of deteriorating seeds include electrolytes which decrease the resistance of water to the passage of an electric current. High vigor seed are not very leaky, so the water in which they are steeped gives a high resistance or low conductivity reading. Low vigor seed, on the other hand, can be very leaky and the steep water gives a low resistance or high conductivity reading. The conductivity tests are usually made on a seed sample, e.g., 20 to 100 seeds, but a modern instrument is available for evaluating conductivity on a individual seed basis.

The conductivity test is used in England for evaluating the vigor of pea and bean seed, and increasingly in the U.S. to evaluate seed vigor and storability in soybeans, beans and cotton.

Tetrazolium Test

The tetrazolium (TZ) test was developed in Germany in the early 1940s as a rapid method for estimating the germination of seed. Since the 1960s, the TZ test has gained wide acceptance not only as a rapid method for estimating germination, but also as a powerful method for assessing the vigor of seed and diagnosing physiological problems of seeds.

The TZ test is based on the reduction of a chemical (2,3,5-triphenyl tetrazolium chloride) from a soluble, colorless form to an insoluble red pigment by the activity of a group of enzymes in the cells of seed. The enzymes, dehydrogenases, are involved in respiratory processes in seed. Thus, their activity, i.e., capability to reduce TZ, is an index of the "aliveness" of seed cells and tissues. In the TZ test physiologically sound tissue stains bright red, physiologically weak tissue "stains" dark purplish red or faint red, and dead tissue does not stain. The physiological condition (or vigor) of individual seeds is evaluated by analysis of the extent and location of physiologically weak and dead tissue in the seed.

The overall objective of seed vigor testing is to evaluate the physiological quality of seed. The specific objectives in using any one or a battery of vigor tests ranges from diagnosis of physiological quality problems in in-house quality control programs to evaluating the stand and plant-producing potential of seed lots for marketing.

Summary

Crop stand establishment is mainly affected by the physiological quality or vigor of the seeds planted, the microenvironment of the seed bed, and their interactions. The germination test which has long been the standard test for evaluating the stand and plant producing potential of seed lots, has serious limitations. The test is made in the laboratory under near optimal conditions, which seldom occur in the field, and germinability, the seed capability evaluated, is lost only in the most advanced stages of deterioration. Recognition of the deficiencies of the germination test has prompted the development and increasing use of a variety of supplemental tests, called vigor tests, which can be used to establish the physiological quality or vigor of seed lots much more effectively than does the standard germination test.

The physiological quality of seed affects germination, emergence and plant growth and development. In certain situations, yield reductions can also be a consequence of planting seed of low physiological quality.

Considering the need of farmers to reduce the risks associated with crop production to the greatest extent possible, a decision to plant high quality seed is a good place to start.

SEED ADDITIIVES: COATING/PELLETING

Ed Bartkowski[1]

Application of organic and inorganic substances to seed was described in the literature over 100 years ago. Prior to engineering precision seed planters, economic production of most vegetable crops and in particular root crops such as carrots was limited by the high labor expense of thinning a stand. Coating and pelleting of seed improved seed size and shape uniformity and insured precision planting with state of the art planters. Additionally, coated seed substantially reduced the labor costs of thinning a crop and increased to 90% plus the marketable pack-out product.

With the realization that forages were of agronomic and economic significance, scientists, growers and governmental agencies increased sowing of forages on marginal soil types and rugged terrains. Aerial seeding opened new areas but lack of adequate seed ballistics produced less than uniform results. The additional weight of coating rendered the needed ballistics and provided a delivery system of biological organisms and chemical agents along with the seed to improve stand establishment.

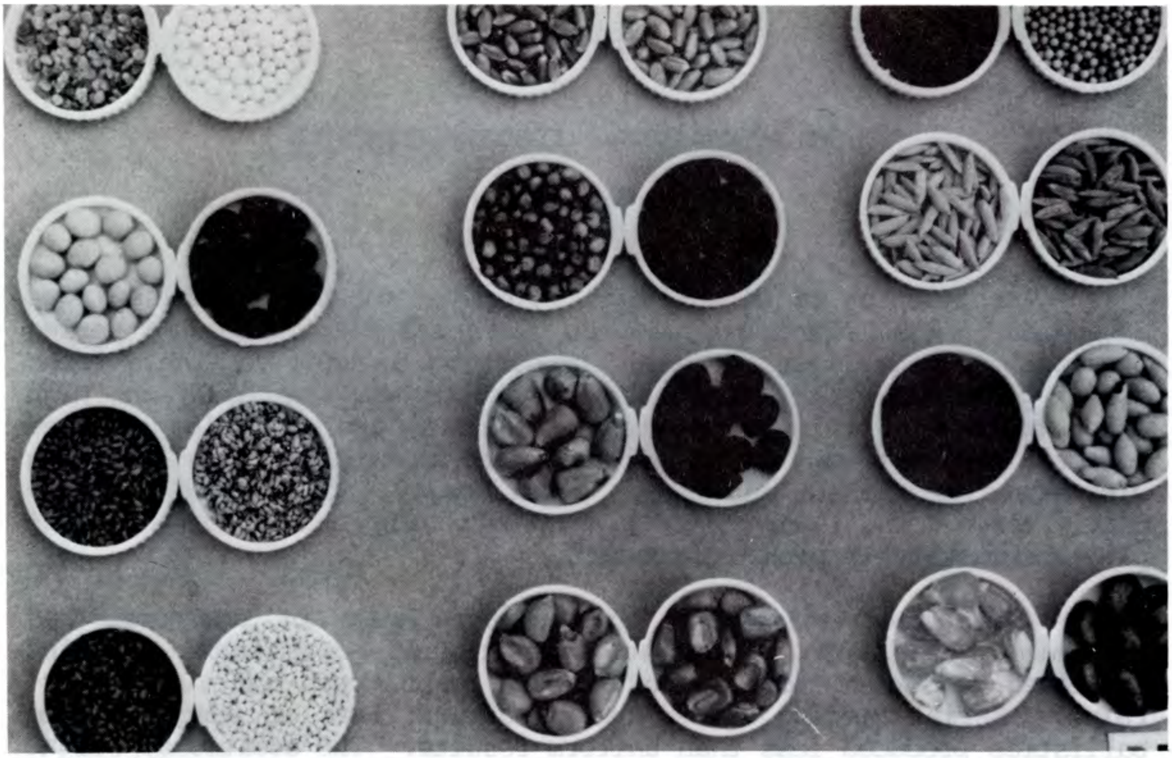
Seed size and planting methods for large grain seed are such that handling is not a major problem. Nevertheless, reasons for coating and pelleting grain seed include flexibility in sowing time and uniform seed size to reduce the number of graded seed types that are carried in inventory by hybrid seed companies. Additionally, loading capacity through coating onto seed provides a delivery system to the zone of utilization for multi-functional and protectant compounds.

Today, a combination of improved polymeric chemistry, exacting formulations, process specifications and quality assurance has provided multi-functional seed coatings whose benefits have been confirmed by researchers and been profitable for growers.

A wide variety of fillers can be employed with seed without toxic reaction. The selection of filler might therefore depend on factors including availability, ease of handling and the objective of circumventing undesirable soil conditions.

----

[1]Director, Research and Quality Control, CelPril Industries, Inc., Manteca, CA



Coated and uncoated seed of various field and vegetable crop seed.

Differential seedling growth of maize resulting from coating (R) and not coating (L) seed before planting.

A variety of binders have been utilized. Certain solvent-binders or adhesive solutions have generated difficulties, but no generalized basis for exclusion of binder ingredients is certain. Important binder characteristics include gas and moisture permeability, relatively facile divestment of the pellet and a bio-degradable nature. This usage has been more predicted on availability and the non-toxic character expected than on utilization of the bio-degradable feature for timed release of the seed from the coat or pellet.

Seed coating and pelleting combinations of nutrients, fungicides, herbicides, buffering compounds and microorganisms contribute to major agronomic, horticultural and ornamental species. Coating and pelleting enables seed to germinate and emerge under less than ideal seed bed and soil moisture conditions. Coatings, especially containing fungicides, significantly enhance both percentage of seedling emergence and plant survival when compared with non-coated seed in field soils ranging in pH from 4.8 to 8.1. Coated seed generally consist by weight of one third coating material and two thirds seed. Pelleted seed may range as high as 50 parts pelleting material to one part seed.

Coated seed is a superior method of inoculation for legume seed. Coating provides 1) a substrate to carry very high numbers of rhizobia per seed, 2) a protective environment until conditions are suitable to support germination and nodulation and 3) a controlled method to match select strains of Rhizobium spp. for particular variety X environmental interactions. Nodulation of coated seed has been shown by university researchers to remain significantly higher over time than non-coated, pre-inoculated seed.

Incorporation of herbicides into both seed coatings and seed pellets has encountered limited success. Herbicide coating/pelleting appears to be most effective when the seed bed is finely prepared, soil moisture is slightly under field capacity and soil temperatures permit rapid seedling emergence. However, storage of herbicide coated/pelleted seed under typical warehouse conditions has been shown to be lethal to sensitive seed species.

SEED ADDITIVES: INOCULANTS

Thomas J. Wacek[1]

Rhizobia bacteria form a symbiotic association with legumes which results in the legume being able to fix gaseous nitrogen from the air into a form that is usable by the plant (ammonia). This association allows the legume grower to grow legumes without using nitrogen fertilizer as is required for non-legume plants and to grow a plant which can contribute usable nitrogen to succeeding non-legume crops such as corn.

Rhizobium bacteria are common soil organisms living and surviving in soils where legumes are normally grown. An inoculant is a concentrated form of Rhizobia bacteria which a farmer can use to ensure that the legume he plants will have an adequate supply of these organisms to obtain the maximum level of nitrogen fixation.

The farmer should use an inoculant when he has not grown legumes for a number of years in a particular area or when the area in which he is planting legumes has been exposed to stress conditions such as low pH or drought. Also, sandy or low organic content soils require the use of Rhizobium inoculants.

Rhizobium inoculants are available in either humus based or clay based forms. These can be supplied either as a pre-inoculant on purchased seed, or as a separate packaged inoculant product which the farmer applies to his seed at the time of planting. Also there are packaged inoculant products which include higher than normal levels of Rhizobium species along with stickers which allow the farmer to supply very high levels of bacteria for particularly stressful conditions of low pH and low soil moisture. These high levels of rhizobia may also be supplied as a calcium carbonate pelleted pre-inoculated seed.

Inoculants are prepared and applied to seed in several different forms with each inoculant type having one or more advantage or disadvantage as indicated in the chart below.

----

[1]Director, Research and Development, KALO Inc., Columbus, Ohio.

System or type of inoculant	Advantage	Disadvantage
pre-inoculated - humus	easy to use	number of Rhizobia may be less than optimum
pre-inoculated - clay	easy to use, good coverage of seed	number of Rhizobia may be less than optimum
pre-inoculated - with humus $CaCO_3$ pellet	very high levels of Rhizobia	more expensive
planter box - humus	fresh & high number of Rhizobia	not convenient for farmer, spotty coverage
planter box - clay	fresh & high numbers, very good coverage	not convenient for farmer
planter box - with sticker & high levels	very high numbers of Rhizobia	more expensive, time consuming

There are several "do's and "don'ts" concerning the use and handling of inoculants. The more important of these characteristics need to be reviewed occasionally with both the farmer-customer and company employees. The five more basic points concerning the use of inoculants are identified and discussed below.

1. Inoculants contain rhizobium species which must be alive and viable to work. These rhizobium bacteria are living biological organisms and must not be handled like chemicals or fertilizer. Therefore, we recommend that the farmer store inoculants or pre-inoculated seed in cool areas. Treat inoculants or pre-inoculated seed like you would like to be treated, i.e., do not store where they will become too hot and dry or too cold.

2. Rhizobium inoculants are specific. This means that only inoculants labeled for alfalfa will work on alfalfa. Or conversely, an inoculant labeled for use on clovers, soybeans or other legumes will not work on alfalfa.

3. Some seed are planted after mixing with fertilizer slurries. This is acceptable as long as the pH of fertilizer is above 6.0. Inoculating alfalfa seed which has been treated with a fungicide is acceptable at the planter box but it is recommended that the farmer inoculate fungicide treated seed just prior to planting. Pre-inoculated seed which also have been pre-treated with a fungicide is satisfactory since the seed processors and inoculant companies only do such mixed pre-treating when they have already checked the compatibility of the particular fungicide and rhizobia.

4. Do not use an inoculant which has expired. Every inoculant company places an expiration date on their inoculant packages. After this date, the manufacture can no longer guarantee that the rhizobia are present in sufficient number to supply an adequate level of rhizobia. Therefore, be sure to check the expiration date given on the package.

5. Use a sticker when using a packaged planter box inoculant. The instructions for use are on the package. This is important because the seed are the carrier of the inoculant into the soil, and it is important to get as much of the inoculant as possible in the area of the developing roots. In this regard, it is important to remember that the rhizobium bacteria infect the developing root and not the seed. The use of a sticker takes more time, but it is time well spent because it ensures that most of the inoculant gets to the root zone.

Table 1 is from Advances in Agronomy Vol. 34, 1981, written by Tom LaRue and Tom Patterson and titled; "How Much Nitrogen do Legumes Fix?"

The values listed vary from state to state and from how the tests were made. However, the important point is that the values are quite substantial and illustrate the benefits of nitrogen fixation both with regard to the ability of legumes to manufacture their own nitrogen fertilizer and with regard to the ability of legumes to contribute nitrogen to non-legume crops.

A question often asked is, "When should a farmer use an inoculant?" There are three situations when the use of inoculants will pay big dividends. They are: (1) definitely when he has not grown the same legume in a particular field for more than two or three years; (2) anytime when a legume is planted in sandy, low organic soils, or soils exposed to stresses such as low pH; (3) when he is unsure of the number or quality of the rhizobium in his soils.

We believe it is important to look at rhizobium inoculants as one management tool which allows the legume to express its full genetic yield potential. Inoculation will not solve all the problems of growing legumes, but it can definitely assure you that you have eliminated one very important variable, i.e., the ability of the legume to have all of the nitrogen it needs.

The advantage the seedsman obtains from the use of an inoculant is that it provides one additional management tool which will ensure that the seed performs to its maximum genetic potential. The use of pre-inoculants, when possible, ensures the seedsman that the

Table 1. Nitrogen fixed by forage legumes.

Plant species	Amount of N fixed (lbs./acre/year)		Year Reported
1. Alfalfa	204 - 259	Geneva, New York	1933
"	189	Lexington, Kentucky	1950
"	132	Rosemount, Minnesota	1981
2. White Clover	114	Lexington, Kentucky	1950
	239	Northern Ireland	1976
"	47 - 168	Beltsville, Maryland	1954
3. Red Clover	137	Lexington, Kentucky	1950
4. Sweet Clover	125	Riverside, California	1949
5. Vetch	98	New Brunswick, N.J.	1936
"	164	Riverside, California	1949
6. Korean lespedeza	172	Lexington, Kentucky	1950

farmer will indeed use an inoculant. A disadvantage of pre-inoculation is that the inoculant may not be as viable as when the farmer applies the inoculant at the planter box just prior to planting.

Other points which the seedsman should consider with the use of inoculants are: (1) inoculants can affect the seeding rate, (2) the seed will look different after inoculation; (3) germination or other quality parameters may change depending on how fragile is the seed.

Finally, the seedsman must look at inoculants just as the farmer looks at them -- as one more, and necessary, management tool at his disposal with which he can ensure the performance of his seed and with which the seedsman can ensure the ultimate satisfaction of the farmer.

Figure 1. Plants of red clover from non-coated and "NOCULIMED" seed.

SEED ADDITIVES: CHEMICALS

Wayne A. Beckwith[1]

Seed treatment technology has entered into a new era. The traditional mercurial and Captan type compounds are being replaced or enhanced by new systemic type compounds. With this new systemic chemistry, new concepts in seed treatment research such as herbicide safeners, foliar fungicides and biological fungicides have already begun to leave the research laboratories and are now in commercial use. Thus, seed are no longer just a means of propagating a new crop but are also carriers of new agricultural management technology.

In the next few years, we should see seed increasingly become carriers for new technology providing superior disease, insect and nematode control for one to two months, or longer, after emergence. This new chemistry will allow pinpoint application of chemicals which will reduce the amount of chemical per acre versus other forms of application. This should complement integrated pest management systems and conservation tillage practices for a greater cost benefit per acre.

We may also be on the verge of a breakthrough in the disinfection of all types of seed-borne diseases. This includes fungal, bacterial and viral diseases. This type of technology will have significant impact on costly control measures for disease problems, like Halo Blight of beans, and reduce restrictions on international shipments of seed.

The introduction of biological fungicides provides season long suppression of some major soil-borne diseases. "Quantum™ 4000", a selected strain of <u>Bacillus subtilis</u>, is now used on peanuts. The bacteria colonizes the root system of the plant to suppress infection of <u>Rhizoctonia</u> and <u>Fusarium</u> throughout the growing season. "Quantum 4000" has been classified as an inoculant by EPA, and, is thereby exempt from registration.

Conventional seed treatment chemistry provided cheap insurance for stand establishment. Due to the narrow range of activity of most new systemics, these contact fungicides and insecticides will remain an important combination treatment for a broad range of disease protection. Such combinations are common today, like "Vitavax®" and

----

[1]Western Regional Research Manager, Gustafson Inc., Dallas, TX

Thiram on small grains and sweet corn and "Apron®" with Vitavax and Thiram or Captan on soybeans.

In the following tables, a listing of the major seed treatment chemicals in use today along with some potential new compounds under development for the near future is presented in the following tables. These tables are arranged by category of activity: Table 1) Contact fungicides, Table 2) Locally systemic fungicides, Table 3) True systemic fungicides, Table 4) Bacterial seed treatment, Table 5) Contact insecticides, Table 6) Systemic insecticides, Table 7) Biological seed treatments, Table 8) Herbicide safeners, and Table 9) Miscellaneous applications, including herbicides, trace elements, growth regulants, repellants, and osmotic regulants.

Paralleling these changes in seed treatment chemistry has been the development of seed treating equipment for safe, accurate application of these chemicals. All seed treating equipment utilizes three basic concepts: 1) A method to measure the chemical, 2) A method to measure the seed, and 3) A method to mix the seed with the chemical.

The first seed treatment materials, such as copper carbonate, were applied as a fine dust. Originally, farmers mixed the dust and grain together with shovels in their grainery. In 1926, Gustafson introduced the first mechanical seed treater for dust formulations to meet the need for more efficient application.

Thiram, mercury and Captan treatments were introduced as wettable powder formulations from the mid 1930's through the early 1950's. In 1946 the slurry treater was developed to allow the powder to be mixed with water and metered on to the seed as a slurry. In response to the development of true liquid mercury compounds, Gustafson developed the first Mist-O-Matic seed treater in 1955. Because liquid mercury needed to be applied at ultra-low rates, this treater provided good, uniform seed coverage by atomizing the small among to chemical through use of a spinning disc in the seed flow chamber.

In response to new seed treatment chemicals, such as Apron and Baytan® 30, that are more expensive and require very critical application rates, Gustafson recently introduced the Accu-treat™ treater. This treating equipment achieves greater application accuracy by volumetrically metering both the chemical and the seed.

In addition to the changes in seed treatment chemicals and equipment, two new concepts have been developed in the methods of applying chemical additives. First, is the need to achieve accurate dosing of each seed with these new systemic chemicals. The second new approach is polymer film coatings.

Table 1. Contact Fungicides.

Compound	Technical Source	Crops	Spectrum of Activity
Captan	Stauffer, chevron	Most major cops	Broad spectrum seed and soil-borne diseases
Thiram	DuPont	Most crops	Broad spectrum seed and soil-borne diseases
DIFOLATAN®	Chevron	Cotton, rice	Closely related to Captan
TERRAZOLE®	Uniroyal	Cereal grains, cotton, sugar-beets	Broad spectrum, Rhizoctonia
Maneb & related zinc mixtures	DuPont Rohm & Haas	Most major crops	Broad spectrum
Heavy metal fungicides	Kocide	Most seed type types	Seed-borne blights, Broad spectrum soil diseases
Kathon	Rohm & Haas	Cotton	Most seed and soil dis-eases, some bacteria
BOTRAN®	Upjohn	Peanuts	Rhizopus, Botrytis, Aspergellus
LESAN®	Mobay	Cotton, beets	Recently withdrawn by manufacturer Pythium, Aphanomyces

Table 2. Locally Systemic Fungicides.

Compound	Technical Source	Crops	Spectrum of Activity
DEMOSAN®	DuPont	Cotton, edible beans, soybeans	*Rhizoctonia*, *Sclerotium*, *Pythium*
TERRACLOR®	Uniroyal	Cereal grains most crops	Bunt, *Rhizoctonia*
Rovral	Rhone-Poulenc	No current US registrations	Broad spectrum, does not control *Pythium*

Table 3. True Systemic Fungicides.

Compound	Technical Source	Crops	Spectrum of Activity
VITAVAX®	Uniroyal	Cereal grains, cotton, rice, corn, peanuts, soybeans, edible beans	Smuts of cereals, *Rhizoctonia*, *Helminthosporium* *Phomopsis*, *Fusarium*
MERTECT®	Merck	Wheat	Dwarf and common bunt *Fusarium*
APRON®	Ciba-Geigy	Several major crops	*Pythium*, *Phytophthora*, downy mildew
GUS 4551	Sandoz	Pending registration	Same activity as APRON
Topsin-M	Pennwalt	Potatoes	*Rhizoctonia*, *Fusarium*
Benlate	DuPont	Crucifers	Black-leg
BAYTAN®	Mobay	Small grains registration pending	Smuts, bunts, leaf rusts take-all suppression
EPIC®	BASF	Cotton E.U.P.	*Rhizoctonia*, *Phoma*
IMAZALIL®	Janssen	Cotton, barley, wheat	*Thielaviopsis*, *Verticillium*, and *Helminthosporium*

Table 4. Bacterial Seed Treatments

Compound	Technical Source	Crops	Spectrum of Activity
Streptomycin	Pfizer, Merck	Edible beans, potato	Halo Blight of beans bacterial decay
GUS 4003	Not disclosed	Research only	Under investigation
GUS 4800	Not disclosed	Research only	Fungal, bacterial and viral-seed borne disease

Table 5. Contact Insecticides

Compound	Technical Source	Crops	Spectrum of Activity
Malathion	American Cyanamid and others	Seed and edible grains	Storage insecticide Lepidoptera, short residual
Methoxychlor	DuPont and others	Most seed	Storage insecticides Coleoptera
RELDAN®	Dow	Seed and edible grains, pending	Storage insecticide long residual at 6 ppm
ACTELLIC®	I.C.I.	Seed and edible grains, pending	Storage insecticide
LORSBAN®	Dow	Cotton, edible beans, sweet and field corn	Soil insects, seed corn corn maggot, seed corn beetles
Lindane	Chevron, I.C.I.	Several grain and vegetable crops	Soil insects such as wireworm, seed corn beetles and maggots
DIAZINON®	Ciba-Geigy	Edible beans, peas	Soil insects, seed corn maggot, short residual
Heptachlor	Velsicol	Cereal and grain crops	Soil insects, registration canceled, on a phase-out program
Pyrethrums	Natural occurring plant extracts	Grains	Storage insecticide, short activity
Diatomaceous Earth	Mined silicates	Exempt from registration	Primarily storage insects

Table 6. Systemic Insecticides.

Compound	Technical Source	Crops	Spectrum of Activity
DI-SYSTON	Mobay	Cotton	Post emergent insects aphids, thrips, mites
THIMET®	American Cyanamid	Cotton	Same as DI-SYSTON
AZODRIN®	Shell	Cotton	Aphids, thrips, Whitefly
ORTHENE®	Chevron	Cotton	Aphids, thrips, cutworms
MAGNUM™	Union Carbide	Experimental	Nematodes, cutworms, corn root worms, fall armyworms and others
GUS 6015	Not disclosed	Experimental	Under investigations
ISOPHENFOS®	Not disclosed	Experimental	Wireworms, seed corn maggot at low rates

Table 7. Biological Seed Treatments

Product	Technical Source	Crops	Spectrum of Activity
QUANTUM™ 4000 (*Bacillus subtillis*)	Abbott	Peanuts	*Rhizoctonia*, *Fusarium*
DIPEL® (*Bacillus thuringensis*)	Abbott	Several grains	Stroage insecticide *Lepidoptera*
Rhizobia Inoculants	Several	Small seeded legumes and sobyeans	Nitrogen fixation

Table 8. Herbicide Safeners

Compound	Technical Source	Crops	Spectrum of Activity
CONCEP® II	Ciba-Geigy	Sorghum	Safeners against herbicide Dual
SCREEN®	Monsanto	Sorghum	Safeners against herbicide Lasso

Table 9. Miscellaneous Seed Treatment Applications

Function	Compound and/or Application
Herbicides	Eptam on alfalfa
Trace Elements	Sodium molybdate on soybeans zinc compounds on rice
Growth Regulants	Peanut Additive D
Repellants	MESUROL bird repellant
Osmotic regulants	Super Slupper - Bio Sorb

Conventional seed treating methods involve metering of a volume of chemical per hundred weight of seed. Since seed of the same kind vary greatly in size and density, we cannot assure accurate application of systemic chemicals from lot to lot or with seed of different grades. The efficacy of many new systemic chemicals will be dependent upon the accurate dosage to each seed within the lot. Consequently new seed treatment labels may be written as grams of chemicals per seed unit. The chemical Tachigaren is currently applied in this manner in Europe on sugar beets. Typically they apply eight to twelve grams per seed unit, which is defined at 100,000 seeds.

Most new systemic chemicals are highly efficacious, but have activity against a narrow range of pathogens. Consequently, combinations of seed treatment chemicals are required for broad spectrum control of diseases and insects. Additionally, new systemic insecticides are being evaluated at high application rates for extended periods of insect control when compared with conventional treatments. Both practices create new challenges in accurately applying and holding the chemicals on the seed. To meet these challenges, Gustafson has been actively developing polymer film coatings. Unlike pelleted seed or nutrient and Rhizobia coated seed, these polymer coatings will be micro-thin and will not change the shape or size of the seed. Changes in seed weight will be minimal, probably ranging from one to three percent.

The reasons for developing seed coatings are numerous. The following list profiles several objectives.

1. Improve the adhesion of chemicals for low dust-off and improved efficacy.

2. Increase the loading potential of chemicals on seed for higher rates of application and multiple chemical combinations.

3. Improve seed flow characteristics and plantability.

4. Improve worker handling safety especially with systemic insecticides.

5. Develop the capability to apply multiple layers of chemicals to the seed for the best activity.

6. Reduce the phytotoxicity of some types of chemicals.

7. Prolong the activity of chemical additives for improved seedling protection.

8. Regulate moisture uptake to reduce imbibitional chilling injury of some seed types or improve germination rates of arid crops.

9. Improve the dispersion of chemicals and color additives to the seed for uniform application and quality appearance.

Sorghum seed are frequently treated with a combination of Captan, Apron, a herbicide safener and an insecticide, therefore, we have concentrated our coating research on this crop. Currently we are testing several polymer formulations which show good potential to reduce or eliminate existing plantability problems caused by chemical buildup.

These experimental coating formulations are a multiple component polymer system designed to have the following characteristics:

1. High concentrations of binding solids

2. Low viscosity

3. Adjustable hydrophillic-hydrophobic balance

4. Form hard films upon drying

5. Produce seed coatings with good plantability, uniform seed flow, little or no dust-off and good seed germination under warm and cool test conditions.

To evaluate these experimental seed coatings, tests are conducted for dust-off, warm and cool germination, planter buildup using a John Deere metering cup, and seed flow during the plantability test. The following table presents some typical results with seed coating experiments on sorghum.

	Germination		Dust-off
Treatment	Cool	Warm	mg/30gm
Captan + APRON® + CONCEP® II	63.5	64.5	0.80
Captan + APRON + CONCEP II Coated with GUS 501-SC	67.5	71	0.00

In the above test, germination was evaluated on rolled paper towels at 18C for cool temperature tests and 25°C for warm tests. With several coatings evaluated, cool germination tests suggest these coatings may reduce imbibitional chilling injury although more extensive evaluations are required on this subject. The dust-off results represent the milligrams of dust collected on a filter paper after 20 gm. of seed was tumbled in a air chamber for ten minutes. The new polymer coating consistently demonstrated the ability to eliminate the loss of active chemicals by dust-off.

Plantability evaluations are conducted by running fifty pounds of sorghum seed through a John Deere maxi-emerge planter. The feed cup mechanism is pre-weighed and chemical buildup recorded as grams of increased weight caused by the deposits on the feed cup. Seed flow is also monitored during this test buy collecting seed for 36 seconds at various time intervals throughout the test. The grams of seed collected are then plotted against time to determine the uniformity of seed flow.

Figure 1 shows the seed flow and buildup of two coatings compared to the uncoated control. All seeds were treated with Captan, Apron, and Concep II. Two samples were coated with ploymer coatings. The buildup results from the experimental coating GUS 101-SC demonstrated that some polymers can cause buildup problems greater than an uncoated seed. Experimental coating GUS-509-SC produced extremely low buildup levels and good uniform seed flow due to its film hardening characteristics.

Figure 2 represents the results of a similar study in which all seed samples tested were treated using the same methods as described above. Both experimental coatings, GUS 515-SC and GUS 520-SC, produced substantially less buildup than the uncoated control with greater seed flow uniformity. GUS 520-SC incorported additional film hardening additives which resulted in half the buildup of the GUS 515-SC coating.

In addition to developing new polymer coating formulations, equipment research and development will be necessary since these ploymers will have handling characteristics much different than existing flowable chemical formulations. In the near future, Gustafson hopes to solve both the polymer development and application equipment needs to provide the seed industry with economical polymer coatings in high capacity continuous flow treating systems. This coating technology will become the basis for further advances in seed applied chemistry which should produce tremendous benefits to the seed industry and agriculture in general.

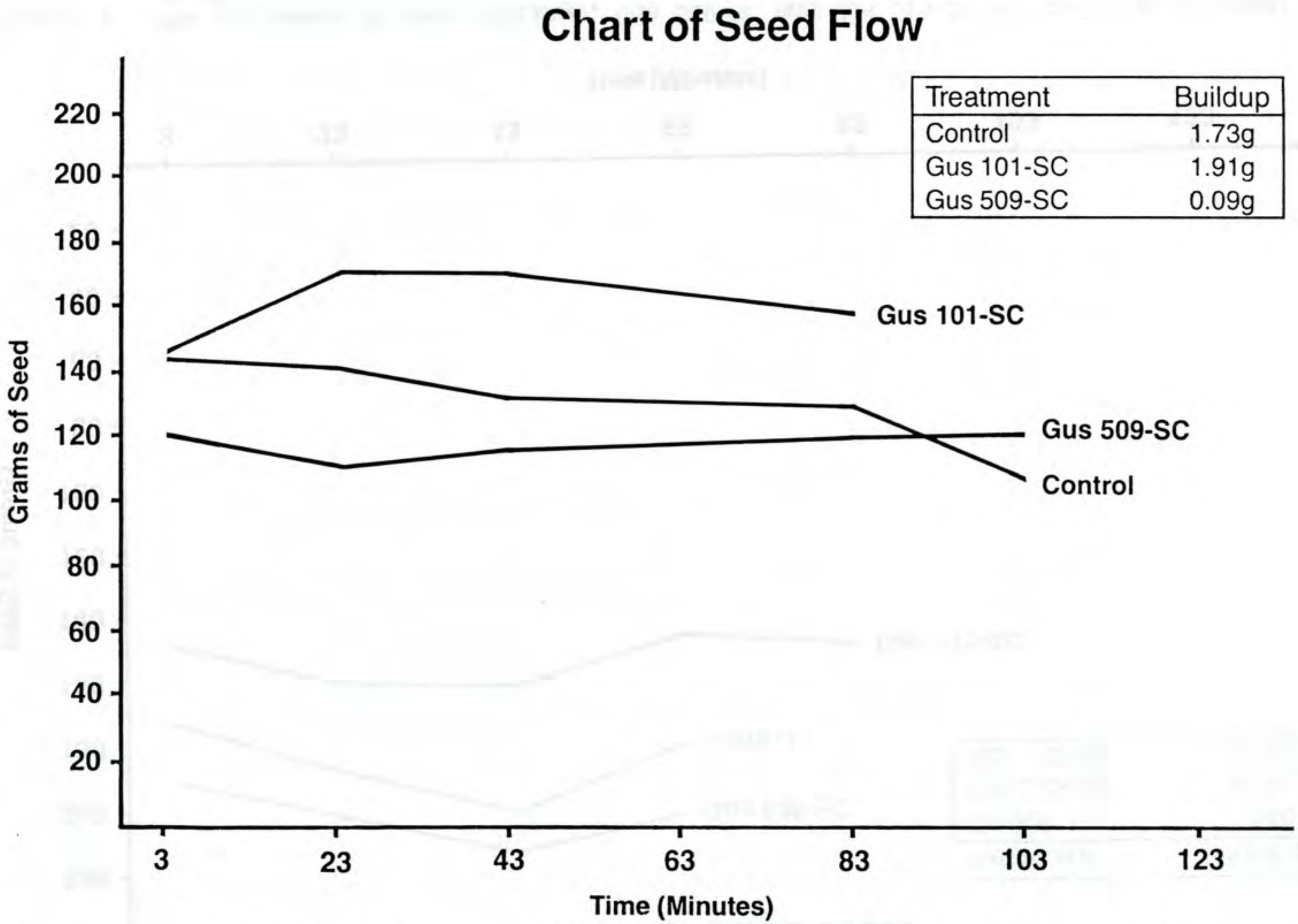


Figure 1. The influence of seed coatings, Gus 101 SC and Gus 509-SC on the grams of seed/36 sec which passed through a mechanical planter at various time periods of planter operation.

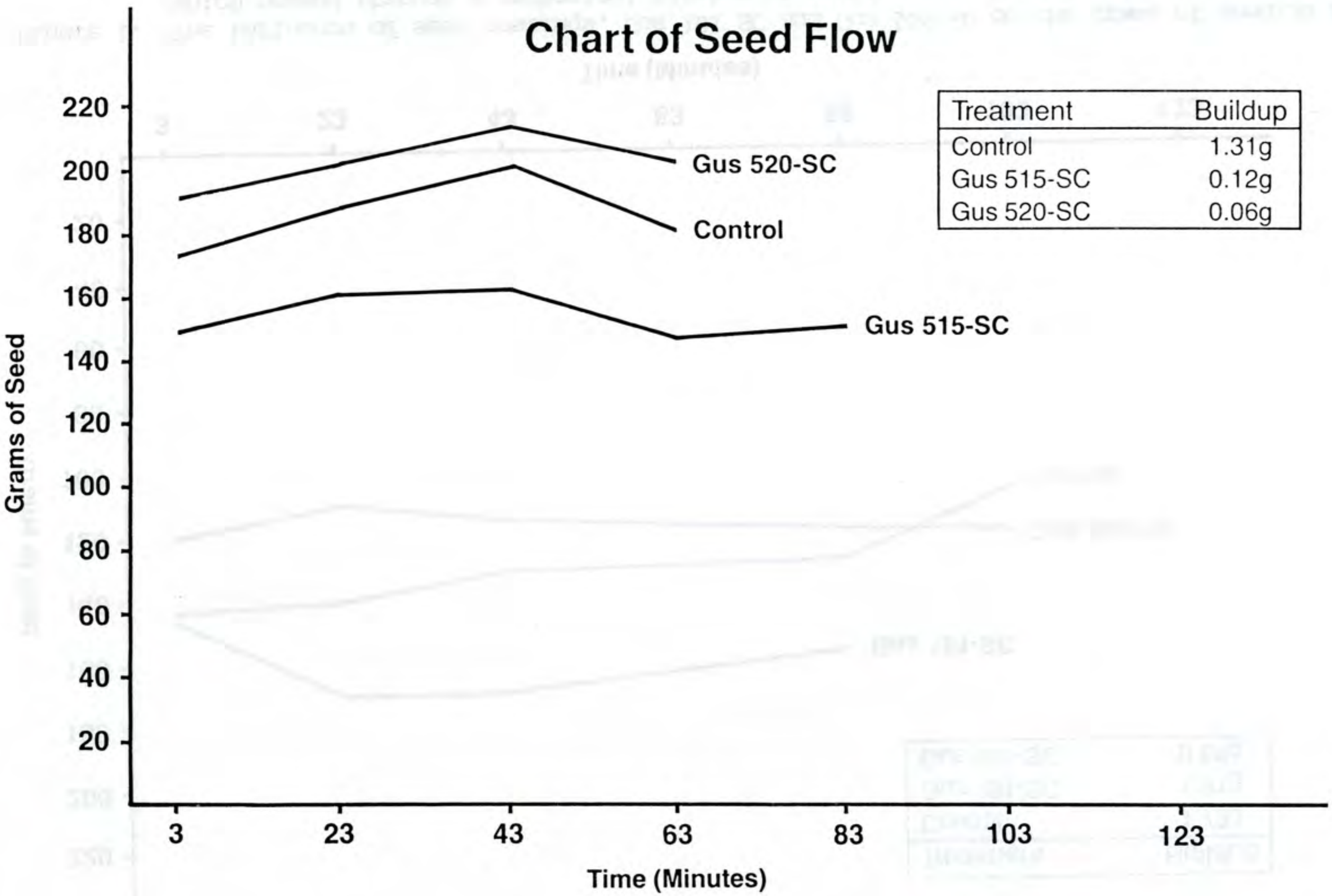


Figure 2. The influence of seed coatings, Gus 520-SC and Gus 515-SC on the grams of seed/36 sec. which passed through a mechanical planter at various time periods of operation.

ENDOPHYTES: BANE OR BOON?

TURFGRASSES

(How endophytes modify turfgrass performance and response to insect pests in turfgrass breeding and evaluation trials)[1]

C. R. Funk, P. M. Halisky, S. Ahmad, and R. H. Hurley[2,3]

Abstract

Endopphytic fungi (Acremonium spp.) were associated with (1) enhanced resistance to Crabus spp. and Sphenophorus parvulus in Lolium perenne, and (2) improved persistence, fall recovery, and resistance to weed invasion in old turf trials of Festuca arundinacea and L. perenne. Field observations also suggest an association of endophytic fungi with resistance to Blissus leucopterus hirtus and improved summer performance in F. rubra, F. longifolia and L. perenne. Possible endophyte effects must be considered in turfgrass evaluation trials and in breeding programs designed to efficiently detect and utilize non-endophytic sources of pest resistance and perhaps stress tolerance.

Introduction

New Zealand scientists (Prestidge et al. 1982; Moertimer et al., 1983) were the first to report that an endophytic fungus (Figure 1), Acremonium loliae Latch, Christensen and Samuels, was associated with resistance to the Argentine stem weevil, Listronotus (= Hyperodes) bonariensis Kuschel, in Lolium perenne L. (perennial ryegrass). Other studies (Funk et al., 1983) showed that the resistance of L. perenne to various species of lepidopterous sod webworms

----

[1]New Jersey Agricultural Experiment Station Publication Title and Numbers D-15267-1-85, D-11130-2-85, D-08130-21-84.

[2]Respectively, Professors of Turfgrass Breeding, Plant Pathology, and Entomology, New Jersey Agricultural Experiment Station, Rutgers University, New Brunswick, New Jersey, 08903, USA and Vice President, Lofts, Inc., P. O. Box 146, Bound Brook, New Jersey, 08805, USA.

[3]Dr. Hurley presented the information contained in this paper under the title, "Endophytes: Bane or Boon? Turf Grasses.

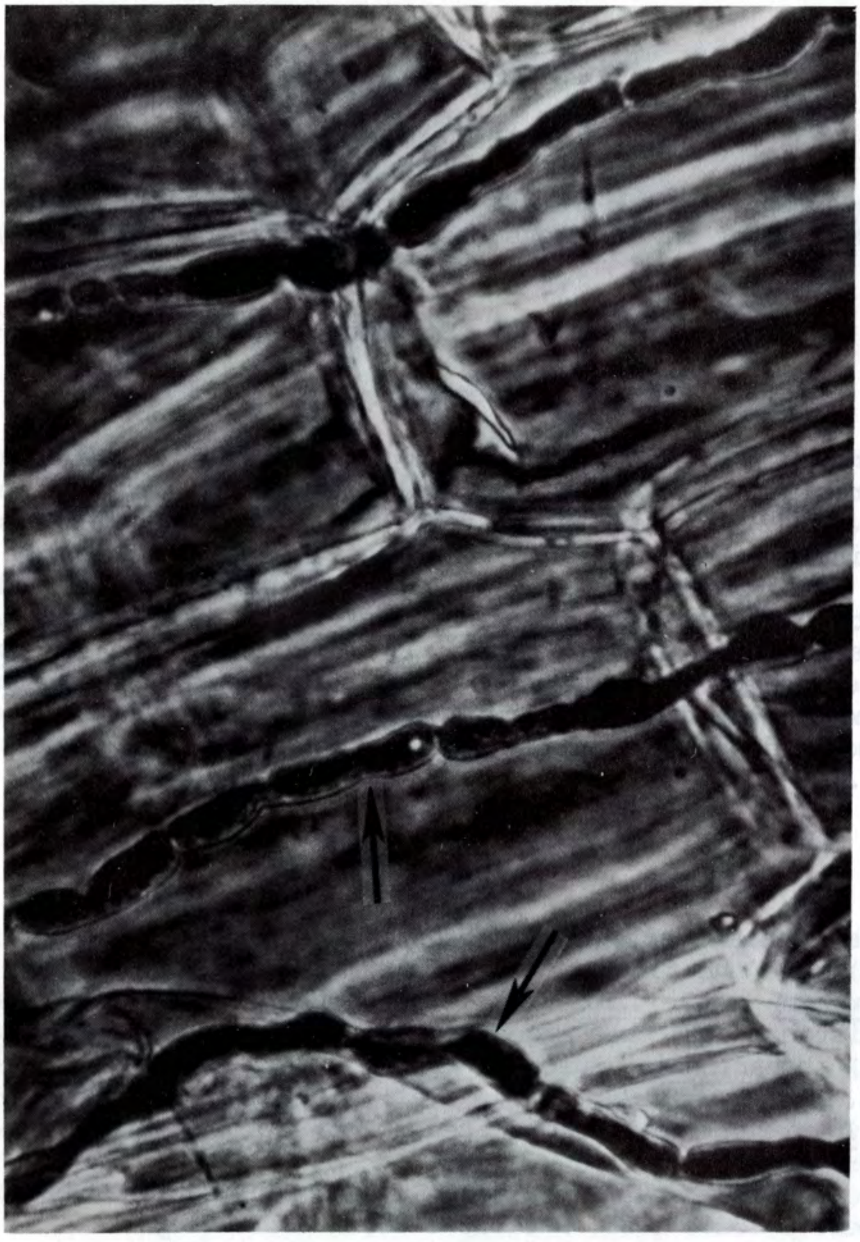


Figure 1. Hyphae of an endophytic fungus (arrows) shown in the cells of a leaf.

was also associated with the presence of a fungal endophyte. Perennial ryegrasses rated as highly resistant to sod webworms were shown by microscopic examination and enzyme-linked immunosorbant assay (ELISA) (Johnson et al., 1982) to contain a very high percentage of plants infected with the Lolium endophyte. Ryegrasses showing substantial injury from larval feeding were free or mostly free of the endophyte. Field resistance to sod webworms was expressed both as a 10-fold reduction in larval feeding and a nearly complete absence of larvae from the soil beneath endophyte-containing plants. The maternal transmission of sod webworm resistance was very striking, indicating an absence of pollen transfer. Maternal transmission of endophyte-mediated resistance results from the observation that most of the seed produced on an endophyte-infected plant contains the endophyte. Increased yield and greater persistence of endophyte-containing pastures of Festuca arundinacea Schreb. (tall fescue) have been reported in Texas (Read, 1983). Bradshaw (1959) reported that endophyte-containing plants of Agrostis tenuis Sibth. and A. stolonifera L. growing in low maintenance turfs normally produced more tillers than adjacent bentgrass plants which were free of endophyte. Clay (1984) observed increased vigor and persistence in Danthonia spicata (L.) Beauv. infected with the endophytic fungus, Atkinsoinella hypoxylon (Peck) Diehl.

Materials and Methods

Large numbers of cultivars, selections and single-plant progenies of L. perenne, F. arundinacea, F. rubra L. subsp. commutata Gaud. (Chewings fescue), and F. longifolia Thuill. (hard fescue) have been and are currently being evaluated in turf trials at Adelphia and North Brunswick, New Jersey. Many of these trials have been maintained for several years to assess long-term persistence and performance under a wide range of managment practices. Observations of possible endophyte effects were made when naturally developing insect infestations or environmental stresses occurred on various trials. Assessments of endophyte presence in seed or foliage were made microscopically using lactophenol-trypan blue or rose bengal as described by Funk et al., (1983) and Saha et al., (1984).

Results and Discussion

Association of Lolium Endophyte with Resistance to Billbugs in a Test Established in 1977 at Adelphia, New Jersey.

Ahmad and Funk (1983) reported differential resistance of perennial ryegrasses to Sphenophorus parvulus Gyllenhal (the bluegrass billbug) prior to knowledge of possible effects of the Lolium endophyte (Figure 2). Billbug resistance was expressed as both a reduction of larval damage and a nearly complete absence of larvae from

Figure 2. Typical billbug damage on perennial ryegrass plots with low (left) and high (right) levels of endophyte infection.

plots of resistant ryegrasses. Further studies show that the Lolium endophyte was positively associated with the enhanced resistance of perennial ryegrasses to this insect pest (Table 1). However, there were also strong indications of varying amounts of non-endophytic sources of resistance. Significant differences occurred in both turf damage and insect counts among endophyte-free ryegrasses. The maternal transmission of resistance to billbugs also was evident. A total of 105 single plant progenies derived from five maternal sources of endophyte gave 104 resistant progenies and only one susceptible progeny. This is consistent with our observation that up to five percent of the seeds produced by an endphyte-infected ryegrass plant may escape infection. A total of 339 single plant progenies derived from five non-infected maternal parents were all susceptible. These results indicate an absence of pollen transfer. This maternal inheritance of resistance to the bluegrass billbug also supports the concept of endophyte-enhanced resistance.

Association of the Lolium Endophyte with Performance of Perennial Ryegrasses in a Turf Trial Seeded September 1978 at Adelphia, New Jersey.

The components of two breeding composites were seeded in a turf trial in September 1978. Breeding composite LP-5000 consisted of the open-pollinated progenies of 471 selected turf-type ryegrass plants grown in an isolated nursey. Breeding composite GH-77 consisted of the open-pollinated progenies of 63 selected turf-type ryegrass plants.

Data presented in Table 2 show that endophyte-infected versus endophyte-free progenies within each breeding composite performed in a very similar manner during the 1979 season. The test was irrigated and received a moderately high level of maintenance during this period. This and other evidence suggests that the presence or absence of the Lolium endophyte generally has little if any influence on turf performance in newly established trials not significantly affected by insect problems or severe environmental stresses.

The percent green turf data compiled during September 1980 primarily reflects differences in injury resulting from feeding by sod webworms. The association between endophyte presence and resistance to sod webworm was striking under the conditions of this test. It is also noteworthy that essentially all ryegrasses subsequently showed complete recovery from the extreme injury sustained.

The percent green turf data and turf quality ratings taken during August and September of 1983 largely reflect damage from the bluegrass billbug, although, damage from drought stress, white grubs and other insects was noted. The presence of the Lolium endophyte did not appear to deter feeding by or injury from the various species of white grubs present.

Table 1. Billbug infestation, endophyte frequency and concomitant damage in eight cultivars and selections of perennial ryegrass in turf trials at Adelphia, New Jersey[1].

Ryegrass cultivar or selection	Mean % turfgrass damage	Mean counts of billbugs per $1.0m^2$	Mean % endophyte infected tillers
1. H5-1252	1a[2]	0.0a	98a
2. Pennant	3a	0.0a	100a
3. Regal	4a	5.4a	100a
4. Omega	40b	32.3c	0b
5. Derby	40b	43.0c	8b
6. Yorktown II	49b	48.4c	5b
7. H4-600-1	78c	107.6d	0b
8. H4-412-1	83c	134.5e	0b

[1]Test was seeded August 1977 and maintained at 2.0 cm. cutting height, high fertility, and irrigated as needed until June 1980. After June 1980, it was mowed at 5.0 cm, not irrigated, and maintained at a reduced fertility level. Billbug counts and turf injury readings were made during early August of 1981 after a period of moderately-severe drought stress.

[2]Means followed by the same letter do not differ significantly at the five percent probability level.

Table 2. Performance of endophyte-infected versus endophyte-free single plant progenies of two breeding composites of Lolium perenne seeded September 1978 in turf trials at Adelphia, New Jersey.

Breeding composite	Number progenies examined	Mean turf quality 1979	Mean % green turf[1] Sept. 1980	Sept. 1983	Mean turf quality[2] 1983
LP-5000					
a. Endophyte-free	436	6.6	13.3	61.6	4.4
b. Endophyte-infected	35	6.5	83.9	80.4	6.5
c. Difference[3]		-01 ns	+70.6**	+18.8**	+12.1**
GH-77					
a. Endophyte-free	49	5.2	12.6	62.6	4.9
b. Endophyte-infected	14	5.2	86.1	85.0	7.0
c. Difference[3]		+0.0 ns	+73.5**	+22.4**	+2.1**

[1]1980 data compiled during a sod webworm infestation; 1983 data compiled during an outbreak of bluegrass billbug.

[2]Based on a scale of 0-9 (9 = best).

[3]Difference associated with presence of the endophyte.

** = significant difference (p 0.01); ns = non significant difference.

Association of Endophytic Fungi with Increased Persistence and Improved Performance of Perennial Ryegrasses and Tall Fescues in Low Maintenance Turf Trials at North Brunswick, New Jersey.

Striking differences were observed in persistence, recovery from summer stress and ability to resist weed invasion during the early fall of 1983 in perennial ryegrass and tall fescue turf trials. These tests had been established during August 1976 at North Brunswick, New Jersey. They received irrigation and were maintained at moderately high fertility with frequent close mowing (2-cm) until June, 1981. At that time, the mowing height was raised to 5-cm, irrigation was discontinued, fertility levels drastically reduced and weed control treatments discontinued. A substantial amount of Digitaria spp. (crabgrass) had invaded the test by the midsummer of 1982 and produced a nearly complete ground cover by midsummer of 1983. The tall fescue test showed moderate crabgrass invasion during this period.

Evaluation of Surviving Ryegrasses: Indications of maternal inheritance of improved persistence, recovery from summer stress and resistance to weed invasion suggested that endophytes might be involved in improved performance. In addition, and average of 98% of the tillers removed from the 15 best-performing, single-plant progenies of perennial ryegrasses and from four replicated plots seeded with freshly-harvested seed of 'Regal' perennial ryegrass were infected with the Lolium endophyte. This observation of maternal inheritance and the fact that all surviving entries were infected give excellent evidence that persistence was associated with the presence of the Lolium endophyte. Unfortunately, remnant seed from this test had been discarded making it impossible to assess the endophyte status of the ryegrasses that did not survive. However, since our entire sample of surviving ryegrasses was endophyte positive, it is unlikely that progenies free of endophyte could have survived the severe summer stress, possible insect damage and heavy crabgrass competion. On the other hand, it is probable that some progenies containing endophyte did not survive. Best performance may well require a combination of non-endophytic sources of pest resistance and/or stress tolerance enhanced by an effective endophyte. Endophytes probably vary just as much as other biological organisms in their ability to enhance genetic sources of pest resistance, plant persistence and stress tolerance. Good performance may also require a high frequency of endophyte-infected plants. Named cultivars low in endophyte-infected plants did not survive under the extreme stresses of this test.

Evaluation of Surviving Tall Fescues: This test included 400 open-pollinated, single-plant progenies of tall fescue plants which had been selected from old turfs in Virginia, Pennsylvania, New Jersey, Georgia, Alabama, and North Carolina. Turf plots were established in the same order as the plants occurred in the spaced-plant nursery. Therefore, progenies in adjacent and nearby plots received a very similiar sample of pollen. Many of these progenies performed poorly throughout the entire test period. However, many others performed well during the early years of the test. These better selections can be divided into two groups. The first group (I) continued to perform well throughout the period of the test and recovered quickly and completely from the severe summer stress and crabgrass competition during the summers of 1982 and 1983. The second group (II) gave similiar high performance scores during the first two years of the test, showed a moderate decline in performance by the fourth and fifth years, recovered rather poorly after the summer of 1982, and showed severe thinning and very poor turf when rated in October, 1983 (Table 3). The 32 best single-plant progenies of group I were all highly infected with the tall fescue endophyte with an average of 98% infected tillers. The 11 single-plant progenies selected from group II showed an average of only 8% infected tillers. This strongly suggests that the dramatic differences in persistence, resistance to crabgrass invasion and recovery from summer stress of the tall fescues were also associated with the presence of an endophyte.

Enhanced resistance to sod webworms and perhaps other insect pests was undoubtedly a contributing factor in the survival of endophyte-containing ryegrasses. The better turf-type perennial ryegrasses had been shown to completely recover from prolonged defoliation from sod webworms in turf trials at Adelphia. However, the Adelphia tests did not contain crabgrass. The very severe crabgrass competition at North Brunswick undoubtedly reduced the recovery of plants weakened by insects and environmental stress. It is likely that the endophyte(s) also enhanced stress tolerance to produce the observed response. Insect populations and apparent insect damage did not appear sufficient to account for the great differences observed, especially in the tall fescue test. Either the insects escaped our attention, or the improved performance and persistence of endophyte-infected ryegrasses and tall fescues were associated with physiological factors related to improved stress tolerance and competitive ability.

The Role of Endophytic Fungi in Enhanced Performance of Fine Fescues

Epichloe typhina (Pers.) Tul., the causal organism of the choke disease, is the sexual stage of a fungus which is similiar to or identical with the endophytes associated with enhanced performance of perennial ryegrass and tall fescue. Sampson (1933) observed that red fescue (*F. rubra* L.) plants containing this endophyte produced a wide array of symptoms. These ranged from stromata being present on all panicles of an infected plant to plants showing no external evidence of infection. Intermediate types included plants with only a few panicles showing choke and others showing reductions in floret

Table 3. Turf performance ratings of endophyte-containing versus adjacent plots and endophyte-free single-plant progenies of tall fescue.

Date	Mean turf performance scores (9 = best)		
	Endophyte-infected progenies (32 entries)	Adjacent plots (64 entries)	Endophyte-free progenies (11 entries)
1976-1977	5.8	5.9	6.2
1978-1979	5.6	5.2	5.7
1980-1981	6.0	4.8	5.2
Sept. 1982	6.7	4.6	5.0
Oct. 1983	7.2	2.4	2.5

fertility, seed yield, and seed viability. Plants of fine fescue which are infected with the choke disease fungus but do not produce stromata but which do produce high yields of viable seeds are very similiar to symptomless plants of Tall fescue and perennial ryegrass which contain a "non-choke-inducing endophyte" (NCI).

Many seed lots used in the 1983 National Fine Fescue Test contained high frequencies of endophyte-infected seed. These included cultivars of F. longifolia Thuill (hard fescue) 'Valda' (63 percent infected seeds), 'Biljart' (52%), and 'Spartan' (14%); F. rubra L. subsp. commuata Gaud. (Chewings fescue) 'Beauty (72%), 'CF-2' (22%) and 'Center' (18%); and F. rubra L. subsp. rubra (strong creeping red fescue) 'Pernille' (34%) and 'Ensylva' (24%). The presence of high percentages of endophyte in seed lots of commercial cultivars of fine fescue suggests that NCI endophytes are also common in the fine fescues. Since selection for high yields of viable seed is of high priority in the development of any new cultivar, it would seem that cultivars with NCI endophytes can be developed with acceptable seed yielding potential. A limited seed yield test at Adelphia indicated that endophyte infection had no adverse effect on seed yields in hard fescue. Fifty five attractive hard fescue plants were selected from an old turf and established in a spaced-plant seed production nursery. The 25 infected plants produced an average of 23.4 grams of seed whereas the 30 endophyte-free plants produced an average of 23.2 grams of seed. We were unable to observe any external symptoms or choke expression on any of the infected plants.

The endophyte-infected entries 'Valiant' hard fescue and 'Longfellow' chewings fescues showed significantly better turf performance and fall recovery in 1983 and 1984, and fewer chinch bugs (Blissus leucopterns hirtus Montandon) than any other hard or Chewings fescues present in a test seeded September, 1978 at Adelphia, New Jersey. The Longfellow and Valiant plots were established with 48 and 94% endophyte-infected seed. Tillers removed in 1984 showed an increase in endophyte infection to 84 and 97%, respectively. After six years the turf plots containing Valiant and Longfellow averaged 92.5% green turf cover whereas six other fine fescues in the same test averaged only 17.3% green turf cover. Similarly a count of chinch bugs present averaged 37.5 /m^2 in these two grasses compared with an average of 122.5 /m^2 in six other fine fescues.

This apparent resistance of Valiant and Longfellow to chinch bugs could have resulted from their unattractiviness to the insects because of denser turf and freedom from disease and summer injury. Adjacent plots, thinned by summer stress and disease may have merely provided a more favorable habitat for the chinch bugs since they prefer a warm, dry environment. It is also possible that these fescues are, in fact, more resistant to chinch bugs by virtue of their high (84-97%) endophyte content.

Conclusions

1. Non-choke-inducing endophytes have shown promise of enhancing the performance and persistence of a number of important grasses used for turf and conservation purposes, at least under certain biotic, edaphic and environmental situations.

2. Endophyte effects need to be considered in cultivar performance trials.

3. The development and evaluation of non-endophytic sources of pest resistance and stress tolerance can be accomplished more efficiently with increased awareness of and knowledge concerning endophyte effects.

4. Endophytes can be incorporated into most turfgrass cultivars using standard breeding techniques and procedures.

5. Inoculation techniques are being perfected to quickly and efficiently develop endophyte-containing cultivars and for the interspecific transfer of endophytes.

6. Turfgrass breeders will likely remove endophytes from breeding populations in order to select for non-endophytic sources of pest resistance and stress tolerance. The appropriate endophyte might then be added to enhance performance if desired.

7. Increased knowledge of the genetic variation within endophytes and their interactions with various hosts will be needed to gain the greatest possible benefits from endophyte-enhanced performance.

Acknowledgments

This research was conducted under New Jersey Agricultural Experiment Station Project Numbers 15267, 11130, and 08130 supported by United States Hatch Act Funds and other gifts and grants. Additional support was received from the United States Golf Association Green Section and Education Fund. We thank Dr. Saha C. Dhanonjoy, Ms. Jennifer M. Johnson-Cicalese, Mr. William K. Dickson, and Mr. Ronald F. Bara for technical assistance, Ms. Aida Bianca for secretarial help, and Ms. Maria Van Heemstra for her translation of the summary of this paper in French.

Literature Cited

1. Ahmad, S., and Funk, C. R. 1983. Bluegrass billbug (Coleotera: Curculionidae) tolerance of ryegrass cultivars and selections. Jour. of Economic Entomology 76:414-416.

2. Bradshaw, A. D. 1959. Population differentiation in Agrostis tenuis Sibth. II the incidence and significance of infection by Epichloe typhina. New Phytol. 58:310-315.

3. Clay, K. 1984. The effect of the fungus Atkinsonella hypoxylon (Clavicipitaceae) on the reproductive system and demography of the grass Danthonia spicata. New Phytol. 98:165-175.

4. Funk, C. R., Halisky, P. M., Johnson, M. C., Siegel, M. R. Stewart, A. V., Ahmad, S., Hurley, R. H., and Harvey, I. C. 1983. An endophytic fungus and resistance to sod webworms: Association in Lolium perenne L. Bio/Technology 1:189-191.

5. Johnson, M. C., Pirone, T. P., Siegel, M. R., and Varney, Dr. R. 1982. Detection of Epichloe typhina in tall fescue by means of enzyme-linked imminosorbant assay. Phytopathology 72:647-650.

6. Mortimer, P. H., and di Menna, M. E. 1983. Ryegrass staggers: Further substantiation of a Lolium endohyte aetiology and the discovery of weevil resistance of ryegrass pastures infected with Lolium endophyte. Proc. New Zealand Grassland Association 44:240-243.

7. Prestidge, R. A., Pottinger, R. P., and Barker, G. M. 1982. An Association of Lolium endophyte with ryegrass resistance to Argentine stem weevil. Proc. 35th New Zealand Pest Control Conference pp. 199.222.

8. Read, J. C., Davis, C., Giroii, E., and Camp, B. J. 1983. The effect of fungal endophyte Epichloe typhina on animal performance. Agronomy Abstracts p. 113.

9. Saha, D. C., Jackson, M. A., and Tate, R. L. 1984. A rapid staining method for detection of endophytic fungi in turf grasses. Phytopathology 74:812.

ENDOPHYTES: BANE OR BOON?

FORAGE GRASSES

Vance H. Watson[1]

Tall fescue (Festuca arundinacea Schreb.) is a major forage grass in the United States and is grown on an estimated 35 million acres. It is the most important cool season perennial grass grown in Mississippi. Tall fescue is adapted to a wide range of soil and climatic conditions, easy to establish, tolerates poor grazing management, and stands persist almost indefinitely. Nearly all of the tall fescue grown in Mississippi is the variety, Kentucky 31. It is a productive variety that furnishes 200 to 250 grazing days each year.

Even though tall fescue has a lot of excellent agronomic characteristics, it is widely criticized for causing poor animal performance and other livestock health problems. One of the most serious problems of cattle grazing fescue is poor weight gains with an associated series of signs called the "summer syndrome" or fescue toxicity that was named by Dr. Joe Robbins of the USDA Lab in Athens, Georgia. It is characterized by one or more signs which can include rough hair coats, long periods of standing in water, lameness, loss of the tip of the tail, diarrhea, appearance of increased respiration with a preference for shade, elevated body temperature, and nervousness (Figure 1).

One of the first papers describing endophytes in tall fescue was published in 1941. Neill's paper entitled "The Endophytes of Lolium and Festuca", appeared in the December 1941 issue of The New Zealand Journal of Science and Technology. The endophyte, Epichloe typhina (Pers.) Tulog, now known as Acremonium coenophialum Morgan-Jones and Gams and considered responsible for fescue toxicity, was described in detail in this report. However, the information presented in this paper was essentially lost to the scientific community for years, probably due to the events of World War II.

This information and its subsequent importance was rediscovered in the 1970's by two different research teams. One of the teams was located at the USDA Agricultural Research Service Russell Agricultural Center in Athens, Georgia. Dr. Joe Robbins of the Russell Center visited a farm owned by A. E. Hayes near Madison,

---

[1]Coordinator, Forage and Pasture Programs and Professor of Agronomy, Mississippi Agricultural and Forestry Experiment Station.

Figure 1. A cow displaying severe, classical symptoms of fescue toxicity. Note rough coat, loss of one hoof and poor physical condition attributed to continuous grazing on tall fescue severely infested with Acremonium Coenophialum.

Georgia. Mr. Hayes had two 40-head herds of cattle, each grazing on different 80-acre tall fescue pastures. One herd had shown symptoms of fescue toxicity for several years, while the other herd had shown none. Dr. Robbins and his team began looking for some agent or agents that were responsible for the difference in performance between the two herds. In 1976, they began investigating the tissue inside the fescue plant. They found a fungus, now identified as Acremonium coenophialum. When plant tissue from the two pastures was examined, the pasture producing a high incidence of fescue toxicity was nearly 100% infected with the fungus, while the other pasture was only 10% infected.

Concurrent research developments at Auburn University and its Black Belt substation could prove to be the most significant breakthrough for cattlemen in recent years. Their results showed that beef gains of tall fescue pastures could be doubled by overcoming a single problem--the fungus that infests the grass. L. A. Smith and colleagues at the substation found that fungus-free tall fescue supported an average daily steer gain of 1.48 pounds and per acre beef gain of 395 pounds, nearly double that of fungus-infested pastures, Table 1. Steers grazing fungus infested fescue had rough hair, and they did not shed their winter coats. They also showed body temperatures 2°F higher than normal, excessive salivation, and nervousness. Hot weather magnified these adverse symptoms. We visited these experiments in mid-June, 1984, and the differences in the cattle grazing the infected and fungus-free fescue was so dramatic that a grade school child could tell them apart.

In another experiment, fescue hay and fescue seed from fungus-free and fungus-infested pastures were used in a feeding trial. Cross-bred steers weighing 530 pounds were assigned to four diets containing either 60% fungus-free seed, 60% infested seed, 85% chopped fungus-free hay, or 85% chopped infested hay. The test rations were fed during late summer when temperatures reached 94 - 99°F.

Average daily gains of steers fed the fescue rations were typical of those made by steers grazing fungus-free and fungus-infested fescue, but body temperatures were elevated only half as much by the fungus, Table 2. Feed intake was lower for steers eating diets containing infested hay and seed. Forage intake of grazed steers was not measured, but higher stocking rates on infested pastures were indicative of reduced forage consumption. Steers fed the fungus-infested seed showed signs of severe heat stress and rapid breathing. All steers eating rations containing infested feed were highly excitable.

The fungus (Acremonium coenophialium) occurs between cell walls of fescue leaves and stems and cannot be seen externally. It does not appear to be transmitted from one plant to another. Fungus-free pastures adjacent to infested pastures have remained "clean"

Table 1. Steer performance on tall fescue pastures as affected by fungus, black belt substation, auburn university, 1978-80

Pasture	Beef gain per acre	Av. daily gain	Body temp.	Hair coat rating[1]
	Lb.	Lb.	°F	
Free of Fungus	395	1.48	102.7	1.3
Fungus present	210	.65	104.8	3.2

[1]Rating: 1 = slick; 5 = rough

Table 2. Steer performance as affected by fungus - infested tall fescue steed or hay Auburn University, Auburn, Alabama.

Diet	Daily gain	Daily feed	Body temp.
	Lb.	Lb.	°F
Fungus-free seed .	2.11	14.1	102.3
Infested seed. . . .	.44	9.1	103.2
Fungus-free hay. . .	1.45	10.5	102.2
Infested hay	.63	9.2	103.3

for over 5 years. The fungus apparently is transmitted through the seed. A survey of several tall fescue pastures in Mississippi showed a heavy infestation of this fungus.

What can cattlemen do about fescue toxicity? Fescue toxicity is controlled by grazing fungus-free fescue or reduced by diluting infested fescue with another crop such as white or red clover (Figure 2). The first step in management is to test the fescue pastures to establish the level of fungus that is present. If the pastures have over 5% infestation, some control measures are probably warranted. Several states have established Fescue Diagnostic Laboratories for testing fescue tissue and seed, and they offer several suggestions for consideration. There are several situations in which a livestock producer or seedsman could use the testing service to advantage. First, it can be used to determine the presence (and, if present, the level of infestation) or absence of the fungus in an existing tall fescue pasture. This can be done by collecting plant samples from a pasture and submitting them for analysis.

An analysis for the fungus can also be performed on fescue seed. For example, a producer who is interested in buying or selling fescue seed and wants to know the level of fungus in that seed lot can submit a sample for analysis; the laboratory will report the approximate percentage of seed infected with the fungus. Similarly, a producer who has seed on hand which was harvested from his or her farm can have an analysis performed for the purpose of determining whether or not the seed can be used to establish new fescue pastures with low levels of fungus infestation. Since the fungus is known to be seed transmitted, seed analysis prior to establishing a new pasture can help prevent the further establishment of infested fescue pastures. Two states, Alabama and Mississippi, now require the level of endophyte to be shown on the seed tag.

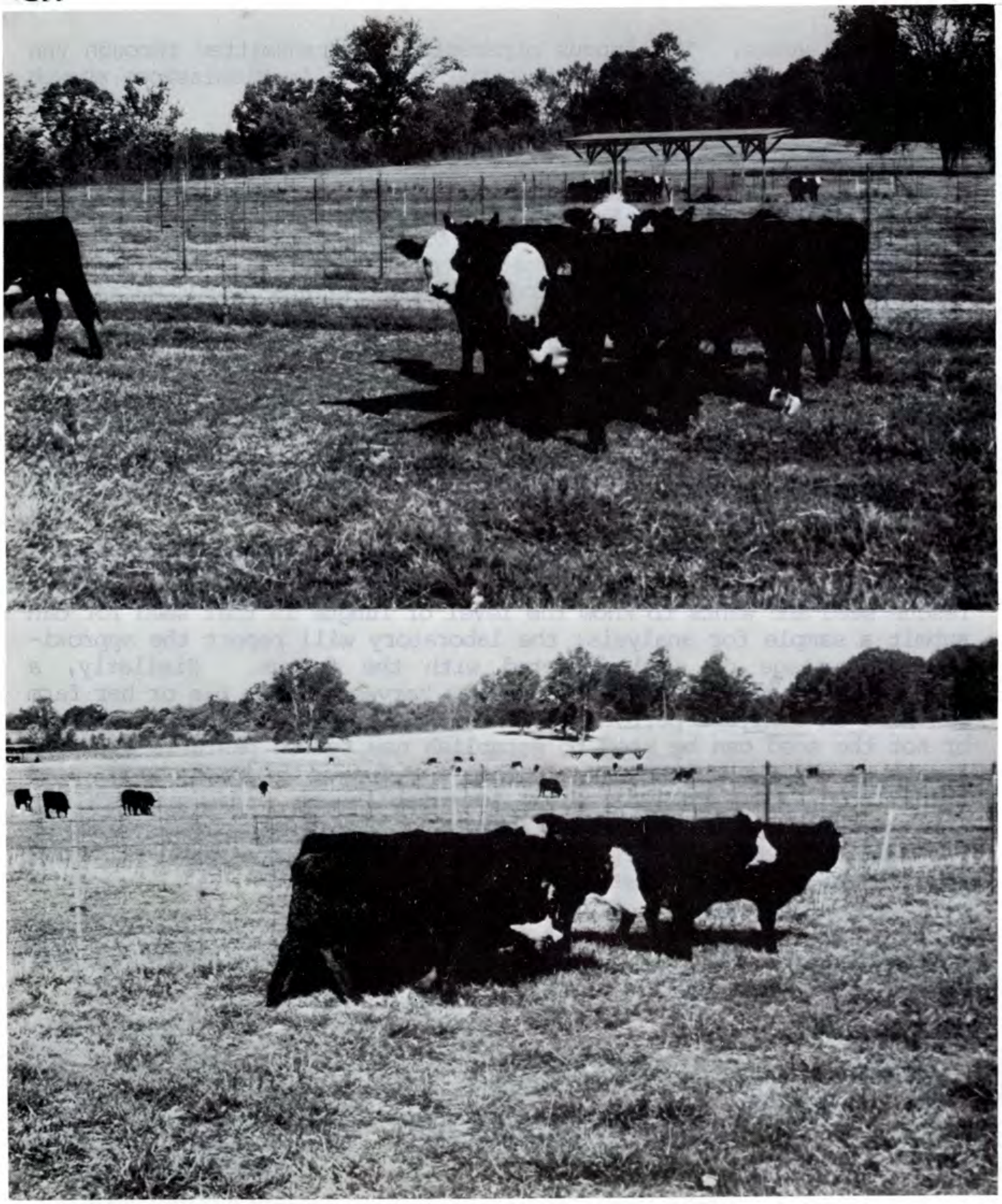


Figure 2. Steers of the same age gained at nearly twice the daily rate when pastured on endophyte free tall fescue (above) as when pastured on heavily infested tall fescue (below)

QUALITY ASSURANCE TECHNIQUES

1. Guidelines for the Diffusion Mediated Volatile Aldehyde Assay. D. O. Wilson, Jr., and M. B. McDonald, Jr., Ohio State University, Columbus, OH.

2. Guidelines for Endophyte Detection Procedures for Plant and Seed Tissue. Compiled by Charles Sciple, Miss. Dept. of Agri. & Comm.; D. J. Blasingame and M. V. Patel, Miss. Coop. Ext. Service.

DIFFUSION MEDIATED VOLATILE ALDEHYDE ASSAY

Dale O. Wilson, Jr. and M. B. McDonald, Jr.[1]

Introduction

Problems with vigor and storability of soybean [Glycine max (L.) Merr.] seeds have stimulated the adoption of vigor tests to supplement the standard germination test as a basic quality control tool in soybean seed production. Some the more accepted vigor tests suffer from excessive subjectivity (tetrazolium test) or require more than one week for completion (cold test). The attempt to combine predictive value and practical utility has resulted in a search for new biochemical vigor tests which would eliminate subjectivity and require only a day or less for completion. Many of these tests, such as the quantification of respiration rate (Woodstock 1968) or ATP (Ching 1973), have proven difficult, inconvenient and expensive to conduct (AOSA 1983).

Recent work (Woodstock and Taylorson 1981; Harman, Nedrow, Clark and Mattick 1982) has demonstrated an association between volatile aldehyde production during early germination and low soybean and pea seed vigor. The source of these aldehydes in the seed is not known although volatile aldehydes are clearly products of lipid peroxidation (Frankel, Neff and Selke 1981; Dillard and Tappel 1979) and can be produced by the action of lipoxygenase found in a wide variety of seeds (Grosch 1976). Aldehydes are formed during germination in many plant species (Stotzky and Schenk 1976) and may result from the action of hydroperoxide lyase on fatty acid hydroperoxides (Vick and Zimmerman 1967; Sekiya, Kajiwara and Hatanaka 1979). If lipid peroxidation is a primary cause of seed deterioration (Stewart and Bewley 1980; Wilson and McDonald 1985), the accumulation of hydroperoxide, which is the primary product of lipid peroxidation, may be a basic index of the physiological status of the seed and might serve as a useful index of seed vigor.

----

[1]Former Graduate Research Assistant and Professor, Dept. of Agronomy, Ohio State University, Columbus, OH.

Supplies (Figure 1)

3-Methyl-2benzothiazolione hydrazone (MBTH)
Tetamethyl thiuram disulfide (Thiram)
Benomyl (Benlate fungicide)
Filter paper, 9 cm Whatman #1
Erlenmeyer flasks, 500 ml
Distilled or deionized water
Spectrophotometer or colorimeter
$FeCl_3$-$6H_2O$
Acetone
Formaldehyde
Neoprene stoppers #7
Test tubes, 16 x 150 mm
Parafilm

Assay Procedure

Equilibrate all seed samples to same moisture level. We used soybeans with 8% water (fresh wt. basis). This can be done by placing small paper bags of seed together in an airtight container for a week. Just before the test, dry treat the seed with a finely ground mixture of benomyl and thiram at a rate of 0.75 g of each active ingredient per one kg seed. Place nine disks of filter paper in the bottom of each flask and add 15 ml distilled water. Place 100 soybeans in each flask on top of the filter paper. Prepare a control flask by adding only the fungicide. Into each flask place a test tube containing 10 ml 0.2% MBTH solution (0.2g MBTH and distilled water to 100 ml). Seal each flask with a stopper or parafilm and incubate in the dark at 25^0C for 24 hours (Figure 2A). Prepare a second labeled set of test tubes, each containing 2.5 ml of 0.23% ferric chloride solution (0.38 g $FeCl_3$-$6H_2O$ and distilled water to 100 ml). Remove test tubes from the germination flasks and cover with parafilm. Mix the contents of each tube by inverting three times. Remove parafilm one tube at a time and transfer 1 ml of the solution into the corresponding labeled tube of $FeCl_3$ solution. Prepare a reagent blank by adding 1 ml of fresh MBTH to an $FeCl_3$ tube, cap all the tubes with parafilm and invert three times to mix. Let react at room temperature for five minutes then add 6.5 ml acetone to each. Cap with parafilm and mix by inverting several times. With the colorimeter adjusted to 635 nm, set the absorbance to zero using the blank sample and measure the absorbance of the contents of each tube within a few minutes. Preferably, run the standard curve at the same time (Figure 2B).

Standard Curve

Make up 0.002% formaldehyde as follows: Mix 2.70 ml of 37% formaldehyde solution with distilled water to make 100 ml of 1% solution. Take 2.0 ml of this solution and bring volume to 1000 ml with distilled water to make a 0.002% formaldehyde solution. Add 5 ml 0.4% MBTH solution to each of 8 test tubes. Add varying amounts of water and 0.002% formaldehyde according to Table 1. Cap with parafilm and mix by inverting 3 times. Let react at room temperature for 20

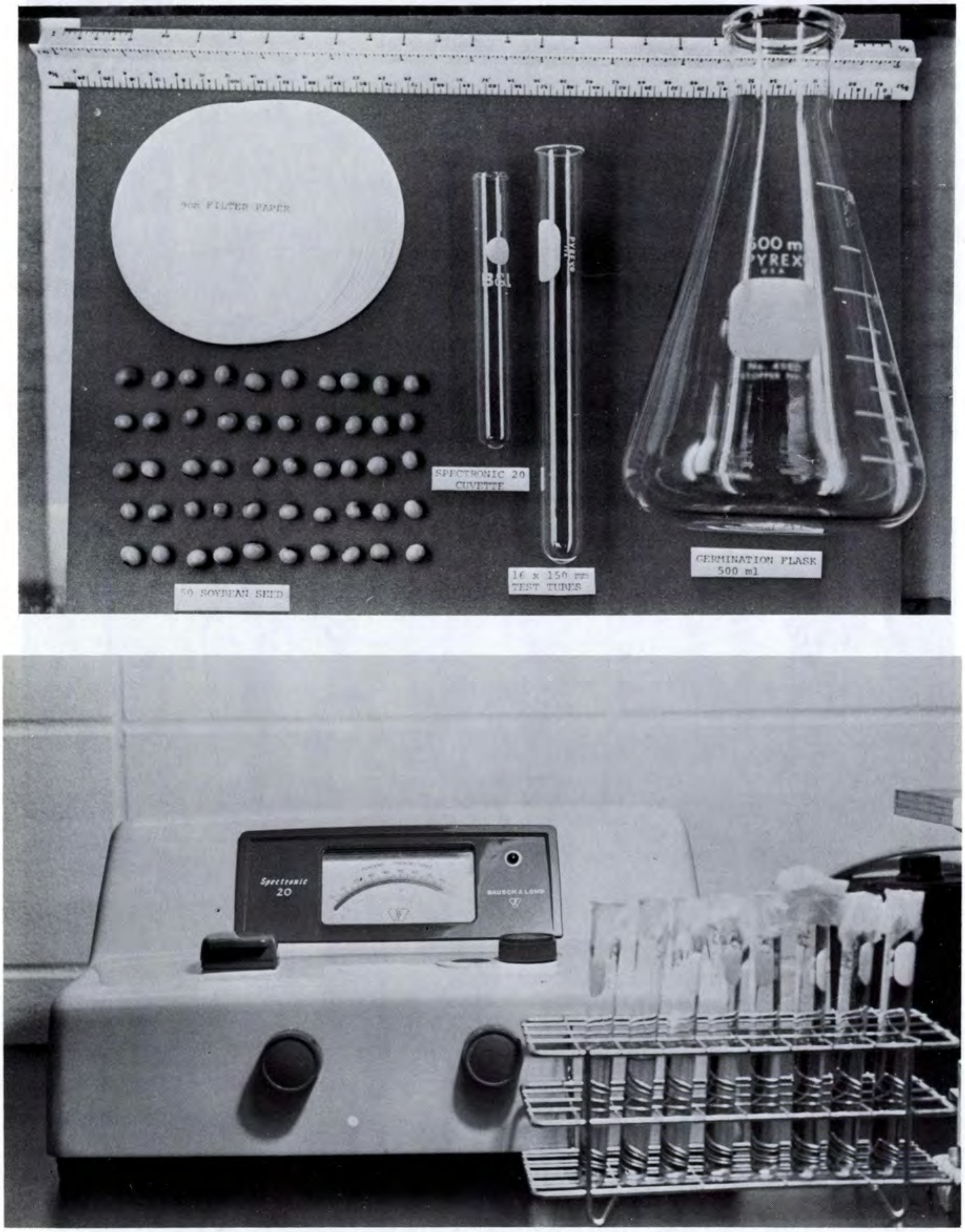


Figure 1. The basic equipment needs used for conducting the volatile aldehyde assay.

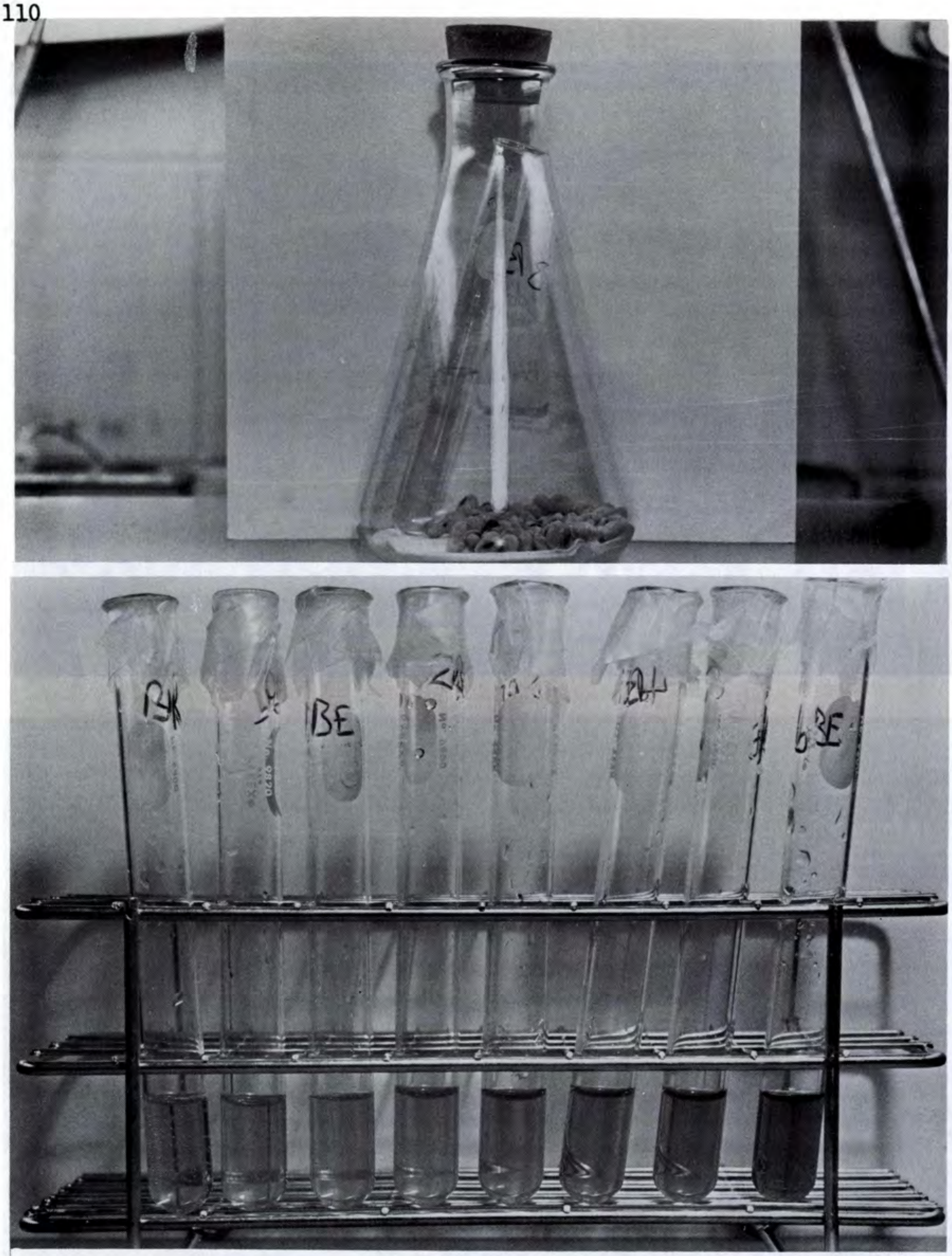


Figure 2. (above) Passive trapping aparatus used to capture aldehydes by diffusion from germinating soybean. (below) An array of solutions at the completion of the chemical test; the darker the solution color the lower the seed quality.

Table 1. Composition of the reaction tubes used to construct the standard curve during the course of the aldehyde assays.

μg Formaldehyde	Working Standard	H_2O	0.4% MBTH
	----------ml----------		
0	0	5	5
1	0.05	4.95	5
2	0.1	4.9	5
5	0.25	4.75	5
10	0.50	4.5	5
20	1.0	4.0	5
50	2.5	2.5	5
100	5.0	0	5

minutes. Transfer 1 ml from each tube into corresponding tubes containing 2.5 ml $FeCl_3$ solution. Mix by inverting and let sit 5 min. Add 6.5 ml acetone to each tube and measure absorbance at 635 nm using the 0 μg tube as a blank. Construct the standard curve by plotting absorbance versus ug formaldehyde. Absorbance values from seed samples can be converted to "μg aldehyde as formaldehyde" using the curve.

Preliminary results indicate that for soybeans, a capture of about 2 μg aldehyde as formaldehyde per 100 seeds is normal for high quality seed. From 4 to 6 μg indicates soybeans which, though possibly able to germinate well in the laboratory, have suffered a loss in vigor detectable by field planting or vigor tests such as accelerated aging. Samples yielding more than 8 μg aldehyde will probably exhibit a decline in laboratory germination as well as very poor field emergence.

Modifications

To increase sensitivity, decrease the amount of MBTH solution placed in the test tube. Adjust the standard curve accordingly. The whole reaction sequence could be done in a single tube, perhaps in a spectronic 20 cuvette by using smaller quantities of reagents. In the absence of a colorimeter, a color chart might be built by comparison with the standard curve using layers of colored plastic film.

References

Assoc. Off. Seed Anal. (1983). Seed Vigor Testing Handbook. Contr. No. 32. To the handbook on seed testing.

Ching, T. M. (1973). Adenosine triphosphate content and seed vigor. Plant Physiology 51, 400-402.

Dillard, C. J. and Tappel, A. L. (1979). A comparison of pentane, ethane, hexanal and acetone as *in vivo* indices of lipid peroxidation. Lipids 14, 980-993.

Frankel, E. N., Neff, W. E., and Selke, E. (1981). Analysis of autoxidized fats by gas chromatography-mass spectrometry: VII. Volatile thermal decomposition products of pure hydroperoxides.

Grosch, W., Laskany G., and Weber, F. 1976. Formation of volatile carbonyl compounds and cooxidation of β-carotene by lipoxygenase from wheat, potato, flax, and beans. Journal of Agricultural and Food Chemistry 24, 456-459.

Harman, G. E., Nedrow, B. L., Clark, B. E. and Mattick, L. R. (1982). Association of volatile aldehyde production during germination with poor soybean and pea seed quality. Crop Science 22, 712-716.

Sekiya, J., Kajiwara, T. and Hatanaka, A. (1979). Volatile C_6-aldehyde formation via hydroperoxides from C_{18}-unsaturated fatty acids in etiolated alfalfa and cucumber seedlings. Agricultural and Biological Chemistry 43, 969-980.

Stewart, R. R. C. and Bewley, J. D. (1980). Lipid peroxidation associated with accelerated aging of soybean axes. Plant Physiology 65, 245-248.

Vick, B. A. and Zimmerman, D. C. (1967). Lipoxygenase and hydroperoxide lyase in germinating watermelon seedlings. Plant Physiology 57, 780-788.

Wilson, D. O. and McDonald, M. R., Jr. (1985). The lipid peroxidation model of seed aging. Seed Science and Technology (Submitted).

Woodstock, L. W. (1968). Relationship between respiration during imbibition and subsequent growth rates in germinating seeds. p. 136-146. In: E. A. Locker (ed.) 3rd International Symposium on Quantitative Biology of Metabolism.

Woodstock, L. W. and Taylorson, R. B. (1981). Ethanol and acetaldehyde in imbibing soybean seeds in relation to deterioration. Plant Physiology 67, 424-428.

PROCEDURES FOR DETECTING ENDOPHYTES
IN PLANT AND SEED TISSUE[1]

Stain Test for Plant Tissue

a. Tillers must be randomly collected; one tiller each, from a minimum of thirty plants. The more tillers taken per sample, the more accurate the test.

b. Samples arriving in the mail should be free of contaminating fungi and other grasses such as annual ryegrass, orchardgrass and crabgrass.

c. Freezing upon arrival will preserve samples and make subsequent peeling of tissue easier.

d. Remove the outermost sheath from the tiller. Tissue should have no obvious discoloration from saprophytes and should have as little chlorophyll as possible.

e. Isolate a longitudinal section of sheath approximately 3-5 mm in width.

f. Place the section on a microscope slide and scrape gently with a scalpel. Separating the upper and lower epidermis and exposing the mesophyll tissue. Place the epidermis side down in both halves.

g. Stain immediately with aniline blue-lactic acid stain[2]. Allow dye to remain at least 15 seconds but no more than one minute.

----

[1]Information compiled from various references and actual experience by the authors; Charles Sciple, Don Blasingame and M. V. Patel.

[2]Method of Preparation of Aniline Blue Stain:

1. Prepare a 1% w/v aqueous ainiline blue solution in water.
2. Prepare a solution of 1 part lactic acid (85%) to 15 parts water.
3. Mix one part of solution 1 with 2 parts of solution 2.
4. Use stain as is or dilute with water if sections are too dark.

h. Blot off excess dye with a tissue. Sections should remain on the slide, but may adhere to the tissue; if so, remove the sections and place them in their original position on the slide.

i. Place a coverglass on the sections and flood with water.

j. Examine each half of each section at 200x magnification. Score a section as positive if any identifiable hyphae are present (Figure 1).

Stain Test for Seed

a. Seed sample should be properly collected. (Sample all of 1-5 bags, 10% of all remaining bags). Seed in bulk should be probed.

b. Take a subsample of the seed sample (2g is sufficient).

c. Digest seed overnight (8 hr. minimum) in a 5% solution of sodium - hydroxide.

d. Rinse the digested seed thoroughly in running tap water.

e. De-glume seed with forceps and place on microscope slide in a drop of aniline blue stain. Crush seed with scalpel. Wipe the scapel blade between seeds to prevent carryover of hyphae.

f. Place coverglass on seed and squash with gentle pressure.

g. Examine at 200x magnification, scoring a seed as positive if any identifiable hyphae are present.

Figure 1. Hyphae of an endophytic fungus (arrows) shown in the cells of a leaf.

REGISTRATION LIST

ALABAMA

Curvin Hursh
Escambia Farm & Seed Co., Inc.
Star Route A - Box 81
Atmore, AL 36502

Carl Martin
Escambia Farm and Seed Co., Inc.
Star Route A - Box 81
Atmore, AL 36502

Jim Bostick
Alabama Crop Imp. Assn.
So. Donahue Drive
Auburn University, AL 36849

Bob Burdett
Alabama Crop Imp. Assn.
So. Donahue Drive
Auburn University, AL 36849

Peter Niehoff
Elysian Farms
Rt. 1, Box 250-B
Gallion, AL 36742

Benny H. Nowell
Triangle Seed Cleaners
Rt. 1, Box 158-A
Headland, AL 36345

Foy Campbell
Funk Seeds Intl.
P. O. Box 2782
Montgomery, AL 36105

Peter C. Jones
CPJ International
PO Box 11309
Montgomery, AL 36111

Yasar Yonak
Blount World Trade Corp.
P. O. Box 4420
Montgomery, AL 36103

Martin Fobasso
Alabama A&M University
P. O. Box 579
Normal, AL 35762

Goulomou Kpoghomou
Alabama A&M University
P. O. Box 579
Normal, AL 35762

Marvin Burns
Dept. of Ag. Sciences
Tuskegee Institute
Milbank Hall
Tuskegee, AL 36088

Bobbie Clark
Dept. of Ag. Sciences
Tuskegee Institute
Milbank Hall
Tuskegee, AL 36088

Pauline David
Dept. of Ag. Sciences
Tuskegee Institute
Milbank Hall
Tuskegee, AL 36088

Collie Graddick
Dept. of Ag. Sciences
Tuskegee Institute
Milbank Hall
Tuskegee, AL 36088

Desmond Mortley
Dept. of Ag. Sciences
Tuskegee Institute
Milbank Hall
Tuskegee, AL 36088

Howard Gunn
Dept. of Ag. Sciences
Tuskegee Institute
Milbank Hall
Tuskegee, AL 36088

Sadkham H. Nima
Dept. of Ag. Sciences
Tuskegee Institute
Milbank Hall
Tuskegee, AL 36088

Sampson Hopkinson
Dept. of Ag. Sciences
Tuskegee Institute
Milbank Hall
Tuskegee, AL 36088

ARKSANSAS

Ed Barnhill
Rohm & Haas Seeds
503 Dent Ave.
Bay, AR 72411

Steve Cranford
Department of Agronomy
Univ. of AR
115 Plant Science Bldg.
Fayetteville, AR 72701

Yohannes Degago
Department of Agronomy
Univ. of AR
115 Plant Science Bldg.
Fayetteville, AR 72701

D. E. Longer
Dept. of Agronomy
Univ. of Arkansas
115 Plant Science Bldg.
Fayetteville, AR 72701

Steve Moore
Dept. of Agronomy
Univ. of Arkansas
115 Plant Science Bldg.
Fayetteville, AR 72701

Sidney Skinner
Dept. of Agronomy
Univ. of Arkansas
115 Plant Science Bldg.
Fayetteville, AR 72701

James Watkins
Dept. of Agronomy
Univ. of Arkansas
115 Plant Science Bldg.
Fayetteville, AR 72701

Randy Dismuke
Delta & Pine Land Company
Rt. 1, Box 60
Harrisburg, AR 72432

Dennis J. Stephens
South East Dist.
PO Box 4462
Little Rock, AR 72219

Ottilio Bariola
Alice-Sidney Dryer & Seed Co.
P. O. Box 81
Jerome, AR 71650

Richard Graves
Alice-Sidney Dryer & Seed Co.
P. O. Box 81
Jerome, AR 71650

David Luter
Carter-Cox Seeds, Inc.
Box 26
Knobel, AR 72435

Lanny Ashlock
AR Co-Op Ext. Service
P. O. Box 391
Little Rock, AR 72203

Roger Clark
Holder-Conner Seed Co.
2301 McLain Street
Newport, AR 72112

Noyal Jones
Holden-Conner Seeds
2301 McLain Ave.
Newport, AR 72112

Bill David Kennedy
Holden-Conner Seeds
2301 McLain Ave.
Newport, AR 72112

Verlon Spencer, Jr.
Holden-Conner Seeds
2301 McLain Ave.
Newport, AR 72112

Verlon Spencer
Rohm and Haas Seeds
PO Box 87
Newport, AR 72112

R. Jane Barris
Jacob Harris Seed Co., Inc.
PO Box 946
Stuttgart, AR 72160

Don Bullis
Brunson-Bullis Equipment Co.
P. O. Box 1355
West Memphis, AR 72301

Dan Mascheck
Rohm & Haas
PO Box 2629
West Memphis, AR 72301

Mack McCrary
Rohm and Haas Seeds Inc.
PO Box 2629
West Memphis, AR 72301

Mark Smith
Rohm & Haas Seeds, Inc.
P.O. Box 2629
West Memphis, AR 72301

Andy Strickland
Rohm & Haas Seeds, Inc.
P.O. Box 2629
West Memphis, AR 72301

Kim Todd
Rohm & Haas Seeds, Inc.
PO Box 2629
West Memphis, AR 72301

CALIFORNIA

Suzanne Day
Campbell Inst. for Res. & Tech.
Rt. 1, Box 1314
Davis, CA 95616-9610

Ernesto Cazares
ARCO Seed Co.
110 E. Ross Ave.
El Centro, CA 92243-9797

Joe Cornejo
ARCO Seed Co.
110 E. Ross Ave.
El Centro, CA 92243-9797

Albert Gonzales
ARCO Seed Co.
110 E. Ross Ave.
El Centro, CA 92243-9797

Floyd Lydum
ARCO Seed Co.
110 E. Ross Ave.
El Centro, CA 92243-9797

Joe Salgado
ARCO Seed Co.
110 E. Ross Ave.
El Centro, CA 92243-9797

Sergio Nieto
Asgrow Seed Company
P. O. Box 716
Gonzales, CA 93926

Stan Bayer
Cornnuts, Inc.
P. O. Box 215
Greenfield, CA 93927

Dorothy Babski
USDA, SCS
P. O. Box 68
Lockeford, CA 95237

Ed Bartkowski
CelPril Industries, Inc.
P. O. Box 1032
Manteca, CA 95336

Kirk Cunningham
Cunningham & Associates
1643 Fireside St.
Orange, CA 92667

Tim Sullivan
Burpee Seed Co.
335 South Briggs Rd.
Santa Paula, CA 93060

Philip Shrauger
Petoseed Co., Inc.
P. O. Box 4206
Saticoy, CA 93004-0206

Manual Tarango
Petoseed Co., Inc.
P. O. Box 4206
Saticoy, CA 93004-0206

COLORADO

Mr. & Mrs. Warren R. McCue
Arriba Grain & Feed Co., Inc.
P. O. Box 167
Arriba, CO 80804

Jerry Haynes
Jacks Bean Co.
Holyoke, CO 80734

Terry Quinn
Oliver Mfg. Co., Inc.
P. O. Box 512
Rocky Ford, CO 81067

Jim Thomas
Oliver Mfg. Co., Inc.
P. O. Box 512
Rocky Ford, CO 81067

DISTRICT OF COLUMBIA

Richard C. Russell
USDA, ARS
P. O. Box 2890
Washington, D. C. 20013

FLORIDA

Clarence Maura
Soil Conservation Service
Plant Materials Center
14119 Broad Street
Brooksville, FL 33512

Daniel Stankey
Soil Conservation Service
Plant Materials Center
14119 Broad Street
Brooksville, FL 33512

Pat Alvarez
Speedling, Inc.
P. O. Box 220
Sun City, FL 33586

Ron Bradtmueller
Central States Enterprises, Inc.
P. O. Box 52
McAlpin, FL 32062

Wesley Putnel
Central States Enterprises, Inc.
P. O. Box 52
McAlpin, FL 32062

Don Rogers
Central States Enterprises, Inc.
P. O. Box 52
McAlpin, FL 32062

GEORGIA

Mr. & Mrs. T. Lee Gregg
Gregg Farms
P. O. Box 269
Concord, GA 30206

Ed Dowling
Jacques Seed Co.
P. O. Box 370
Lincoln, IL 62656

Jay Winebrinner
Jacques Seed Co.
P. O. Box 370
Lincoln, IL 62656

Perry Winebrinner
Jacques Seed Co.
P. O. Box 370
Lincoln, IL 62656

Steve Thibo
Loveland Industries
P. O. Box 266
Mahomet, IL 61853

Mark Cox
Custom Farm Seed
P. O. Box 160
Momence, IL 60954

Ruth Luebeck
Custom Farm Seed
P. O. Box 160
Momence, IL 60954

Chris Pflederer, Jr.
Sommer Bros. Seed Co.
P. O. Box 248
Pekin, IL 61554

Paul Stone
Pioneer Hibred, Int'l.
Illinois-Wisconsin Div.
P. O. Box 40
Princeton, IL 61356

Walter F. Smith
Black Products Company
65 West 144th Street
Riverdale, IL 60627

H. A. Stults
Stults Scientific Eng. Corp.
3313 S. 66 Freeway
Springfield, IL 62703

John Hummel
USDA/ARS
Dept. of Agri. Eng.
1304 W. Penn. Ave.
Univ. of IL
Urbana, IL 61801

Joe Lamb
Illinois Crop Imp. Assn.
508 S. Broadway
Urbana, IL 61801

Karen Greetis
Geo. J. Ball, Inc.
P. O. Box 335
West Chicago, IL 60185

Victor Rojas
Geo. J. Ball, Inc.
P. O. Box 335
West Chicago, IL 60185

INDIANA

Rod Gerber
Blount Industrial Products
P. O. Box 256
Bluffton, IN 46714

Bill Wallace
Blount Industrial Products
P. O. Box 256
Bluffton, IN 46714

Richard E. Helmuth
Helmuth Corp.
828 E. 116th Street
Carmel, IN 46032

Joe Deford
IN Crop Imp. Assn., Inc.
3510 U.S. 52 South
Lafayette, IN 47905

Fred Halsema
IN Crop Imp. Assn., Inc.
3510 U.S. 52 South
Lafayette, IN 47905

Ed Dowling
Jacques Seed Co.
P. O. Box 370
Lincoln, IL 62656

Jay Winebrinner
Jacques Seed Co.
P. O. Box 370
Lincoln, IL 62656

Perry Winebrinner
Jacques Seed Co.
P. O. Box 370
Lincoln, IL 62656

Steve Thibo
Loveland Industries
P. O. Box 266
Mahomet, IL 61853

Mark Cox
Custom Farm Seed
P. O. Box 160
Momence, IL 60954

Ruth Luebeck
Custom Farm Seed
P. O. Box 160
Momence, IL 60954

Chris Pflederer, Jr.
Sommer Bros. Seed Co.
P. O. Box 248
Pekin, IL 61554

Paul Stone
Pioneer Hibred, Int'l.
Illinois-Wisconsin Div.
P. O. Box 40
Princeton, IL 61356

Walter F. Smith
Black Products Company
65 West 144th Street
Riverdale, IL 60627

H. A. Stults
Stults Scientific Eng. Corp.
3313 S. 66 Freeway
Springfield, IL 62703

John Hummel
USDA/ARS
Dept. of Agri. Eng.
1304 W. Penn. Ave.
Univ. of IL
Urbana, IL 61801

Joe Lamb
Illinois Crop Imp. Assn.
508 S. Broadway
Urbana, IL 61801

Karen Greetis
Geo. J. Ball, Inc.
P. O. Box 335
West Chicago, IL 60185

Victor Rojas
Geo. J. Ball, Inc.
P. O. Box 335
West Chicago, IL 60185

INDIANA

Rod Gerber
Blount Industrial Products
P. O. Box 256
Bluffton, IN 46714

Bill Wallace
Blount Industrial Products
P. O. Box 256
Bluffton, IN 46714

Richard E. Helmuth
Helmuth Corp.
828 E. 116th Street
Carmel, IN 46032

Joe Deford
IN Crop Imp. Assn., Inc.
3510 U.S. 52 South
Lafayette, IN 47905

Fred Halsema
IN Crop Imp. Assn., Inc.
3510 U.S. 52 South
Lafayette, IN 47905

Phyllis Hoovler
IN Crop Imp. Assn., Inc.
3510 U.S. 52 South
Lafayette, IN 47905

Jamie Wray
IN Crop Imp. Assn., Inc.
3510 U.S. 52 South
Lafayette, IN 47905

Marvin Baldwin
Bailey Seed Farms, Inc.
R. R. 6, Box 178
Portland, IN 47371

Bill Bailey
Bailey Seed Farms, Inc.
R. R. 6, Box 178
Portland, IN 47371

IOWA

Doug Cross
AgriPro Seeds
R. R. 2, Hwy. 30E
Ames, IA 50010

Mark Cleveland
Pride Co., Inc.
Hwy. 61
DeWitt, IA 52742

Tim Primus
Northup King Co.
PO Box 272
Jefferson, IA 50129

Bruce Hill
Pioneer Hi-Bred International, Inc.
7000 Parkway
Johnston, Iowa 50131

Mike Jermier
Pioneer International
Box 256
Johnston, IA 50131

Gregory K. Mangold
Stauffer Seeds, Inc.
Box 377
Lone Tree, IA 52755

Barry Kuhlmann
Northup King
P. O. Box 478
Waterloo, IA 50704

KANSAS

Bill Hallman
Paymaster Seeds
Drawer R
Leoti, KS 67861

Donald Garwood
Soil. Conser. Service
Plant Materials Center
Rt. 2, Box 314
Manhattan, KS 66502

Mr. & Mrs. James Stanelle
Agronomy Dept.
Kansas State University
Throckmaton Hall
Manhattan, KS 66506

Steve Laudwig
Taylor Products Co., Inc.
5300 Main
Parsons, KS 67357

Murland L. Taylor
Taylor Products Co., Inc.
5300 Main
Parsons, KS 67357

KENTUCKY

Mr. & Mrs. Wayne Still
Univ. of KY
Division of Regulatory Services
Room 102, Scovell Hall
Lexington, KY 40546-0064

LOUISIANA

Susan Chang
LA Foundation Seed Program
LA Ag. Exp. Station
LSU Agri. Center
Rt. 2, Box 30-D
Alexandria, LA 71302

Andy Drummond
LA Foundation Seed Program
LA Ag. Exp. Station
LSU Agri. Center
Rt. 2, Box 30-D
Alexandria, LA 71302

David Jewell
Funk Seeds, Intl.
4810 Duhon Lane
Alexandria, LA 71312

Paul Stuart
Funk Seeds, Intl.
4810 Duhon Lane
Alexandria, LA 71312

Matthew Keppinger
La. Dept. of Agriculture
Office of Ag. & Env. Ser.
PO Box 18190 -B Un. St.
Baton Rouge, LA 70893

Leon C. Standifer
Horticulture Dept.
La. State University
Agriculture Center
137 Agronomy-Horticulture Bldg.
Baton Rouge, LA 70803-2120

Derwood Delaney
La Forest Seed Co., Inc.
Rt. 2, Box 123
Lecompte, LA 71346

R. W. McPherson
R. W. McPherson & Assoc.
P. O. Box 5011
Monroe, LA 71211

Joe W. Haahn
Chipman Chemicals, Inc.
198 Wildwood
Pineville, LA 71360

Kenneth Ebersole
Thornwell Warehouse Assn.
P. O. Box 766
Welsh, LA 70591

MARYLAND

Richard C. Russell
USDA/Soil Conservation Service
B-509, BARC-E
Beltsville, MD 20705

MICHIGAN

Steve Galgoczi
Crippen Mfg. Co., Inc.
P. O. Box 350
Alma, MI 48801

Brian T. MacMaster
Rose Lake Plant Mat. Center
USDA, SCS
7472 Stoll Road, RR #7
East Lansing, MI 48823

Linda McIntosh
Neogen Food Tech
4245 Okemos Road
Okemos, MI 48864

MINNESOTA

Myles Bakken
Dahlgren & Co., Inc.
1220 Sunflower Street
Crookston, MN 56716

Charles Habstritt
Univ. of Minnesota
Agriculture Division
109 Hill Building
Crookston, MN 56716

Dennis Wamre
The Rapat Corporation
Hawley Industrial Park
Hawley, MN 56549

Paul Harguth
Pillsbury Co.
1100 North 4th St.
LeSueur, MN 56058

Harold Wondra
Pillsbury Co.
1100 North 4th Street
LeSueur, MN 56058

Steve Cashman
Carter-Day Co.
500 - 73rd Ave., N.E.
Minneapolis, MN 55432

Douglas DeLong
Northrup King co.
Box 959
Minneapolis, MN 55440

Kent Mellen
Carter-Day Co.
500 73rd Ave., N.E.
Minneapolis, MN 55432

Brad Nylander
Conklin Co., Inc.
P. O. Box 155
Shakopee, MN 55379

Warren D. Poole
Conklin Co., Inc.
P. O. Box 155
Shakopee, MN 55379

Irvine F. Forsberg
Forsbergs, Inc.
P. O. Box 510 - Airport Rd.
Thief River Falls, MN 56701

Jerry M. Nelson
Forsbergs, Inc.
P. O. Box 510 - Airport Rd.
Thief River Falls, MN 56701

MISSISSIPPI

Roy Armstrong
Mid America Grain
Amory, MS 38821

Dick Wax
The Wax Company, Inc.
P. O. Box 60
Amory, MS 38821

John Wax
The Wax Company, Inc.
P. O. Box 60
Amory, MS 38821

Edward Guerry
Rohm & Haas Seeds, Inc.
Box 236
Artesia, MS 39736

Gary Gilder
Sanders Seed Co.
P. O. Box 940
Cleveland, MS 38732

Gregory Brinson
Soil Conservation Service
Plant Materials Center
Coffeeville, MS 38922

Joe Snider
Soil Conservation Service
Plant Materials Center
Coffeeville, MS 38922

Richard A. Graves
Graves Seed Lab., Inc.
Rt. 8, Box 298
Columbus, MS 39702

Bobby Hendrix
Gustafson, Inc.
Riverbend Apts. #6204
Cypress Lane
Greenville, MS 38701

James A. Wolfe
Soil Conservation Service
Suite 1321, Federal Building
100 West Capitol Street
Jackson, MS 39269

Don Blasingame
MS Coop. Ext. Service
P. O. Box 5426
Miss. State, MS 39762

Julio C. Borbon-Reyes
Graduate Student
Plant Pathology & Weed Science Dept.
Mississippi State University
Miss. State, MS 39762

Charles Sciple
State Seed Testing Lab.
P. O. Drawer S
Miss. State, MS 39762

Vance Watson
Forage & Pasture Prog. Coord.
P. O. Drawer ES
Miss. State, MS 39762

Howard Brown
Delta & Pine Land Co.
Scott, MS 38772

Roy Gilbert
Delta & Pine Land Co.
Scott, MS 38772

Bob Fulgham
Brayton Chemicals, Inc.
PO Box 1416
Tupelo, MS 38802-1416

MISSOURI

Jeff Pierce
Pierce Seeds
Rt. 1, Box 11
Caruthersville, MO 63830

Jerry Schuerenberg
MO Seed Improvement Assn.
Rt. 1,
Matthews, MO 63867

Bill Ward, Gen. Mgr.
Seedsmen's Digest
10714 Manchester Rd.
Suite 202
St. Louis, MO 63122

NEBRASKA

Darrel Krieg
Jacks Bean Co.
P. O. Box 190
Grant, NE 69140

Dan McPeak
Jacks Bean Co.
P. O. Box 190
Grant, NE 69140

James Bartek
Griswold Seed Company
P. O. Box 81466
Lincoln, NB 68501

Tom Hirsch
Griswold Seed Company
P. O. Box 81466
Lincoln, NB 68501

Roger Berney
J. C. Robinson Seed Co.
Golden Harvest
Waterloo, NB 68069-0301

NEW JERSEY

Rich Hurley
Lofts Pedigreed Seed, Inc.
Box 146, Chimney Rock Road
Bound Brook, NJ 08805

Wilson J. Merrick
USDA-SCS
Plant Materials Center
Box 236-A, RD #1
Cape May Court House, NJ 08210

NEW YORK

Evan Mann
Stanford Seed Co.
P. O. Box 951
Binghamton, NY 13902

Alan Taylor
Dept. Horticultural Sciences
Seed Lab., NY Ag. Exp. Station
P.O. Box 462
Geneva, NY 14456

NORTH CAROLINA

Donald H. Baker
N.C. Foundation Seed Producers, Inc.
P. O. Box 33245, Method Station
Raleigh, NC 27606

Saunders C. Bennett
NC Crop Improvement Assn., Inc.
3709 Hillsborough Street
Raleigh, NC 27607

G. H. Miller, Jr.
NC Foundation Seed Producers, Inc.
P. O. Box 33245, Method Station
Raleigh, NC 27606

Charlie Whaley, Jr.
NC Foundation Seed Producers, Inc.
P. O. Box 33245, Method Station
Raleigh, NC 27606

OHIO

Tom Wacek
Kalo Laboratories
P. O. Box 12567
Columbus, OH 43212

Mr. & Mrs. Dave Ballenger
Robinson Hybrids, Inc.
4796 Dildine Rd.
Delaware, OH 43015

Mr. & Mrs. Ralph Stegbauer
Madison Seed Co.
13455 State Rte. 38, S. E.
London, OH 43140

OKLAHOMA

Gary Bird
Eckroat Seed Co.
P. O. Box 17610
Oklahoma City, OK 73136

Ronnie Shugart
Eckroat Seed Co.
P. O. Box 17610
Oklahoma City, OK 73136

PENNSYLVANIA

Fred Gaston
Stanford Seed Co.
R. R. 1, Box 405
Muddy Creek Road
Denver, PA 17517

Linda L. Blake
Agway, Inc. - Seed Div.
P. O. Box 129
East Butler, PA 16029

Linda Wilhelm
Agway, Inc. - Seed Div.
Rt. 4, Zeager Rd.
Elizabethtown, PA 17022

Thomas E. Klein
Mercator Corp.
P. O. Box 142
Reading, PA 19603

Joe Beebe
Grower
R. D. 4, Box 226
Towanda, PA 18848

NORTH CAROLINA

Robert B. Wright
A.R. McKay Processing Machinery
PO Box 96
Hickory, N.C. 28603

OHIO

David Hiser
Robinson Hybrids
4796 Dildine Rd.
Delaware, Ohio 43015

SOUTH CAROLINA

Jim Alston
Geo. W. Park Seed Co.
P. O. Box 31
Greenwood, SC 29646

Lewis Howe
Geo. W. Park Seed Co.
P. O. Box 31
Greenwood, SC 29646

TENNESSEE

Gus Baurnfind
Grain Equipment, Inc.
5735 Heathrow Cove
Memphis, TN 38115

Dave Grimm
Asgrow Seed Co.
5680 Gaywinds Ave.
Memphis, TN 38115

Virgil Harden
Harden Proc. Equip. Sales
P. O. Box 18880
Memphis, TN 38118

Mr. & Mrs. Jim Henderson
Harden Proc. Equip. Sales
P. O. Box 18880
Memphis, TN 38118

Peggy Stumbo Johnston
Buckman Labs.
P.O. Box 8305
Memphis, TN 38108

Edd Sullivan
Consolidated Equip. Co., Inc.
P. O. Box 18535
Memphis, TN 38181-0585

Mr. & Mrs. John Franklin
TN Dept. of AG
P. O. Box 40627 Melrose Station
Nashville, TN 37204

Mr. & Mrs. Lester Venable
TN Dept. of AG
Div. of Marketing
P. O. Box 40627 Melrose Station
Nashville, TN 37204

Mr. & Mrs. Edward Smith
Edward Smith & Sons Seeds
Rt. 1, Box 163
Stantonville, TN 38379

Perry T. Butler
Butler Seed & Delinting Co.
Tiptonville, TN 38079

TEXAS

Wayne Beckwith
Western Reg. Res. Mgr.
Gustafson, Inc.
17400 N. Dallas Pkwy, Suite 220
Dallas, TX 75252

Kyle Rushing
VP for Research
Gustafson, Inc.
17400 N. Dallas Pkwy.
Suite 220
Dallas, TX 75252

Mr. & Mrs. Daniel A. Thornton
Winco Agri-Products of TX
P. O. Box 337
Eagle Lake, TX 77434

Ben Castruita, Jr.
SeedTec Intl., Inc.
P. O. Box 2212
Hereford, TX 79045

Robert Duffy
Garrison Seed & Co., Inc.
P. O. Box 927
Hereford, TX 79045

Coby Kriegshauser
Scott Seed Co.
Box 1732
Hereford, TX 79045

Dale Pierson
Garrison Seed & Co., Inc.
P. O. Box 927
Hereford, TX 79045

Lemoin Unger
Loveland Industries
3203 81st St.
Lubbock, TX 79423

Mike Coyne
"Peggie"-Martin & Assoc.
P. O. Box 613
Pearsall, TX 78061

Rodney Carpenter
Paymaster Seeds
Box 1630
Plainview, TX 79072

Bud Hughes
Paymaster Seeds
PO Box 1630
Plainview, TX 79072

Donnie G. Helton
Paymaster Seeds
Box 1630
Plainview, TX 79072

Charles Denison
Douglass W. King Co., Inc.
P. O. Box 20320
San Antonio, TX 78286

Louis J. Jupe
Douglass W. King Co., Inc.
P. O. Box 20320
San Antonio, TX 78286

John Taff
Douglass W. King Co., Inc.
P. O. Box 20320
San Antonio, TX 78286

VERMONT

Jeff Morehouse
Stanford Seed Co.
Washington Road
East Barre, VT 05649

WISCONSIN

James R. Larson
Didion, Inc.
P. O. Box 400
Johnson Creek, WI 53038

Margaret L. Anderson
Stauffer Seeds
2622 Blaney Rd
Madison, WI 53711-5699

John C. Tadder
Stauffer Seeds Inc.
2622 Blaney Rd.
Madison, WI 53711-5699

Jim Huppert
Jacques-Seed Co.
720 St. Croix St.
Prescott, WI

Bill Kelly
Jacques Seed Co.
720 St. Croix St.
Prescott, WI 54021

John Mahar
Jacques Seed Co.
720 St. Croix St.
Prescott, WI 54021

BARBADOS

Andrew M. Maxey
Agency for Intl. Development
Reg. Dev. Office/Carribean
P. O. Box 302
Bridgetown,
BARBADOS

CANADA

Tony VanRoon
OSECO, Inc.
P. O. Box 219
Brampton, Ontario L6V 2L2
CANADA

Martin Krebbs
W. G. Thompson & Sons Ltd.
Box 250
Blenheim, Ontario NOP 1A0
CANADA

Neil McAllister
W. G. Thompson & Sons Ltd.
Box 250
Blenheim, Ontario NOP 1A0
CANADA

David Robert
W. G. Thompson & Sons Ltd.
Box 250
Blenheim, Ontario NOP 1A0
CANADA

CHILE

Sergio Massai Drago
Molinera de Sol
Central Golden Harvest Res.
Astorga 517
Rancagua
CHILE

DOMINICAN REPUBLIC

Mr. & Mrs. Charles N. Mariotti
Sociedad Industrial Dominicana
C. POR A.
P. O. Box 726
Santo Domingo, Republica Dominicana
DOMINICAN REPUBLIC

JAPAN

Hiroshi Hosoya
Kaneko Noki
21-10 Nishi 2-Chome
Hanyu City, Saitama 348
JAPAN

Takuya Ishikawa
Kokusen Co., Ltd.
776 Kozono Ayase City
Kanagawa Prf
JAPAN