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1986 SHORT COURSE
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SEEDSMEN

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SEED TECHNOLOGY LABORATORY

MISSISSIPPI STATE **MISSISSIPPI**

Sponsored By The Mississippi Seedmen's Association

PROCEEDINGS (VOLUME 28)

THIRTY-FOURTH SHORT COURSE FOR SEEDSMEN

APRIL 7-9, 1986

SEED TECHNOLOGY LABORATORY

MISSISSIPPI STATE UNIVERSITY

MISSISSIPPI STATE, MISSISSIPPI 39762

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THE BASICS - NOW AND IN THE FUTURE

Larry Svajgr[1]

I am pleased to be a part of the program at this 34th Short Course for seedsmen here at Mississippi State. I have been in the audience here on more than one occasion in the past several years, but this is my first opportunity to participate in this capacity. I readily admit that I consider it an honor and a privilege to be a part of such a well-respected and historically prestigious seed meeting.

I live in Indiana, but I don't attend the famous Indianapolis 500 Race. I have never gone but I do listen to it every year on the radio. I am not a racing fan at all, but it is just sort of expected that everybody in Indiana listens to it. Regarding that race, it really wasn't many years ago that everyone said those Indy 500 cars have peaked out on speed - they can't ever go 200 miles an hour. It's physically and aerodynamically impossible on a 2 1/2 mile circular track. Two hundred was broken a few years ago and this year I understand they are hitting over 214 during some tire testing. They'll never break 200!

Whenever you base decisions, judgments or expectations on some standard, even what appears to be a standard of excellence at the time, the standard changes. Whether it is a car race where the standard is easy to measure or the seed industry where you may need a few more yardsticks, it is basically the same. The standards, or the basics if you will, are always changing. There is no place to be complacent - there is no status quo - there is no doing it like we did in the good old days. You either change with an industry or you will soon be out of step, out of date, and very probably, out of business. I can't talk about "back to basics" or critically analyze what the basics may be for the future without giving you some definition of basics. In the seed industry or any other industry, the "basics" are the cumulative levels of acceptance at a given point in time.

A little background. Agriculture is changing rapidly and markedly. It has become more knowledge-based than capital-based; the family farm concept is in question; it depends on global markets and economics; comparative advantage is critical; it is an economy of appropriateness, not of scale. The past five years of molecular biology advances, micro-electronics and computer advances, and a drastically

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[1]Manager, Indiana Crop Improvement Association, Inc., Lafayette, Indiana

changed financial environment have set the stage for what may become one of the most pronounced changes in U.S. agricultural history.

Bio-tech and the underlying molecular biology represents powerful new tools for agricultural scientists. Research now underway will very probably lead to crops with increased resistance to salt soils, heat, cold, disease, drought, and other environmental conditions; plants that produce their own insecticides and herbicides; or food plants with tremendously enhanced nutritional value.

Computers and artificial intelligence systems are beginning to provide powerful new management tools for the sophisticated manager. Micro-electronic controls on farm equipment such as fertilizer and chemical monitors, self-adjusting combines and tillage machinery will improve efficiency, productivity and product quality.

These and other changes will have dramatic impacts on the people engaged in farming and all the related input and service industries which comprise modern agriculture. More farm operators, the decision makers, will need college-level education followed by top quality continuing education and technology transfer. There will be a greater need for skilled service technicians to keep the systems running. New processing technologies will demand a better trained labor force as well as market representatives trained to merchandise new products, including the best quality seed of the most highly adapted crop varieties.

The number of people required on farms will continue to decline and those remaining must begin to diversify more. Those persons displaced from farms or agri-business must be retrained for the new technologies or aided in seeking alternative employment. Despite these changes, I believe agriculture will remain a vital part of America's economy. We have the land, the water, the climate and the science base necessary for the new agriculture. The future will be punctuated by change, challenge and competition.

I believe we are in the early innings of a whole new ball game in agriculture and a completely new era in the seed industry. A new era measured in decades, years or even in months - take your choice.

I am not talking about low commodity prices, devaluation of land, credit crunches and bankruptcies, either. They are popular topics and certainly a change and a challenge, but these aren't the things of which eras are really defined.

I want to focus on what is really happening in the seed industry that is the cutting edge of new definitions, changing philosophies and high technology. Where has the seed industry come from, where is it, and where is it headed?

I want to discuss a few key areas that I believe greatly impact the seed industry today. I may not paint a complete picture, but I have selected areas that I believe merit review and in some cases, criticism. Remember, I am opinionated so I will not hesitate to criticize where I believe it is due; however, I will never criticize without suggestion. That should be left for the same people who chronically grumble but never bother to vote.

I will limit my comments to five selected areas: technology, varieties, marketing, seed regulation, and seed certification. Strange bedfellows these may seem, but bear with me - it is all supposed to come together at the end. I will highlight the first four - technology, varieties, marketing and seed regulation and give you a pretty heavy load of the fifth, seed certification because that is the one that hits me right where I live.

Number one - technology. Technology related to our business, the seed industry, is improving and changing almost daily. You are aware of many of these but let me tough on a few. Inbreeding, we see expanded use of computers, new concepts unconventional breeding techniques, as well as new biotech procedures for genetic engineering, etc. New tools! The end product will still need to be bagged and delivered to the farmer. Your responsibility is to stay tuned and be part of the chain. Technology relating to seed production; there are new and better chemicals for weed and pest control, precision planters, improved harvesters and generally less requirement for labor. The bottom line is lower cost production and a higher quality product. New technology in seed conditioning. Every year I see research results with good data regarding improved seed handling, drying, cleaning, new and better seed treatments and a host of other things that are continuing to improve all aspects of seed conditioning. If you stay awake at even half of the sessions at this meeting and keep your ears and eyes open, you are going to learn a whole lot more than I can hope to tell you from the speaker's stand this morning. In addition, we are seeing technological advances in seed testing and laboratory procedures. We are seeing better standardization of existing tests, new tests, more research and better ability overall to evaluate seed quality. So, whether the advances in technology in the seed industry are in breeding, production, conditioning or testing, they all dovetail, fit together and ultimately improve the industry as a whole. And, finally, the technology of information processing is jumping ahead by leaps and bounds. We are able to gather information more quickly, process it almost instantaneously and disseminate it where it needs to go in a fashion unheard of only a few years ago. Computers and other micro-electronics are truly revolutionizing the seed industry in almost all areas. This alone makes it a pretty exciting time to be involved.

The second major area I want to touch on is varieties. Years ago there were very few varieties of any of the major crops and all but a few were developed by the U.S. government and public institutions. Today, in almost all crop areas, the varieties are the products of private companies, private breeding organizations and public institutions. We are in the transition from public to private now and it will continue until most varieties of widely grown crops will be proprietary varieties. This has been difficult for some people to accept because somehow public varieties are looked upon as sacred and something that must be retained at all costs. In my opinion, private varieties are nothing more than the result of an industry that is finally beginning to mature. The government doesn't produce many other products; it doesn't necessarily have to produce crop varieties, but I am convinced we will have a strong complimentary relationship between public and private breeders for years to come. Varieties of some of the minor crops will be produced by public breeders for many years to come and special problems in the major crop areas will be investigated by public institutions as well. I am a firm believer in the private industry - I am also a strong supporter of crop research in public institutions. To me, there are no sides involved, no public versus private. There are simply areas of expertise to be utilized and profits to be made by those who remain competitive. That's a bird's-eye view of how I see the variety picture now and in the future.

The third major area I want to review briefly is the whole area of seed marketing. This includes the sellers, the buyers, and how the seed itself is actually being sold today. Let's go simple to complex. The buyers are the farmers. They were the buyers years ago - they are currently buying the seed and they will be buying the seed in the future. The complexion may change and the way farmers are categorized as a buying group is changing and I'll mention more about that in a second.

Who is selling the seed? Years ago most of the crop seed in the United States was sold by farmers who produced seed and sold it to their neighbors and people in a fairly localized area. Because of communication and transportation limitations, sales ares of major crop seeds were fairly small. As the tools we have available improved, so that marketing changed and currently much of the seed in this country is marketed by fairly large professional seed organizations and companies who may utilize full-time dealers, farmer-dealers, etc. We have multi-national companies involved who have picked up marketing opportunities through mergers and acquisitions; we have a large group of mid-sized companies and we still have a few farmer-type seed producers who sell and market seed in a relatively small area. As time goes on, I believe we will see the trend continue but I also believe there is a place in the seed industry for small independent seedsmen providing they are willing to be professional and meet the competition. Seed marketing is now done on a worldwide basis which in recent years has become a real boon for the seed industry in this country.

I have touched briefly on the seller and the buyer but I feel I must give you a concern I have regarding seed marketing. Seed marketing and distribution in some respects is in the horse and buggy stages even though the marketers are geared up with many of the high technology tools I have alluded to earlier. In large part, I am referring to the farmer-dealer concept. Farmer-dealers came into being years ago as a method of selling and distributing crop seeds. In many cases, the farmer-dealer is nothing more than a preferred customer. He may or may not sell seed in addition to what he utilizes for his own planting. The problem as I see it is that the typical farmer-dealer calls on a clientele that may represent a group of farmers that are currently having the most serious financial problems. The USDA recently put out some information regarding classes of farmers. They looked at numbers of farmers with gross incomes under \$100,000, between \$100,000 and \$500,000, and \$500,000 plus. Those with gross incomes of under \$100,000 were in reasonably good financial condition because most of them had off-farm employment and were able to keep their operations reasonably solvent. Those with operations over \$500,000 gross income were also in reasonably good shape but the group with gross incomes between \$100,000 and \$500,000 had the largest amount of outstanding debt and had the highest number that were facing serious financial problems. Ironically, it is that higher-risk group of farmers that farmer-dealers traditionally call upon to sell seed. Why? They don't traditionally call on very small farmers because the opportunity for significant sale is not there and they're not going to the extremely large operators because the large operators buy direct. The big farmers aren't going to mess around and pay dealer commissions. Marketing can be improved. Companies need to think in terms of company stores, retail outlet operations, etc. They need to recognize that many of their dealers as preferred customers and be aware of the fact that a significant number of the farmers being called upon by farmer-dealers may be some of those with potential serious financial problems. Whether we like it or not, I believe we have reached a time in the seed industry where we need to remove the excess fat and deliver a good quality seed product to the user as efficiently and economically as possible. Caps, jackets, salesman and dealer trips and open-ended return policies are costly. It is time for the industry to re-examine some of these things and adjust marketing programs accordingly.

The fourth major area is one we all love to talk about - seed regulation. We particularly like to talk about it when we know there aren't any regulatory people in the room. Actually, we really shouldn't joke about them because we all know there are very few problems with legislator personnel that a little discussion can't aggravate!

Seed regulation is an important part of the seed industry. We mustn't forget that seed regulation is in place not just as consumer protection, but also to assist in the orderly labeling and movement of seeds. Years ago when commercial seed movement was in its fledgling stages, regulation was needed and probably hard pressed to assure that seed was labeled, let alone was properly labeled. One of my criticisms of seed laws and seed legislation is they seem slow to adjust with an industry that is currently extremely competitive and generally demonstrates a high level of professionalism. Many states' seed laws are still currently designed principally to regulate the professional industry with very little attention paid to inferior quality seed moved by non-professional seedsmen or bin-run grain sold by farmers. This is an intolerable situation, it is being addressed by a few states and certainly needs to be addressed by a few others. If we are going to regulate the industry selling good seed, let's also regulate the junk. Also, we have had instances where the seed industry has come up with technological improvements in seed quality - for example, seed pelleting, and seed coating - and the regulators collectively were slow to react with legislations which would facilitate labeling and marketing. I realize it takes time to make these changes, but in some cases there just seems to be a lack of communication in general. Currently, we are facing problems with hybrid seed labeling where the Federal Seed Act permits one type of label and it will not be acceptable by a particular state or states. The most serious problem in seed regulation today is the non-uniformity of labeling required by various states. I was talking with a seed company representative last summer whose company was distributing wheat seed in seven states. In essence, they had to try to prepare a label with varying information to facilitate the labeling laws of all seven states. The bottom line was that what was necessary in one state was considered unlawful labeling in another state. In my opinion, this is totally absurd and has a significant impact on restraining the flow of seed across the United States. I believe that seed regulation, as an integral part of the seed industry, should facilitate seed movement and marketing - not act as a restraint. I firmly believe it is possible to make the appropriate changes if we could simply get people to sit down, communicate and truly understand the purpose of seed regulation. A final note about regulation, as you probably have heard - there may not be a Federal Seed Act within the next couple of years. What impact this will have on what little uniformity we now share between states regarding labeling, I do not know. Obviously, we can get along without a Federal Seed Act, but it will certainly put more responsibility upon individual states to work toward labeling and regulation uniformity. I believe the regulating agencies in the states should be looking to form advisory committees or councils if they have not already done so with representation from all aspects of the industry including representatives of the farmer/user as well as the seed companies and sellers. Whatever happens regarding the Federal Seed Act, I believe the state regulating agencies need to exert real leadership and make efforts to improve the uniformity of labeling. If we are left without a Federal Seed Act and individual states take off in fifty directions, we will have taken one giant step backward.

Seed Certification, the final major area that I will address today. I am glad to be able to include this in this presentation because I am definitely opinionated in this area. I believe in the seed certification system or I would not remain involved with it. However, there is no question that the role of the certification program itself and the role of the certifying agency is changing.

Seed certification began in this country shortly after the turn of the century in the early 1900's. The objectives of the program were quite simple. Certification was to provide a framework of quality control standards through which crop seeds could be produced to assure seed buyers of specific standards for varietal purity and physical quality. In its early stages the industry lacked the competitiveness and experience necessary to provide buyers with a consistent supply of acceptable seed. A third-party system of uniform assurance was needed. Thus, seed certification was born to fill a very important need for the times. As you heard me say earlier, competition is now providing the consumer with much of the protection he needs to be assured of good quality seed that will perform. Seed certification is no longer "needed" as a base for information, expertise and general "policework" as it once was. The traditional blue tag isn't viewed by all seed companies as a necessity to sell seed. Possibly that is due in part because too many certifying agencies always think of certification with traditional limits on their thinking. That may be the problem because tradition is, in many cases, the name given to the hallowed, time-honored and staunchly-defended way of doing things that keep us from doing things that keep us from doing them better.

However, I believe the very things that made seed certification important years ago still make certification important for seed companies today if we are willing to analyze our programs, redefine some of our emphases and go out and sell our redirected programs. I want to define seed certification and take a look at the benefits and beneficiaries. Then, I am going to go out on a limb a bit with some different ideas as we look ahead.

Seed certification by its simplest definition is a systematic approach to maintain varietal purity and identity of seed crops through standards administered by an official agency. We bring varieties into the program, walk the fields, check the samples, grow them out, issue tags and generally the farmer is assured he is getting the variety that the label states. It has been that way pretty much throughout the years. It may not be an exact science but it has done a remarkable job in accomplishing its major purposes.

There have been, are, and will continue to be two major beneficiaries. One, the farmer/user with the assurance that he is getting the right variety; and two, the seed producer is assured that he is getting a very sound quality control program.

Here is where I get more opinionated. Before I proceed, let me say "these comments are strictly my own and do not necessarily represent those of the Indiana Crop Improvement Association, its members or Board of Directors. I make no claims regarding these remarks, their merchant ability or fitness for a particular purpose and warranty them only until I am proven wrong."

For years we have been taught to sell seed certification based on the benefit to the farmer/user - almost exclusively. Buy the blue tag, reduce risk, certified seed doesn't cost, it pays and so on. These were true and still are.

Now let's analyze certification and evaluate its benefits to the seedsman or seed company. Some of these are pretty traditional and are those that have been talked about in the past. The unbiased records, field inspections, lab tests and post-control growouts (to name a few of the major areas) do provide a uniform foundation upon which any seed company can rely for good quality control. These are certainly real benefits and in my opinion, can alone justify the cost of certification. But, it is not that simple any more. Example: I was driving down a wet highway recently. I met a truck. It splashed crud up on my windshield. I grabbed the lever, turned on the wiper, forgot which car I was in and inadvertently set the cruise control. It didn't do anything for my ability to see, but at least I was ready to hit the ditch in comfort and style.

Anyway, I am going to make certification more complex and begin to change this traditional role I have been talking about. What are some of the benefits that certification can provide that may have already been there but are not so obvious as the ones we usually think about? Before I briefly discuss some of these, I want to throw out a few terms that are becoming more important in the seed industry that we really didn't hear even a few years ago; variety ownership; genetic engineering, variety protection, breeder plot inspection, liability, franchising varieties, royalties, variety fingerprinting, lawsuits, roguing contracts, exclusive releases, plant patents, and chemical hybridizing.

Hey, folks, we <u>are</u> in a new era.

I mentioned the unbiased records certification provides. In my opinion, the records are 90% or more of seed certification. Everything we do in the field, lab, with growouts, is to verify the record system. We literally keep an unbroken pedigree of every certified seed lot produced and can trace them back to the original breeder seed. this is quite a system. A virtually air-tight seed lot record maintained by an unbiased third-party. I think you can begin to see the value when you talk about potential liability problems.

In the last five or six years in Indiana, we have used these records to assist members in several situations that I believe very easily would have gone on to litigation had we not gotten involved.

Here are some of the not-so-obvious benefits. These records can help document ownership; they can help maintain plant variety protection and increase that protection; they can help prevent litigation or assist if something does go to court; they can increase your security and lower your risk in general; records can be helpful in assessing royalties or research fees; they can help solve problems with labeling, especially seeds going out of state if there is a problem and records can definitely be helpful in cases where there is arbitration and help avoided lawsuits.

So, when you take a close look at these records that are routinely maintained to certify seed, you can begin to see how valuable they can be to you as a seed marketer. You have quality reports for making in-house sales decisions; unbiased lab reports in case there is a problem with a customer who has purchased your seed and field reports with specific situations helping in contractual arrangements. Certification can also help in determining mixtures both in fields and in samples to try to help solve problems and avoid potential problems.

Certification is assisting companies in describing new lines. We have been able to provide data that companies can use when making application for plant variety protection and of course, the tag and labeling records are great as I mentioned before, for helping companies assess royalties and research fees. One area that has been minimized that really needs to be sold is the value of having the certifying agency grow out a sample of every lot of seed. This can provide one of the most important pieces of ammunition that may be needed if there is a customer complaint. (All certifying agencies do not conduct growouts)[2]

One final major benefit is the ability of the certifying agency to act as a liaison in contractual agreements. This can be in the field, in the lab, etc. These benefits are here, now, and are real - so we need to ask the question, how do we as certifying agencies work toward building this new role and selling this new role? First, I believe we need a true commitment to professionalism in everything we do. Then we need to listen and respond. Listen and respond! There are probably a hundred different ways we can do this and I am not going to go into detail, but we need to listen, try to find out the true needs of the industry, and then we need to respond by developing the services and programs based on those needs. We already provide many of these things as I have mentioned - we just don't always recognize their complete value in this new era in the industry. Over time I have learned that

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[2]Editors note

seed companies don't certify seed or use our services because we are nice guys. Our programs have to be necessary, useful and affordable. Then we need to go out and sell them. The system is in place - it is tried and it's true. It ay need some reshaping, some fine tuning, some rethinking, but it can provide services that I believe are truly needed in today's highly competitive business climate. With litigation popping up at the drop of a hat, I really believe our programs can be beneficial. Be assured, I am not trying to scare anyone by mentioning the legal aspects, but I truly believe that certification can provide seed companies with what I call "defend ability". Certification is a legally endowed program, recognized by law, and protected by law. This is important in helping solve problems. What I think is amazing on top of all this, is certification is economical. To spend a dime a bag to certify wheat or soybeans or ten or twelve cents a bag to have seed corn inspected is the buy of the year. Companies can get everything I have talked about up to right now - all those obvious and not-so-obvious benefits for about ten cents a bag. Considering what is happening to liability insurance rates, certification is truly a bargain.

Finally, there are two other reasons I encourage use of certification. It provides an orderly system of seed production, conditioning and labeling and one that is accepted by all facets of the industry, including state governments and the federal government. With so many varieties coming into the picture, some people may believe farmers are getting confused and I would certainly hate to see anyone impose any type of program of variety registration or mandatory certification (especially federal). I believe the more the existing programs are used, the less risk we run of this potential.

Finally, we are seeing many companies moving into the seed business which are not experienced in the seed area. It may be through an acquisition or merger, or whatever, but we are seeing decisions being made that may or may not have the best interest of the customer at heart - but we are seeing them. I believe these types of people in the industry need us and our relationship with those of you who have the experience.

I think you can tell I believe in the seed certification system. I have given you all of the pros - are there any down-sides?

Regarding the system per se, I really can't think of any important negative aspects, It works and it works very well. However, I feel obligated to mention two areas that currently have somewhat of a negative impact on certification and our ability to sell it across the United States.

Number one - non-uniformity of standards and procedures between states. I won't elaborate but this certainly can create problems for companies who want to certify in several states.

Secondly, and I have to be a little careful here, but I believe the attitude of some of the administrators of certification in some states could be improved in some areas; more effort to sell the program, more cooperation, more flexibility; and more service-oriented in general.

Looking ahead, I'm convinced seed certification can be a significant part of the industry in the future if certifying agencies are willing to communicate with the other segments of the industry, make adjustments in their programs, and are willing to go out and really tell the people in the industry how important certification can be in a seed program.

One thing I am sure about. Whether it be technology, varieties, marketing, seed regulation or seed certification, we are truly in a new era regardless of how you measure it. Things are changing rapidly but I see a bright future for the seed industry as a whole. My advice for the future is, communication and cooperation among the people working in the five areas I've reviewed. Individually we are good - as a team, we will be great! I know that I am an optimist - I just can't help it. I am the type who would go after Moby Dick with a rowboat, a harpoon and a jar of tartar sauce. That's optimism! Back to Basics is a great theme for this meeting because of regardless of what area of the industry we represent, we need to, be sure we always pay attention to the basics. Remember though, the standards are always changing. So stay tuned in. The watch word is, we must always keep up with the basics, and never go back for them.

SEED DRYING PRINCIPLES

Edgar R. Cabrera[1]

Introduction

Seed drying is a mass transfer process in which moisture is removed from the seed in a vapor form and is absorbed by surrounding air. Thus, the seed must be surrounded by an ample supply of dry air capable of absorbing the moisture given off by the seed. Since the moisture content of seed is greatly dependent upon the humidity of the air, knowing certain air properties will contribute to our understanding of the seed drying process. Drying of seed in a deep bed dryer is characterized by the establishment of a drying front which must move through the whole mass of seed to complete drying. Several factors including air relative humidity, temperature, air flow rate and permeability of the seed to internal moisture migration, affect the efficiency of drying.

Equilibrium Moisture Content

The colloidal nature of seed allows them to take up or give off moisture depending upon the relative humidity of the surrounding air. The moisture in the air is present in a gaseous form and excerpts pressure. The moisture in seed also excerpts a certain pressure. There is a continuous movement of moisture in the vapor form from the air into the seed and vice versa, but if the water vapor pressure in the air is grater than the water vapor pressure in the seed, eventually there will be an increase in the moisture content of the seed, Figure 1. On the contrary, if the water vapor pressure in the seed is greater than the water vapor pressure of the air, the seed will eventually loose moisture, until an equilibrium of vapor pressures is attained, Figure 1. At this point it is said that seed have reached their equilibrium moisture content. The equilibrium moiste content is determined to a great extent by the relative humidity of air. Oil seed tend to have a lower equilibrium moisture content than starchy seed, as shown in Table 1.

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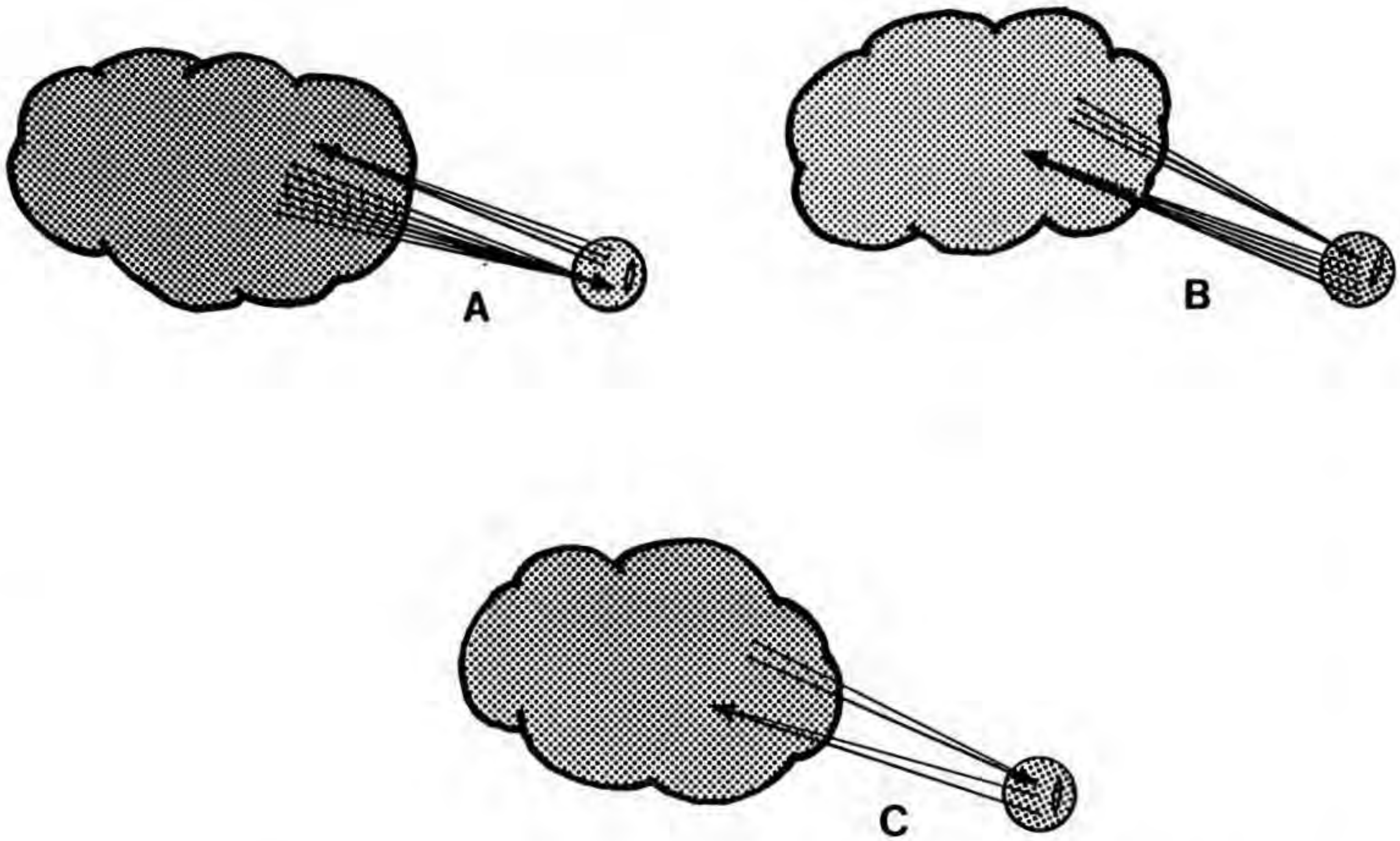

Figure 1. a) Water vapor pressure (wvp) in the air greater than wvp in seed.
b) wvp in seed greater than wvp in air.
c) Equilibrium moisture content attained.

Table 1. Equilibrium moisture content for seed of various crops at different relative humidity values (25C).

Crop	Relative Humidity					
	15	30	45	60	75	90
Alfalfa	-	6.4	7.4	8.6	13.0	18.0
Barley	6.0	8.4	10.0	12.1	14.4	19.5
Corn	6.4	8.4	10.5	12.9	14.8	19.1
Peanuts	2.6	4.2	5.6	7.2	9.8	13.0
Rye	7.0	8.7	10.5	12.2	14.8	20.6
Sorghum	6.4	8.6	10.5	12.0	15.2	18.8
Soybeans	4.3	6.5	7.4	10.3	13.1	18.8
Sunflower	-	5.1	6.5	8.0	10.0	15.0

STL, MSU

Air Properties

Air is used in drying because of its ability to remove moisture from seed. The functions of air during drying are a) to evaporate the moisture from the seed surface by creating a water vapor pressure differential and b) to carry the evaporated moisture away from the seed mass. Therefore, for drying to occur the air should be dryer than the seed.

Air can be naturally dry. In certain geographical areas the relative humidity (RH) of air is sufficiently low during the harvesting period that seed drying can be accomplished with natural air. Unfortunately this is not always the case and the relative humidity of the air must be reduced by mechanical means. Moist air can be dried by actually removing its moisture with a dehumidifier. This practice is very seldom used in commercial drying. Instead the air is heated to reduce its relative humidity. When heat is added to air, its water holding potential is increased. Figure 2 shows the water potential of air at 75F and 80% RH. Air under this conditions contains 0.015 lb of water/lb of air. If the temperature is increased to 99F, its water holding capacity is doubled.

The psychometric chart graphically represents air properties. Personnel dealing with seed drying should be acquainted with its use. Figure 3 illustrates how high the temperature rise of the drying air should be to lower the relative humidity of the previous example to 40%. Point A is 75 F-80% R.H. Point B is 99 F-40% R.H.

Relative humidity of ambient air can be determined with a sling psychrometer. A sling psychrometer consists of two regular thermometers mounted on a casing that can be slung by hand, Figure 4. The sensing bulb of one of the thermometers is covered by a wet sock or wick and measures the wet-bulb temperature, while the un-modified thermometer reads the dry-bulb temperature. These temperatures, when plotted in the psychometric chart allow you to determine the relative humidity as well as other properties of air.

Drying of Individual Seed

Two processes are involved in the removal of water from seed:

a) Moisture from the seed surface is evaporated

b) Moisture from within the seed is transferred to the surface.

When dry air surrounds the seed, water molecules from the seed surface move to the air, leaving the moisture level in the periphery of the seed lower than in the inside, and a moisture gradient is established within the seed. Water molecules, therefore, must move from the inside to the drier area of the seed to nullify the moisture gradient,

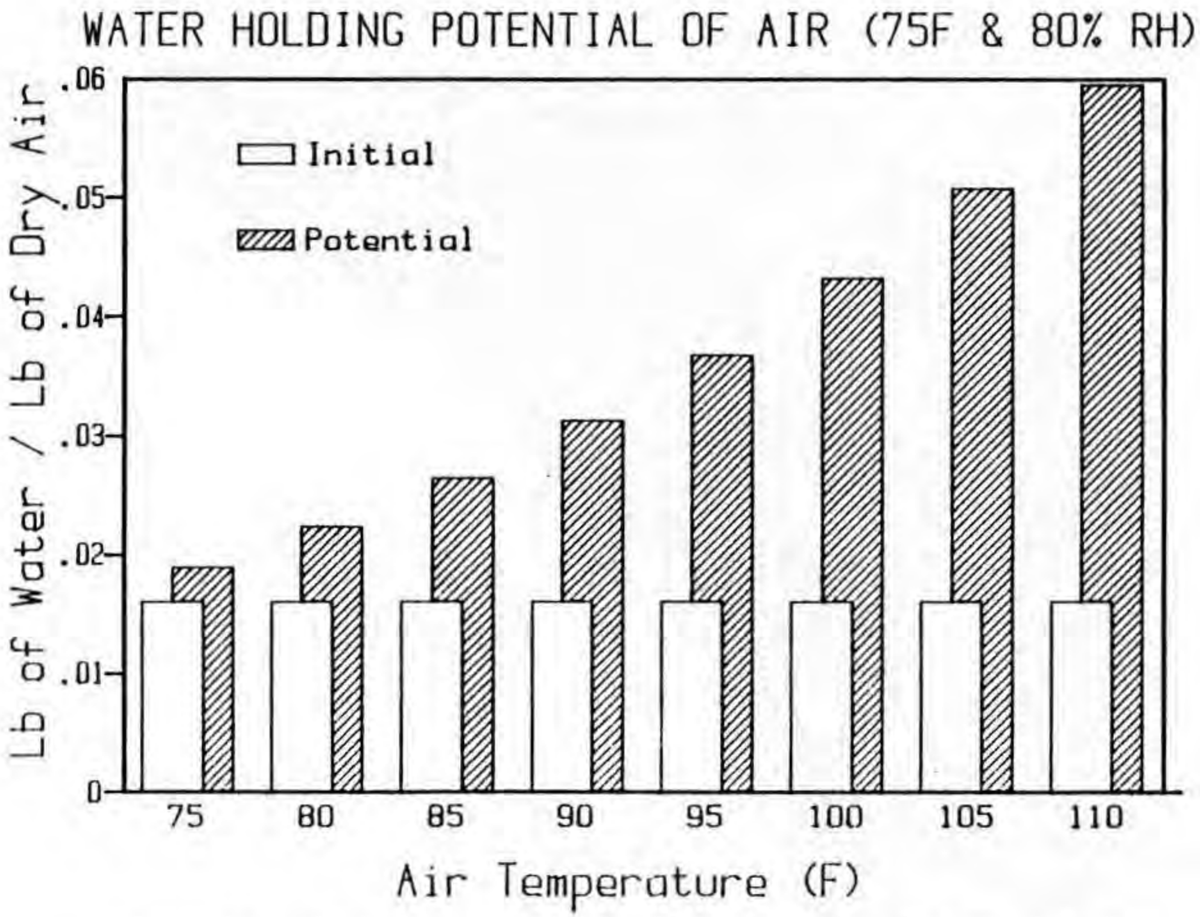

Figure 2. Water holding potential of air at 75F and 80% relative humidity compared to potential at higher temperature.

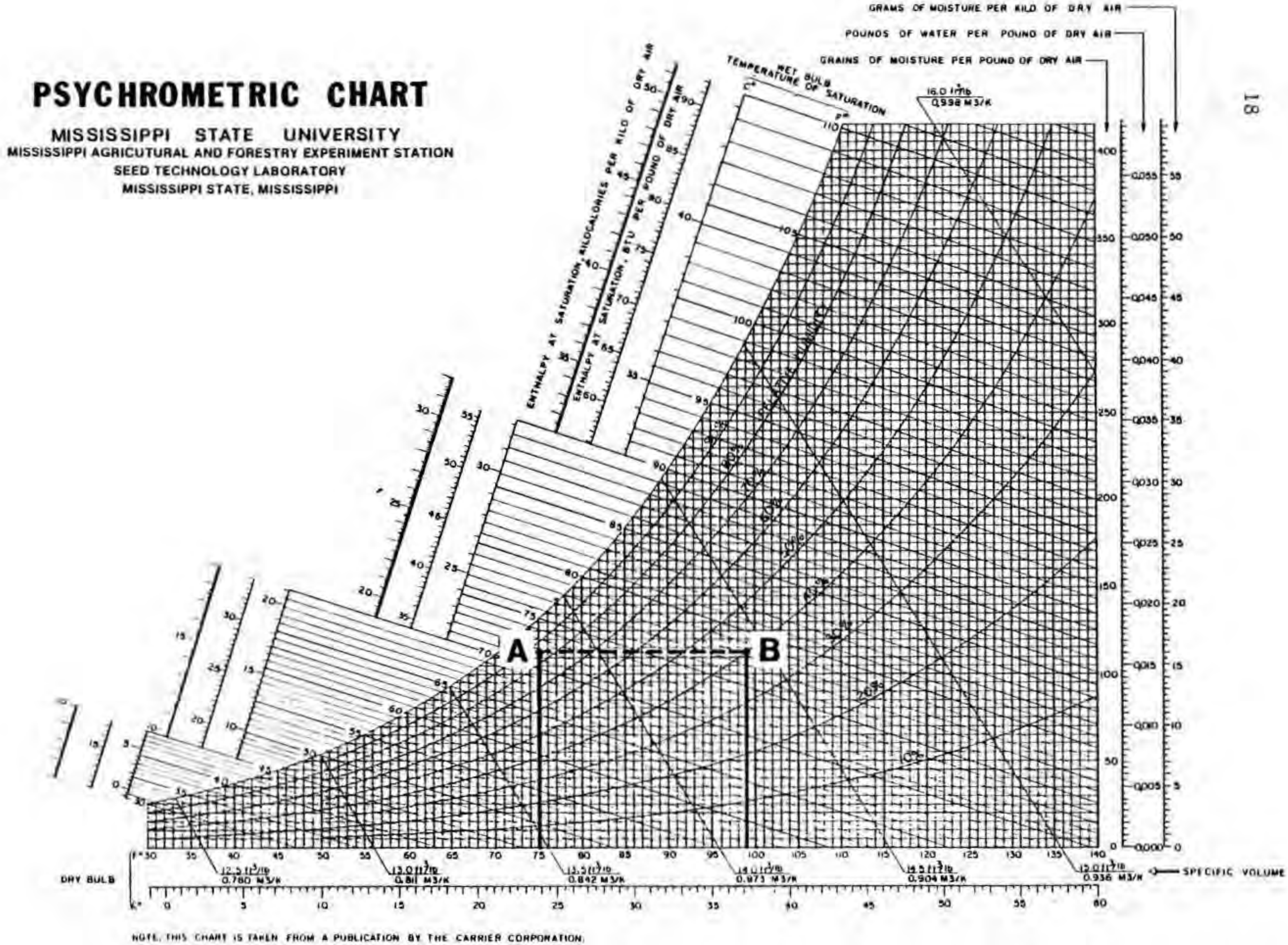

Figure 3. Psychrometric chart showing air properties. To lower the relative humidity (RH) of 75F and 85% RH air (point A) to 40%, the air should be heated up to 99F (point B).

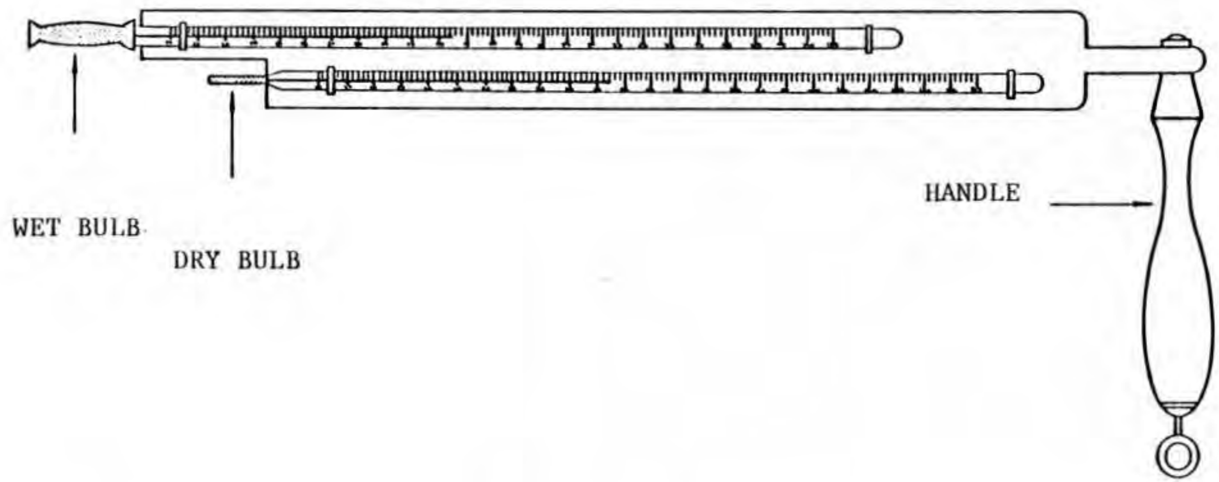

Figure 4. Sling psychrometer. Instrument is rotated about 2 to 3 times per second until readings attain constant valves

and can be evaporated. After this occurs an equilibrium is established between the water vapor pressure of the air and seed and no further drying takes place, Figure 5.

Drying in a Deep Bed Dryer

In deep bed drying, air is introduced in the plenum chamber and forced through the mass of seed to remove excess moisture. Drying, however, does not occur simultaneously in all seed at the same time, but rather a drying front is created and it moves slowly in the direction of the air flow until it reaches the top of the batch. An illustration of this process is shown in Figure 6. A few minutes after dry air begins to flow through the seed mass, a drying front is formed at the bottom of the batch. The drying front slowly moves up leading the drying zone. The drying zone consists of a few inches of seed next to and below the drying front and it is in this area where drying is actually taking place. The drying front can be rather easily identified. Seed temperature below the drying front approaches plenum air temperature, while seed temperature above the drying front is several degrees lower. The temperature of the exhaust air is several degrees lower than plenum air indicating the temperature drop due to evaporation. The relative humidity of exhaust air is higher than plenum air since it contains the moisture removed from seed. Figure 6 shows the theoretical changes of temperature and relative humidity that occur in a bin during drying.

Magnitude of Water Removed in Drying

The high volume of water removed by drying is frequently taken for granted. To dry 1000 bushels of rice seed that come from the field with 20% moisture down to 13%, 466 gallons of water must be removed. This is the equivalent of eight and one half 55-gallon drums, Figure 7. To calculate the loss of weight by drying the following formula can be applied:

$$FW = IW \times (100 - IM) / (100 - FM)$$

Where:

FW = final weight
IW = initial weight
IM = initial moisture percentage
FM = final moisture percentage

Example:

What is the final weight of 50,000 lb of corn harvested at 35% moisture and dried to 12%?

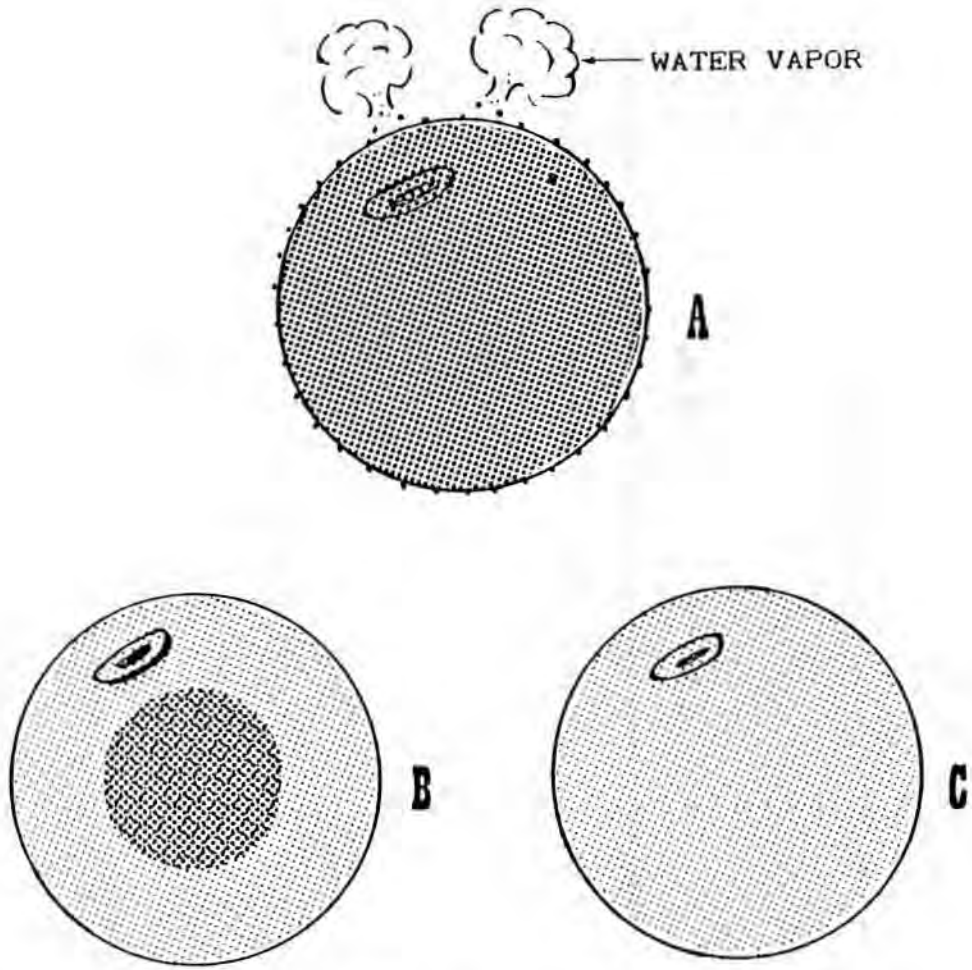

Figure 5. Drying of individual seed. a) Moisture from the seed surface is evaporated. b) Moisture from within the seed is transferred to the surface. c) Dried seed.

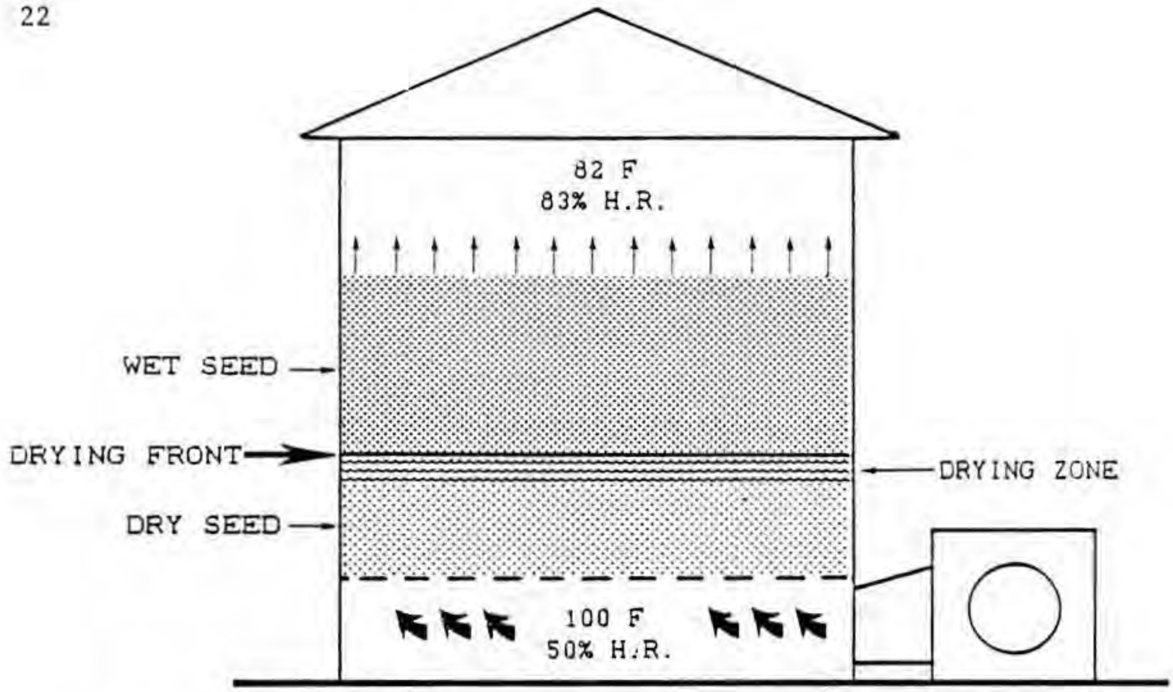

Figure 6. Drying in a deep bed dryer. Establishment of the drying front.

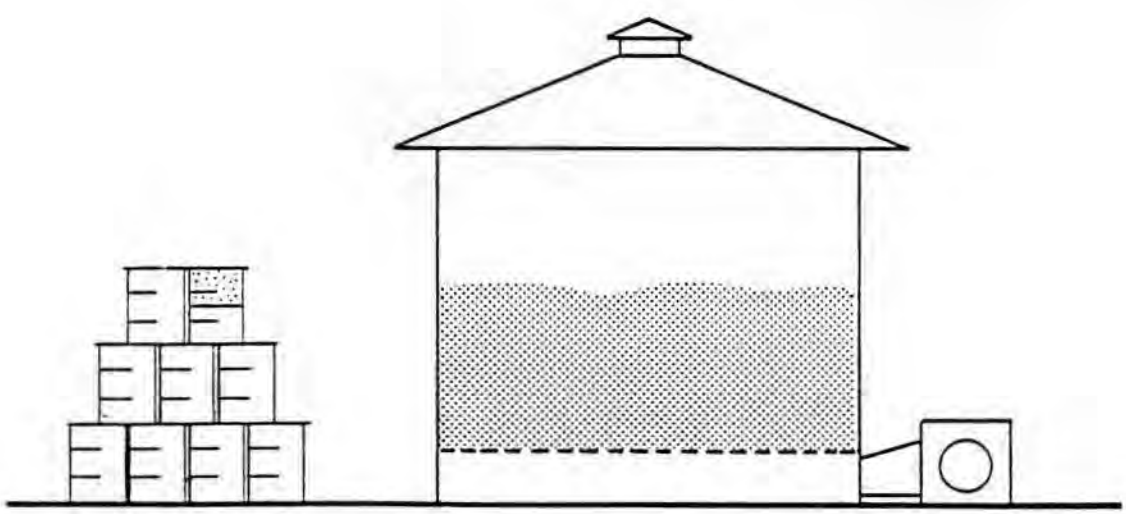

Figure 7. To dry 1000 bushels of rice seed from 20% to 13% moisture, 466 gallons of water must be removed.

FW = 50,000 lb X (100 - 35) / (100 - 12)

FW = 36,932 lb

The weight loss by drying is 13,068 lb.

Main Factors Affecting Seed Drying

Several factors influence the rate at which drying takes place; the most important, however, are described as follows:

1. Initial seed moisture content

The removal of water does not occur at the same rate during the drying process. Figure 8 shows the rate of moisture removal of one layer of high moisture seed. At high seed moisture levels water is removed more rapidly from seed. As seed moisture is reduced it becomes harder to remove. The lower the moisture level, the more tightly the remaining moisture is held by the seed and the more energy is required to remove it.

2. Relative humidity of the air

It was mentioned earlier on that dry air is required for seed drying. The lower the relative humidity of air, the faster drying will occur. It is possible thought, to remove water from high moisture seed (above 18% MC) using high relative humidity air (80% RH) down to about 15 - 16% in the case of cereals, but it will take a relatively long period of time. To accelerate drying, lower relative humidities are used and the equilibrium moisture content is not quite reached. In deep bed drying, relative humidities of 40 - 55% are commonly used. Because of this, over-drying of seed at the bottom of the bin is also common, since they are allowed to reach equilibrium moisture content due to the long exposure to dry air. Excessive drying can cause seed germination problem even physical damage without mechanical handling. Over-drying of seed in the lower section of a bin can be minimized with the use of stirring devices that slowly transfer the seed from the bottom to the upper part of the bin, Figure 9. Another practice is to invert the air flow when the drying front is located about half the way up the seed mass.

3. Temperature

In order to reduce relative humidity, the air is heated. Excessive temperature can have two detrimental effects on seed. Over-drying can occur by using excessively dry air, rendering the seed more susceptible to mechanical damage during handling and conditioning. But perhaps the greatest risk is to physiologically damage the seed with excessive temperature. Susceptibility of seed to high temperature varies with the species, but generally high moisture seed are more

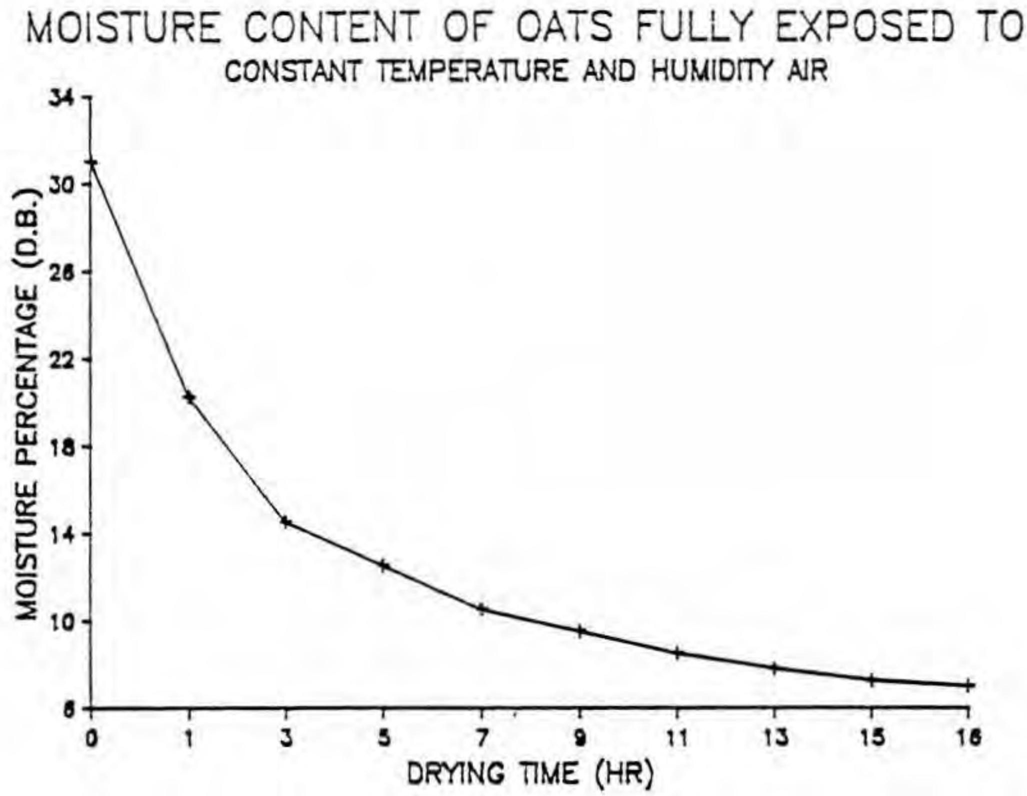

Figure 8. Rate of moisture removal in one layer of high moisture oat seed sample.

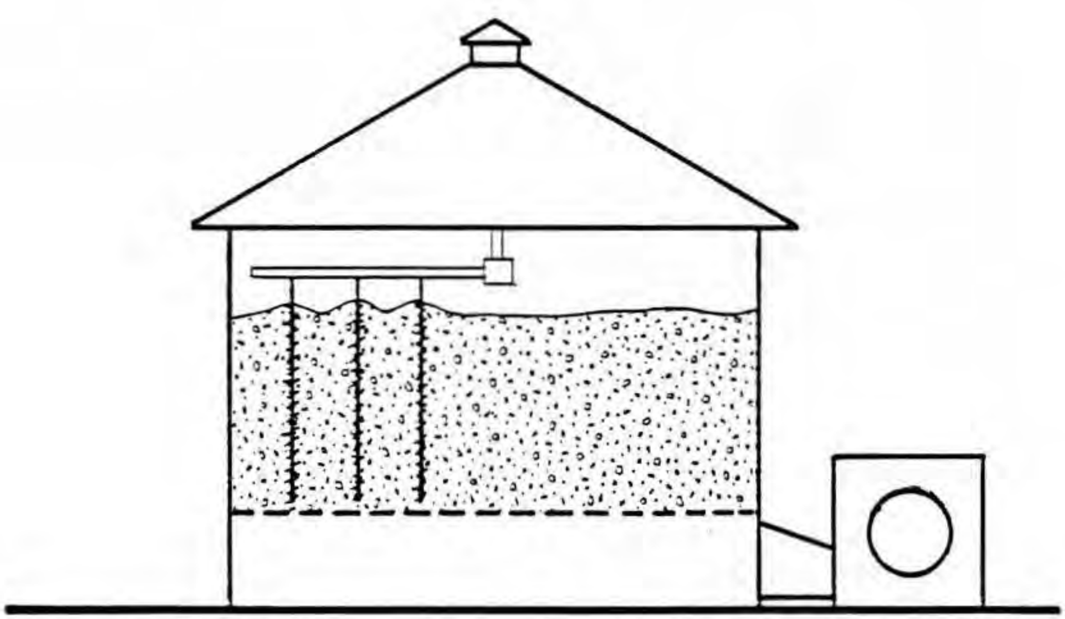

Figure 9. Stirring devices slowly move the seed from the bottom of the bin to the upper layer of seed.

susceptible, therefore, care should be exercised during the initial stages of drying not to use high temperatures. As drying advances and lower relative humidities might be needed, air temperature can be increased.

As a general rule, though, drying air should not exceed 110F.

4. Air flow rate

One of the functions of air during drying is to serve as a vehicle to remove the evaporated moisture from the seed mass. This implies the need of sufficient air volume to take-up and remove all this moisture. Airflow rates requirements will very according to seed kind, initial moisture level and seed depth. Table 2 shows the recommended air flow rates for different crops at different moisture levels and depths. These recommendations are applicable to relatively dry areas. Drying in the humid south requires the use of higher air flows in the order of 9 - 12 cubic feet of air per bushel per minute (cfm/bu/min). Using high airflow rates will also reduce over-drying in the bottom section of a batch, since drying time is reduced and exposure of seed to low relative humidity air is also decreased.

The air-flow delivered by a drying fan is dependent upon the size of the fan and the static pressure developed in the plenum chamber. Static pressure is defined as the pressure required to force a given air flow through the seed mass, Figure 10. For any given fan, the greater the static pressure the lower the airflow delivered, Figure 11. Several factors affect static pressure:

a. Seed size

The smaller the seed the greater the static pressure. Figure 12 shows the static pressure found in sorghum seed as compared to the static pressure in soybeans using the same air flow rate and at the same depth.

b. Seed depth

The greater the depth the greater the static pressure. It takes more pressure to force the air through a deeper layer of seed, regardless of the volume, Figure 13. The static pressure developed in soybean seed at different depths is shown in Figure 14. Note that as the seed depth is doubled the static pressure increases about four times.

c. Airflow rate

The higher the air flow rate the higher the static pressure. It takes more pressure to force a grater volume of air through the seed mass. Figure 15 illustrates the increase of static pressure as higher air flow rates are used in ear corn at various depths. The increase of

Table 2. USDA recommended maximum grain depths and minimum air flows for natural air drying.

Type of Grain	Grain Moisture Content %	Recommended Maximum Depth of Grain Feet	Minimum Air Flow cfm/bu.
Wheat	20	8	3
	18	10	2
	16	12	1
Oats	25	8	3
	20	11	2
	18	12	1.5
	16	16	1
Shelled Corn	25	6.5	5
	20	10	3
	18	12	2
	16	16	1
Grain Sorghum	20	8	3
	18	10.5	2
	16	16	1
*Rice	22	6	4
	20	8	3
	18	8	2
Barley	20	8	3
	18	10	2
	16	14	1
	16	14	1
Soybeans	20	10	3
	18	12	2
	16	16	1

*Based on recommendations by Texas A&M University.

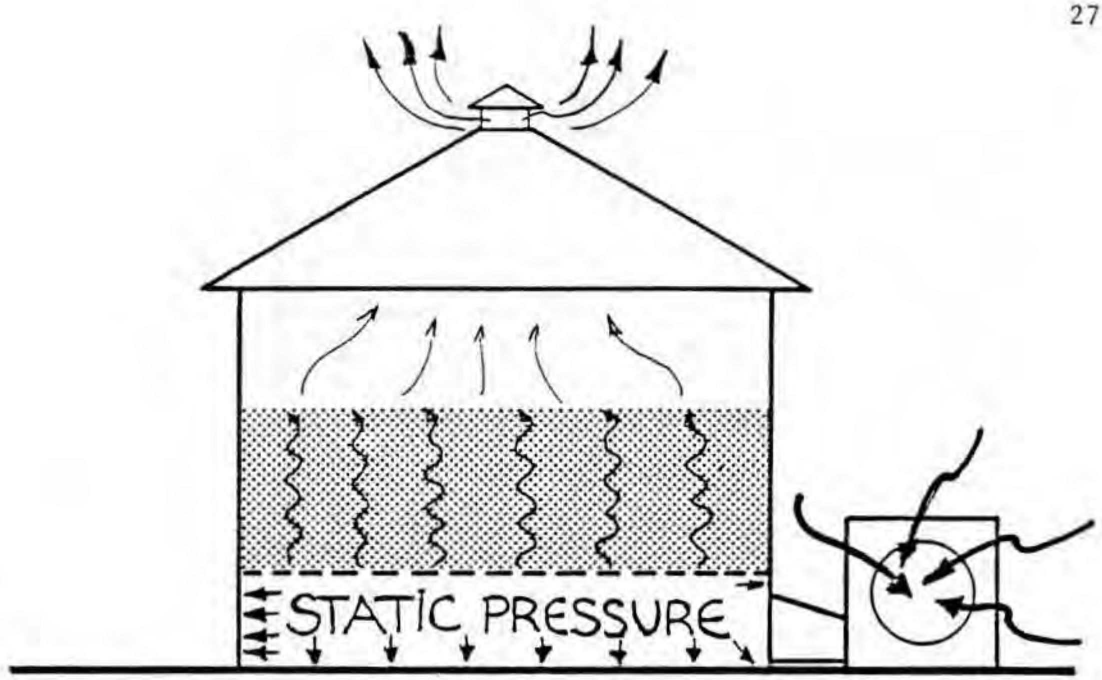

Figure 10. Static pressure in the plenum chamber of a drying bin.

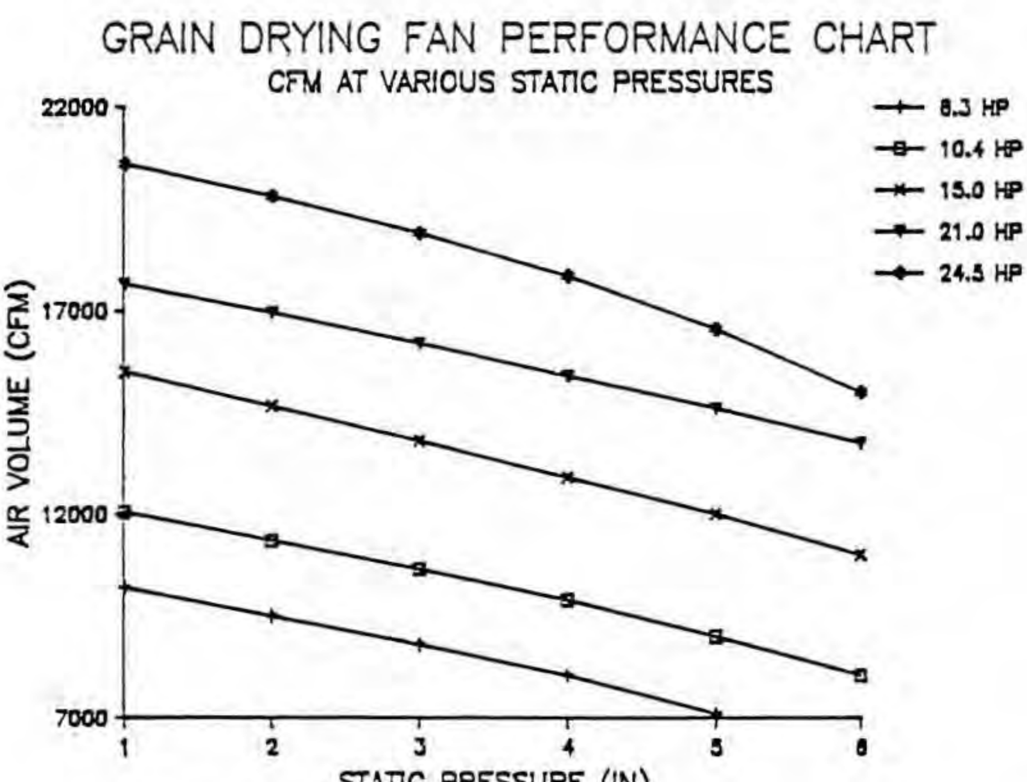

Figure 11. Air flow delivered by various sizes of centrifugal fans (expressed in maximum brake horse power) against different static pressures. Source: Combustion Equipment Company, Form 182-3MArg-JDM.

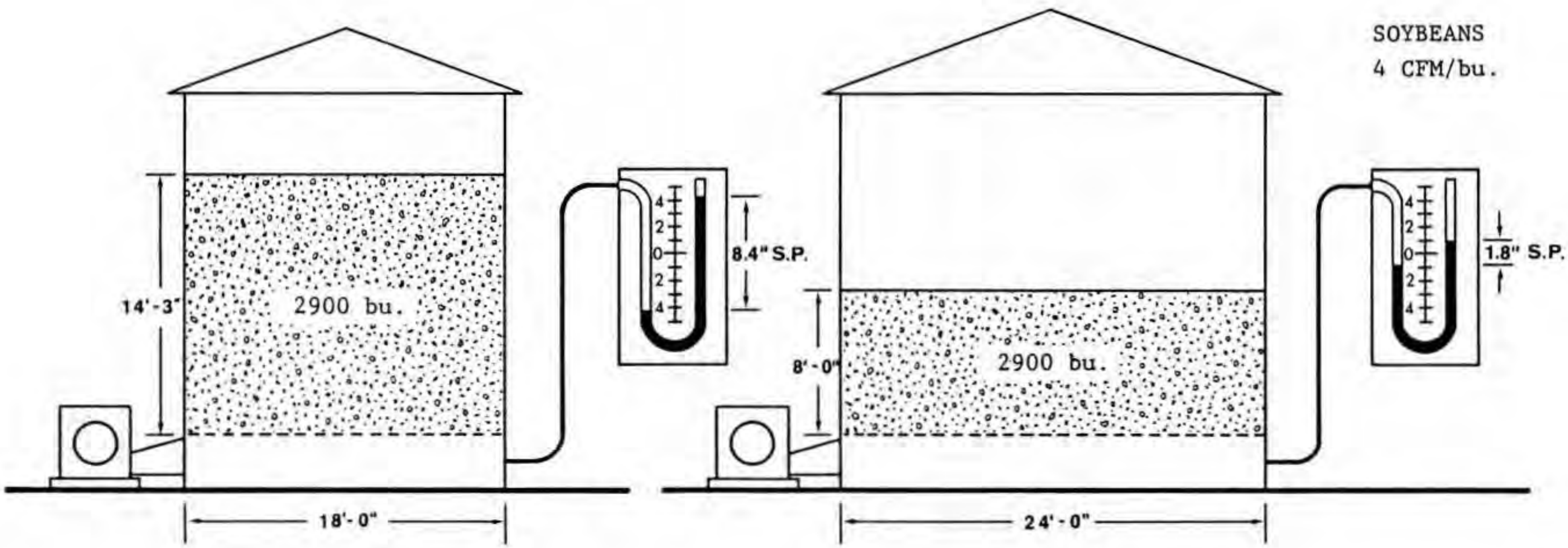

Figure 12. Static pressure developed when drying 2900 bushels of soybeans using 4 CFM/bu in 18 ft and 24 ft diameter bins.

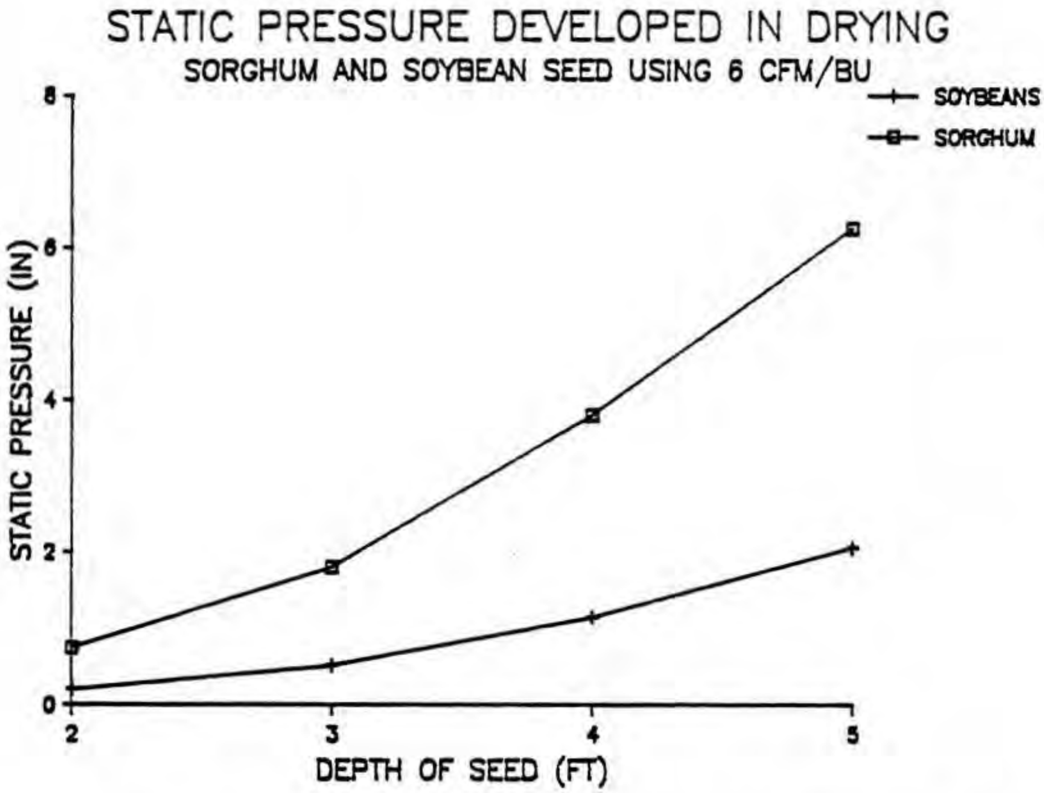

Figure 13. Influence of seed size on static pressure using 6 CFM/bu at several depths.

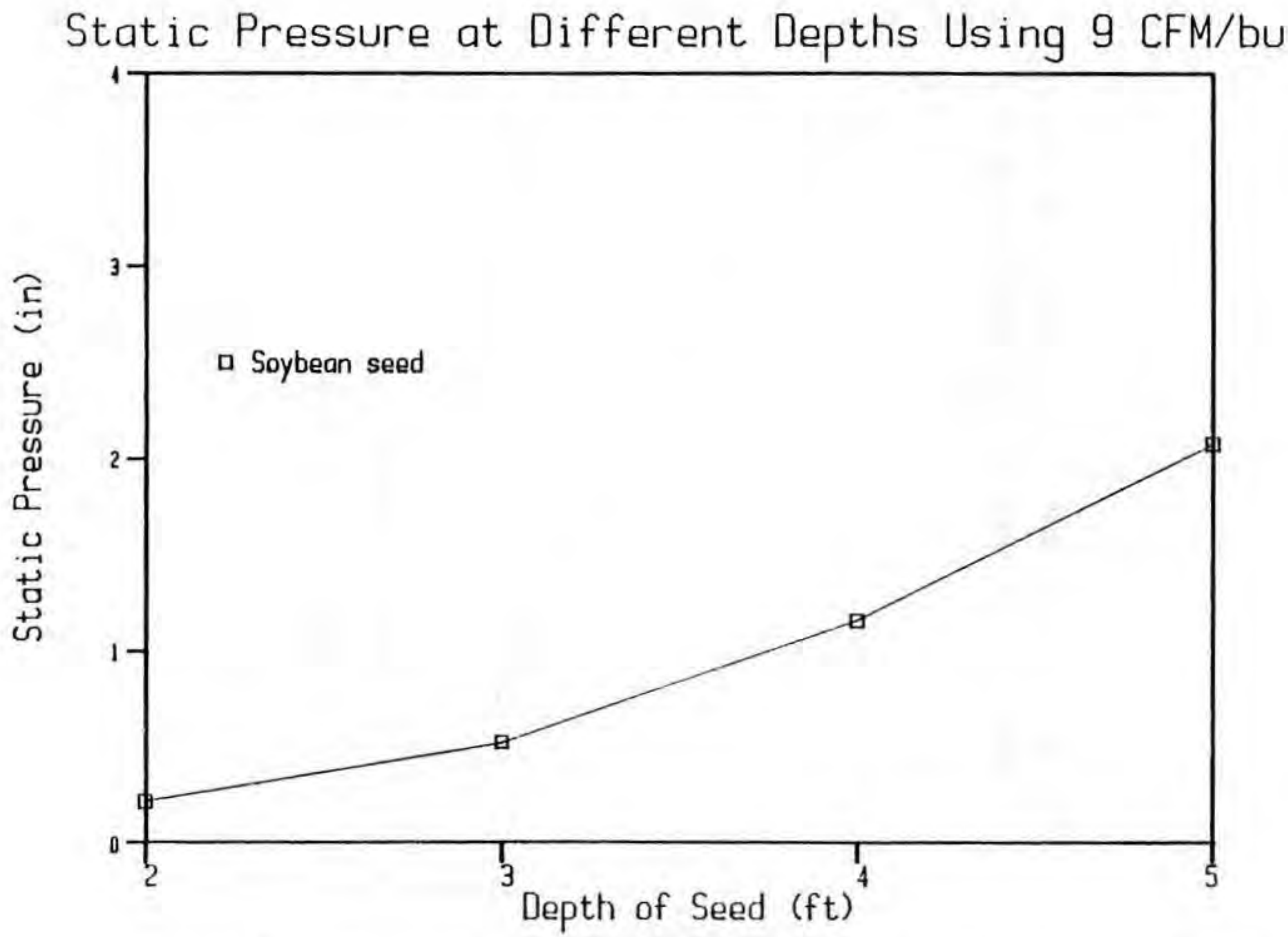

Figure 14. Effect of seed depth on static pressure when drying soybeans using 9 CFM/bu.

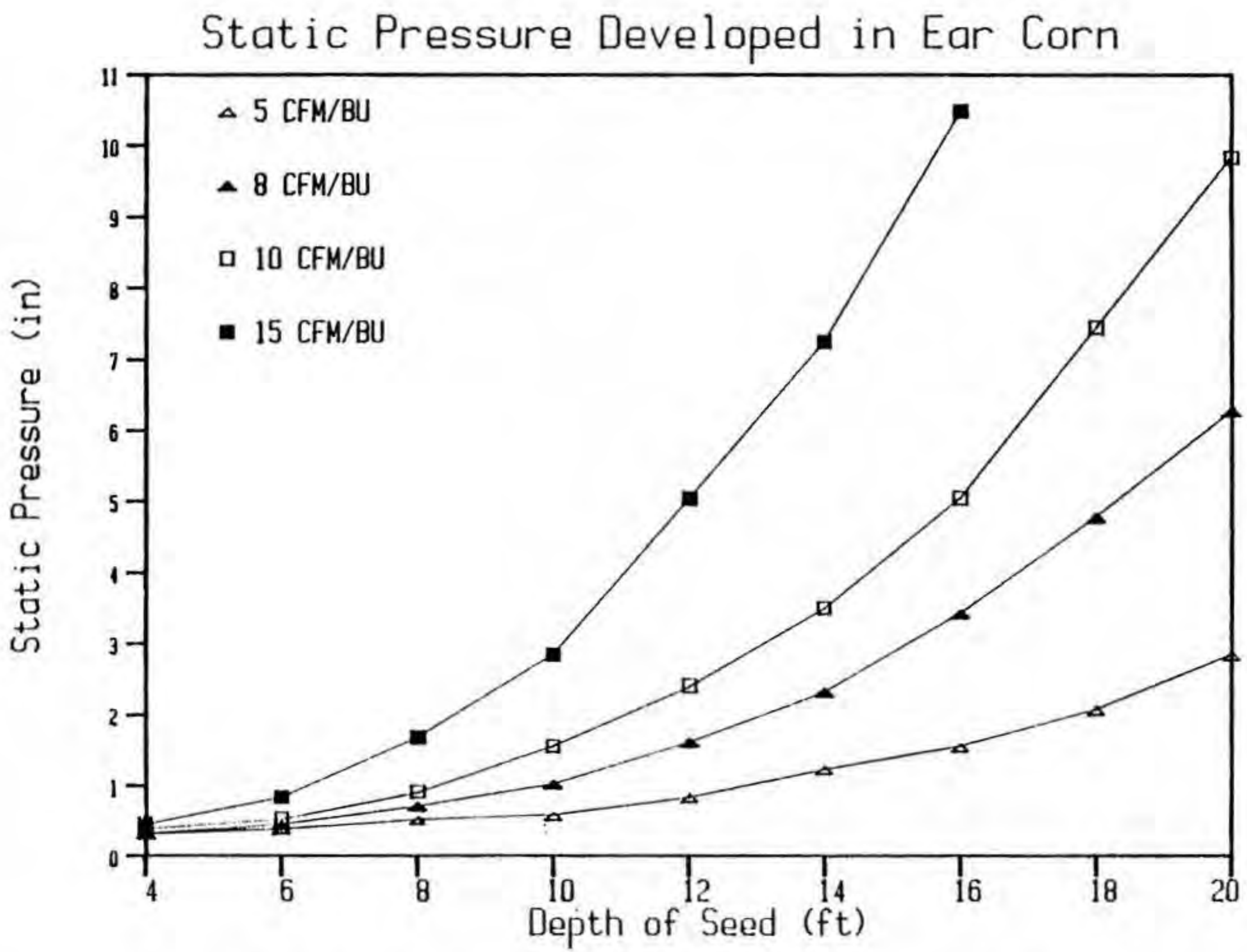

Figure 15. Static pressure developed in the plenum chamber when drying ear corn at different depths using several air flow rates.

static pressure is compounded when air flow rate and seed depth are increased.

d. Amount of trash in the seed

The presence of trash, including very fine material will increase the static pressure. In addition, trash may cause uneven movement of the drying front thereby resulting in a un-uniform drying.

e. Inadequate design of drying system

A minimum of 10% open area is required in the false floor to minimize static pressure. A general rule is to use transitions that will allow a maximum air velocity of 1250 feet per minute. Sufficient exhaust area is needed for the exit of humid air. The use of adequate number of "gooseneck" ventilators will permit free exhaust of the drying air.

5. Permeability of seed to moisture migration

The rate at which moisture moves from the inside to the periphery of the seed depends upon the permeability of the seed to moisture migration. When sufficiently high airflow is used, moisture transfer to the seed surface becomes the limiting factor. In rice seed the permeability to moisture movement is low. If drying is accelerated by using high temperature air a stress develops due to a difference of moisture within the seed and mechanical checking or cracking can occur. Rice drying requires sweating periods to allow the equalization of moisture within the seed.

Summary

1. In order to minimize seed quality losses in the field, seed are often harvested at high moisture content and dried down to levels safe for storage.

2. Seed drying requires large amounts of energy, therefore, understanding the processes involved during drying can help minimize costs.

3. Seed are hygroscopic. Their moisture content is a function of the relative humidity of the air. Drying usually involves removing the moisture of seed without quite reaching the equilibrium moisture content.

4. Drying of individual seed involves the evaporation of moisture on the surface of the seed and the movement of inside moisture to the periphery.

5. Air performs two functions in drying: provides the energy to evaporate moisture from the seed and removes the evaporated moisture away from the seed mass.

6. Drying in a deep bed drier occurs as a drying front moves in the direction of the air flow. The whole batch is not dried until the drying front has moved throughout the entire mass of seed.

7. The relative humidity of air can be reduced by heating. The relative humidity of drying air in normally between 40 - 55%.

8. High moisture seed are more susceptible to heat damage. Even at lower moisture levels temperatures higher than 110F should be avoided.

9. Airflow rate will be determined by fan size and static pressure. The greater the static pressure the lower the air flow delivered by a given fan.

10. The smaller the seed, the greater the depth, air flow rate and amount of trash, the greater the static pressure. Any obstruction to air flow in a drying system will also contribute to a greater static pressure.

11. The permeability of the seed to internal moisture movement can limit the rate of drying. Increasing drying rate by using high temperature can cause internal stress in the seed to the extent of creating fissures or cracks.

SOYBEAN SEED HANDLING

M. Misra, L. Baudet, and Y. Shyy[1]

Introduction and Objective

Improper handling of soybean seed can substantially reduce seed quality. Many commercial conveyors are available for bulk handling of seed. These conveyors were designed for grain and information on the damage caused by these conveyors in seed handling is limited.

The objective of this research was to compare several seed handling systems with respect to their effect upon soybean seed quality. The ultimate goal is to provide the soybean seed producer with information upon which to base the purchase of new system and optimize the operation of those already in hand.

Description of Conveyors

A survey was conducted to determine the types of conveyors being used by approved soybean seed conditioners in Iowa. A total of 74 questionnaires were sent with 66 conditioners responding. This survey indicated that 25.8% of the conditioners use steel-flighting augers, 24.2% use belt conveyors, 19.7% use augers with rubber-flighting intakes, 15.2% use pneumatic conveyors, 10.6% use flight conveyors, 3% use other conveyors and 1.5% do not use any conveyors for bulk handling of soybean seed. Based on the survey information, six conveyors were included in the experimental design. These conveyors were:

1. Steel-flighting Auger: A steel-flighting auger (Figure 1) is the most common device on the farm for bulk handling of seed. It implements a rotating helix inside a tube for lifting of the seed. Because the helix and the tube are made of metal, mechanical damage to seed can occur.

2. Auger with Rubber Intake: The main feature of this auger is a two-foot rubber intake section (Figure 2). Originally a safety feature, the rubber intake offers some protection against seed damage.

3. Pneumatic Conveyor: Seeds in this device are conveyed by a moving air stream. The seeds are conveyed through the intake pipe

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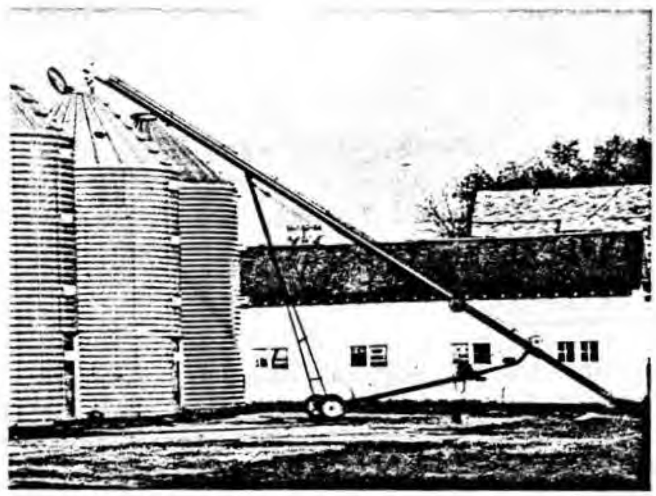

Figure 1. An auger is often used on the farm to fill bulk storage.

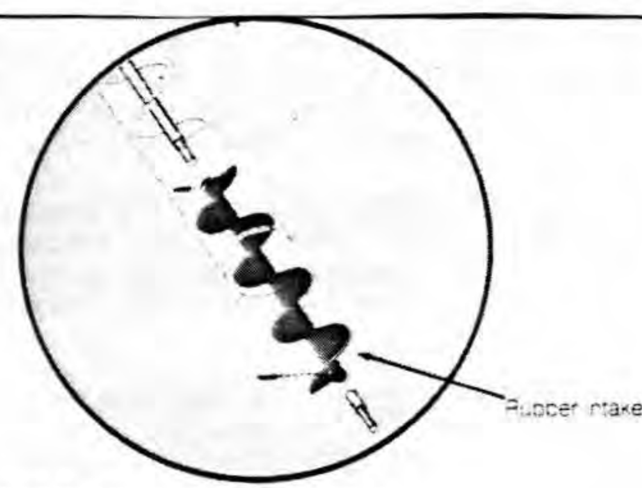

Figure 2. Auger with rubber intake.

(Figure 3) to the separator cyclone and into an airlock. From the airlock, the seeds drop into the discharge pipe and conveyed to the discharge cyclone.

4. The Belt Conveyor: In this conveyor, a rubber belt travelling through a steel tube carries the seeds (Figures 4a and 4b). Since the seeds are carried on the belt, damage to seeds can be minimized.

5. The Rubber-flight Conveyor: This conveyor has rubber flights molded on a rubber belt (Figure 5) to prevent the roll back of seeds during handling. The flight conveyor can therefore be operated at higher angles of inclination than the belt conveyor without increasing the belt speed.

6. The Steel-core Bristle Auger: This auger uses nylon bristles instead of metal flightings to move the seed (Figure 6). The nylon bristles are attached to a steel core. The steel core provides strength to keep the material moving and the bristles provide a sweeping action to minimize seed damage during handling.

Experimental Procedure

The total experimental design included six conveyors, two angles of inclination (30^{o} and 15^{o}), two volume controls (full capacity and half capacity), two consecutive passes through each conveyor, and two seedlots. Seedlot 1 consisted of 1200 bushels of Pella soybean seed grown in Madrid, Iowa by the University Farm Service. The seeds were harvested in October, 1984 at an average seed moisture of 14.8% and put in 20 bushel plastic lined bulk bags for the handling experiments. Seedlot 2 was a proprietary variety and was a surplus production from the previous year. The seedlot was at 10.7% moisture, was cleaned by the conditioner and stored in 60-pound seed bags. A thousand of these bags were transported to the warehouse for the seed handling experiments.

Two bins, made of wood and angle iron were used for this research (Figure 7). One of the bins was suspended from a forklift to provide the desired angle of inclination. Each bin was equipped with a 4 inch x 16 inch slide gate at the bottom. Prior to the experiments, the slide gates were calibrated to control the volume of seed flow into the conveyor. The conveyor transferred seed from one bin to the other.

The time for each conveying run was recorded using a chronometer. The capacity of each conveyor was calculated by dividing the weight of seeds conveyed by the time recorded.

During conveying, samples were taken from the inlet and exit end of the conveyor. Each sample of approximately 2 kilograms of soybeans was obtained by cutting across the stream of seed flow several times with a container. For the second pass, samples were taken only at the

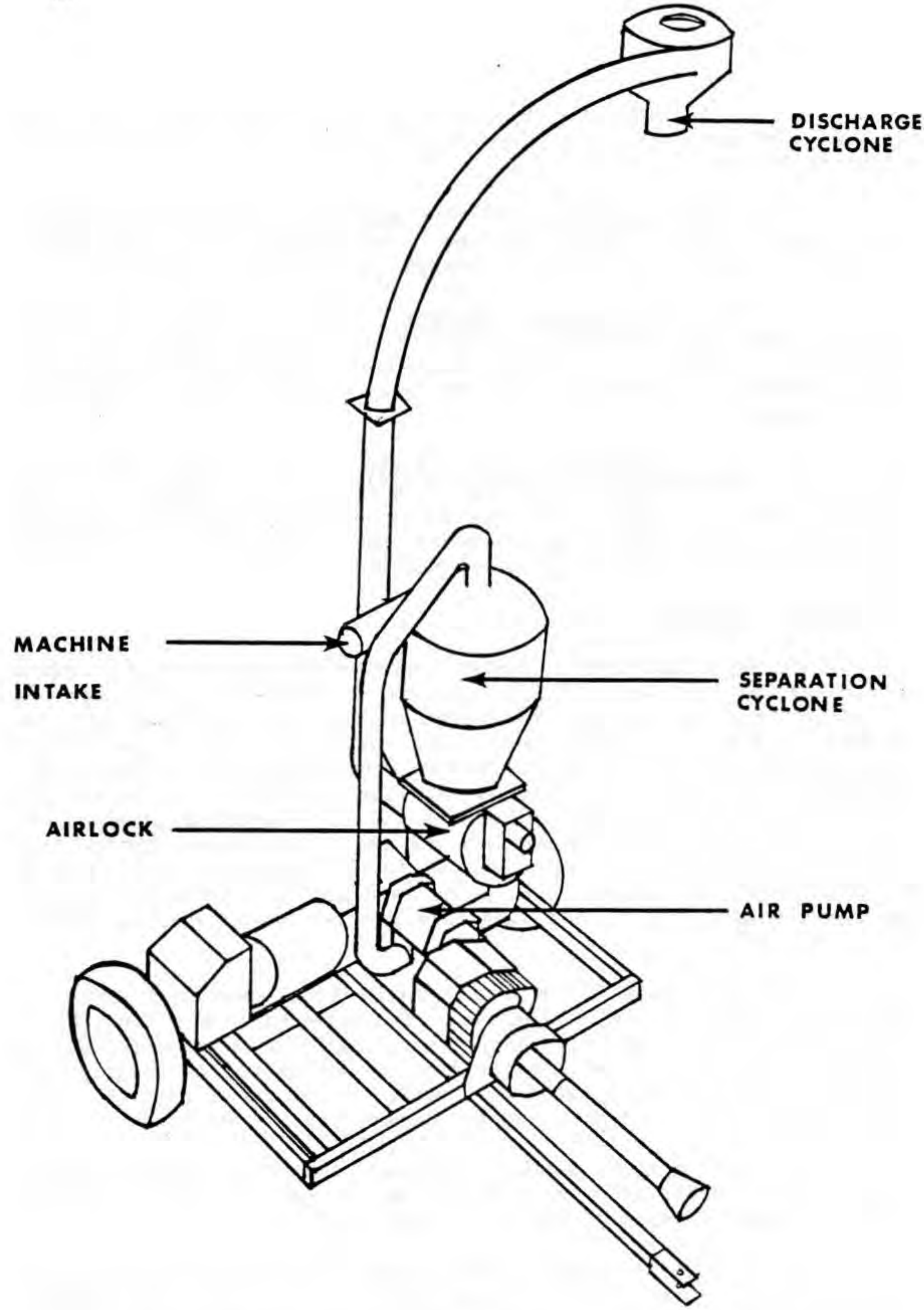

Figure 3. The Pneumatic Conveyor

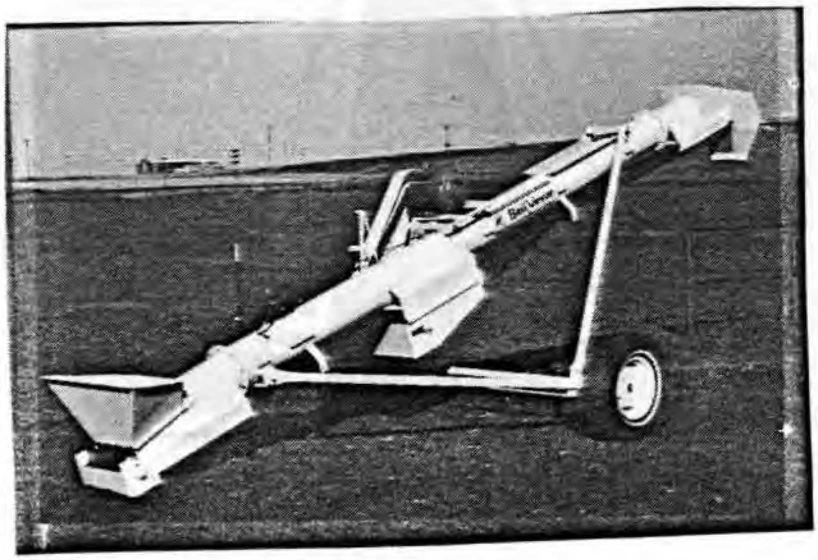

Figure 4(a). The Belt Conveyor

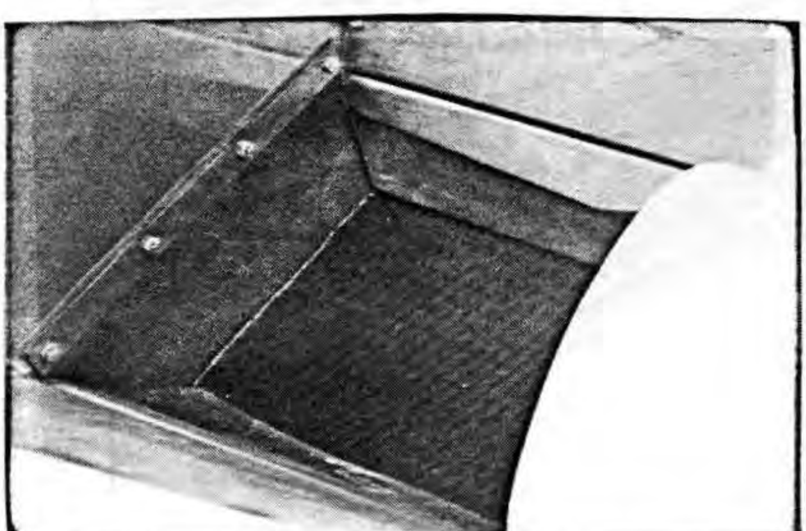

Figure 4(b). Close-up of the belt in the tube of the Belt Conveyor

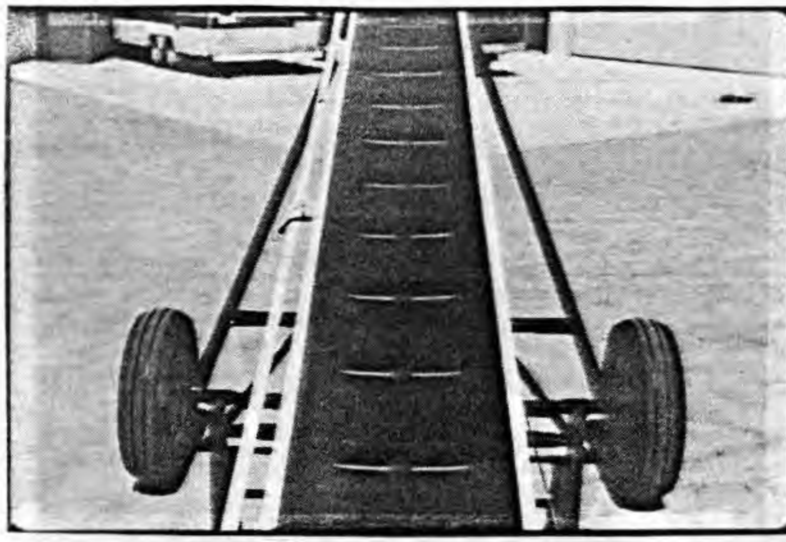

Figure 5. The Rubber-flight Conveyor

Figure 6. The Steel-core Bristle Auger

2 SEEDLOTS WITH DIFFERENT MOISTURE CONTENT

6 CONVEYORS - STEEL FLIGHTING AUGER
RUBBER INTAKE AUGER
PNEUMATIC CONVEYOR
BELT CONVEYOR
NYLON BRUSH CONVEYOR
FLIGHT CONVEYOR

2 ANGLES OF INCLINATION - 30°
15°

2 VOLUME CONTROLS - FULL CAPACITY
HALF CAPACITY

2 CONSECUTIVE PASSES THROUGH EACH CONVEYOR

2 REPLICATIONS

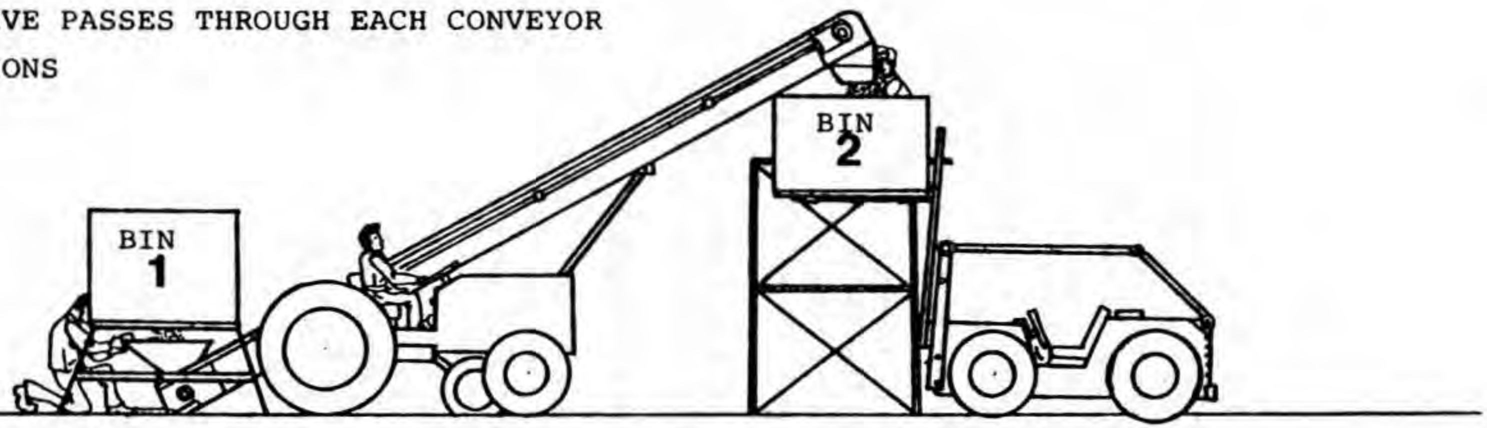

Figure 7. The Experimental Set-up

exit end of the conveyor, since the sample at the inlet for the second pass is the same sample as collected at the exit end during the first pass.

The seed quality of the samples was evaluated in terms of germination, seedcoat damage, and splits. The germination tests were conducted by the Iowa State Seed Laboratory according to the "Rules for Testing Seeds" of the Association of Official Seed Analysts. Four replications of 100 seeds were planted in a kimpak substrate, germinated at 25°C for 7 days, and the percentage normal seedlings recorded. The sodium hypochlorite soak procedure was used to determine seedcoat damage. In this procedure, two replications of 100 seeds were soaked in a 1% sodium hypochlorite solution for ten minutes. The seeds with seed coat damage swelled visibly and were counted. Splits were obtained by passing the sample through a 10/64-in. slotted hand sieve. The material that fell through the sieve often contained weed seeds and small undamaged seeds in addition to splits. These materials (other than splits) were removed by hand and the percentage of splits was calculated on the basis of weight of actual splits.

Data analysis was made by the Statistical Analysis System using a Completely Randomized Block experimental design.

Results and Discussion

Significant differences in capacity (maximum delivery) were found for various types of conveyors and angles of inclination (Figure 8). The flight conveyor, on the average, had the highest capacity (2373 Bu/hr) followed in order by the belt conveyor (2255 Bu/hr), the steel flighting auger (2166 Bu/hr), the pneumatic conveyor (2092 Bu/hr), the steel-flighting auger with rubber intake (2053 Bu/hr), and the nylon bristle auger (1883 Bu/hr). For all conveyors, the capacities declined at 30° angle of inclination compared to 15° angle of inclination. The capacity of the belt conveyor was reduced by 46% when the belt conveyor was operated at 30° angle of inclination. The pneumatic conveyor capacity was reduced only 3% by increasing the angle of inclination from 15° to 30°.

After two consecutive passes, the steel-flighting auger produced the highest increase in splits (0.56%) followed in order by the rubber intake auger (0.24%) and the pneumatic conveyor (0.2%) (Table 1). The nylon brush conveyor produced only a very small increase in splits (0.02%) and the remaining two conveyors, i.e. the belt conveyor and the flight conveyor did not produce any increase in splits in two consecutive passes. The steel flighting auger also produced the highest seed coat damage (4.3%) in two consecutive passes. The rubber intake auger and the pneumatic conveyor inflicted about equal seed coat damage (2.8%) in two consecutive passes. The corresponding seed coat damage for the nylon brush conveyor, the flight conveyor and the belt conveyor were 1.59%, 0.66% and 0.38%, respectively. The steel flighting auger, the

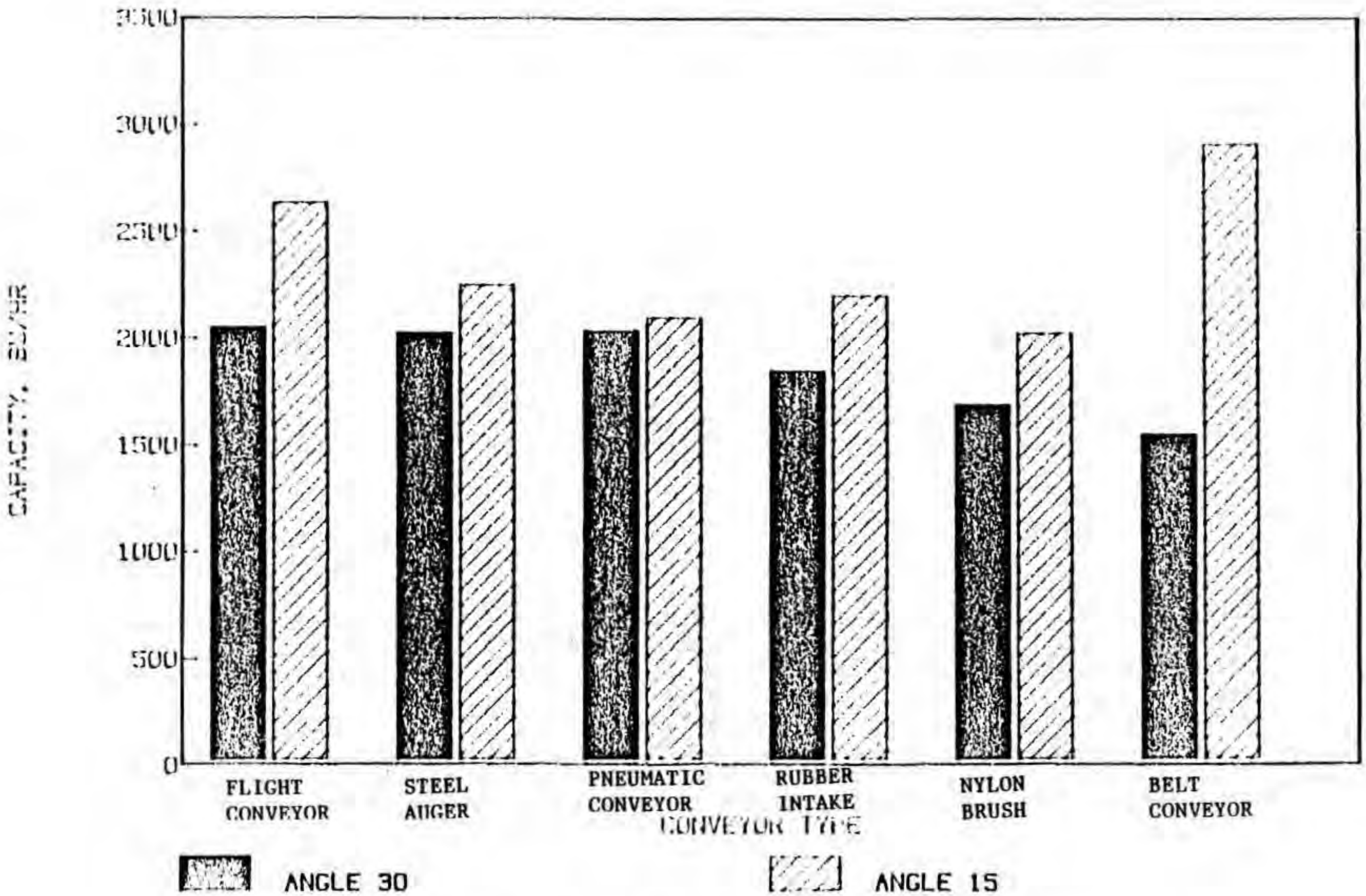

Figure 8. Effect of conveyor type and angle of inclination on capacity.

Table 1. Average splits, germination and seedcoat damage for various types of conveyors; averaged across seedlots, angles of inclination and volume flow.

Types of conveyor	Splits Initial (%)	Splits After 1st pass (%)	Splits After 2nd pass (%)	Germination Initial (%)	Germination After 1st pass (%)	Germination After 2nd pass (%)	Seed Coat Damage Initial (%)	Seed Coat Damage After 1st pass (%)	Seed Coat Damage After 2nd pass (%)
Steel flighting auger	0.147_{a}	0.418_{a}	0.704_{a}	$93.1_{a,b}$	91.9_{b}	$90.6_{b,c,d}$	6.53_{a}	$9.13_{a,b}$	10.8_{a}
Rubber-intake auger	0.157_{a}	0.281_{b}	0.397_{b}	90.9_{c}	$90.1_{b,c}$	88.5_{d}	7.28_{a}	$9.00_{a,b,c}$	$10.1_{a,b}$
Pneumatic conveyor	0.140_{a}	0.246_{b}	0.340_{b}	$91.1_{c,b}$	89.6_{c}	$88.5_{c,d}$	7.84_{a}	9.71_{a}	$10.7_{a,b}$
Belt conveyor	0.117_{a}	0.117_{c}	0.116_{c}	$92.0_{c,b}$	91.8_{b}	$91.1_{b,c}$	7.50_{a}	7.25_{d}	7.88_{c}
Nylon brush conveyor	0.136_{a}	0.151_{c}	0.159_{c}	$92.1_{c,b}$	$91.2_{b,c}$	$92.3_{a,b}$	7.63_{a}	$8.19_{b,c,d}$	$9.22_{b,c}$
Flight conveyor	0.141_{a}	0.146_{c}	0.142_{c}	94.7_{a}	94.2_{a}	94.3_{a}	7.12_{a}	$7.78_{c,d}$	8.03_{c}

*Means with the same letters within columns do not differ significantly at the 5 percent level.

rubber intake auger and the pneumatic conveyor reduced the germination by very similar amounts (2.5%) in two consecutive passes. The remaining three conveyors, i.e. the nylon brush conveyor, the belt conveyor, and the flight conveyor, induced no significant decrease in germination during conveying (Table 1).

A significant interaction of conveyor type and angle of inclination was found for splits produced during conveyance of seedlot 2 (Table 2). At steeper angle of inclination for seedlot 2, the steel flighting auger produced 1.49% splits in two consecutive passes which is very undesirable and must be avoided. The rubber intake auger also produced more splits (0.66%) at steeper angle compared to 15° angle of inclination (0.4%). The pneumatic conveyor showed a reverse trend, which can not be fully explained. A possible explanation may be that the seeds were slowed down in the exit cyclone due to the additional length of pipe needed for increasing the height of discharge. The three remaining conveyors i.e. the belt conveyor, the nylon brush conveyor and the flight conveyor did not produce any appreciable amount of breakage to soybeans in any angle of inclination.

The interaction of conveyor type with volume flow is shown in Table 3. For seedlot 2 the steel flighting auger produced a substantial increase in splits (1.225%) in half volume flow condition. The rubber intake auger and the pneumatic conveyor also produced more splits when operated at half volume capacity as compared to full volume flow condition. The remaining three conveyors i.e. the belt conveyor, the nylon brush conveyor and the flight conveyor were not influenced by the volume flow in term of breakage. The pneumatic conveyor caused a significant decrease in germination in the half volume condition for seedlot 2 (Table 3). The seedlot, after two consecutive passes, had a germination of 82.9%. Further analysis indicated this decrease occurred in both angles of inclination. Further research is recommended to confirm this aspect of pneumatic conveying because of its significance in recommending proper operational procedure to the producer for maintaining seed quality.

Conclusions

The conclusions derived from the first year of research are:

1. The flight conveyor had the highest capacity followed, in order, by the belt conveyor, the steel flighting auger, the pneumatic conveyor, the rubber intake auger, and the nylon brush auger.

2. The capacity of each conveyor decreased at a steeper angle of inclination. This decrease was most pronounced in the belt conveyor and least noticeable for the pneumatic conveyor.

Table 2. Effect of conveyor type and angle of inclination on splits and germination of soybean seed.

		Splits (%)				Germination (%)			
		Seedlot 1		Seedlot 2		Seedlot 1		Seedlot 2	
Type of conveyor	Angle of inclination (Degrees)	After 1st pass	After 2nd pass	After 1st pass	After 2nd pass	After 1st pass	After 2nd pass	After 1st pass	After 2nd pass
Steel flighting auger	15	0.001	0.050	0.427	0.73	94.4	92.7	92.1	92.1
	30	0.012	0.097	0.783	1.49	89.3	87.8	90.8	88.7
Rubber intake auger	15	0.017	0.015	0.230	0.397	88.9	87.4	89.4	87.6
	30	0.031	0.026	0.357	0.660	93.5	92.4	89.9	89.1
Pneumatic conveyor	15	0.074	0.137	0.200	0.353	93.6	93.5	86.9	86.2
	30	0.098	0.146	0.285	91.0	91.8	88.0	84.0	
Belt conveyor	15	-0.032	-0.010	0.061	0.058	92.6	93.5	93.0	92.3
	30	0.043	0.021	0.065	0.068	92.1	90.9	89.3	87.8
Nylon brush conveyor	15	0.007	-0.004	0.092	0.019	93.4	93.8	90.2	91.7
	30	0.012	0.023	0.095	0.108	91.6	93.2	899.5	90.4
Flight conveyor	15	0.004	0.003	0.071	0.062	96.7	94.6	90.7	91.0
	30	-0.025	-0.014	0.078	0.061	94.3	95.8	93.6	93.7

Table 3. Effect of conveyor type and volume of flow on splits and germination of soybean seed.

Type of conveyor	Volume flow	Splits (%) Seedlot 1 After 1st pass	Splits (%) Seedlot 1 After 2nd pass	Splits (%) Seedlot 2 After 1st pass	Splits (%) Seedlot 2 After 2nd pass	Germination (%) Seedlot 1 After 1st pass	Germination (%) Seedlot 1 After 2nd pass	Germination (%) Seedlot 2 After 1st pass	Germination (%) Seedlot 2 After 2nd pass
Steel flighting auger	Full	- .021	0.012	0.516	0.995	91.2	89.8	92.2	90.9
	Half	0.034	0.135	0.694	1.225	92.5	90.6	90.6	89.9
Rubber intake auger	Full	0.042	0.032	0.256	0.486	92.3	92.3	88.5	87.3
	Half	0.006	0.009	0.331	0.571	90.1	87.5	90.8	88.4
Pneumatic conveyor	Full	0.074	0.099	0.144	0.259	92.2	92.3	90.9	87.3
	Half	0.109	0.184	0.221	0.379	92.3	93.1	84.0	82.9
Belt conveyor	Full	0.019	0.022	0.079	0.080	92.6	94.1	91.2	90.4
	Half	-0.008	-0.011	0.069	0.072	92.1	90.3	91.2	89.6
Nylon brush conveyor	Full	0.020	0.032	0.102	0.111	91.8	94.0	89.1	90.5
	Half	-0.001	-0.011	0.085	0.106	93.3	93.0	90.6	91.5
Flight conveyor	Full	-0.016	- .008	0.067	0.059	95.9	94.5	92.3	92.9
	Half	-0.002	0	0.082	0.065	95.1	95.8	92.0	91.9

3. The belt conveyor, the flight conveyor and the nylon brush auger did not cause significant damage to seed during conveying.

4. The steel flighting auger, the rubber intake auger and the pneumatic conveyor produced significant seed damage during conveying if:

    a. the conveyor was not kept full,

    b. the angle of inclination was steep,

    c. the seed moisture was not ideal,

    d. a combination of a, b and c.

SEED CONDITIONING PLANT DESIGN

Virgil Harden[1]

The steps taken for the building of all seed plants are much the same regardless of seed types. Generally the seedsman has visited seed conditioning plants in his immediate area and has ideas of his own concerning the overall concept of his future plant. A design engineer is contacted and the first steps are taken in planning the total conditioning facility.

The design engineer, after visiting the job site and making a ground plot layout giving particular attention to soil bearing loads, traffic flows, side streets, main highways and drainage, begins to lay out the conditioning facility with special regards to the following areas.

Receiving

1. Scale, office and sample area.

2. Types of of trucks, grain buggies or wagons to be unloaded.

3. Holding capacity of receiving pit.

4. Type of unloading pit to be used, i.e., vibro spout, belt conveyor, gravity or other.

5. Volume of seed per hour of receiving equipment.

Bulk Storage

1. Precleaning before storage.

2. Total bushels capacity required.

3. Bushels capacity per tank.

4. Construction of tanks, i.e., concrete, corrugated, smooth wall, flat-bottom or hopper-bottom.

5. Aeration and/or seed drying required.

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6. Types of conveying and seed handling equipment to be used in bulk storage system.

7. Reclaim system to conditioning plant.

Conditioning Plant

1. Types of seed commodities to be cleaned.

2. Desired volume of cleaned seed per hour.

3. Separation problems associated with each seed type.

4. Cleaning equipment to be used - air/screen, spirals, gravity, grading and sizing equipment, debearder, roll mill, scarifier, magnetic separator, color separator, automatic sampler, gently handling seed elevators and conveyors.

5. Treating system, bagged and bulk.

6. Type of packaging equipment to be used - open-mouth bags with sewing machine, valve bags with valve bag packer and/or other types.

Other

1. Total sacked storage warehouse area to be used and forklift traffic pattern.

2. Custom cleaning opportunities available.

3. Bulk cleaned seed storage if required.

4. Expansion flexibility in all areas of facility.

When complete, preliminary drawings are discussed between the seedsman and the design engineer to determine if any changes are required. Changes, if any, are made and detailed plan and elevation drawings are prepared which provide information required to produce detailed equipment lists, prices of same, plus estimates of installation, electrical, concrete and building costs. By totaling all costs, the seedsman then has a clear picture of what he is purchasing and total facility expenditure. If amendments have to be made in order to lower the total expenditure, I suggest they be made in the areas of bulk storage tanks and sacked storage warehouse, not in the equipment needed for the seed cleaning process. The conditioning area is the 'Heart' of the facility and the seed you package is a direct reflection on the seedsman.

When selecting equipment for use in his conditioning plant and storage facility the seedsman should place emphasis on ease of clean-up, prevention of mechanical damage to the seed, efficiency of operation and flexibility. Since there are different types of each of the pieces of equipment needed, the seedsman must select the equipment he feels to be most suitable for his particular situation. Delicate fragile seeds are easily damaged by impact, therefore, equipment that will minimize breakage and splitting should be selected. Keeping this in mind, lets look at different areas of the conditioning facility and equipment available for each.

Receiving Elevators, Distributors & Spouting

All bucket elevators are not created equal. Some manufacturers use faster head shaft speeds in order to obtain higher capacities without advising seedsmen as to the damage created by seed being thrown against the inside of the elevator head cover and by down-legging. Figure 1 illustrates that a bucket elevator, properly designed, driven at correct speed, will make a clean discharge directly into the throat assuring no appreciable damage on vulnerable commodities and little or no back-legging or down-legging. A slight deviation such as five (5) revolutions per minute (RPM) above or below optimum speed causes the cups to spill or throw. Information is available from manufacturers on pulley sizes, speeds, etc. If the information available is for commodities other than seed it may not be applicable to seed and adjustments may need to be made for handling seed.

Plastic cups are normally used to prevent damage on impact between seed and cup. Cup bolts should be used with both flat and lock washers with the flat washer against the inside of the plastic cup. This method of installation prevents the bolt from pulling through the cup or the nut from cutting into the cup during installation. Nylon spacer washers, Figure 2, should be used between cup and belt to prevent lodging of seed causing varietal mixture and clean-up problems.

Care should be taken in the selection of the elevator distributor. Distributors having interlocking turnspouts and hoppered bottoms with overflow spouts are most recommended, Figures 3 & 4. Distributors having flat bottoms and sliding internal spouts are amain source of varietal mixing. When the internal spout is not in direct alignment with the outlet spout spilling takes place within the body of the distributor. When the internal spout is then moved to an alternate hole the spillage within the distributor body is pushed by the internal spout to an adjacent outlet hole where it continues down the spout and into another bin or conveyor and varietal mixing occurs.

Lock-Out Valves

If you have an existing distributor with the previously mentioned problem it can be eliminated by installing leak-proof lock-out

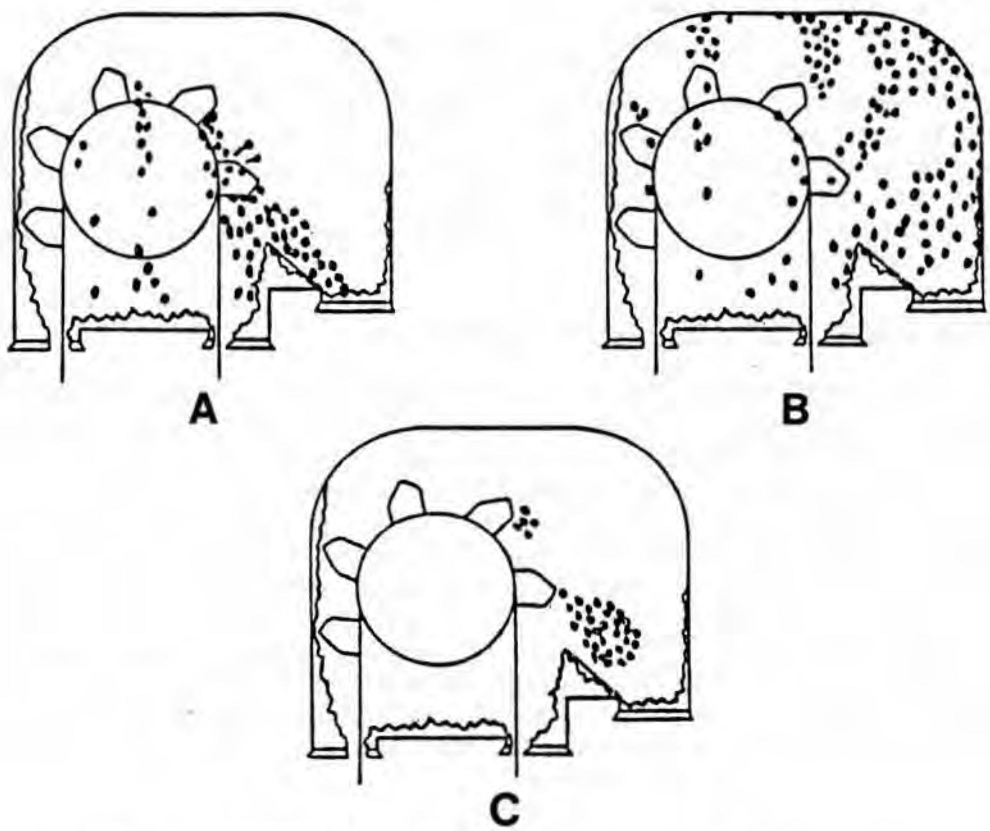

Figure 1. Centrifugal discharge bucket elevator.
a. Head pulley speed too low.
b. Head pulley speed too fast.
c. Optimum head pulley speed.

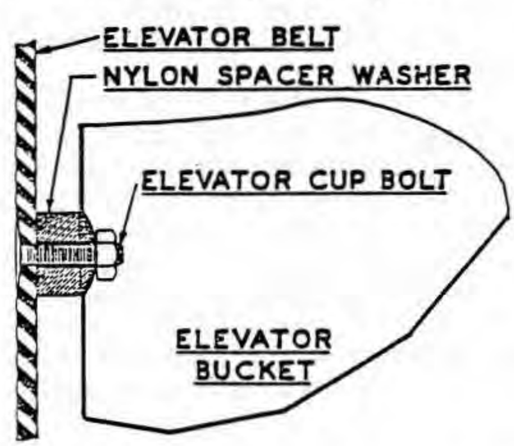

Figure 2. Spacer washer placed between belt and bucket to prevend mixtures. Recommended washer size - 1 in dia. and 0.5 in. thick.

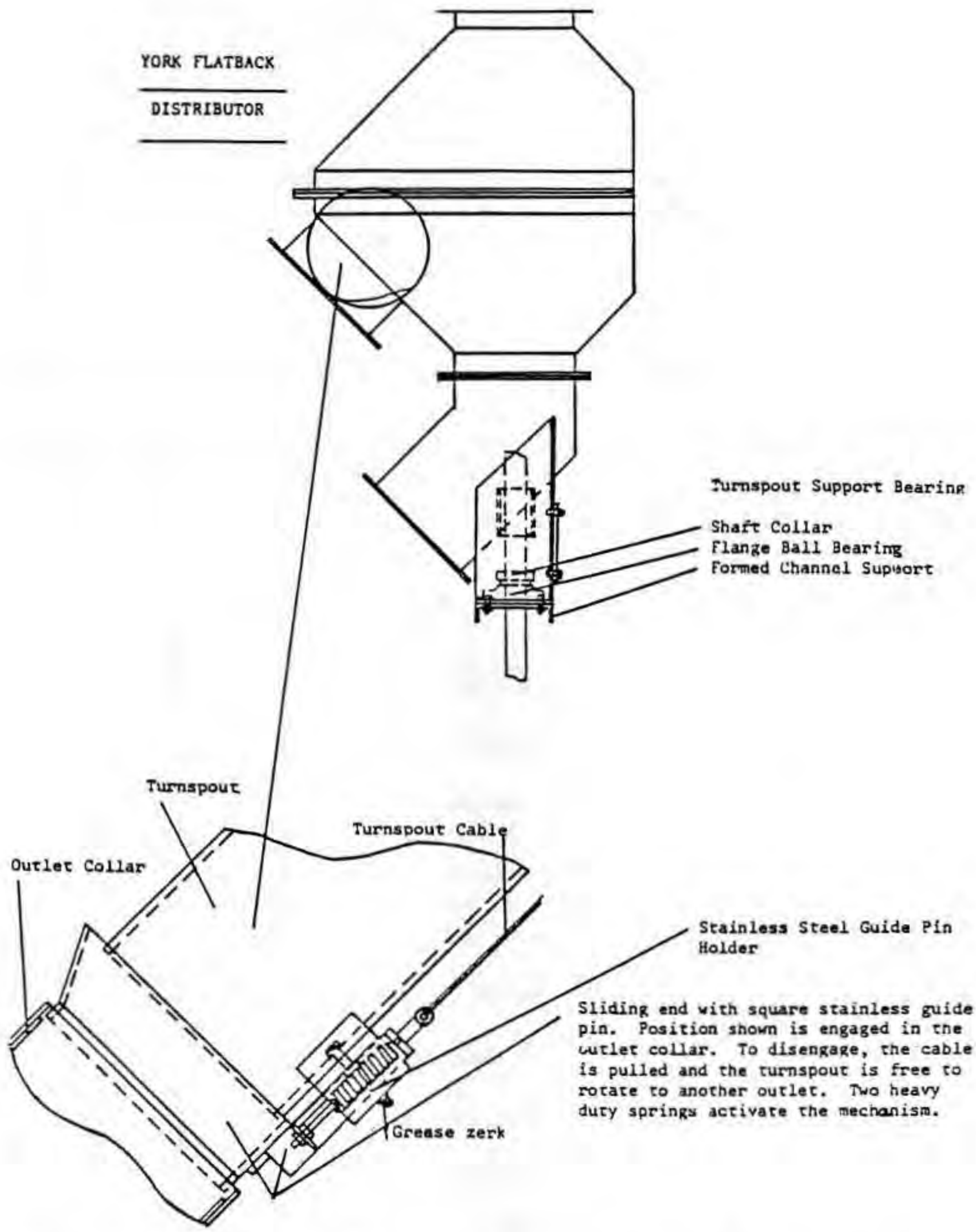

Figure 3. Hoppered bottom distributor with interlocking turnspouts.

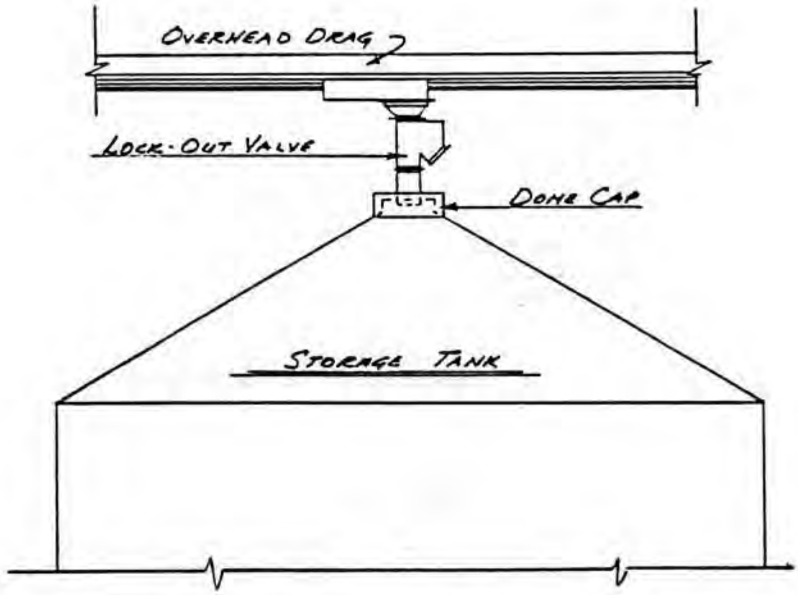

Figure 4. Lock-out valve located between intermediate discharge of drag flight conveyor and storage bin.

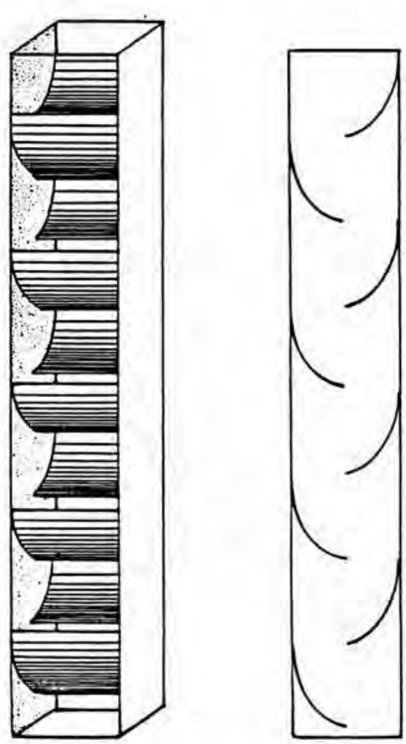

Figure 5. Bean ladder used to minimize mechanical damage in free drops.

bucket valves in the spout from the distributor to the bin or conveyor. Install the valve as close to the bin or conveyor as is practical and place the valve in the 'out' position when using an alternate spout. Any spillage in the distributor will then trickle through the valve and drop to the ground below.

Another use for the lock-out valve is in the spout connection between intermediate discharge gates in overhead distributing drag conveyors and storage bins, Figure 5. Curved slide gates do not fit flush with the bottom of the conveyor trough leaving an area which will hold a small portion of seed when by-passing intermediate bins. When the intermediate gate is then opened to fill the bin below with a second variety, that small portion of the first variety will drop into the bin directly below. with the lock-out valve installed in the spout and in the 'out' position, the gate can be opened allowing the portion of first variety to fall onto the ground eliminating mixture. The valve is then changed to the 'in' position and the intermediate bin filled with the second variety.

Spouts

The rule of thumb is that spout angles should be 45 degrees and have a capacity of about sixty (60) bushels per hour per square inch of spout diameter area. Products which do not flow easily may require spout angles steeper than 45 degrees. Likewise, seeds which roll easily such as soybeans may be piped through spouts having angles less than 45 degrees. Always bear in mind that the longer the spout and the steeper the pitch the faster the seed will be traveling when they reach the end of the spout (Table 1). The faster the seed are traveling the more damage will occur. Table 1 shows the necessity of keeping all spouts at minimum angles and length to eliminate germination damage and breakage. If multiple spouts are used on one elevator and the shorter spouts have a steep angle it may be necessary to use enclosed bean ladders instead of standard round or square spouts.

Bean Ladders

A bean ladder is a rectangular tube having a series of zig-zag curved baffles inside. The open-type ladder has openings on two sides 90 degrees to the inside curved baffles and is used inside bins or tanks. The closed-type ladder does not have the side openings but is enclosed with sheet metal on all sides and is used in place of spouting material when long spouts cannot be avoided. As the seeds flow through the ladder they follow a cascade zig-zag course and never obtain as high a velocity as they would in free fall.

Conveyors

The three best types of conveyors to use in the design of seed conditioning plants are belt conveyors, drag-flite conveyors and

Table 1. Grain velocities in spouts.

Spout Length	Velocity in Feet Per Minute											
	Angle of Spout in Degree											
	35	40	45	50	55	60	65	70	75	80	85	90
5'	400	524	618	700	770	830	885	935	975	1010	1050	1075
10'	570	742	875	990	1090	1180	1255	1320	1380	1435	1485	1520
15'	696	908	1070	1210	1335	1440	1530	1615	1690	1755	1820	1860
20'	805	1047	1235	1400	1540	1665	1770	1870	1950	2025	2100	2150
25'	899	1170	1380	1560	1725	1860	1975	2085	2180	2265	2340	2400
30'	985	1280	1510	1710	1890	2040	2165	2285	2390	2480	2570	2635
40'	1135	1480	1750	1975	2180	2355	2500	2640	2760	2865	2970	3040
50'	1270	1655	1950	2210	2440	2635	2800	2955	3090	3210	3320	3400
60'	1390	1810	2140	2420	2670	2880	3065	3240	3390	3520	3640	3720
70'	1500	1960	2310	2615	2880	3110	3315	3500	3660	3800	3930	4025
80'	1605	2090	2470	2795	3080	3330	3540	3740	3905	4055	4200	4295
90'	1705	2220	2620	2960	3275	3535	3760	3965	4150	4310	4460	4575
100'	1795	2340	2765	3120	3450	3720	3960	4180	4370	4540	4700	4800
125'	2005	2620	3090	3500	3860	4165	4440	4680	4890	5080	5250	5370
150'	2200	2865	3390	3835	4225	4560	4850	5120	5350	5560	5750	5880
175'	2375	3100	3665	4140	4565	4935	5250	5540	5790	6000	6215	6350
200'	2540	3310	3900	4420	4880	5270	5600	5910	6180	6420	6640	6800

This table indicates approximate velocities that will be attained by whole dry grains flowing freely in smooth metal spouts of various lengths and of various angles in relation to the horizontal. The velocities are based on an angle of repose of 28 degrees for grain.

vibrating pan conveyors. These conveyors are of the self-cleaning type and handle the seed gently with the least amount of germination reduction and mechanical damage.

Vibrating conveyors are best used where distance are short. In the past vibrating conveyor frames had to be bolted to the floor or other sturdy structure because the vibrating action of the pan was not counter-balanced. This is still the case with some manufacturer's conveyors. However, there are now manufacturers making counter-balanced vibrating conveyors having intermediate discharges that can even be suspended from cables.

Belt conveyors are best used where seed has to be conveyed for long distances. If multiple intermediate discharges are required as in a distributing conveyor over bulk storage bins then the drag-flite conveyor will probably be the best conveyor for the installation. Generally in multiple tank storage the overhead conveyor with multiple discharges will be the drag-flit type with the return conveyor being the belt type. Drag-flite conveyors are also good to use for the return conveyor because they are totally enclosed and dust free.

Precleaning

There are pros and cons of precleaning field seed prior to bulk storage. Since precleaning removes most of the large and small foreign materials in the seed mass, more desirable seeds are stored in the tanks. Aeration and drying costs are also minimized with removal of undesirables. With most of the foreign matter removed from the seed during precleaning, capacity during the actual cleaning process will increase.

Installation expense and clean-up problems when more than one variety of seed is being received simultaneously are the main drawbacks to precleaning. Precleaners are mostly installed when a seedsman has at least 100,000 bushels of one variety of seed to receive. He uses two receiving elevators in the pit, one feeding the surge bin over his precleaner and one feeding directly into bulk storage. When a truck dumps the variety of which he has the greater amount he uses the elevator feeding the surge bin over the precleaner. When another variety is received the second elevator is used to divert the seed directly to bulk storage by-passing the precleaner. After harvest the seedsman can then bring the varieties of lesser amounts back through the precleaning process and transfer them on to the cleaning plant or back to bulk seed storage tanks.

Bulk Storage Tanks

Uncleaned seed bulk storage tank are offered in either flat-bottom or hopper-bottom design. The advantage of hopper-bottom tanks is that they save man-hours in unloading and clean-up. However installation costs are much higher than with flat-bottom tanks and drying with heat within hopper-bottom tanks can be troublesome.

Flat-bottom tanks are better designed for drying with stirall systems and have the advantage of being lower in cost per bushel of storage. Drag-flite conveyors can be used directly under the middle of flat-bottom tanks for unloading purposes to eliminate the use of tube augers. The point where the drag conveyor passes through the tank wall must be sealed if the tank has any type of aeration system in order to force air from the fans up through the perforated floor. The main disadvantage to this type of installation is the repair of broken conveyor chains.

If the budget allows sufficient bulk field seed storage properly designed for all of your more fragile seeds is highly desirable. My customers report an increased average clean-out loss of four percent when their soybeans are stored in on-farm storage bins. Due to increased costs however, most on-farm storage is not properly designed for fragile seeds.

Air-Screen Cleaners

Several models of air-screen cleaners are available for the seedsman. A cleaner having both top and bottom air separations is desirable for commercial seed conditioning plants. Immature seeds, hulls and other lighter seeds and contaminants are removed in the air separation. By removing as many contaminants as is possible with the air separation, lesser amounts of materials have to be separated with the screen portion of the cleaner resulting in better total separation of contaminants and greater total capacity.

Features which should also be considered when selecting the air-screen cleaner are: adjustable feed-rate hopper, variable air controls, individually adjustable screen pitch, variable shoe shake, screen cleaning balls or brushes, flow options, accessibility of parts and the number and size of screens in the cleaner.

Always select the size cleaner having enough total screen area to make the necessary separation for the desired capacity. The selection should be made considering the worst possible percentage of contaminants which are to be removed. In border-line cases it is best to select the next larger size air-screen cleaner. This basic rule is also good to follow in selecting all other types of finishing equipment such as spirals, gravity, length and thickness graders, sacking equipment, etc.

Surge Bins

As the air-screen cleaner is the first piece of conditioning equipment inside the cleaning plant, the over-cleaner bin should have sufficient holding capacity to operate the cleaner continuously for at least two hours. For example, if the air-screen cleaner has a capacity of 200 bushels per hour input feed, the over-cleaner bin should hold at least 400 bushels of bulk uncleaned seed, more if possible. With this design, reclaim conveyors and elevators from bulk storage require a minimum amount of attention in order to keep the seed cleaning equipment operating at full capacity.

Bins over finishing equipment need not be the same capacity-cleaning ratio as for air screen cleaners, but should be large enough to allow flexibility in properly adjusting each piece of equipment. All bins over cleaning equipment should have discharge gates that properly match feed inlets. Capacity and cleaning efficiency is drastically reduced when this rule is not followed.

Access Walkways

Wide access walkways around cleaning equipment are very desirable because they allow work space for maintenance. Two-foot wide walkways should be the minimum; three-foot wide walkways are more desirable. Handrails, kneerails and toerails need to follow OSHA standards and stairways instead of ladders should be used where possible.

Gravity-Flow

Try to design your plant with a minimum number of elevators which lift and drop seed. Expenses of today's materials cause high overall costs in trying to build a total gravity-flow plant. For this reason newer plants are designed and built with multiple elevators. However, these can be kept at a minimum in handling fragile seed commodities. For example, if you are using both spiral and gravity separators for cleaning soybeans, try to design the plant with some gravity-flow by locating the spirals above the gravity separators. A built-in by-pass can be had by simply installing a two-way valve in the spout to the over spiral bin and extending the down spout to the gravity surge bin. Wheat and rice seed are not as susceptible to breakage as are soybeans but all seeds need to be handled as gently as possible.

Continuous-Cup Elevators

The Mitchell type or continuous-cup elevator is good for any type of seed conditioning plant. It is slow moving, discharges the seed easily and is totally self-cleaning. The continuous-cup elevator usually has an open angle-iron frame housing permitting visual inspection of the seed. Continuous-cup elevators are available with multiple rows of cups for handling different commodities simultaneously. A triple-row continuous-cup elevator could (1) receive seed from the air-screen cleaner which would be discharged into the over spiral bin, (2) receive seed from the spirals which would discharge into the gravity surge bin and (3) receive seed from the gravity separator which would discharge into the clean seed sacking bin. With the addition of a fourth row the elevator could also receive the off-grades from all cleaning equipment and discharge them into the screenings system. Continuous-cup elevators are generally more expensive than conventional bucket elevators and are limited to about 2,000 bushels per hour capacity.

Conventional Elevators

When conventional bucket elevators are used inside the cleaning plant care should be taken to select those having optional head speeds or easy-dump discharge features. Slatted boot pulleys also help to eliminate mashing of seed between the boot pulley and elevator belt.

Automatic Samplers

Some states require the use the automatic samplers in the seed conditioning process. Automatic samplers are available in many different variations allowing seedsmen to collect samples in bins, conveyors and spouts. Seedsmen using samplers in several locations throughout the conditioning plant are able to locate cleaning problems with ease. Should any one of the pieces of seed cleaning equipment be out of proper adjustment automatic samplers will assist in identification of the problem.

Seed Treaters

If seeds are to be treated the treater-room needs to be isolated with wall enclosures from the rest of the cleaning plant. A costly problem can be eliminated by being sure red-dyed treated seed does not mix with splits and off-grades. Treaters having diaphragm-type pumps should be kept as close to the floor as is possible, generally within 15 feet. Too much head pressure will rupture the diaphragm causing pump failure. Treaters having spray nozzles give better coverage of chemical on the seed. Round or hex shaped drums used as film coaters need to be used with fragile seeds such as soybeans. Be sure to pay attention to the accessibility of chemical drums to the treater area because they are difficult to handle by hand. One suggestion is to paint the floor of the treater room a reddish color. Treatment with red dye is sure to be spilled in the treater room area and with a reddish colored floor the spills are not as noticeable. Slope the floor to a drain to permit wash-down clean-up after treating.

Valve Bag Packers

Valve bag packers are real time and space savers. A valve packer having a 10-horsepower blower can bag six to seven 60-pound bags of seed per minute and since the bags are self sealing without 'ears' they can be pelletized in a minimum amount of space. It only takes one person to operate a twin-tube packer. Labor expense can be lowered by using such a unit with a capacity of from 720 to 840 bushels per hour. New electronic weighing systems are said to have an accuracy of plus or minus 1/10 pound and are not effected by heat or cold weather changes. Bag weights on electronic packers can be checked while the bag is on the fill spout which is also a time saver.

Multiple-Use Bins

When a seedsman has a commodity his customers want to purchase in bulk rather than bagged he needs to design his plant in such a way that his bins will have the flexibility to store bulk seed from the field, cleaned seed for bulk load-out and cleaned seed for sacking purposes if possible. Multiple-use bins need to be of welded steel construction without any ledges or holding pockets and with steep valley angles for total clean-out. To help eliminate varietal mixtures try to use the same bin over again for the same variety. This is true of all storage bins whether they be used for clean seed or for bulk field seed.

Flexibility

Take time when looking over the plans prepared by the design engineer to be sure the plant offers all available flexibility. Room for expansion should be allowed. The cost of changing flows is very little when plans are on paper but can be extremely expensive once equipment is erected. Leave room for expansion in both field seed bulk storage and inside the actual cleaning plant. There may be additional varieties and/or seed types which you will want to include in your conditioning in the future. I do not know of any type of equipment, building or foundation that has been reduced in price over the past several years. Your conditioning facility will be at its minimum cost at the time of first erection. Provide extra room; it will cost less now than later.

I once had a customer who wanted to clean only soybeans in a plant which I was designing for him. He really never noticed how much additional room was provided for future equipment in the cleaning area until his plant was completed. At that time I could tell he was a little concerned. However, the day came about 18 months later when he wanted to add all the necessary equipment for cleaning seed rice. He was very pleased I had the foresight to leave the required space in the cleaning area to add all of the necessary length and thickness separators, surge hoppers, support stands, walkways and conveyors. When completed the added equipment had the appearance of having been part of the original installation rather than a botched up addition. This particular customer has also added to his facility a continuous-flow dryer, bulk storage tanks and precleaner which have the appearance of being part of the original installation because the original design plans incorporated the necessary space requirements.

Up-dating and/or Renovation

Seedsmen always seem to be striving for ways to produce cleaner and healthier seeds with high vigor and germination for their customers. Because the seed industry has become such a highly competitive business, the time comes when a seedsman must update or renovate all or a portion of his conditioning plant to remain competitive or give himself an edge over his competition. In many cases a seedsman with an existing plant may want to add equipment for cleaning seed types other than those he has cleaned in the past. If the space required for the new equipment is available in the existing plant the cost for expansion can be kept at a minimum. However, other questions the seedsman should consider are:

1. Will harvest of the new seed type overlap into that of the seed types he is already cleaning?

2. What problems will he have with existing equipment in receiving, conveying and mixing of seed types?

3. Does he have sufficient bulk and flat storage for the additional product(s)?

If answers to these questions are favorable and do not require costly changes in existing equipment the seedsman has one very desirable advantage in adding the needed equipment to his existing plant in that he may clean the additional seed types without the addition of personnel. Conversely, if the additional seed types require costly changes in existing facilities the best solution may be to build an additional plant designed specifically for the additional seed types or forget about trying to clean the additional seed types entirely.

When the decision is made to update his plant the seedsman will want to consider several options. This is also an excellent time to decide if more capacity is needed for those seed types he is already cleaning. Most all seed conditioning equipment is available with capacities up to 500 bushels per hour. Those that are not can be purchased in multiples to reach desired capacities. However, problems arise in conveying the increased capacity through the existing plant. In many instances surge bins will have to be added or increased in size. Bucket elevator capacities must be increased but not by using the method of simply increasing the head pulley speed which can cause seed damage as previously discussed. Sometimes the capacity of bucket elevators may be increased by simply changing belt and buckets.

For example, let's use a bucket elevator having a head pulley which is 12 inches in diameter with a six-inch face width. The optimum speed at which the head pulley is turning is 60 revolutions per minute and the elevator is equipped with a 6-inch wide belt and 5 x 4 cups on twelve-inch spacing. The capacity of such an elevator would be 230 bushels per hour based on an eighty-percent cup fill. Punching the existing belt for 6-inch cup spacing and adding the necessary cups would increase capacity to 460 bushels per hour and by purchasing a new 6-inch belt punched for 6 x 4 cups on 6-inch spacing capacity increases to 550 bushels per hour.

Further updating may also include the addition of enclosed spiral separators which reduce noise, dust and spouting requirements. Enclosed spiral separators are furnished with interchangeable cores of flat, medium or steep pitch and installation costs are kept at a minimum when cores finally wear to the point of replacement.

Length graders can be used for removal of broken and hulled kernels of rice from seed lots or for lifting small weed seeds and vetch from wheat. Dockins graders or precision sizers are available for 'red' rice removal. Gravity separators have been used to minimize cleaning problems associated with almost all seeds.

Contrary to popular belief, gravity separators no longer have to be anchored to the floor or on elevated concrete pads. With the introduction of gravity separators which have counter-balanced construction they can be placed almost anywhere as long as the strength of the support structure is adequate.

When updating includes the additional of some or all of the previously mentioned equipment care must be given to proper flow for the best overall conditioning process.

Air-screen cleaners having brush screen cleaning systems which require excessive maintenance and down-time can be converted to ball-tray screen cleaning, Figure 6. Some manufacturers also have retro-fit kits for individual drives often referred to as "DI" kits. Check with the manufacturer of your unit for pricing and availability.

Valve bag packers having mechanical weight controls can be converted to a more precise electronic control system at a cost which is generally recovered within a year in savings of bagged seed losses.

There are just a few ideas which may be of interest. If you are a seedsman planning to build a new seed conditioning facility or want to update your plant, do not hesitate to contact a knowledgeable design engineer for assistance. Their ideas and services will save you money.

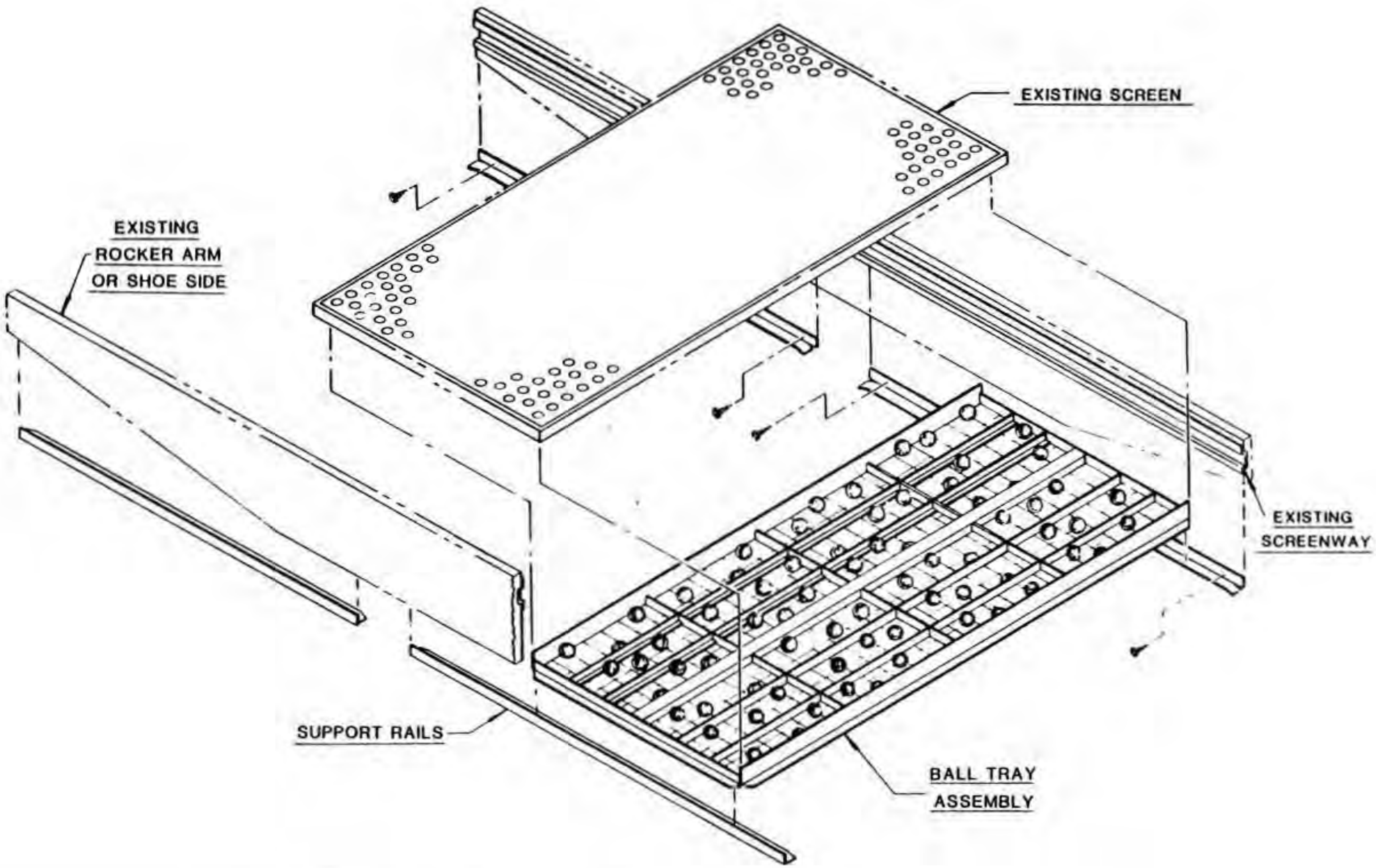

Figure 6. Installation of a ball tray screen cleaning device in an air-screen cleaner.

SEED DEVELOPMENT AND MATURATION

Howard C. Potts[1]

The culmination of the life cycle of most higher plants is the development of its reproductive unit, the seed. The seed, in terms of sexual reproduction, is a mature, fertilized ovule consisting of the embryonic axis, food reserves and an outer covering.

The life of any seed can be divided into four stages: (1) its origin in the flower of the mother plant, (2) its development and maturation, (3) its resting stage, and (4) its resumption of growth or germination.

Seed Development and Morphology

At a specific time in the life cycle of all flowering plants, the physiological and biological processes change from the production of vegetative organs - leaves & stems - to the reproductive organs - the flowers. Despite differences in the appearances of flowers, those floral organs involved in the formation of seed are quite similar for most species. The male and female reproductive organs of most flowering plants are comparable. Typically, each flower is produced at the end of a stalk, the pedicle, which is modified and specialized for reproduction. The tip of the pedicle, where the floral organs are attached, is usually somewhat enlarged. This enlarged region is called the Receptacle. In a typical complete flower, the receptacle gives rise to the four basic floral organs - sepals, petals, stamens, and pistil.

The sepals and petals have no direct role in actual seed development, but serve as a protective organ and in some cases attract insects, necessary for pollination. The Stamens, the male reproductive organs of a flower, are located inside the petals. Each stamen is typically composed of a threadlike stalk, the Filament, which is terminated by an enlarged four-lobed, usually yellow organ - the Anther. The primary role of the filament is to position the anther so the pollen is dispersed in a manner typical of its species. The pollen grains are formed inside the anther. When mature, the anther ruptures and releases the pollen.

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The female reproductive organ, the Pistil, is located at the center of the flower. The enlarged base, which may rest on or be surrounded by the receptacle, is the Ovary. Extending from the ovary is the stalk-like Style, which terminates in an expanded portion called the Stigma (Figure 1).

Pistils and ovaries can be simple or compound. Within each ovary one or several ovules can be produced. The common bean is an example of a species with a simple pistil that produces several ovules (Figure 2). All species of the grass family have a simple ovary which produce only one ovule. A compound ovary is composed of two or more cavities or carpels. One or many ovules may be formed inside each cavity. Cotton and okra are examples of species having compound ovaries.

Some species produce flowers having no stamens or non-functioning ones. Such flowers are referred to as pistillate or male-sterile. The flowers of the female inflorescence or ear of maize have no stamen. When the pistil is absent, the flower or floret is referred to as staminate. The florets produced on the tassels of maize are normally staminate. Flowers and florets containing neither male nor female reproductive organs or containing non-functioning ones are sterile and, of course, are not involved in seed formation.

Some species, such as maize and cucumber, produce staminate flowers on one part of the plant and pistillate flowers on another part of the same plant. Such plants are referred to as being Monoecious. In a few species, individual plants produce only pistillate or staminate flowers. Such species are Dioecious. Papaya and date palm are examples of dioecious species.

Grass flowers are so small and inconspicuous that many people think grasses have no flowers. Because they are so different from flowers of most other plants, a separate terminology is applied to some of their floral organs. The complete perfect flower of a grass plant consists of a pistil with a single, simple ovary, two styles with featherlike stigmas, and three stamens (rice has six stamens). The reproductive organs of grasses are enclosed by two leaflike structures. The larger structure is the Lemma and the smaller the Palea. The Lodicules, two small saclike structures located inside the lemma and the palea, expand when the flower's reproductive organs are mature. Expansion of the lodicules causes the lemma and palea to separate and expose the stamens and stigmas. The lemma, palea, and enclosed organs are called a floret. Florets are produced individually or along a central axis in groups of two or more; they are connected by small stems, known as Rachillas. The individual or groups of florets are subtended by two leaflike structures called glumes (Figure 3).

The maize flower is a significant exception to the basic organization of grass florets. The female florets are arranged in paired rows

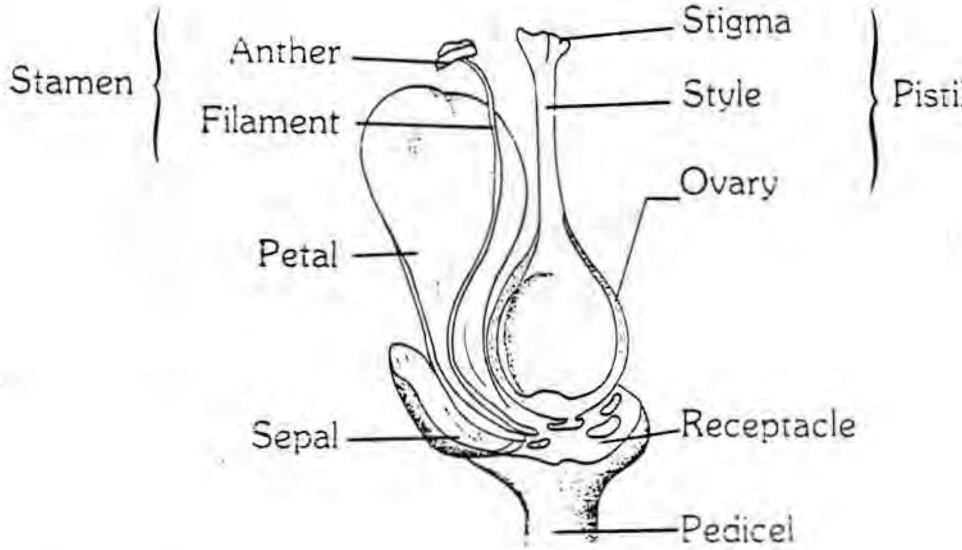


Figure 1. Diagram of a longitudinal section of a complete flower.

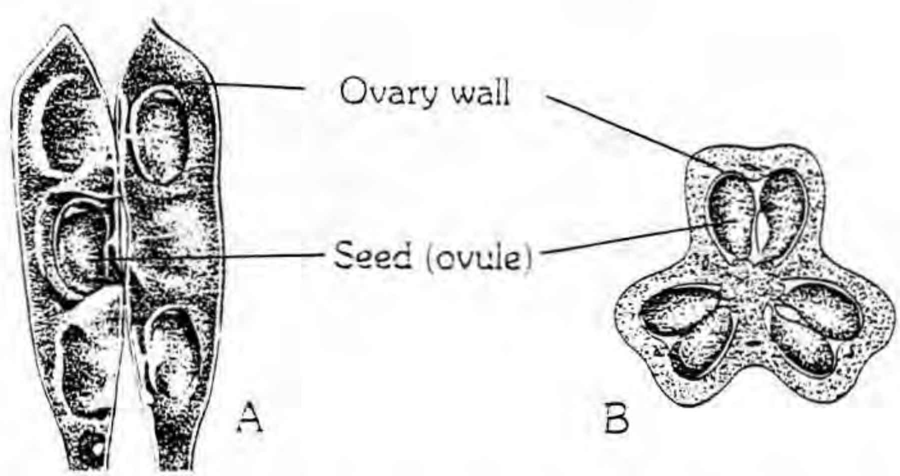


Figure 2. Comparison of simple pistil of the common bean, *Phaseolus vulgaris* (A), and sesame, *Sesamum indicum* (B), having a compound ovary.

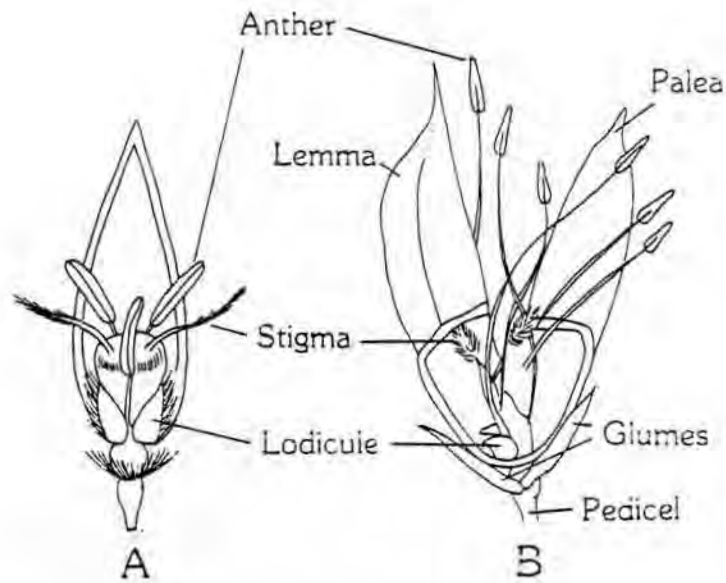


Figure 3. Open oat floret, *Avena sativa* (A) and rice spikelet, *Oryza sativa* (B).

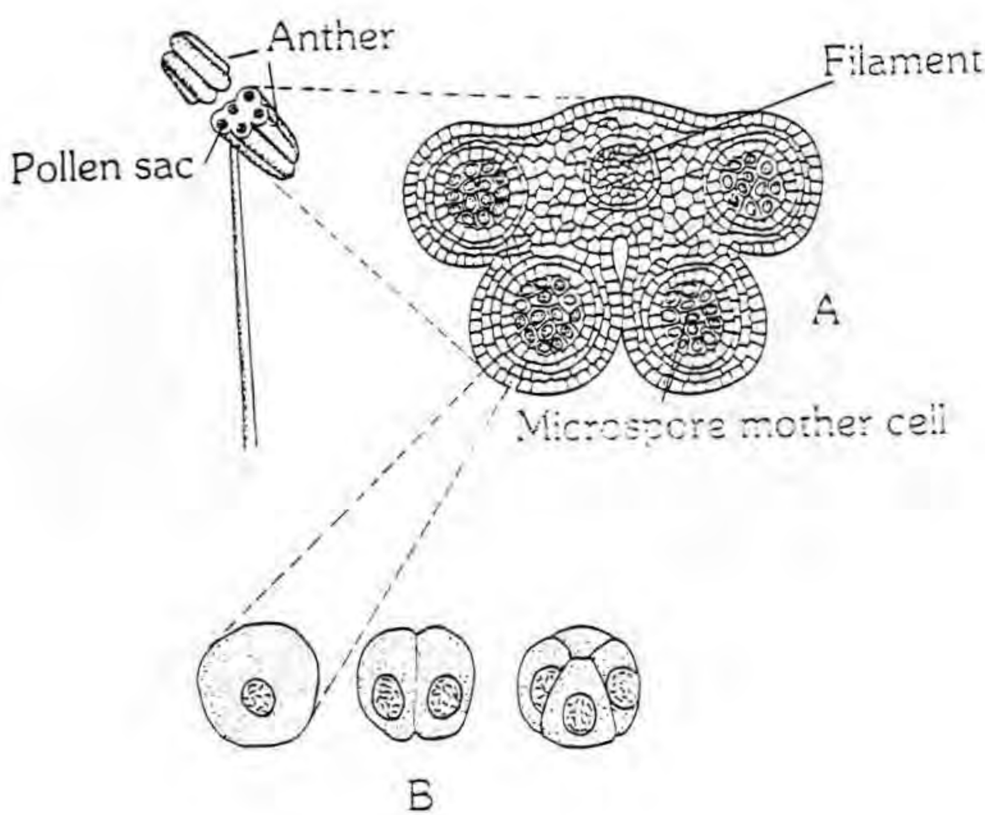


Figure 4. Development of a pollen grain from a microspore mother cell.

along a central axis, the cob, and each floret produces a long single stigma-style (the silk).

Only the essential parts of a flower - the pistil and stamens - are directly involved in seed formation. The process of pollen grain development is called microsporogenesis. A cross section of a developing anther reveals that each of the four lobes is filled with cells called microspore mother cells (Figure 4). Through meiosis, a cell division process by which the number of chromosomes is reduced, each microspore mother cell divides twice. These divisions result in the formation of four microspores, each containing half (1N) the chromosome number of the mother plant. The wall of the microspore becomes the wall of the pollen grain. Prior to being shed, this wall thickens and the outer surface usually becomes roughened with spines, pits, plates, or ridges, according to the species.

The ovules develop from cells of the placenta which line the inside of the inside of the ovary wall. Each ovule starts as a mass of cells, called the nucellus, which enlarges rapidly. This tissue is one to several cell layers in thickness and surrounds the single but much larger megaspore mother cell. The developing ovule is raised from the ovary wall on a short stalk called the Funiculus. As the funiculus elongates, one or more layers of cells, the Integuments, envelope the megaspore mother cell, except over a small opening called the Micropyle. The functional megaspore then divides mitotically three times, giving rise to an embryo sac containing eight genetically identical nuclei.

In the mature embryo sac the large cell near the micropyle is the Egg cell. The smaller cells at each side of the egg cell are called Synergids. The two nuclei near the center are the polar nuclei. The three cells at the end opposite the egg cell are the Antipodals. Thus, a mature ovule ready for fertilization consists of an embryo sac with generally six cells and two polar nuclei. The embryo sac is surrounded by the nucleus, which, except for the micropyle, is surrounded by the integuments. The entire structure is attached to the ovary wall by the funiculus (Figure 5).

When a pollen grain lands on a stigma of the same species, pollination has occurred. Mature pollen grains may be transferred from the anther to the stigma by gravity, wind, or various insects. When pollen is transferred to the stigma of flowers of the same plant, self-pollination occurs. When pollen is transferred to stigmas in genetically different plants, cross-pollination takes place.

Events occurring after pollination are similar for all flowering plants. Normally, the pollen grain germinates within a few hours after contacting the stigma, producing a pollen tube which grows through the style and the ovary wall. The tip of the pollen tube passes through the micropyle and penetrates the embryo sac where the pollen tube ruptures, discharging its two sperm nuclei. One of the sperm nuclei joins with

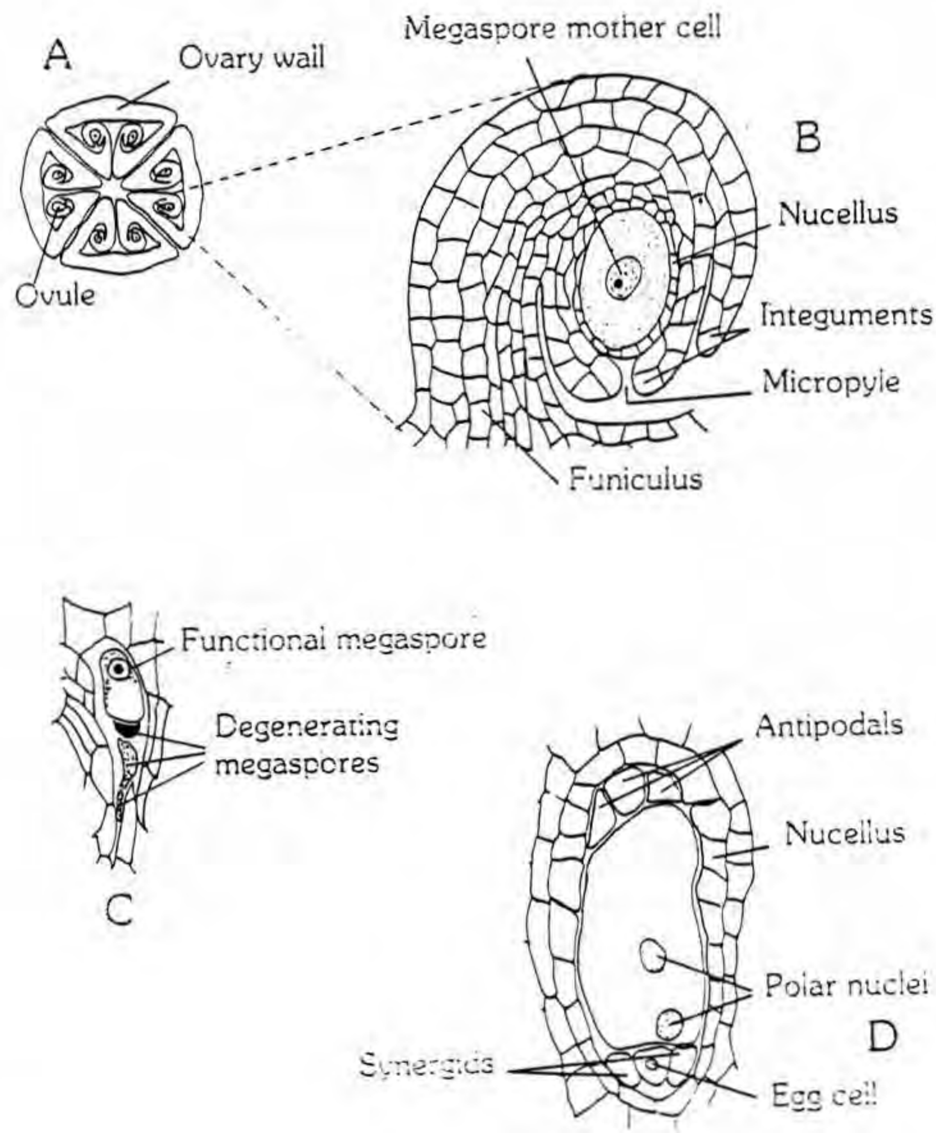


Figure 5. Diagram of embryo sac development.

and fertilizes the egg cell, forming the first cell of the new plant, the Zygote. The second sperm nucleus fuses with both polar nuclei to form the primary endosperm nucleus. Fertilization of the egg cell re-establishes the normal (2N) chromosome number of the species. The fusing of the three nuclei initiates the formation of the endosperm (3N). The two separate unions, sperm with egg and sperm with polar nuclei, are referred to as double fertilization, an event unique to the plant kingdom (Figure 6). Double fertilization must occur within every ovule in the ovary or the seed will not be formed.

In beans, for example, this means that, depending on the number of ovules, one or more pollen grains are required to fertilize the ovules produced in each ovary. In rice, only one pollen grain is necessary for fertilization because only one ovule is formed in each pistil.

Seed Development

Following fertilization, the newly formed cells, the zygote and endosperm, start dividing. The zygote produces a row of cells, the proembryo (Figure 7). After a few hours or days, the proembryo cell farthest from the micropyle enlarges and divides, forming the first cells of the embryo. Of the cells formed by this division, the cell nearest the micropyle gives rise to the roots and associated underground plant parts. The other cell gives rise to the above-ground parts: stems, leaves, and eventually flowers (Figure 8).

A few days after fertilization the first difference becomes apparent between embryos which will have two cotyledons (dicots) left and those which will have only one (monocots) right (Figure 9). As the seed continues its development, it increases in size and dry weight until growth is completed and germination capability is achieved. This point is generally referred to as physiological maturity of the seed. No further morphological development takes place.

The mature embryo of most dicotyledonous seed consists of an embryonic axis to which the two cotyledons are attached. The formation of these two structures utilizes most or all of the endosperm, depending on the species. At one end of the axis, above the cotyledonary node is the Epicotyl or Plumule which will produce the above-ground structures of the plant. At the other end of the embryonic axis is the Radicle which will develop into the primary root. Between the radicle and the cotyledonary nodes is an area called the Hypocotyl. The embryonic axis, cotyledons and endosperm (when not totally consumed in embryo formation) are completely covered by the Testa (seed coat) which is formed by drying and hardening of the integuments. The scar on the surface of the testa, the Hilum, is formed when the funiculus is broken from the now mature, fertilized ovule (seed) (Figure 10). The micropyle can be seen on the testa of some seeds. Examples of dicots includes beans and soybeans.

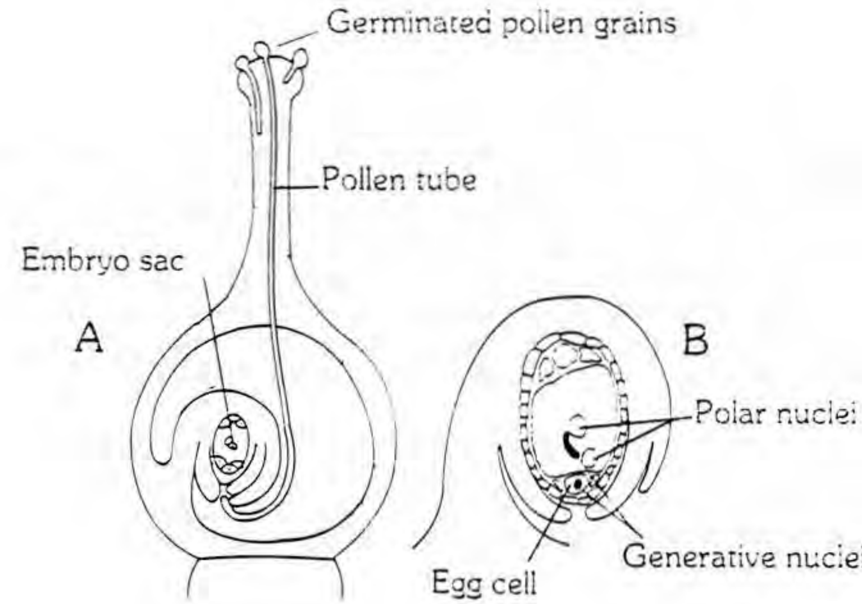


Figure 6. Double fertilization process.

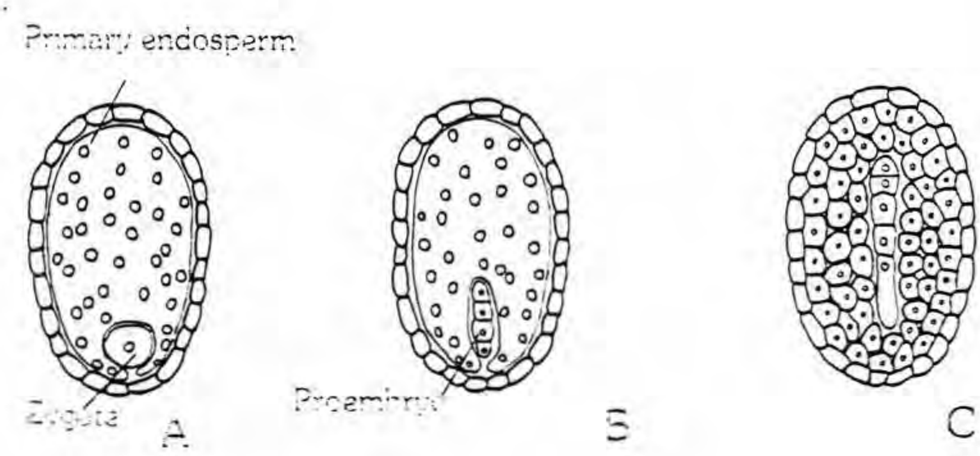


Figure 7. Development of the proembryo.

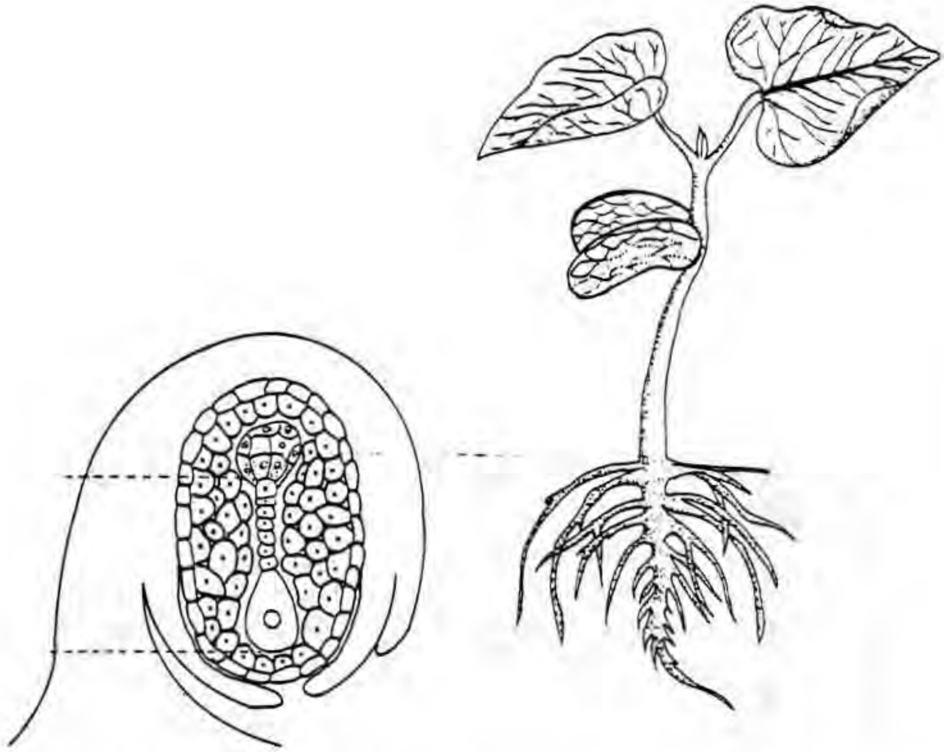


Figure 8. Relation between polarity of proembryo cells and the future seedling.

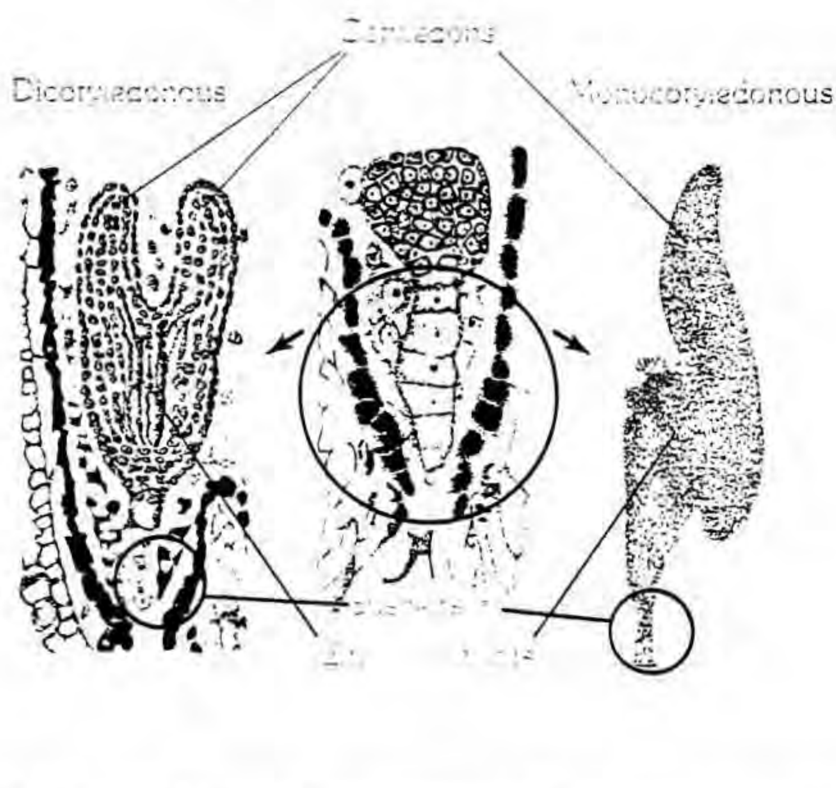


Figure 9. Differences between dicotyledonous and monocotyledonous embryos.

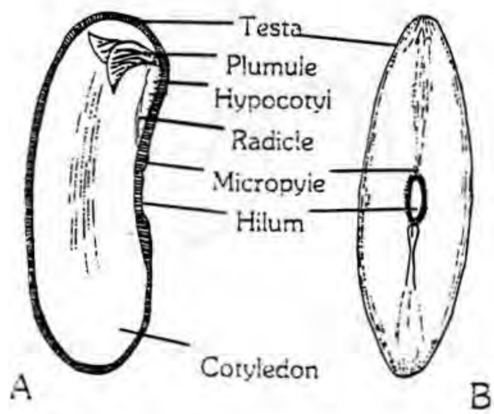
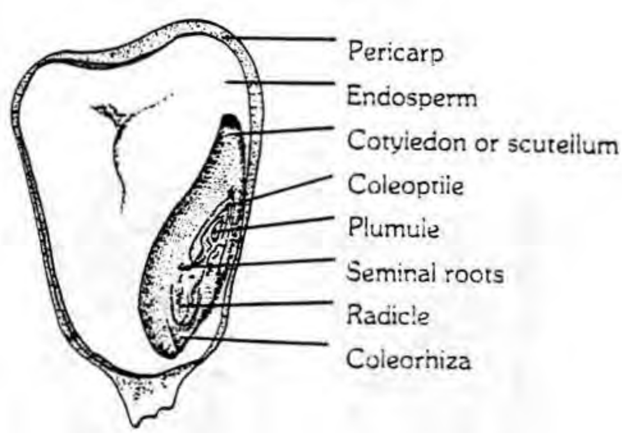


Figure 10.
Features of the mature embryo of a dicotyledonous plant.

Figure 11.
Longitudinal section of a caryopsis.



The development pattern of the monocot seed is very similar to that of a dicot seed except for the number of cotyledons. Also, in most economically important monocot species, the endosperm is not totally consumed during development of the embryo. Therefore, the mature monocot seed contains both cotyledonary and endospermic forms of stored food. Maize, wheat, and barley are examples of monocot seeds.

Seeds of the grass family are classed botanically as fruits. The embryo, as defined previously, is embedded in the endosperm. The ovary wall, or pericarp, rather than the integuments, functions as a protective layer outside the seed coat. This type of one-seeded fruit is called a Caryopsis. A longitudinal section of the embryonic axis reveals those structures common to all seed. The cotyledon in a caryopsis is called the Scutellum. In addition, there are protective tissues; the Coleoptile encloses the epicotyl, and the Coleorhiza encloses the radicle. Rudimentary seminal roots, located in the region of the cotyledonary node, can be seen in most grass species (Figure 11). The Mesocotyl is the region located between the epicotyl and the cotyledonary node.

It should be evident that for a seed to be valuable for reproductive purposes, its embryo must be alive. The longevity of any seed depends on many factors - the environment in which it is stored, its chemical composition, its physical structure, etc. It is important that we know the structure of the seed with which we work, not only for proper selection and use of equipment for harvesting, threshing, and handling seed but also to relate this structure to different stages of a quality control program. In purity tests, for example, it is necessary to know the seed characteristics of the species with which we are working to be able to separate it from the other seeds, weeds or inert matter. It is necessary to know the embryonic structure and its relation to the tissues of the future plants to evaluate results of germination, tetrazolium and other growth tests.

Summary

In summary, the four basic floral organs are sepals, petals, stamens, and pistil; the latter two are directly involved in seed formation. Pollen formation takes place in the anthers. When a pollen grain lands on a stigma of the same species, pollination has occurred. Then, a sperm nucleus fertilizes the egg cell, re-establishing the normal (2N) chromosomes number of the species. The seed or reproductive unit is a mature fertilized ovule comprised of the plumule, radicle, one or two cotyledons, food reserves, and an outer covering, the pericarp or testa.

MINIMIZING MECHANICAL SEED MIXTURES

R. C. Milner[1]

Quality control involves many aspects of seed production, and like other segments of quality control, minimizing mechanical mixtures is extremely important.

Mixtures of concern when producing seed are:

1. Seed of other varieties

2. Seed of other kinds (other crops), and

3. Weed seed.

When going about the tasks of preventing mechanical mixtures, all phases of seed product in must be considered, including:

1. Field Production

2. Harvesting and Storage, and

3. Seed Conditioning.

Field Production

The areas of field production that must be considered when preventing seed mixtures include:

1. Selection of planting seed

2. Land selection

3. Planting equipment

4. Isolation of the seed crop from other varieties and/or other crops.

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[1]Inspector, Mississippi Seed Improvement Association, Miss. State, MS.

Selection of Planting Seed

After it has been decided what crop and variety of seed will be produced, the seed that is selected to plant to produce this seed crop must be free from seed of other varieties, of other crops, and of weed seed, if a pure seed crop is to be produced.

The seed label can be very helpful in selecting the best planting seed. The seed label should indicate the presence of seed of other varieties, other crops, and of weed seed. It is further recommended that a representative sample of the seed by obtained before planting and that you have the sample analyzed for the presence of other seed by a reputable seed testing laboratory, either State or private.

Land Selection

After being convinced of the purity of the planting seed, land must be selected for producing the seed crop.

Land selection is a much more important part of seed production than some might believe. What crop was produced of the land last year or in recent years? Many crops produce "Hard-Seed" which can produce volunteer plants the following year or for several years after being grown on the land.

Too, the land may be contaminated with weeds that produce seed that are difficult or impossible to remove from the seed being produced, by conventional seed cleaning equipment.

Planting Equipment

When the planting seed and the land for producing the seed crop have been selected, the planting equipment that will be used to plant the crop must be thoroughly cleaned to remove any contaminating seed from previous use. Failure to remove such seed will result in mixtures in the seed field.

Isolation of the seed crop from other varieties and/or other crops

In addition to preventing cross-pollination of cross-pollinating crops, proper isolation of the seed field from fields of other varieties and/or other crops is necessary to prevent mechanical mixtures during harvest. An adequate clipped or disked space between different varieties and/or crops must be provided, for turning the harvesting equipment, in order to prevent the harvester from picking up seed from adjacent fields.

Harvesting and Storage

When the seed crop has been successfully produced without seed mixtures, it then becomes necessary to further prevent seed mixtures by preparing the equipment to harvest the seed crop.

Items that will be used during the harvesting operation are:

1. The harvester (combine for other equipment)

2. Hauling equipment

3. Seed handling equipment

4. Storage bins.

The Harvester (combine or other equipment)

The harvester is probably the most difficult piece of equipment to clean that will be used in seed production. For this reason suggestions will be made here that should result in the best cleaning job and will allow the job to be done in the shortest period of time. Time lost in the clean-up operation can be very important when the seed field is ready for harvest and the weather is favorable for harvest, since delays in harvesting after seed maturity can greatly reduce seed quality.

Washing the combine with large volumes of pressurized water, to remove seed that is left in the combine from previous use, is the most efficient method of cleaning and will result in the most thorough cleaning job.

The use of compressed air, which is favored by some to remove seed from the combine, tends to cause the seed to bounce back and forth in the machine and will slow down the cleaning process.

There are some preparations that will be needed before starting to wash the combine. Remove or open all doors, inspection plates, side panels and seed screens of the combine. This will allow easier access to the areas to be cleaned and allow seed to be more easily removed during the washing operation.

Instead of starting the washing procedure at the cutter-bar or header, where the seed being harvested will enter the combine, first wash the short return auger that discharges material directly over the cylinder or thrashing area. If the return auger were to be cleaned after the cylinder area has been cleaned, material from the return auger would be washed onto an area that would have already been cleaned. From the cylinder area,wash back through the machine following the path the seed will take during the harvesting operation.

During the process of washing, allow the combine to operate occasionally with a good amount of water in the combine. The action of the moving parts and the turning of the seed augers with plenty of water pressure will greatly aid in flushing seed and trash from the combine.

Now wash the seed elevators and grain hopper and remember to thoroughly wash the unloading auger. Wait until last to wash the feeder chain leading from the header deck. Wash the feeder chain toward the header deck. Then wash the header deck and cutter bar. Go back through the combine with a good light to be sure that no seed is left in the machine.

Hauling Equipment

After harvesting, seed will then have to be transferred from the harvester to the storage bin or directly to the conditioning plant; therefore clean hauling equipment must be provided for this purpose.

Use the same approach when cleaning grain carts as was used when cleaning the combine. Open all doors, remove caked-on material, then wash in a systematic manner that will not re-distribute contaminating seed to areas that are already clean.

Trucks with welded steel beds are usually fairly easy to clean since there are few cracks for seed to lodge; however, trucks with wooden beds pose more of a problem to clean since there will usually be many cracks in sides and floors of wooden beds where seed can lodge.

Remember to clean ledges of the framework of the truck under the truck bed. If seed is not removed from these ledges, nothing will prevent seed from these areas from falling into the dump-pits or other unloading facilities while the truck is being unloaded,thus causing seed mixtures at that point.

Seed Handling Equipment

Remember to thoroughly clean handling equipment such as dump-pits, elevators, augers and conveyors before using.

Storage bins

Unless seed is to be transferred from the field directly to be conditioning plant, some clean place must be provided to store the seed.

In addition to thoroughly sweeping and vacuuming the walls and floors of the storage bin, make sure that all seed is removed from cracks along the walls and floors, especially at the junction of the walls and floors. Usually there will be flanges at these junctions where considerable amounts of seed can be lodged. Make sure that no seed is lodged in such places as in ledges over the doors and where ladders are attached to the walls of the bins.

Most storage bins will have an unloading auger located under the bin floor. Several pounds of seed can be contained in the auger housing tube. To aid in the cleaning of this area, first remove the auger from the tube, then close all doors of the storage bin and allow the aeration system to operate. This will blow loose seed from the tube.

Seed Conditioning

The final stage of seed production, before the seed is safely in the seed bag, where mixtures can occur is during seed conditioning or seed cleaning operations.

Anything that is left in the plant from previous use can end up in the seed bag; therefore, thorough cleaning of the plant must be completed before seed conditioning begins.

Equipment and areas of the plant that the seed to be cleaned will come in contact with are:

1. Dump-pits
2. Conveyors
3. Elevators
4. Holding bins
5. Seed cleaning equipment, and
6. Bagging equipment.

Before cleaning the equipment in the plant, seed should be removed from walkways, framework of the building, other ledges located above the equipment in the plant. If these areas are not cleaned first, seed can fall after the equipment below has been cleaned or during seed conditioning causing mixtures.

Like the prevention of mechanical mixtures in the other areas of seed production, the primary goals when cleaning the conditioning plant should be first, to remove all seed in the plant from previous operations and second, to do this job in a reasonable length of time. Few seedsmen can afford unnecessary "down-time" for the plant clean-up operation.

These goals cannot be attained unless there is a definite clean-up plan established in advance in order that the clean-up operation can de done in a systematic manner. If the cleaning is done at random, cleaning a little here and a little there, it is difficult to know when the cleaning job has been completed and also, seed could be redistributed in areas of the plant that have already been cleaned.

After walkways and ledges of the building have been cleaned, then the cleaning of the plant itself should begin at the point where the seed to be conditioned will enter the plant; then clean, following the path the seed will take as it moves through the plant during conditioning. Make sure each area is thoroughly clean before moving to the next area to be cleaned.

Start at the dump-pit and clean each elevator, conveyor, holding bin, and each piece of cleaning equipment until the bagging equipment has been reached and cleaned.

Then go back through the entire plant using a good light and make sure all seed has been removed.

Only after having done all the things in all phases of seed production that have been discussed here, can the seedsman be confident that the seed offered for sale will be pure and free from mechanical mixtures.

QUALITY CONTROL[1]

James C. Delouche[2]

The timely and proper application of sound management practices in the various phases of the seed business is essential for success. The time is now past when management could concern itself exclusively with buying, selling, bill collecting and shipping, while leaving the technical operations entirely in the hands of hourly-wage employees. Technical expertise, experience,facilities, are also essential to the successful operation of a seed business, but alone they are not sufficient. They must be integrated and "out-to-use" by management, and directed toward the basic concern of any supply business - consumer satisfaction.

One of the most powerful management techniques in the seed business is quality control. Unfortunately, it is often considered as something beyond the resources of all except the very largest seed companies. This attitude apparently derives from the association of quality control is a sophisticated management technique, it is equally available and applicable in the most modest seed business.

In the seed industry, quality control has three important aspects. These are:

1. Establishment of minimum acceptable seed standards.

2. Formulation and implementation of a system and procedures for exceeding the established quality standards, and maintenance of same.

3. A systematic approach to identification of causes of quality problems and their resolution.

The idea of high quality and the concept (and application) of quality control must permeate all phases of the seed business and not just be restricted to a momentary curiosity and a few routine tests after the seed are in storage or marketing channels. Concern about seed quality and actions to insure that standards are achieved and maintained

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[1]This paper appeared in slightly different form in the 1975 Proceedings, Vol. 17.

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begins with selection of seed for planting, extend through production, harvesting, drying, processing, storage and distribution, and end only with satisfactory performance of the seed in the farmer's field.

Quality control techniques are not unfamiliar to seed producers and seedsmen. Generally, however, they are randomly applied and uncoordinated. Some things are done routinely and well. Others are left undone. Poor quality seed is most often the result of something that was not done or not done properly. Quality control integrates random and uncoordinated activities that are directed toward achievement of quality standards into a comprehensive, systematic and continuing effort. It does not permit vital operations or procedures to be accomplished or unaccomplished by chance or the whims of employees.

Quality control is concern about quality and attention to the various operations involved in the seed business. The procedures used in quality control range from simple, such as spot control of dodder in a clover seed field, to the complex, such as complete redesign of a handling and conveying system to minimize seed injury. Quality control seeks to prevent problems or when they are unpreventable, to minimize their effect. The most effective solution of a seed quality problem is always its prevention.

What is Seed Quality?

Most seedsmen have a rather definite concept of seed quality. However, their concept is often not sufficiently broad to encompass all the important attributes or aspects of quality. The concept of seed quality for too many seedsmen simply means, "that which can be gotten by with."

Seed quality comprises many attributes or characteristics of seed. In terms of individual seed, these characteristics include trueness-to-variety, viability, vigor, mechanical damage, disease infection, treatment coverage, size and appearance. Extended to the population of seed that makes up a lot, quality characteristics include moisture content, storage potential, incidence of contaminants (weed and other crop seed, inert matter), uniformity of the lot, and performance potential. Highest quality seed are genetically pure, germinable, vigorous, undamaged, free from contaminants and diseases, properly sized (when necessary), adequately treated (for kinds that are treated) and of over-all good appearance. This ideal of quality is seldom achieved. Few seed lots meet all "ideal specifications." For this reason, minimum quality standards are established in most seed operations. These minimum standards are not a goal - the goal is always highest quality - but represents the lowest levels of the various quality characteristics that are acceptable.

Seed quality is important and it is becoming more important. The progressive seedsmen uses quality as a competitive technique just as he uses price and service. Quality fosters customer appeal, helps the seedsmen to develop a positive reputation (or good image), and results in satisfied customers and repeat business.

The Games Seedsmen Play

The attitude of management is the key factor in developing an effective quality control program. It is impossible to establish any sort of quality control program unless management is committed to certain quality standards. And, this commitment must be serious and consistent. All too often, management becomes gravely concerned bout quality only when very serious problems arise and complaints are numerous, or when it is otherwise convenient. As things smooth out or as the season ends, the concern vanishes,the problems are forgotten, and the next season gets underway in the same old manner.

A willingness to "just get by" is perhaps the real cause of most seed quality problems and attendant complaints. Getting by is one of the games that seedsmen play. Although, it takes many forms, the seedsman is always the protagonist and the seed analyst, seed control official, and certification inspectors are bit players.

One game is called "shopping". Samples are sent at various laboratories until the desired results (usually the highest) are obtained. These results are then used as a basis for labeling. Another, is a version of the old "now you see it, now you don't" game. A sample is sent to a laboratory for both germination and purity analysis. If germination is good and purity is not, then the laboratory gets another sample for germ. Resamples, however, are sent for purity only until by chance one turns out good. There are many variations of this game depending on which quality factor shows up low. Still another game might be called "divide and conquer". A seedsman has 500 bushels of wheat seed. A sample is sent to the laboratory and the results show good germ and purity but excessive noxious weed seed. The lot is divided into two 250 bag lots, and two samples are sent for tests. The results of the tests might show that in one of the samples the noxious weed seed is within permissible limits, while in the other it is still excessive. The half of the lot that has the good test is labeled, while the other half with the bad test is divided again, and so on, until as much of the lot "passes" as possible. Many other games could be described.

We have referred to the above procedures used by some seedsmen as "games", but they're not usually intended as such. Most of the seedsmen who use such procedures do so in good faith. They have the idea that if any test indicates that the seed are of reasonably good quality then they must be of good quality - regardless of test results from other labs that indicate variable or low quality. This is a natural reaction - most of us want to believe the best things - even seed. Yet, the variability inherent in sampling and testing must be recognized and appreciated. If 10 germination tests of a lot of seed average 75%, the odds are good that at least one of the 10 tests will show a germ above 80%. And, if enough tests are made, one will probably give a 90% germ. The average germ, however, will still be about 75%.

During many years I've been associated with the Mississippi State Seed Testing Laboratory, over 200,000 samples have been tested and we've been taken to task by seedsmen literally hundreds of times for reporting "low" test results. In only one case, however, have we received a complaint about our test results being too high. Seed testing laboratories do make mistakes and their interpretations do get out of joint with those of other laboratories. Seedsmen should keep them on their toes. However, if two laboratories test different samples from the same lot and one finds 500 dodder seed, while the other finds only 200, the test giving the low count is not always correct. The dodder count is probably somewhere in between - about 350/lb. A similar situation might pertain when germination test results differ widely among laboratories.

We have spent some time discussing the philosophy of "getting by" because it is one of the first things that has to go before a quality control program can be installed. Since most seedsmen will have to depend on a seed testing laboratory for the information needed to make the quality control program go, an understanding of the nature of seed testing results is also important. Most laboratories simply report results, they do not comment or interpret test results. This must be done by the person in the company responsible for quality control.

The quality control program is based largely on inspections, timely and scheduled sampling, testing and interpretation of test results. Managerial decisions relative to disposition of seed lots, over-hauling of physical facilities to minimize quality problems, modification of procedures, etc., can then be taken from an enlightened perspective.

Standard Procedures

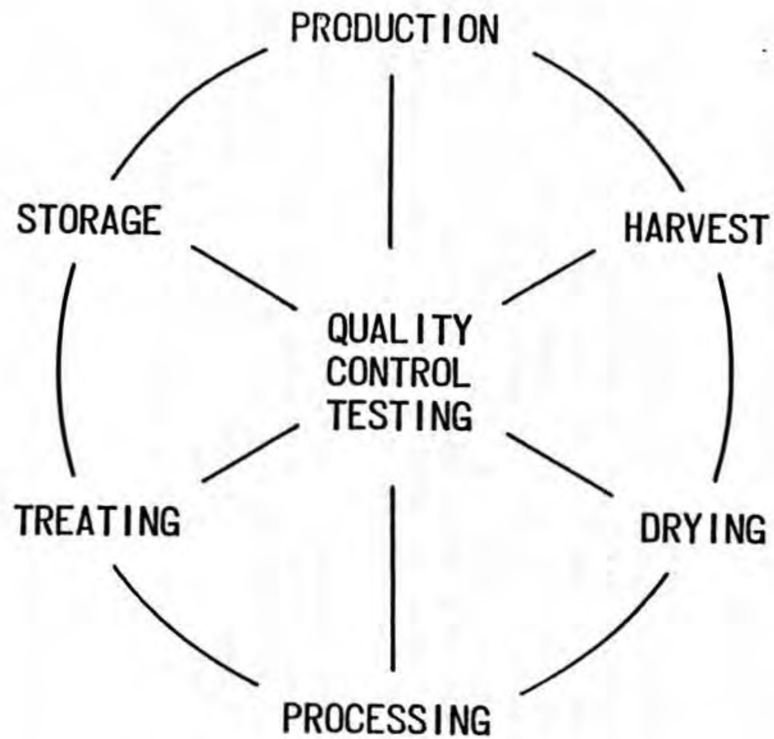
Retirement of the "getting by" philosophy and a new or renewed determination by management to produce, package,and market high quality is the basic requisite for a quality control program. But, determination and motivation - as important as they are - are simply not enough. They must be coupled with know-how, organization, and a willingness to sacrifice some short term gains for long term growth and development. A quality control program is not for the dabbler or even the pure trader in seed. Rather, it is for seedsmen who actively participate in the production, processing and marketing of seed and who lay their reputation on the line each time he sells to a processor, wholesaler, retailer or directly to the farmer.

The first step in quality control is establishment of minimum standards for the seed handled by the company. These standards must encompass all the major quality attributes of seed: variety, trueness-to-variety, other crop seed, weed seed, inert material, germination percentage, physical condition and appearance, treatment, vigor, etc. It really boils down to this question: what kind and quality of seed do you want to be associated with your company's name? Concern about quality must prevade all operations (Figure 1).

For illustration, assume that the company is moderate in size and specializes in the production, processing, and marketing of soybean seed. Minimum standards might be established as follows: (1) only recommended varieties produced: (2) varietal purity, not more than 2 off type or other variety seed per lb.; (3) pure seed, 98% (or not more than 1.5% inert); (4) weed seed, none; (5) germination, 85%; (6) splits and broken seed (fragments missing), 2%; (7) cracked or rupture seed coats, 5%; (8) shriveled and very small seed, discarded; (9) soil particles, none; and (10) appearance, all seed processed over a spiral to remove misshapen seed (and soil particles, splits, badly broken seed, etc.).

How are these standards going to be met or, since they are minimum standards, even higher standards achieved? Obviously, an organized effort, educational program, and timely sampling and testing will be required. Someone in the company has to be responsible for the various activities that make up quality control. And, he has to know the things that must be done if the seeds are to meet the established standards.

Production is organized and contract growers are carefully selected on the basis of uniformity and cleanliness of land, type and condition of equipment, attitude (progressive or non-progressive), knowledge and appreciation of modern production practices, available labor, and so on. Seed production is important. Indeed, it is the first and most important consideration in a quality control program. There is much truth in the old adage, "you can't make a silk purse out of a sow's ear." If the contract grower delivers damaged, trashy, low quality seed to the plant, then more often than not, damaged, low quality seed will leave the plant. The cleaning plant is not the place to "create" quality, it can only enhance and refine what is already there. Yet, many seed plants are more often engaged in salvage operations than in dressing up an already high quality product. I am acquainted with a soybean seed producer who takes great pride that his seed usually meet minimum certification standards without cleaning, and he should be proud. I also remember another grower who had produced some cowpea seed, banged them up thoroughly during harvesting and ended



THE QUALITY CONTROL LABORATORY IS THE HUB OF A SEED QUALITY CONTROL PROGRAM

FIGURE I

From: Grabe, D. F. 1968. Proc. MS Short Course.

up with 5% inert matter. Since this was too high, he started recleaning...and recleaning, and by the time he got through, germination was below 30% and inert matter was 22%.

Contract growers must be advised throughout the production cycle. Recommended cultural, weed and insect control practices should be followed. The fields should be checked several times during the growing season by the production supervisor for the company and/or quality control specialist. A thorough inspection just before harvest is critical. It is at this time that off-types, other varieties, weeds, and other crop plants can be best detected and most effectively rogued. Harvesting equipment, truck beds, wagons, and bins should also be inspected for cleanliness at this time.

The timing of harvest of a seed crop is very important. Considerable damage can result from harvesting when the seeds are too high or too low in moisture. The operation and adjustment of the combine are also important. The grower should be advised on cylinder speed and clearance settings and taught how to determine when changes in settings are needed by visual inspection of the harvest seed. Instruction and advice on the handling of the harvested seed (unloading into bins, etc.) to minimize injury and on aeration or drying procedures should also be given to the grower.

The grower will generally do a good job if he has suitable equipment, is properly advised and instructed, has the right attitude, and is provided with sufficient incentive (contract price) to justify the extra effort and greater care required to produce quality seed.

Sampling and Testing

Sampling and testing during the production phase are not neglected. Several pounds of pods can be gathered at the time of the pre-harvest inspection and hand threshed. Moisture content can be determined and the seed stored for reference in case problems arise later. The hand harvested seed should be highest in quality. Additional samples should be taken for moisture test as the seed are loaded into the bin so that aeration or drying needs can be determined, and for germination tests and visual examination for mechanical damage. Remnant seed should be filed for future reference as needed.

The seed should usually be sampled again before processing (assuming that some time elapses between harvesting and processing) and after processing (just before bagging or after bagging). The latter sample will usually be the sample tested to obtain information needed for labeling purposes.

Adequate records and timely sampling and resting procedures are the key elements in a quality control program for seed or any other commodity. The results of tests made at various stages provide information needed to identify both chronic and acute problem areas. Since identification of the problem is requisite for a satisfactory solution, progress in improvement of quality can only be achieved by knowledge of how quality is decreased.

Very often serious problems or deficiencies in seed quality become evident only during the marketing phase - causing direct financial loss, damage to reputation, and much valuable time spent on post-mortems. Post-mortems are necessary when a problem arises to determine its probable cause. Indeed, a business that does not post-mortem complaints or problems will not be a business for long. This procedure can be very effective in getting to the root of the problem, provided a corpse(s) and suitable tools for the autopsy are available. Usually, however, only a sample from the "complaint" lot and the file sample required by law are available. Examination of these samples will generally reveal - if everything was on the up and up - that there is a difference in one or more specific quality factors between the "complaint" sample and the file sample. Most often, however, the reason for or cause of the difference(s) cannot be determined or identified (Figure 2).

Let us look at two specific problems. First, consider the problem arising when a complaint is made by a farmer or filed by a seed control official that a lot of wheat offered for sale was a mixture of varieties, whereas it was represented to be essentially pure Variety X. On post-mortem, two situations can arise: (1) examination or testing of the file sample shows that it too is not pure, or (2) the file sample can be pure as labeled. In the first situation, the seedsmen either did not (a) use pure seed for planting and failed to rogue, (b) carelessly mixed the seed in combining, binning or processing, or (c) accepted someone's word that the seed was of Variety X. He cannot determine the cause of the mixture more specifically unless he has ample records on land history, seed source, field inspection, roguing, and processing, and samples of the seed planted (original source), the seed just before harvest, after harvest and after each subsequent operation. If he does have these records and samples, then the cause of the problem can probably be determined and corrective actions taken.

When the other situation prevails (i.e., the file sample is pure but the complaint sample is not) the problem area is rather easily identified. The mixture most likely resulted from errors in tagging (a few bags of another variety got mixed in with the lot), assuming there was no chicanery on the complaint end.

Another problem: A seedsman or planter sends a large lot of cotton seed to a custom delinter for delinting and treating in February. After delivery of the delinted, treated seed, he submits a sample for testing and results come back indicating 57% germination. He has in his records results of a test made by the same laboratory in late October

CONTROL CHART FOR STORAGE

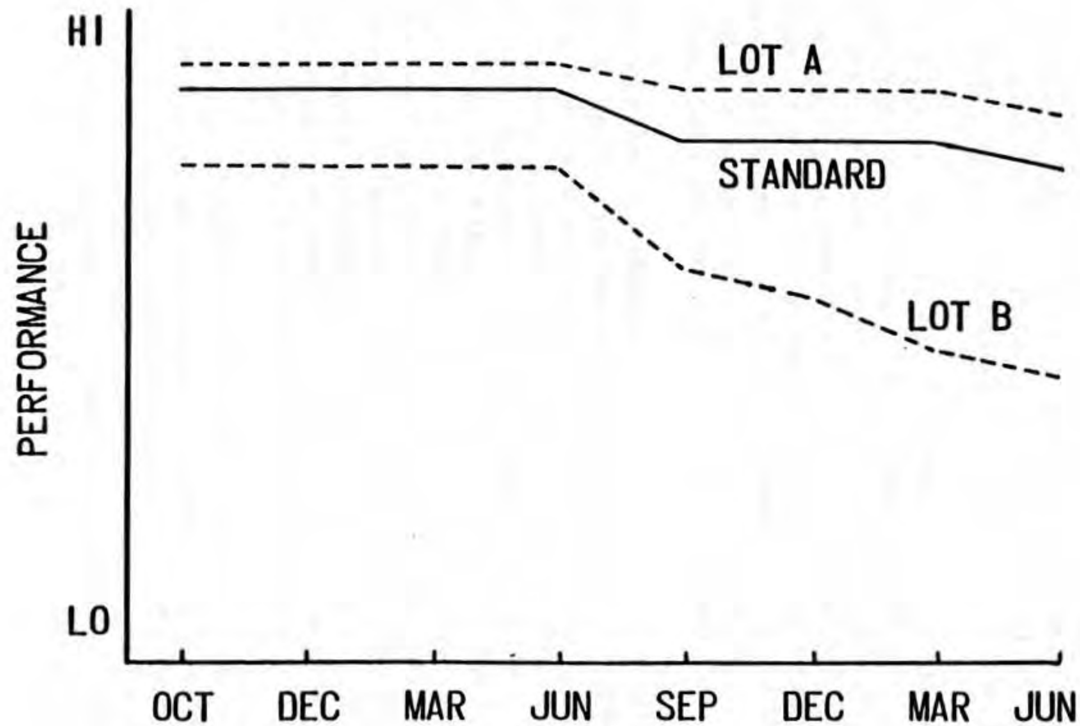


FIGURE 2

From: Grabe, D. F. 1968. Proc. MS Short Course.

showing 84% germination and requests that the delinter make good on the seed that he (the delinter) has ruined. A casual consideration might suggest that the delinter did indeed ruin the seed. But, did he? This question cannot be answered unless a portion of the original lot was not delinted or a sample taken just before delinting is on file. When a file sample taken just before delinting and treating is available, then an analysis will indicate if the seed or the deliner is at fault. Furthermore, if delinting was detrimental to the seed, examination of the sample will often incidence of mechanical damage, low vigor, etc.

Sampling after each operation in seed harvesting and processing does take time and space, but it is essential to any quality control program. As previously discussed, tests need not be made on each sample. Many of the samples are simply filed away so that they will be available when needed to post-mortem problems and identify problem areas. After the lot is marketed and the "complaint" season is past, the samples can be discarded with the exception of the file sample required as part of the lot record by the various seed laws.

Some tests, of course, should be made on the samples drawn after the various stages in harvesting and processing. Time of harvest should be determined by moisture test insofar as the weather permits. Knowledge of seed moisture content at harvest permits proper adjustment of the combine, and effective handling, drying storage of harvested seed. Analysis of the seed after harvest will indicate whether the seed are of sufficiently high quality to keep as seed and the most efficient processing and cleaning procedures for bringing the seed to their highest quality level. When the seed are stored for a relatively long period of time before processing (1 to 2 months or longer), another test just before processing is desirable to detect any change in quality of the seed that might cause it to drop below an acceptable level.

Quality control also encompasses inspections and examinations other than those made on systematically drawn samples. Periodic, visual inspection of the seed during combining will often indicate that adjustments have to be made to prevent excessive seed loss or to reduce mechanical damage. Similar examinations during processing can detect malfunction of equipment or reveal the need for modification of procedures used (Figure 3).

Quality control is constant concern about quality and attention to the various operations and procedures that affect quality favorably or adversely. When these traits are instilled in all employees, quality problems might not all be prevented, but they will surely be minimized. And, the seedsmen won't be faced with the same set of problems each season.

CONTROL CHART FOR MECHANICAL DAMAGE

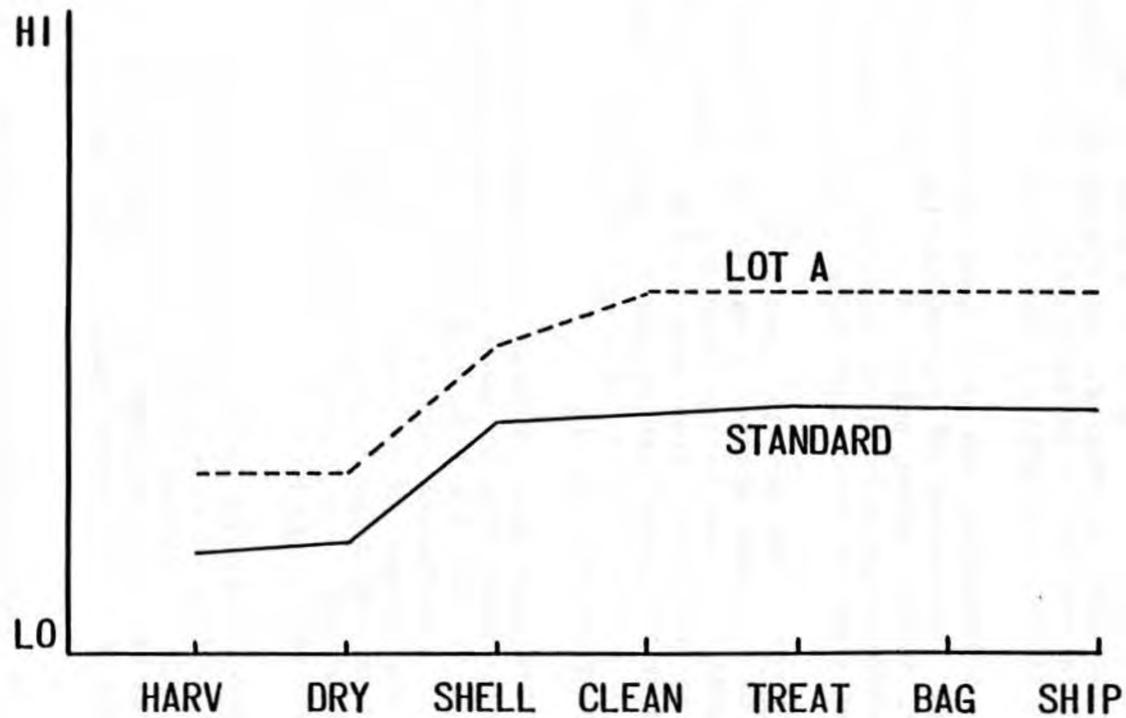


FIGURE 3

From: Grabe, D. F. 1968. Proc. MS Short Course.

Application of Quality Control Procedures

We have considered what quality control is, what quality control is not, the importance of timely sampling and resting in the quality control program, and the benefits and uses of a quality control in a seed business. These have been a general discussions and not directly applied to the production, processing, and storage of a specific seed. The emphasis in this section is on application of the quality control philosophy and techniques to a specific kind of seed.

Soybean seed production and sales have increased dramatically in the past 15 years. The number of farmers saving their own seed decreases each year, so the market potential still looks very good. The modest quality control program outlined below for soybeans is generally applicable to other kinds of seeds, particularly the non-hybrids.

1. Seed Source: The varietal purity of a seed crop cannot be better than that of the seed planted - but it can be worse. Use of varietally pure, weed free seed is the first step in quality control. If the seed are to be certified, then seed source is specified (as to class) and checked by the certification agency. When non-certified seed are produced, use of purple or blue tag seed for planting is one of the best ways of ensuring varietal purity.

2. Land: The land used for seed production should be fertile, well drained and reasonably free of weeds - at least those weeds whose seeds are difficult to separate from soybeans. The land ought not to have been planted to a different variety of soybeans the previous year, their is always the danger of volunteers. In situations where a planting has to be on land grown to another variety the previous year, the land should be worked several times before planting so that volunteers will germinate and be destroyed.

3. Planting: Planters should be cleaned before filling, and planting scheduled so that only one variety is planted each day. When more than one variety is planted in different fields on the same day, one or two sacks can easily be unloaded at the wrong site. Seed should be inoculated. Save a 1 to 2 pound sample of the seed planted for the record.

4. Isolation: The distance between varieties should be at least the distance specified for certified seed, even if non-certified seed are to be produced.

5. Cultural Practices: Good cultural practices - including weed control - are necessary. Use practices recommended for good commercial soybean production.

6. Field Inspection: The person responsible for quality control or the production supervisor should inspect the field several times:

MICROCOMPUTER APPLICATIONS AND SEED

Gary A. Reusche[1]

Introduction

Every seedsman has heard of the microcomputer and its potential for farming and business. A person would almost have to live on another planet to have missed the onslaught of this new technology. But just what can the microcomputer do for the seed industry?

The microcomputer can be adapted to a wide range of uses. Uses such as record keeping and quality assurance, seed laboratory management, dynamic conductivity analyses, and weather records and emergence modeling are possible. But these applications are just the beginning. Other applications will be coming. For example, microcomputers can control drying by switching on fans and burners depending on climatic factors. Research in Virginia on peanuts has shown that by using microcomputer-assisted drying you can decrease drying costs by 25% with a minimal increase in drying time (10%).

If the user buys a modem and communications software he can tap in to extensive databases that provide extension information, marketing information, the New York Times, and much more. This trend is going to increase. Already users can make their own airline reservations and do their banking by microcomputers. Soon mail-order houses will get into the act, and spare parts, equipment and the like will be available quickly and at a competitive advantage for the microcomputer user.

It is my opinion that every seedsman will have a microcomputer within ten years. A common recommendation to potential users of microcomputers is to first select the software that makes the computer work, and then pick a computer/printer (hardware) that will run the software.

There are many sources of software for microcomputers. The most important is the commercial vendor, who deals with software designed for the large markets. This includes software for business, such as spreadsheets, databases, and programs for specific applications.

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Spreadsheets

An electronic spreadsheet doesn't do anything that can't be done with a pencil and a piece of accounting paper, but it does it so fast and so conveniently that it is one of the most widely used software packages. Lotus 1-2-3, Symphony, SuperCalc, CalcStar, VisiCalc, and Multiplan are all examples of spreadsheets. Information is organized in rows and columns on the computer screen, just like on a piece of paper. This can be visualized by a simple example (Figure 1).

Figure 1. Example of Simple Spreadsheet

	C O L U M N S		
	A	B	C
Row 1	# bags	cost/bag	total
Row 2	25	10.75	a2*b2
Row 3			

In the example there are nine cells. It is a "spreadsheet" with three columns and three rows. Each cell can be identified by the column/row intersection. In the cell "a1", column A has been labeled "# bags". Likewise, in the cell "b1", column is B shown as "cost/ bag". Finally column C has been labeled "total".

The example shows "25" in the cell a2 and "10.75" in the cell b2 and finally "a2*b2" in the cell c2. The two numbers, 25 and 10.75, refer to the number of bags and cost per bag respectively. The entry in c2 is a formula, instructing the computer to take the value in cell a2 and multiply it by the value in b2. The user indicates the formula, but it is not displayed on the screen. the actual value that is calculated by the formula is shown on the screen (in the example, 268.75 would appear in c2).

From the brief example, it should become apparent that there are many different applications for a spreadsheet. Some examples are crop budgets, lease vs. buy analysis, costs associated with storing grain, drying costs, simple payrolls, inventories, and more. Many spreadsheets will work in concert with database management programs to extend the possibilities many fold.

Databases

Database management programs can organize and access large amounts of information. One good way to grasp the basics of a database is to think of a 3" x 5" care system that is used to keep up with card addresses. On each 3" x 5" card is listed the name, street, city, state and zip code of an individual.

In the jargon of the database, each 3" x 5" card is a "record". within each record, the user defines a number of "fields". For example, one field could be for name, another for street, yet another for city, and so forth (Figure 2).

Figure 2. Simple Database for Addresses

	field	field	field	field	field
Record 1	Name	Street	City	State	Zip
Record 2	Name	Street	City	State	Zip
Record 3	Name	Street	City	State	Zip
Record 4	Name	Street	City	State	Zip
Record 5	Name	Street	City	State	Zip

After all the names and addresses are entered into this example, the user can begin to access the database. He can use the database to print address labels. He can use the database to print form letters (often in coordination with a word processor) for each person in the database. He can sort all the records by state, by zip code and by last name. He can instruct the computer to find the record for a particular name, or find all records for a specified state. The ways to access the database are numerous.

Spreadsheets and databases can be customized by the user to keep records on whatever is desired. There are limitations as to what can be done with spreadsheets and databases, and software for specific applications will sometimes be required.

Business Software

In general, software is widely available for business purposes. Much of it is excellent, but the user must choose wisely. Many different versions of software are available for payrolls, accounts receivable, inventories, and the like. If the user finds a package that fits his needs, then this is the software route to take. It is probably a good idea to take as long as six months to make a decision about the particular software that will be bought. One recommendation is to visit somebody that has been using the software for at least 6-12 months and will take the time to show you the system. Software salesmen will make their product sound very good but the final proof is in the working environment. Many times, the user cannot anticipate all the software features that he will eventually require. Only actual usage over a significant period of time will test the software and its merits.

Cost/Benefit

A comment needs to be made concerning the cost of a microcomputer system, and the expected benefits. Improved technologies must pay off. In the case of a microcomputer, the cost of a good business-oriented microcomputer, printer, software, modem, information system, and service agreement is in the range of \$10,000 over a five-year period. Ten thousand dollars can buy a new valve-pack bagger, or can be used in other ways. Perhaps a "bargain" can be found for less money, but it may be a false economy to cut corners on hardware of software.

If \$10,000 is assumed to be a good estimate of cost over a five year period of time, this means that in rough terms (not counting tax benefits, interest costs, etc.) the monthly cost is on the order of \$167. What are the benefits to be gained from this investment?

The benefits resulting from the use of a microcomputer are difficult to value. Quality assurance has been said to be record keeping, record keeping, record keeping. If the microcomputer increases product quality or eliminates costly mistakes, how much is it worth? If the microcomputer provides more accurate data upon which decisions can be made, how can that be priced? Even though these are difficult questions to answer precisely, they have to be addressed when considering the investment to computerize.

QSeed

University professionals write software to fill some perceived gap in the availability of computer programs that will serve their clientele, or design innovative programs through research and development efforts. One such project is the development of a set of computer programs entitled "QSeed" for "Quality Seed".

QSeed has been under development since May, 1983, and has been tested in North Carolina at three different sites since early 1985. It is essentially complete, in terms of design and features.

QSeed is designed for a small to medium-sized seed business, and may be used without modifications if the user's record keeping and quality assurance needs are satisfied by the programs. QSeed is an integrated set of programs that operate as a single unit. Information entered in one program is often required before another program will run.

The development of a single set of programs such as QUALIFY that would fit the needs of all seedsmen is not a practical goal. The BASIC language source code for QSeed is freely accessed for review and modification, and such modifications are anticipated. This is different from most commercially available software which cannot be changed due to copyright protection. A competent programmer will be able to modify and customize the original QSeed design to make changes specific to a particular business need. Or, if a company desires to engage a programmer to write custom software, a study of the features and design of QSeed could save thousands of dollars in development costs and help ensure that expectations of the user are satisfied by the programmer.

QSeed runs on the IBM-PC/XT/AT family of microcomputers and nearly all IBM compatibles that run a version of GWBASIC. QSeed requires 256 K of RAM (Random Access Memory) and at least two disk drives, each storing at least 360 K of data. Lastly, for printed output, a dot matrix printer of nearly any manufacture is necessary. The use of a hard disk drive considerably speeds up the programs, as does the more powerful IBM computer.

QSeed Features

An overview of QSeed features is presented below. For more detailed information, a User's Guide and a technical publication are available.

QSeed is password protected. As the user initially enters the program, the computer prompts for a user ID and password. A valid entry loads the master menu (Figure 3) and permits the user to select an option. Otherwise, the non-authorized user is denied access. A record of the time each user spends logged-in to QSeed is maintained.

Figure 3. QSeed Master Menu

A - Crops & Varieties

B - Grower & Buyer Addresses

C - Production Field & Grower Information

D - Bin Allocation & Bulk Storage

E - Conditioning Plant Records

F - Seed Testing Information

G - Inventory Control

H - Invoice Processing

I - List Buyers Of A Specific Lot

J - Swap Data Disks

K - Log Off System

Each variety of seed for which records are to be maintained by QSeed is defined. Eighty different varieties can be defined for each data diskette. The eighty varieties are divided into four groups, each group identified as a different crop. If a floppy disk system is used, the user can access an unlimited number of data diskettes by selecting an option from the master menu that permits the swapping of data diskettes.

One QSeed program defines all seed growers and buyers. A full address including the telephone number is entered for each grower and buyer record. Up to 999 growers and 999 buyers can be defined. A number is assigned to each grower and buyer, and this number is entered throughout the set of programs when the computer prompts for the grower or buyer name. Printed output includes an alphabetized telephone listing and mailing labels.

Production field records are maintained by QSeed. Each grower can have up to 20 seed production fields, and a separate record if maintained for each production field. The information stored includes such items as the source of the planting seed, the previous cropping history for the field, the date inspections are made, harvest records and the like. Within seconds the user can select a grower and then review a production field summary for that grower. Or, the entire record of a specific field can be selected for review and/or update.

Seed harvest and bulk storage is a complex set of operations that is closely followed by QSeed. Up to 126 bulk storage locations can be defined by QSeed, and separate records are maintained for each fill of a given bulk storage location. A bin, for example, can be loaded and emptied nine different times, and the contents of each fill are recorded and maintained for review.

As seed are received for bulk storage, the user enters a scale report that consists of the weight of the seed, the class, the grower, a grade analysis, pricing information (if priced at receipt otherwise pricing can be added later), and other related information. The user then indicates the bulk storage location where the load is dumped. The contents of each bulk storage location or bin can be reviewed on the screen, or a printed output can be requested. Thus, a bulk seed inventory, based on scale reports for all seed receipts, is maintained.

As seed are removed from bins for conditioning and bagging,the user indicates that a bin is being dumped. The contents of dumped bins are then split up into lots, based on the number of bags that are conditioned from the bin. The break-up of the bin contents into different lots creates a computer record for each lot and the beginning inventory for bagged seed. Each lot record indicates the number of bags in the lot, the use of tags, whether or not the seed has been treated and what treatments were applied, and other similar information. Finally, the bagged seed location of each lot of seed is entered as a two digit code representing a location in the warehouse. QSeed can show bagged seed to be stored in up to 120 different warehouse locations.

The maximum number of lots that QSeed allows for a given variety is 126. Assuming 800 bags per lot and each bag valued at $10, the value of 126 lots is approximately $1 million. If a user sells more than $1 million of a single variety, indicating that the 126 lots is too few, then the variety can be sub-divided into logical groups. For example, the variety definition can also indicate class. If two classes of seed are grown and this method of sub-division is utilized, then 252 lots can be defined. The maximum number of lots for each data diskette is 1,040. (Using the same figures as above, this represents a gross seed sales of more than $8 million per data diskette.) The lot is the unit upon which all seed testing, quality assurance, bagged seed inventory and sales is based.

Seed testing records are divided into two categories: bin records (or bulked seed records) and lot records. In both categories, the information entered is identical and includes the detailed data from purity testing, standard germination testing, vigor testing, and the like. In the case of a bin seed test record, the user identifies the bulk storage location and then enters, reviews or updates the record. In the case of a lot seed test record, the user selects the lot number of the test result and enters the information. One seed testing result is entered for a bin analysis, and up to five different test results can be entered for each lot of seed. Since the computer stores the originating bulk storage location for each lot of seed, the user can view a histogram summary of all seed testing information for a given lot of seed, and this summary will show the trend over time from the bin analysis to the most recent lot analysis.

A printed output of the bagged seed inventory can be requested. The inventory listing shows the starting inventory quantity, the number of bags broken, the number of bags booked for sale, and the number of bags sold. The listing also includes seed testing information, the warehouse code where the bagged seed are located, and other related information

Seed sales using QSeed are based on up-to-date lot inventory records. When seed are sold, the user indicates whether the invoice is an actual sale, or an indication to buy ("booking" the seed). The process starts by identifying the buyer and entering background information about the sale. Then the variety is selected and the computer displays the inventory and quality information for the indicated variety. The user then selects one or more lots for the sale, and indicates the number of bags and selling price. All invoices automatically adjust the bagged seed inventory. At any time the user can make changes to an invoice, switch it from booked to sold, or call it up for review. The user can also request a listing of all buyers for a particular lot of seed.

Quality Assurance Features

Excellent, complete records for all stages of seed production, conditioning, and testing are in themselves the essential feature of a quality assurance program. Having these records available, in an organized and presentable fashion, for timely review, is a major benefit from the QSeed family of programs.

The QSeed programs allow the user to trace a lot of seed from the buyer all the way back to the bulk storage location from which the lot was constituted. The user can view all the truck loads that were dumped into each bin, and identify the growers whose seed were loaded into the bin.

QSeed allows the user to rapidly view seed testing information over time. Trends, instead of one test value, can be viewed. Lots not storing well can be identified, or the homogeneity of the lots originating from a single bin can be assessed.

QSeed permits the sale of seed from up-to-date inventory records. The inventory records indicate the latest seed testing information, and a statistical summary of all the seed tests for a given lot of seed is displayed. This allows the user to have a great deal of information available to him at the moment of sale, and the appropriate choice of lots for a customer is facilitated.

In the case that the user needs to contact the buyers of a particular lot of seed, a listing can be requested that indicates not only the buyers and the number of bags bought by each buyer from the lot in question, but also the telephone number for each buyer. This permits the user to track down problem lots in a very rapid fashion.

Seedlab

Another program that is currently under development at N.C. State University and that will be released this summer is called SEEDLAB. SEEDLAB is designed for a quality control laboratory and performs the following functions:

- logs samples as they are received
- records background information about sample
- allows user to designate analyses to be performed on sample
- allows user to enter results for each analysis performed
- calculates totals, averages and tolerances for the analyses
- prints a report for each analysis
- maintains database on samples and analyses for information retrieval
- permits user to generate hardcopy summaries of database

One of the criteria for the design of SEEDLAB was to develop a system that could form the basis for a multi-user network of computers in a larger seed laboratory.

CASAS

Microcomputers can be interfaced to equipment and control many different kinds of operations. Already mentioned is the possibility to control drying fans and burners. At N. C. State University, Dr. Robert Keys has developed the interfacing and software to run a dynamic conductivity analysis on a number of samples simultaneously. At one minute intervals the computer reads the conductivity of a series of chambers where the seeds are immersed in water. (Seeds when placed in water will "leak" electrolytes. The greater the quality of electrolytes in solution, the lower the seed quality. The conductivity measures the electrolytes that have been leaked.)

Seed conductivity analyses are not new. However, the dynamic nature of the analysis is new (the normal procedure is to take one reading at the end of a certain number of hours soaking). One exciting result of this new procedure is that it may be possible to shorten the duration of the conductivity analysis to two to three hours for many crops. Many seed companies would be interested in a three hour seed test that could be performed on-site with the aid of their microcomputer.

Modeling

Another use of the microcomputer is to accumulate data on the weather, or seedbed conditions, and interpret this data to predict seed quality or emergence. At NCSU, a commercially manufactured battery-powered datalogger is interfaced to nine sensors (soil and air temperature thermistors, soil moisture tensiometer, soil moisture block, relative humidity, solar pyranometer, rainfall gauge, and wind speed anemometer) to allow in-the-field monitoring of seedbed environmental factors relating to seed germination and seedling emergence, permitting an accurate and quantitative description of the environment for vigor studies and the development of emergence models.

Software that has been developed for the microcomputer to automatically input, convert, and plot the accumulated environmental data on a weekly or continuous basis. Data gathered at one-minute intervals and summarized on the hour is also tabulated for maximum/minimum and mean values on a daily and weekly basis.

Summary

The use of microcomputers is an exciting new field. The applications are many, ranging from electronic communications and controlling equipment, to payrolls and quality assurance operations. The key to the use of the microcomputer is software. The decision to purchase software should be carefully studied. The investment in a microcomputer must be considered in terms of the expected benefits.

ECONOMIC EFFICIENCY OF SEED CONDITIONING PLANTS IN MISSISSIPPI

Warren C. Couvillion and Naraseeyappa Rajanikanth[1]

The seed conditioning industry has both technical and economic significance. From a technical point of view, it is through seed that genetic characteristics are transmitted from research results into applied technology. Additionally, through seed this applied technology is transmitted from one crop generation to the next. From an economic standpoint, improved seed increase the productivity of crop agriculture and the production and processing of seed contribute importantly to income and employment.

The conditioning sector of the seed industry is characterized by wide variations in efficiency. While unforeseen changes and differences in financial position and managerial ability of owner-operators are important, a lack of information can account for much of the variation in efficiency. Individual plant managers normally are not aware of the costs of alternative ways of performing a given operation nor of the costs associated with plants of different capacities. In fact, some owner-operators may not know about some of the available technologies.

The study on which this paper is based was designed to help improve the efficiency of the delivery system for improved crop seed in Mississippi.

The study will make available information on the costs associated with owning and operating alternative sizes of seed conditioning firms, operating for varying lengths of time during the year.

The structure of the seed industry is such that seed conditioning plants are not entities within themselves. In almost all cases, seed conditioning is an enterprise within a firm. Usually firms have some complementarity with the conditioning of seeds. For example, seed conditioning units are found on large farms, farm supply businesses, in conjunction with grain elevators or some combination of these enterprises. A seed conditioning plant fits well with other related businesses since the "busy times" in seed conditioning may correspond to "slack times" in other areas.

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Due to consideration discussed above, a modified version of the economic-engineering technique was used in the study. This permitted the specification of a fixed combination of resources for plants of different sizes while holding constant the level of management.

Information on management practices and operational characteristics of the industry was solicited from selected seed processors in the State (15%). Using this information as a base, three sizes of seed processing firms were specified: firms with hourly capacities of 100 (Plant I); 200 (Plant II); and 300 (Plant III) bushels for soybean, rice, or wheat. These capacities are based on a 40 hour work week. Three levels of operation were assumed; 15; 30; and 40 weeks of operation.

The engineering specifications and most technical coefficients for the model seed processing plants were obtained from the Seed Technology Laboratory of Mississippi State University. The remainder of the technical coefficients were developed from data obtained from equipment manufacturers, agribusiness firms, professional workers, and published material.

The operation of a seed conditioning plant was divided into five major components or stages: receiving; drying and bulk storage; conditioning; bagging; and bag storage. The fixed and variable costs of conditioning seed at each stage were developed by applying prices to the relevant factor inputs. The costs arising from both durable and nondurable inputs were summed over all stages for each plant. Total processing costs were then estimated by adding certain costs not readily identified with specific plant stages. Costs were summarized into fixed cost, and total cost. Costs assumed did not include a cost for management.

Cost Analysis

Initial Investment Requirements

The total initial investment requirements for the three plants operating for 15, 30, and 40 weeks per year are shown in Table 1. These data indicate that there are economies in both size and period of operation. Total initial investment ranged from $7.60 cents per bushel for the 100 bushel per hour plant operating 15 weeks to $2.74 per bushel for the 300 bushel per hour plant operating 40 weeks per year.

Operating Costs

Costs of operation were divided into fixed, variable, and total costs. These data are shown in Table 2 in terms of total dollars and costs per bushel. Fixed costs per bushel ranged from $1.49 for Plant I (100 bushels/hour) operating 15 weeks to $0.53 for Plant III (300

Table 1. Summary of initial investment, total and dollars per bushel, by capacity utilization for Plant I, Plant II, and Plant III.

Weeks of Operation	Capacity Utilization	Initial Investment	Initial Investment Per-bushel
		---------(dollars)--------	
Plant-I			
15	60,000	455,925	7.60
30	120,000	553,613	4.60
40	160,000	606,594	3.63
Plant-II			
15	120,000	621,763	5.18
30	240,000	804,734	3.35
40	320,000	946,992	2.96
Plant-III			
15	180,000	823,182	4.57
30	360,000	1,160,849	3.22
40	480,000	1,315,080	2.74

Table 2. Summary of annual operating costs by capacity utilization in dollars and costs per bushel for Plant I, Plant II, and Plant III.

Weeks of Operation	Capacity Utilization	Fixed Per-year	Costs Per-bushel	Variable Per-year	Costs Per-bushel	Total Per-year	Costs Per-bushel
		---------------------------(dollars)---------------------------					
Plant-I							
15	60,000	89,213	1.49	32,548	0.54	121,761	2.03
30	120,000	108,053	0.90	62,252	0.52	170,805	1.42
40	160,000	118,078	0.73	81,986	0.51	200,064	1.25
Plant -II							
15	120,000	121.239	1.01	58,747	0.49	179,986	1.50
30	240.000	156,527	0.65	111,681	0.47	268,208	1.12
40	320,000	183,963	0.57	150,866	0.47	334,829	1.05
Plant -III							
15	180,000	160,535	0.89	85,278	0.47	245,813	1.37
30	360,000	225,657	0.62	165,598	0.46	391,255	1.09
40	480,000	255,403	0.53	221,202	0.46	476,605	0.99

bushels per hour) operating 40 weeks per year. Variable costs ranged from $0.54 to $0.46 for the above mentioned plants. These were smaller economies associated with either side or length of operation in variable costs. Virtually all efficiency in variable costs are associated with size (Table 2).

Economic Feasibility

Often, management faces a variety of problems in making capital expenditure decisions even when reliable estimates of costs and benefits are readily available. this difficulty arises from the uncertainty associated with the planning period and from the fact that capital expenditures are incurred immediately while benefits accrue overtime. The uncertainty element can never be completely eliminated. However, decision making can be improved by a comprehensive feasibility analysis. In this study, the problem was approached by balancing expected future returns against immediate capital expenditures. Three quantitative techniques were employed: (1) breakeven analysis, (2) simple payback period analysis, and (3) discounted cash flow analysis.

Returns were calculated for each of the plants using five assumed levels of merging and three levels of plant operations. Plants were assumed to have outputs of 100, 200, and 300 bushel's per hour for 40 hours per week. Plants were assumed to operate for 15, 30, or 40 weeks per year. Revenues were computed for gross conditioning margins of $1.00, $1.25, $1.50, $1.75, and $2.00 per bushel.

Breakeven

Breakeven points are those points where the cost per bushel is equivalent to the conditioning margin.[2] The total annual operating costs are equivalent to the breakeven margin (Table 2.)

The analysis emphasizes the sensitivity of returns to the volume of product handled and the length of time plants operate. Data indicate that the 300 bushel per hour plant (Plant III) operating 40 weeks requires a margin of $0.99 per bushel to breakeven whereas Plant I (100 bushels per hour) operating for 15 weeks would require a $2.03 margin to breakeven under the assumed conditions.

The Payback Period

The simple payback period is calculated by dividing the amount of capital required for the investment by the estimated annual cash earnings. The payback period is the time required to recover the

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[2]Annual cash earnings include net operating returns, depreciation funds, and interest on investment.

initial investment out of the earnings expected to result from the investment. To accept or reject potential investments would necessitate the establishment of some maximum acceptable payback period and rejection of all investment alternatives that exceed this maximum.

For the purpose of this study, a 10 year planning horizon was used to determine feasibility. Data calculations at selected rates for all three plants operated at selected margins are shown in Table 3.

Discounted Cash Flow

Based on the assumptions, Plant I operating 15 weeks appears to be feasible at a margin of $1.75 per bushel. At 30 weeks and a margin of $1.25 the estimated payback is 8.7 years. If Plant I is operated for 40 weeks, the estimated payback period would be 6.7 years at $1.25 margin.

Plant II and Plant III appear feasible at margins of $1.50 and $1.25 and 15 weeks of operation and $1.25 and $1.00 for 30 and 40 week operations, respectively. Estimated payback periods are shorter for Plant III than Plant II as shown in Table 4.

Conclusions and Implications

The economies associated with increases in plant size are due substantially to increases in the efficiency in the use of the fixed factors, or stated in a more common terminology, the "spreading of fixed cost". Additional increases in efficiency (reductions in per bushel costs) appear to be attainable by increasing the annual output of plants. This may be accomplished by increasing the number of hours of operation per day, such as double-shift operations or extending the time of operation. Another possible method by which plants could increase volume would be "in and out" custom work. An arrangement of this type would increase the volume of the plants while avoiding storage restrictions. Incorporation of other crops into the product mix to take advantage of seasonalities of the soybean-rice-wheat product mix offer additional opportunities for increasing volume. While these alternatives appear to be reasonable means of capturing some of the economies associated with increased utilization, the determination of the economic feasibility of each alternative was beyond the scope of this paper.

If a large percentage of conditioned seed can be marketed in bulk, it appears that individual firms may obtain significant cost reductions by eliminating much of the cost associated with the bagging stage and related operations.

As indicated, plant size and length of operation have substantial effect on cost per bushel. the economies associated with size are

Table 3. Summary table showing simple payback period at selected margins.

Weeks of Operation	Margins									
	Margin	Payback Period	Margin	Payback Period	Margin	Payback Period	Margin	Payback Period	Margin	Payback Period
	(dollars)	(years)	(dollars)	(years)	(dollars)	(years)	(dollars)	(years)	(dollars	(years)
Plant I										
15	1.75	7.9	2.00	6.3						
30	1.25	8.7	1.50	5.6	1.75	4.3	2.00	3.5		
40	1.25	6.7	1.50	4.4	1.75	4.4	2.00	2.8		
Plant II										
15	1.50	6.2	1.75	4.8	2.00	3.9				
30	1.25	5.0	1.50	3.6	1.75	2.9	2.00	2.4		
40	1.25	4.5	1.50	3.2	1.75	2.5	2.00	2.1		
Plant III										
15	1.25	7.3	1.50	5.2	1.75	4.1	2.00	3.3		
30	1.00	7.4	1.25	4.7	1.50	3.4	1.75	2.7	2.00	2.2
40	1.00	6.1	1.25	3.9	1.50	2.9	1.75	2.3	2.00	1.9

Source: Summarized from the Appendix Tables 54-57 (14).

Table 4. Year in which payback occurs by plant size and weeks of operation using discounted cash flow analysis.

Weeks of Operation	Margins				
	$2.00	$1.75	$1.50	$1.25	$1.00
	----------------------------(years)--------------------				
Plant-I					
15	10.0	*	*	*	*
30	5.0	6.0	8.0	*	*
40	4.0	5.0	6.0	10.0	*
Plant-II					
15	5.0	7.0	10.0	*	*
30	3.0	4.0	5.0	7.0	*
40	3.0	3.0	4.0	6.0	*
Plant-III					
15	4.0	6.0	8.0	*	*
30	3.0	3.0	5.0	7.0	*
40	2.0	3.0	4.0	5.0	10.0

[1]Ten year planning horizon using a 12 percent interest rate.

*Indicates that the (discounted) payback period would be beyond 10 years.

Source: Summarized from Appendix Tables 58-66 (14).

determining the economic worth of seed plant of invest-
unted cash flow analysis indicated that Plant I is feasible .50, and $1.25 for 15, 30, and 40 weeks of operation, Plant II and Plant III were feasible at margins of $1.50, for 15, 30, and 40 weeks of operation using discounted cash .

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SORGHUM SEED MINI-COURSE

- Varietal Improvement
- Quality Control
- Outlook

SORGHUM VARIETAL IMPROVEMENT NEEDS FOR THE SOUTH

Lynn M. Gourley[1]

Sorghum is a crop of tropical origin. However, it is involved in the arid to semi-aid areas of the tropics, not the humid areas. My work has been to characterize some of the requirements for sorghum improvement in the humid Southeast or other subtropical high rainfall areas. I will present a sorghum breeders viewpoint.

Most of my comments will address yield constraints in grain sorghum production, however, make some comments about sorghum silage and sorghum-sudan hybrid quality, and conclude with a short discussion of a serious sorghum production constraints found in many of the tropical areas of the world and to a lesser degree here in the Southeastern U.S. - aluminum (Al) and manganese (Mn) toxicities.

A breeding program must evaluate germplasm in the environment where the farmers will be growing the hybrids. In the past, many of the grain sorghum hybrids sold and grown in the Southeast were developed in the drier regions of West Texas.

If water is eliminated as a variable, yields of grain sorghum are almost always lower in the Southeast than on the high plains of Texas. This is attributed to the higher elevation in West Texas and associated with the lower elevation in the Southeast,and higher night temperatures. We know little about the genetic variability of sorghums to elevated night temperatures. We do know that higher night temperatures do hasten anthesis, reducing the number of days from planting to the period of grain-fill, and this results in lower yields. It has been estimated that for every one day reduction in the number of days to bloom for the same hybrid results in about 300 lbs/A less grain produced. Perhaps we need more tropically adapted hybrids in the southeast region.

Some of the so-called cultural constraints can be better reduced through breeding and others through management. Late planting due to cold wet soils, applying nitrogen too late to increase yields, weeds and insects are some problems that frequently reduce yields in the Southeast.

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There is a large amount of genetic variability in sorghum. Seed color, head shape and size, plant height, length of maturity, seed size and other seed or grain characteristics are just a few of the different phenotypic characteristics in which we can measure variability. There are many more heritable characters that we cannot see, but that can be measured under the right conditions.

In humid areas, diseases of sorghum are the most serious factors limiting yield. Charcoal rot, Fusarium stalk rot and Anthracnose can damage stalks causing lodging, low test weight, and low yields.

Anthracnose is also a serious leaf and panicle disease. However, there is good genetic resistance to this disease (Figure 1). There is evidence that a different biotype of Anthracnose has been found in Georgia. Grey leaf spot, zonate, rough spot and a variety or other minor diseases take their toll when sorghum is grown in humid areas. Sometimes the only affect of these diseases is small seed or reduced test weight, but this translates into reduced yield.

Year in and year out, one disease in its many forms and symptoms probably causes more poor yields or reduced grain quality than any other disease in humid areas of the world. It is Fusarium moniliforme. The disease caused by this agent can affect the whole plant as Pokka Bong, or just result in the leaves sticking together as they emerge from the whorl to form a whip, or as a red stalk rot, or as a disease of the panicle. One of its most severe forms is Fusarium head mold (Figure 2). The farmer can literally lose his crop at maturity by a week or rain and high humidity.

Fusarium and other grain molds can cause nearly total loss by the combine grinding of grains to dust. If the grain does make it into the combine hopper, it is severely docked when sold. Sprouting in the head is another hazard of rains at harvest time.

Diseases are not the only problems in the Southeast. The sorghum midge can also reduce yields or destroy nearly the whole crop. Some hybrids on the market now have genetic resistance to the sorghum midge. The fall armyworm is a frequent pest in this area of the country. We have found some genetic tolerance to the fall armyworm, but the level of resistance is not high and the farmer needs to control this pest with insecticides.

I now want to make a few remarks about forage quality. With silage sorghums the breeder needs to consider three biological systems - the plant, the fermentation system in the silo, and the digestion by the ruminant. One of the genetic factors which increases sorghum forage digestibility the most is the brown midrib factor which causes a reduction in the amount of lignin. I recently released eleven male sterile (A-lines) and maintainer (B-lines) with brown midrib genes.

Figure 1. Antracnose resistant hybrid (right) compared to a susceptible hybrid (left).

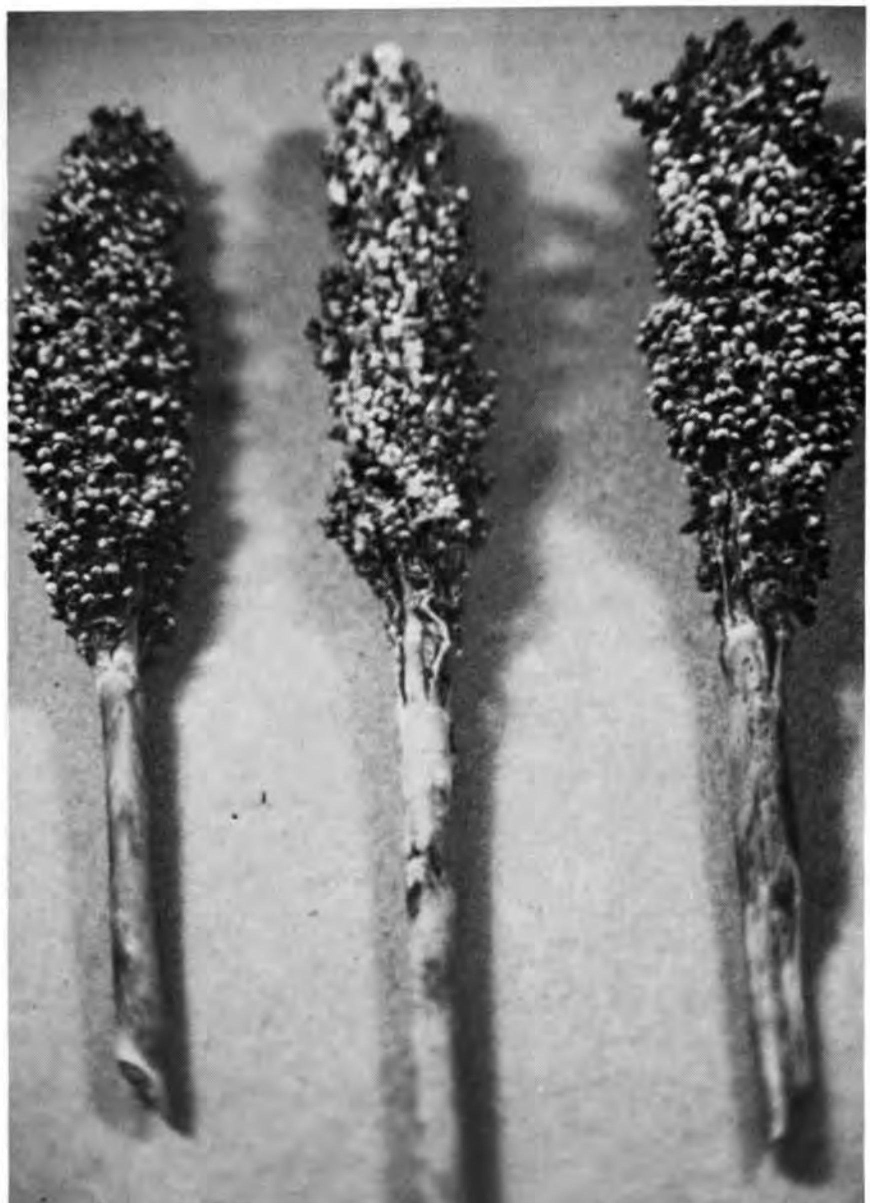

Figure 2. Grain sorghum heads showing varying degrees of head mold. Center most severe.

These genotypes have from 10 to 40% less lignin which makes them more digestible.

The last topic I want to address is the problem of sorghum toxicity to aluminum and/or manganese in acid soils. This is a serious constraint to sorghum production in many topical countries of the world, and to a lesser extent in the Southeast. In the Southeast it is mainly a subsoil problem. All U.S. sorghum hybrids are susceptible to high levels of aluminum saturation above 40%. Research in Colombia, South America has shown that some sorghum genotypes can produce high yields of grain at 65% aluminum saturation (Figure 3). When incorporated into U.S. hybrids, this germplasm should improve sorghum yields in the Southeast when soils have aluminum and manganese toxicity problems.

From this short discussion of problems and research needs to improve sorghum hybrids for some of the production constraints unique to the Southeast, we can see that commercial seed companies will need to address more of these problems in the future as sorghum acreage increases in the higher rainfall areas of the U.S.

Figure 3. Aluminum tolerant variety (right); susceptible variety (left).

QUALITY CONTROL IN HYBRID SORGHUM SEED PRODUCTION

James Allison[1]

The major objectives of any hybrid seed production program are to produce seeds which have a high germination percentage, excellent seedling vigor and are mechanically and genetically pure.

The concern of this section of the conference is how to attain excellent genetic purity in the production of hybrid sorghum seed. Seed labeled hybrid must be 95% hybrid. The goal is to reach the ultimate and have 100% true hybrids. There are difficulties of achieving this goal for the various types of sorghum hybrids-sudangrass, forage and grain sorghum hybrids. The primary emphasis will be on the production of grain sorghum hybrids with 100% pure parental lines and proper isolation. This seems to be a relatively easy task, but there are many factors which contribute to the success or failure of hybrid sorghum seed production.

Isolation and controlling external factors are often the results of many years of planning and working with the same farmers in a give area. Many of the isolation problems can be averted by prior planning between farmers and through cooperation between the various seed companies.

The various types of hybrids are grown in different areas of production - each isolated from the other and from commercial production. Since pollen from undesirable plants, especially sudangrass and shatter cane, can travel five to ten miles under favorable conditions. the cooperation between seed companies in Texas, in planning production, has led to fewer problems with isolation.

One of the big factors in the production of hybrid sorghum seed is the use of genetically pure parental lines. Both the seed row (female) and the pollinator (male) should be as free as possible of any off-type plants. After careful planning for good isolation, pure parental lines, and uncontaminated fields, hybrid seed production is ready to begin.

The primary goal of any hybrid production is to have an abundant supply of desirable pollen available at the same time the female plant is receptive. This will greatly reduce the possibility of external

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contamination or out-crosses. Added insurance is to have pollen available both prior to and after the female plant is receptive. Again, this seems very simple, but to achieve this over years and locations is difficult. Plant breeders can do much to increase pollen shed by selecting better R-lines such as Tx430 and Tx2737 which are excellent early-morning pollinators when compared to R-lines such as TAM428 and Tx435 which are considered to be poor, late-morning pollen shedders. The commercial plant breeders are more aware of this problem than are the public plant breeders.

The proper timing or nicking is greatly influenced by many factors. Different planting dates and locations, especially latitude differences, can have a great effect on timing, particularly if one parental line is more day-length sensitive than the other line. Other factors which greatly influence timing are growing degree days, soil temperature and soil moisture. In many cases one of the parental lines will be more affected by one or more of these factors than the other. Most hegari derivatives are greatly influenced by all of these factors and their flowering times are most difficult to predict.

In many instances, the highest yielding hybrids are obtained from parental lines with the greatest timing spread or the widest split between the seed row and the pollinator. The wider the split, the greater the possibility for lower genetic purity or greater number of undesirable out-crosses. There are several things that can be done to the pollinator rows to insure maximum pollen shed at the desired time.

A. Split-planting - this is planting the pollinator at three (3) different times at 5-7 day intervals and planting early enough to have pollen three (3) days prior to the female being receptive.

B. Plant the pollinator rows at different depths and rates at each planting.

C. Mutilate one row each of the first and second plantings.

D. Plant pollinator on all ends of the field (called stubbing).

The next step to enhance genetic purity is the removal of undesirable plants, referred to as roguing. This is accomplished by three roguings for sudan and forage hybrids and up to five times for grain hybrids. The cost of this operation is between $50.00 to $120.00 per acre. Roguing begins just prior to bloom (full boot stage) and continues throughout the bloom stage. It is necessary to rogue both the seed and pollinator rows. The schedule is as follows:

A. First to remove mutations, volunteer, and any impurities in parental lines.

B. Second, third, and fourth (if necessary) to remove B-lines (shedders) as they occur in the seed row.

C. Fifth - just prior to harvest for cosmetic effect and remove any off-type heads in the seed rows.

Starting with the highest quality parental lines and planting on uncontaminated fields will greatly reduce the roguing cost.

When proper isolation cannot be attained, it may be necessary to rogue adjacent commercial fields for mutations, sudan, and forage hybrids. This usually can be accomplished by one roguing just prior to the female becoming receptive. Also ditches, road-ways, railroads, irrigation pits and abandoned farmsteads, are sources of contaminants such as volunteer sudangrass and johnsongrass. The minimum distance from sudan is two (2) miles and johnsongrass 1/2 mile. These undesirable plants can be controlled by spraying with Roundup, MSMA or DSMA.

Cool temperature during the time the female is receptive will cause foreign pollen to travel greater distances and will result in a greater number of undesirable plants. Hot dry weather during pollination, will cause a lower seed set, but will often result in fewer off-type plants.

Prior to harvest, hand samples are taken for grow-outs and planted in some tropical or semi-tropical location such as Florida, Hawaii, Mexico or Puerto Rice. These samples are taken by criss-crossing the field and taking branches from random selected heads. The objective is to obtain the most representative sample possible for the grow-outs.

At harvest, the pollinator rows are harvested first and sold for feed grain. Prior to harvesting the seed rows, all combines, grain carts, augurs, and trucks are thoroughly cleaned to prevent mechanical contamination. After each pedigree is harvested, the procedure is repeated to insure genetic purity.

As the grain is taken to the conditioning facilities, each truck load is probed several times to obtain a representative sample. A composite sample (30 to 50 pounds) is collected from each field and these samples are sub-divided into various quantities as the company deems necessary for the proper grow-outs. These grow-outs are planted from 1/10 acre to 1/2 acre in size and have a population from 6,000 to 60,000 plants.

Many commercial companies conduct their own winter grow-outs or use the service offered by the Texas department of agriculture in conjunction with the Texas Seed Trade Association. This service is offered on a fee basis and the cost depends on the size sample and the location of the grow-out. It is very important to get the grow-outs planted as soon as possible after they are collected. The dates offered by the Texas Department of Agriculture are as follows:

A.	September 15-20	Mexico
B.	October 15-20	Mexico
C.	November 15-20	Mexico
D.	December 10-15	Puerto Rico

These dates may vary slightly from year to year depending on weather conditions at harvest. Approximately 220 acres are planted in Mexico and 80 acres in Puerto Rico each year. Due to the possibility of a frost in Mexico, most companies have a back-up location in Puerto Rico or Hawaii. Samples can be read in Puerto Rico in 50-55 days where it may take 75 to 90 days at the Mexico location, because of the cooler night temperatures.

Grow-outs for certified seed must be sampled by an official of Texas Department of Agriculture (T.D.A.) and included in one or more of the grow-outs. These are official samples and are read by T.D.A. personnel. With the increased demand for certified seed on the export market this service is becoming more and more important. The standards used by the Texas Department of Agriculture for certification are as follows:

Varietal Purity Grow-out Test Standard

Maximum Objectionable Sorghum Plants Permitted in:

A. Grain Type Hybrid

Grass Types	
Rhizomatous outcross plants, broomcorn origin plants, and/or vigorous and/or tillering plants	0.05% (1:2,000)
non-rhizomatous, single stemmed (non-tillering) plants of the same genetic height as the hybrid including mutation heights	0.10% (1:2,000)
Hegari Types	0.08% (1:1,250)
Other Forage Types	0.10% (1:1,000)
Combination of above three	0.10% (1:1,000)

Off-type heads of same genetic height plants	
Off-type and/or slightly off colored heads	5.00% (50:1,000)
Opposite colored heads	2.00% (20:1,000)
Combination of above two	5.00% (50:1,000)

B. Forage Type Hybrid

Grass Types	0.5% (1:1,000)
Combine Types (including "selfs")	5.0% (50:1,000)
Combination of above two	5.0% (50:1,000)

C. Grass Type Sorghum-Sudangrass Hybrids

Forage Types	0.5% (5:1,000)
Combine Types (Including "Selfs")	5.0% (50:1,000)
Combination of above two	5.0% (50:1,000)

D. Grass Type Sorgo-Sudangrass Hybrids

Forage Types (Including "Selfs")	5.0% (50:1,000)
Combine Types (Including "Selfs")	5.0% (50:1,000)
Combination of above two	5.0% (50:1,000)

E. Grass Type Sudangrass-Sudangrass Hybrids

Forage Types	0.5% (5:1,000)
Combine Types (Including "Selfs")	5.0% (50:1,000)
Combination of above two	5.0% (50:1,000)

F. Male Sterile Seed Stock

Off-Type Plants Other than the Male Sterile	
Counterpart Shedders and Mutations	0.66% (1:1,500)
Plants shedding pollen but otherwise indistinguishable from the male-sterile counterpart	0.10% (1:1,000)

G. Pollinator Lines (B & R)

Off-Type Plants, other than mutations, allowable in the pollinator lines is limited to	0.066% (1:1,500)

The quality control standards for non-certified seed are determined by each individual seed company and in many cases are more strict than those enforced by the certification agency. If the standards which are set by the commercial companies are not met and the seed is rejected it is sold for feed grain. This is very critical to all seed companies, because they have contracts with individual farmers for the production of seed and if the seed is rejected the farmer will not receive his premium for the seed. The price paid to the farmers for seed is 2 to 4 times that of commercial sorghum.

The grow-outs for each grain hybrid are based on the following ratings:

A. Mutations or True Talls
B. B-Lines (selfs) or other grains
C. Forages
D. Grasses
   1. Rhizomatous
   2. Non-Rhizomatous
E. Plant Population

As the crop is harvested each variety is placed in storage or a holding bin until the purity has been determined. At this time, each lot of seed is conditioned and are used to determine germination percentage, mechanical purity, and one last grow-out. This is to determine if the earlier grow-outs are correct and to check and see if any mechanical contamination has taken place in storing or conditioning the seed.

Always keep in mind that seed quality will always vary from year to year. Standards can be set by seed production people, but "mother nature" has a way of playing havoc with many of their goals.

The final objective of commercial seed companies is to have a satisfied and happy customer in order to get repeat business. Any short cuts in the process will jeopardize this objective.

STEPS NECESSARY FOR THE CERTIFICATION OF PLANTING SEED IN TEXAS	RESPONSIBILITIES OF SEEDSMEN AND CERTIFYING AGENCY TO CERTIFY HYBRID SORGHUM SEED IN TEXAS
1. Grower plants genetically pure parent seed of known source.	1. Date chosen by seedsman
2. Grower voluntarily applies to TDA Seed Program for certification of seed.	2. 30 days after planting
3. Seed Program verifies eligibility of land and seed source planted therin.	3. Immediately after application is received by certification agency
4. Seed Program sends information for making field inspection to inspector.	4. Before seed fields are ready for inspection.
5. TDA Inspector inspects seed crop being grown in field.	5. Two inspections before bloom, one inspection after seed begins to color
6. Grower harvests seed crop.	6. When mature
7. Inspector inspects equipment used to condition seed.	7. Before seed conditioned
8. Grower conditions seed.	8. At seedsman's choice
9. Inspector or grower collects sample of seed and sends to TDA Seed Lab.	9. When necessary for grow outs
10. Seed Lab analyzes seed sample and plants for grow-out test	10. In time for grow out selected by seedsman
11. Grower requests Texas Seed Certification Labels from Seed Program.	11. When seed are eligible for certification and when seedsmen request tags.
12. Seed Program verifies eligibility of seed for certification labels.	12. After grow out
13. Seed Program issues certification labels to grower.	13. When certification is completed and at request of seedsman.
14. Growers attach certification labels to containers of the seed in a manner which prevents their removal without mutilation	14. When seedsman packages seed
15. Grower makes seed available for sale to farmers.	15. At seedsman's choice.

GRAIN SORGHUM PRODUCTION AND OUTLOOK IN THE HUMID U.S.

Charles C. Baskin[1]

Grain sorghum production has been up and down in the southern United States for a number of years. This is illustrated by Mississippi acreage from 1970 through 85 (Table 1). Recently acreage has mushroomed. In 1980 there was less than one-half (1/2) million acres in the southeastern states of Alabama, Arkansas, Georgia, Louisiana, Mississippi, South Carolina and Tennessee. By 1985 there was approximately 2.8 million acres (Table 2). Acreage-wise Arkansas led in total acreage with almost one (1) million acres. The smallest acreage was in South Carolina.

The largest percentage increase in acreage from 1980 to 1985 was in Louisiana, followed by Mississippi with the smallest percent increase in Georgia. The increases through the south are presented in Table 3.

There have been several proposed reasons for this increase. One is the need for a crop to rotate with soybeans. Soybean acreage in the south has mushroomed. Mississippi acreage peaked at 4.2 million acres but has decreased to about 2.6 million acres in 1985. Many of the other southern states have followed the same pattern as Mississippi; large rapid increases in soybean acreage. Why do we need a crop to rotate with soybeans? One reason is soybean cyst nematode. By 1984 virtually the entire state of Mississippi had some level of infestation of this pest. Races 3 and 4 were present in many counties. Other southern states have similar situations. Actually the infested area is much greater than the southern region. It has expanded into the lower midwest, particularly up the Mississippi River. When we rotate soybeans with a non-host crop populations are drastically reduced. Grain sorghum is a non-host crop.

Even when nematodes are not a problem the yield of soybeans is improved when grain sorghum is in crop rotation. Arkansas data reflects a seven (7) to eight (8) bushel increase in soybean yields in a rotation. Similar responses come from other rotations. Grain sorghum yields are also increased in the soybean-sorghum rotation.

Another reason given for increase in grain sorghum acreage is declining yields of soybeans. However, when we look at Mississippi data

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Table 1. Acres of Grain Sorghum Harvested in Mississippi* (Thousand Acres).

Year	Acres Harvested	Year	Acre Harvested
1970	116	1978	21
1971	150	1979	33
1972	33	1980	38
1973	30	1981	88
1974	38	1982	110
1975	38	1983	225
1976	41	1984	407
1977	24	1985	620

*Miss. Crop and Livestock Reporting Service

Table 2. Acres of Grain Sorghum Harvested In Seven (7) Southeastern States - 1980-1985.*

State	Year (Thousand Acres)					
	1980	1981	1982	1983	1984	1985
Alabama	34	58	68	100	180	230
Arkansas	203	298	263	320	590	920
Georgia	82	135	135	68	113	138
Louisiana	14	72	145	180	269	410
Mississippi	38	88	110	225	370	620
South Carolina	15	18	35	25	34	47
Tennessee	35	75	85	95	260	465
Total	352	744	841	1,013	1,816	2,830

*Miss. Crop and Livestock Reporting Service

Table 3. Increase in Grain Sorghum Acreages by States, 1980-1985.

State	Percentage (%)
Alabama	676
Arkansas	453
Georgia	168
Louisiana	2,928
Mississippi	1,632
South Carolina	313
Tennessee	1,329

this may not be a valid reason. Average yields are presented in Table 4. Since 1979 Mississippi soybean yields have fluctuated much more than in prior years. Much of this can be attributed to weather. Bean yields have really declined very little. The 1985 Mississippi average was 27 bushels per acre, just two bushels per acre under the record average of 29 bushels per acre in 1979. A more likely reason for the shift to grain sorghum is the declining profitability of soybeans. Cost of production has gone up while prices have slowly declined so that the profit potential in 1982 was $10 to $38 per acre compared to $63 to $102 per acre in 1981, Table 5.

Markets have improved throughout the area. Livestock and poultry producers have "discovered" grain sorghum. The use of local grain sorghum by swine producers and poultry producers has greatly improved the marketing in our area. Local grain elevators have also increased their handling of grain sorghum. Farmers have been able to increase acres cropped by adding grain sorghum to the soybean-cotton farm. Acreage can be increased 25 to 30% without any additional cost for labor and equipment because planting and harvesting does not compete with soybeans. This reduces overhead cost and improves cash flow.

We face some serious problems in grain sorghum production. One is disease. Grain sorghum varieties for the south have traditionally been those from western breeding programs that have performed rather well in testing programs in the South. Few varieties have been developed for the south. Three primary diseases are anthracnose, charcoal rot and a Fusarium complex that cause lower stalk rot, upper stalk rots and grain molds.

Rainfall is also a limiting factor and without irrigation consistent optimum yields are not possible. Only the coastal area averages enough summer rainfall to optimize yields without irrigation. Other areas will need irrigation 3 years out of 5 for optimum yields.

The potential for grain sorghum in the sought is great. With well adapted varieties and some supplemental irrigation the present two-plus million acres could well be six to seven million acres.

Table 4. Average Soybean Yields For Mississippi - 1970-1985.*

Year	Yield (Bu/A)	Year	Yield (Bu/A)
1970	22.5	1978	21.5
1971	21.5	1979	29.9
1972	19.5	1980	16.0
1973	22.0	1981	21.0
1974	19.5	1982	26.0
1975	22.5	1983	19.0
1976	22.0	1984	24.0
1977	21.5	1985	27.0

*Miss. Crop and Livestock Reporting Service

Table 5. Mississippi soybeans returns to land and managment, 1975-84, based on a 25 Bu/A yield.*

Year	Locations: Hill Area	Locations: Delta Area
1975	59.22	76.76
1976	20.91	44.76
1977	51.05	51.05
1978	23.71	53.92
1979	25.16	60.95
1980	34.21	80.76
1981	63.44	101.95
1982	10.16	38.26
1983	4.77	33.71
1984	29.82	72.70

*Miss. Extension Ag. Economics Budget Estimates

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