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Fifteen Basic Facts About Seeds

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FIFTEEN BASIC FACTS ABOUT SEEDS

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The word basic is defined as constituting or serving as the basis or starting point. Most persons, who have a concept of nature, think of a seed as the staring point, the beginning of new life. Those of us more closely associated with crop culture recognize that the true role of a seed is to continue or propagate life rather than start it.

Regardless of whether you are just beginning to develop a serious interest in seeds or have been involved in one or more aspects of the seed industry for many years, there are some basic facts and truths about seeds which must be continually recalled to be successful "husbands" of nature's most vital resource, the seed. In the daily routine many of us tend to forget or occasionally ignore the basic facts about seeds but our forgetfulness or ignorance does not change or negate their importance.

When was the last time you thought about the law of gravity? Few people give conscious thought to this basic law of physics every day, rather we accept it and subconsciously provide for it when conducting our daily activities. There are similar basic facts and truths concerning seeds and man's efforts to utilize them. Some of those basic seed facts are controlled by physical laws and others by biological laws; in both cases we must observe nature's laws or pay the consequences.

The purpose of this paper is to identify and briefly discuss 15 seed facts which, like the law of gravity, are always in effect. Each person should learn these seed facts, place them in the subconscious memory to be recalled before, not after, we experience the consequences.

The first fact about seeds has its primary impact on seed marketing activities.

I.
SEED IS THE ONLY CROP PRODUCTION INPUT THAT INCREASES IN QUANTITY WHEN USED

When a farmer uses a fertilizer, insecticide or herbicide it is gone. When he needs more the next season he must purchase it from his

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supplier. However, when a farmer plants a bushel of soybean seed in a few months he can harvest 30 or 40 times the amount he "used". Every salesman has competition, but only seedsmen intentionally sell their strongest competitors - the farmer - the materials necessary for them to become an even stronger competitor, and sell it at the lowest reasonable price! The fertilizer or pesticide salesman knows that when the farmer uses his products there will be an opportunity for another sale next season. Seedsmen have little such assurance except with hybrid varieties. In future years the American farmer may choose or be forced to save more of his own seeds of wheat, soybeans, rice and cotton to conserve money to pay the fuel bill.

A major factor involved in repeat sales, essential for a profitable business operation, leads to a second basic fact about seeds.

II.
SEEDS OF DIFFERENT SPECIES VARY IN THEIR NATURAL LIFE SPANS

The data presented in Table 1 clearly demonstrate this basic fact. You will note that at the start of the study from which this data was obtained the germination level of the seed of each species was well above 90%. After 12 months, under identical storage conditions, germination of the onion and peanut seed had decreased dramatically, and all seeds were dead after 24 months storage. In contrast, look at the germination of the snapbean, radish and wheat seed.

As indicated in Figure 1, the natural life span of seed of the same species also varies among different lines or varieties. How long will a seed remain alive? Many factors are involved; however, let's consider basic seed fact number three.

III.
MOISTURE CONTENT AND TEMPERATURE ARE THE TWO MOST IMPORTANT FACTORS WHICH INFLUENCE THE RATE OF DETERIORATION IN SEEDS

The role and importance of moisture content in the life of seeds of our economically important field, horticultural and flower seeds are illustrated in Figure 2.

Note that after seed reach physiological maturity, the higher the moisture content the more rapid the rate of the deteriorative processes, whether from respiration, disease or insects. When seed moisture content is above that necessary for safe bulk storage, about 15%, biological activity in the seed mass can produce sufficient heat to injure the living seed within a few hours, unless they are well-aerated.

Seeds high in moisture content are more susceptible to heat damage than the same seed at a lower moisture content. This is especially

Table 1. Germination percentages of high quality seed lots of twelve species during storage under ambient conditions at Mississippi State, Mississippi. (after Delouche)

Kind	Storage Period (Months)		
	0	12	24
Bean, Snap	98	96	92
Clover, Red	94	88	60
Corn, Field	98	96	90
Fescue, Tall	95	85	37
Onion	96	42	0
Peanut, Shelled*	96	60	0
Radish	98	98	95
Sorghum	96	93	82
Soybean*	96	85	42
Wheat	98	97	92

* Hand-shelled.

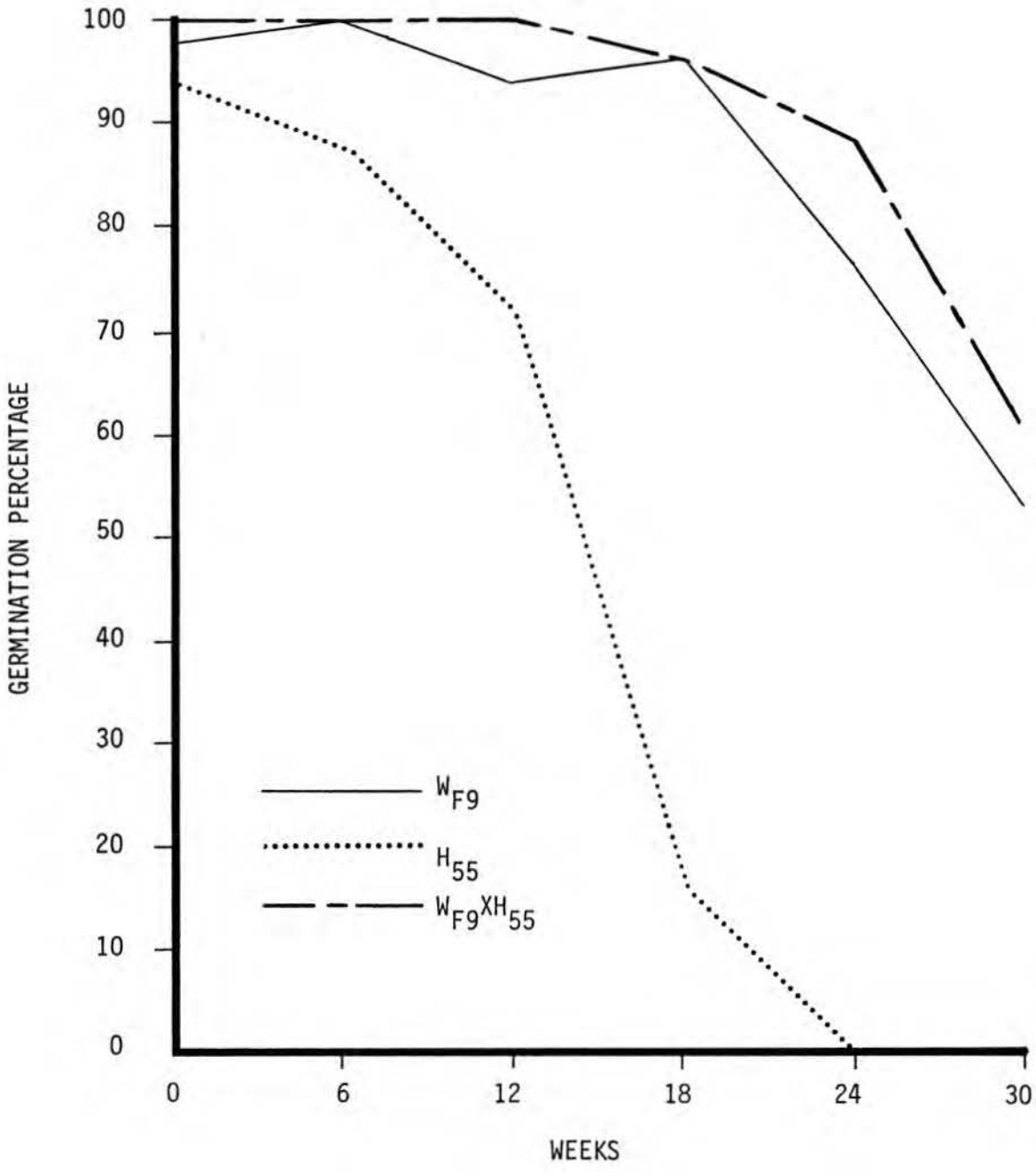


Figure 1. Differences in longevity of seed of two inbred lines of corn and the single cross hybrid under conditions of 86°F and 75% relative humidity. The seed were produced at the same time and location. (after Delouche)

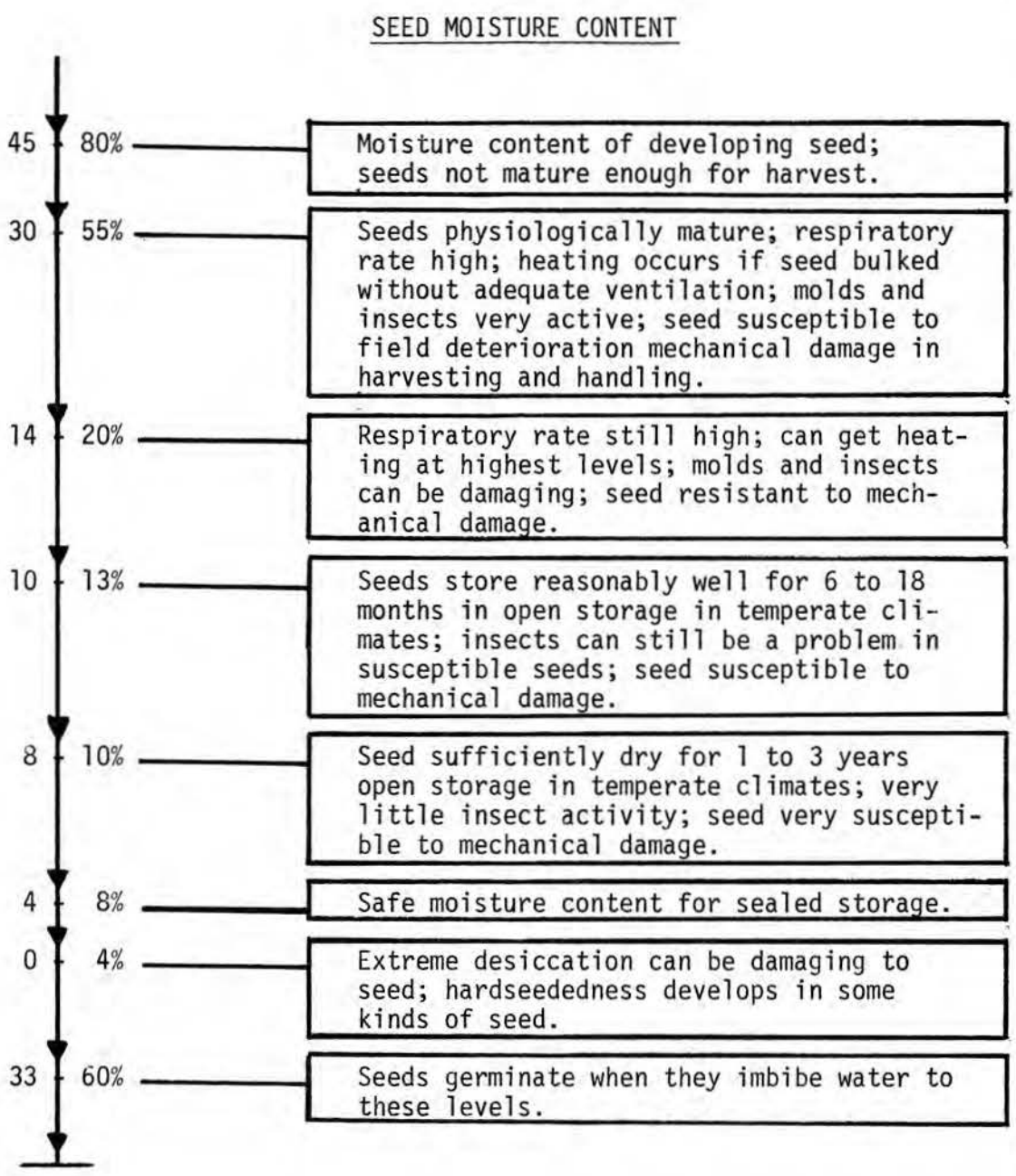


Figure 2. Role and importance of moisture content in the life of seeds. (after Delouche)

important to remember when drying seed with artificially heated air. Do not forget, however, that within the normal temperature range, the biological activity of seeds, insects and most molds increase as temperature increases.

The temperature and moisture effects may compensate or magnify each other in some ways. For example, the higher the seed moisture content, the more adverse the effects of increased temperature; as the seed dry, however, their thermal death point increases. Seeds very high in moisture can be damaged by sub-freezing temperatures but seed with 10% moisture are unaffected by the lowest temperatures that occur in nature.

Not only the moisture content of the seed but also the moisture content of the air which surrounds the seed is important. This leads to a fourth basic fact about seeds.

IV.
SEEDS ARE HYGROSCOPIC

This means that at a given temperature a seed loses moisture to the atmosphere or absorbs moisture from it until the vapor pressures of seed moisture and atmospheric moisture (relative humidity) reach an equilibrium. When seed moisture and the relative humidity of the air are in equilibrium there is no net moisture movement. However, any change in (a) the seed moisture, (b) the relative humidity of the air surrounding the seed, or (c) the temperature, upsets this equilibrium and a net movement of water occurs. This process is virtually continuous under ambient conditions, but is not instantaneous, often requiring several days and sometimes several months before an equilibrium is established.

The action of hygoscopicity and seed moisture equilibration is paralleled by the action of a playground see-saw. The seed, which holds water, is on one end of the see-saw and the air, which also holds water, is on the other end. As indicated in Figure 3-A, when seed moisture and relative humidity of the air around the seed are in equilibrium, there is no net exchange of moisture. If the moisture content of the air is increased (Figure 3-B) there will be a net movement of water from the air to the seed until once again an equilibrium is reached (Figure 3-C). If the amount of water in the air is reduced (Figure 3-D) the seed will lose water to the air until an equilibrium is again attained (Figure 3-E). If we increase the temperature of the air the relative humidity goes down (Figure 3-E) and the seed will lose water to the air until again an equilibrium is reached (Figure 3-F).

The fifth basic fact about seeds relates to drying and wetting of seed during the hygroscopic equilibrium process.

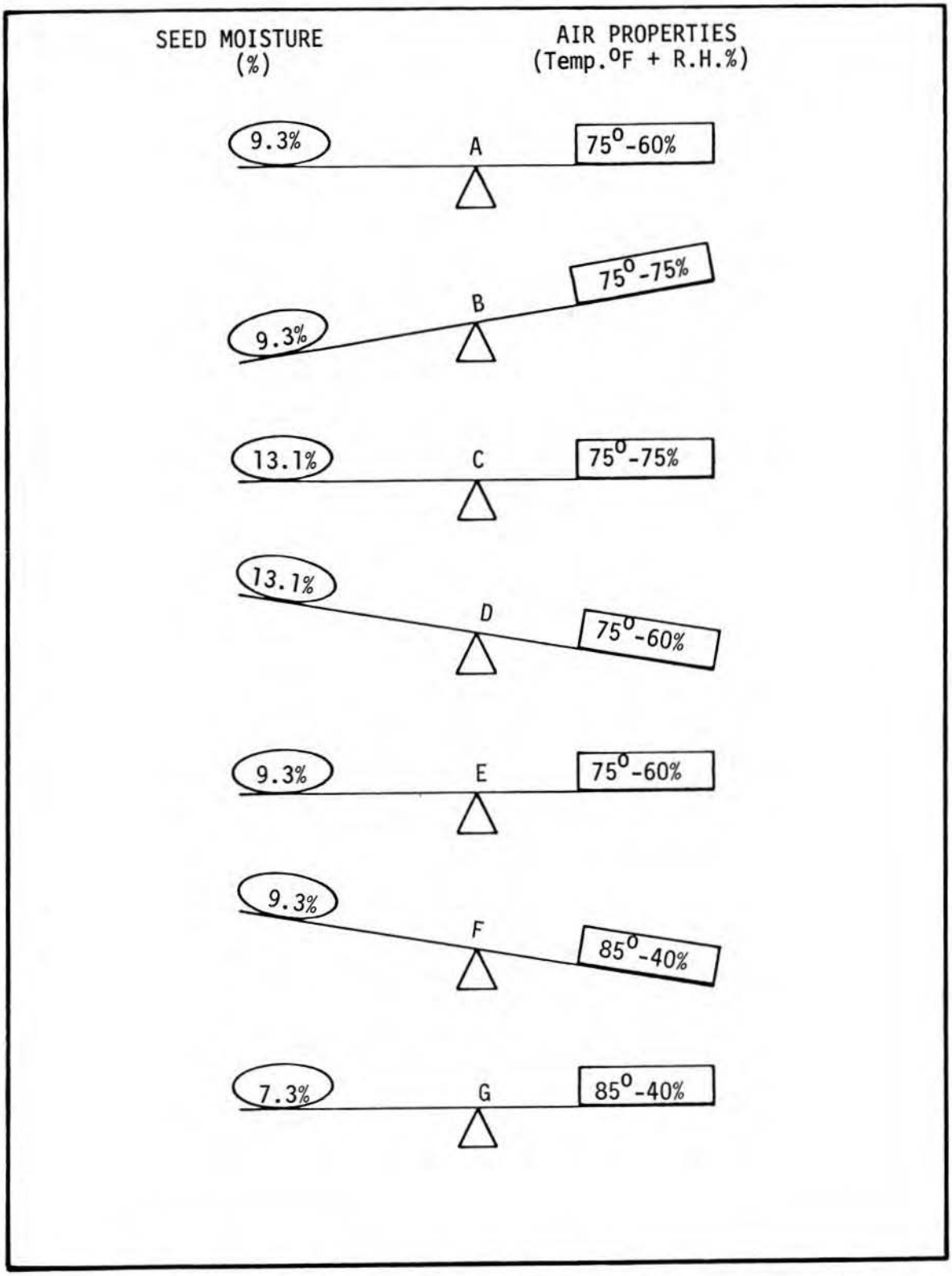


Figure 3. Seed moisture migration as influenced by moisture content of the seed in relation to the temperature and relative humidity of the air.

V.
SEEDS DRY FROM THE SURFACE TO THE INTERIOR

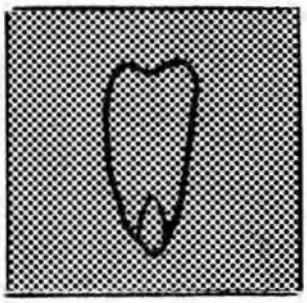
This fact can be demonstrated by looking at a schematic cross-section of a corn seed which permits us to visualize the water molecules in both the seed and the surrounding air (Figure 4). When the relative humidity of the air around the seed is first reduced the seed still has its original moisture content (Figure 4-B) but the amount of water at the seed's surface has been reduced. Now, recall basic seed fact IV; seeds are hygoscopic. Because the relative humidity of the air at the seed's surface has been reduced, the vapor pressure of the water in the interior of the seed is relatively higher. To re-establish the moisture equilibrium, the water molecules just under the seed's surface move to the surface to replace the water on the surface that has evaporated (Figure 4-C). Do not develop the impression that the water in the seed simply rushes to the surface. Because of the laws of physics, a moisture gradient is established from the surface to the center of the seed. If the lower relative humidity is maintained long enough the seed will once again come into equilibrium (Figure 4-D) at a lower moisture content.

The sixth seed face relates to one of the most serious economic problems that we face in the U.S. today - energy.

VI.
THE LOWER THE MOISTURE CONTENT OF A SEED THE GREATER THE AMOUNT OF ENERGY REQUIRED TO FURTHER REDUCE ITS MOISTURE CONTENT

In application this seed fact means that more energy (BTUs) are required to reduce the moisture content of seed from 15% to 13% than from 17% to 15%. This fact is true regardless of the energy source: gas, diesel, propane, wood, coal, etc.

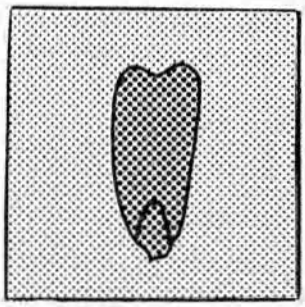
The moisture in seeds is present in two forms, free and bound. For our purposes, we can think of free water as the water molecules in the interspaces of the seed. This water reacts to heat energy in much the same manner as water on the surface of a lake. On the other hand, the bound water in a seed is part of the physical structure of the molecular and colloidal material in seed. A seed high in moisture has a greater percentage of free than bound water. As a seed dries, it gives up both free and bound water; however, because of the stronger attachment of the bound water, a greater percentage of free water is removed from the seed initially. As the ratio of free to bound water decreases, greater amounts of energy are required to break the physical bonds of the increasing percentage of the bound water which must be removed to reduce moisture content.



Seed Moisture 15%

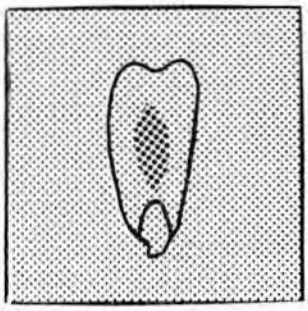
Relative Humidity 75%

Equilibrium



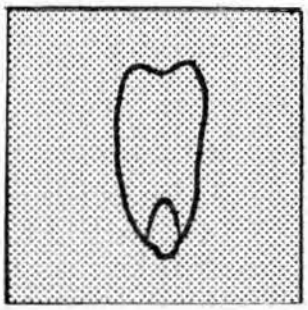
Seed Moisture 15%

Relative Humidity 75%



Seed Moisture 14%

Relative Humidity 55%



Seed Moisture 13%

Relative Humidity 55%

Equilibrium

Figure 4. How a seed dries.

VII.
SEED DETERIORATION IS NOT REVERSIBLE

All living things degenerate over time and die. The apparent sequence of seed deterioration is given in Figure 5. Air dry seed, contrary to most other living organisms, have neither the capability to replenish their energy supply nor to redistribute the stored foods which are located inside the seed. As a consequence, when any of the life sustaining processes in a seed are impaired or lost, they can not be repaired. Thus, the physiological quality of a seed, like a sky diver who has jumped from a plane without a parachute, will continously fall until it dies. How long the sky diver or a seed lives is dependent on how high they are when they start their fall.

The application of seed treatment chemicals or other treatments will not reverse the process of deterioration, although their proper application will permit the seed in a lot to express their maximum potential.

VIII.
MECHANICAL SEPARATION OF SEEDS FROM THEIR CONTAMINANTS IS POSSIBLE ONLY WHEN THERE IS A MECHANICALLY DETECTABLE DIFFERENCE IN AT LEAST ONE OF THEIR PHYSICAL CHARACTERISTICS

The physical characteristics used to separate good seeds from contaminating material are listed in Table 2. Some of the machines used to clean and up-grade seed utilize differences in two or more of these physical characteristics to make the desired separation.

Most of the problems encountered in making the desired mechanical separations arise from the fact that, although there is a visual and often a physically measurable difference between the good seed and the undesired material, these differences are not sufficiently large to be detected (measured) by the machine's separating action. This is true even when the operator is very proficient in equipment selection and adjustment and knowledgable concerning differences in physical characteristics of each component of the seed lot. Every processor knows that the good seeds in each lot vary in their physical characteristics. However, we seem prone to forget that the contaminating materials likewise differ in their physical characteristics.

IX.
MICRO-ORGANISMS ARE PRESENT ON ALL SEEDS

Not all micro-organisms will attack a live seed; however, we must remember that even the air surrounding the seed contains micro-organisms some of which, under the proper conditions, are capable of destroying the seed's value for planting. Most micro-organisms found on seeds are

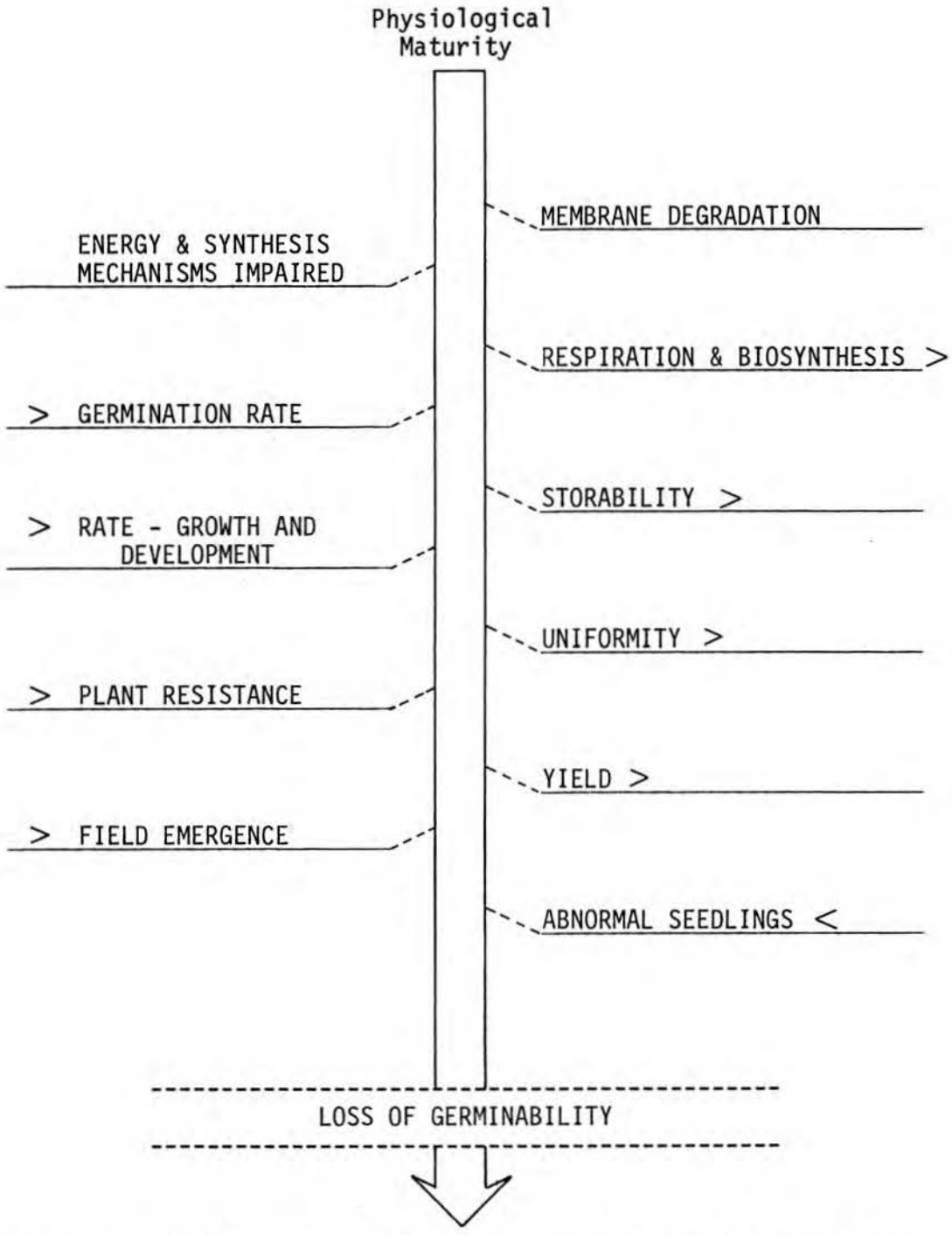


Figure 5. Possible sequence of changes in seed during deterioration. (after Delouche)

	PHYSICAL PROPERTY	MACHINE
1.	Gross Size	Air-Screen Cleaner (screen section)
2.	Length	Indented Cylinder, Disc Separator
3.	Width	Width & Thickness Separator
4.	Thickness	Width & Thickness Separator
5.	Weight	Gravity Table, Aspirator, Stoner, Air-Screen Cleaner (fan section)
6.	Surface Texture	Roll Mill, Magnetic Separator
7.	Shape	Spiral Separator, Roll Mill
8.	Color	Color Sorter

Table 2. Physical properties of seeds and their contaminants and the machines which utilize differences in these properties to make separations.

not of economic importance, but they are present. On the other hand, most of the micro-organisms which are carried inside a seed can be very destructive; loose smuts, pod and stem blight, etc. The application of fungicides in not always the solution.

It seems probable that in the not too distant future the results of a "seed health" test will be a labeling requirement, just as the germination test is today. In my opinion, this should not occur until the seed pathologists accurately determine the association between seed infection levels and crop performance. Seed health evaluation is the "newest" field of seed technology. Are you going to use it to your advantage?

X.
SEEDS MUST BE EXPOSED TO THE PROPER TEMPERATURE, MOISTURE AND OXYGEN CONDITIONS TO INITIATE AND MAINTAIN GERMINATION

Earlier, I implied that moisture and temperature could be a seed's worst enemies. That is true, until we want the seed to germinate and grow. For any seed to germinate, there must be an adequate supply of moisture and a favorable temperature. The oxygen requirement, while small in terms of volume, must be met because certain physiological processes of a germinating seed cannot continue in the absence of oxygen. Some seeds even require light to trigger germination, especially when they are fresh.

XI.
THE EMBRYO OF EVERY TRUE SEED IS FORMED FROM THE UNION OF A SPERM CELL FROM THE MALE PARENT AND AN EGG CELL FROM FEMALE PARENT

With the advent of the sexual revolution and more recently the birth of the so-called test tube baby, everyone from 3 to 93 is aware of this basic fact of life. Of importance to seedsmen is that this same union, between the male and female gametes, is the fundamental basis of the seed industry. Whether producing genetically pure seed, hybrid seed or eliminating unwanted outcrosses, seedsmen are directly affected by the results of this union since it determines the "genetics" of the seed produced. These gametes contain the "life" and life pattern that are passed from generation to generation.

In plants, unlike in animal reproduction, a second union, between a second male sperm cell and two other cells (polar nuclei) in the embryo is also required for the seed to be formed. It is the endosperm formed by the second union that provides food for the embryo's growth.

Since a seed is alive at its conception and alive during its development, why do people sometimes forget the twelfth seed fact?

XII.
A SEED MUST BE ALIVE TO BE OF VALUE FOR PLANTING

In reality, this fact is the total basis for the entire seed industry. If a seed is not alive it is not really a seed but a storage unit for carbohydrates, proteins and fats - a grain. I am continually surprised by the number of "successful" seedsmen who in one way or another follow production, processing or storage practices which ignore this fact. The technology is available to keep seeds alive for a hundred years. The technology is also available to kill any seed in a fraction of a second. Which technology is in use in your operations?

The next basic fact about seeds is:

XIII.
SEEDS REACH THEIR MAXIMUM POTENTIAL AT PHYSIOLOGICAL MATURITY

As depicted in Figure 6, which portrays the maturation and deterioration cycle of a seed as a reproductive unit, physiological maturity of seeds occurs when they attain their maximum dry weight, maximum level of viability and their highest physiological capacity. While it is true that some seeds enter a stage of dormancy shortly after attaining physiological maturity, the dormancy period is not a period of improvement, rather one of preservation of the status attained at physiological maturity.

Since the moisture content of seeds at physiological maturity ranges from 30 to 55% among the species the seed must further dry down before they can be mechanically harvested. It is during this post-maturation-pre-harvest period, referred to as the field weathering period, that the deteriorative phase of seed life sets in. Keep in mind that the seeds produced on any one plant, and certainly in any field, do not all reach physiological maturity at the same time, nor are they exposed to exactly the same environments or levels of insect and disease infestation. Thus, there is some variation in the physiological quality among the seeds of every lot.

From the above, another basic fact about seeds is derived:

XIV.
THE SEEDS THAT ARE ALIVE IN EACH LOT CAN DIFFER IN PHYSIOLOGICAL QUALITY

The term "Vigor", as applied to seeds, is very controversial in some segments of the seed industry. There is no question that within every seed lot and among seed lots there is variation in the physiological capacity of the seeds to reach certain levels of growth in a given time period and set of environmental conditions. However, to date

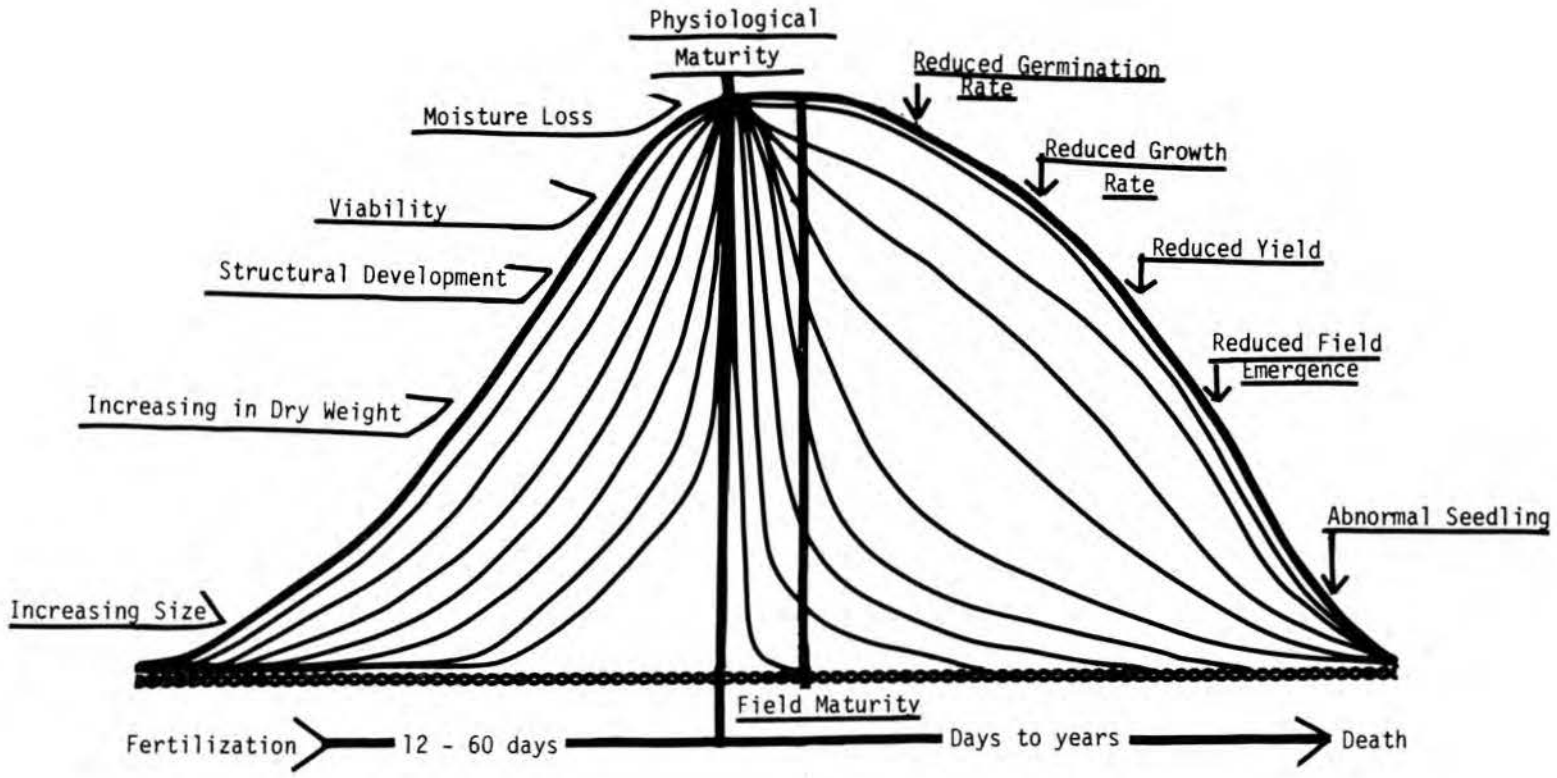


Figure 6. Life Cycle of a Seed

there is a wide variety of opinions concerning how to accurately measure these differences, and especially the "degree" of difference required to affect plant performance. Regardless of your own opinion concerning "vigor" do not ignore the basic fact that differences do exist in the physiological quality of seeds within and among seed lots.

In conclusion, there is one other basic fact about seeds which I believe each of us often overlook in our daily rush to earn a living. Most of you are aware that our seed tech group at MSU spends a great deal of time overseas working with technicians of developing countries to implement seed programs to supply at least a portion of their farmers with good seeds of improved varieties. The fact that we are sometimes housed in the best hotels and occasionally have a chance to see some interesting tourist attractions may give an impression just the reverse of that of the realities of our work.

Two illustrations may be useful in demonstrating the last of the seed facts. Talk with a person who stayed alive by eating the roots from the trees rather than eat the seed he had saved for planting. He knows that "without seed there is no future". Or, observe the look of despair on a young child's face, because for over 100 days the only thing she had to eat was a little gruel made from millet seed. You see, her father's grain bin is almost empty, and although superior varieties had been developed and tested, there was no seed industry to multiply and distribute the seed so that more grain could be produced.

Seriously consider these two illustrations, which are real to millions of people around the world, and you should take a little more pride in your contribution to the seed industry. Do this and I believe you will agree that the most basic fact about seeds is:

XV.
SEEDS ARE BASIC TO MAN'S SURVIVAL