A HISTORY OF SEED TREATMENT
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Introduction

Seed treatment is the principal method by which disease-free seed may be obtained. Seed treatment is intended to do two things: (1) to destroy disease-producing organisms on the seed and thus prevent seedling infection, and (2) to coat the seed with a fungicide that will protect it from decay-producing organisms in the soil. For a seed treatment to be satisfactory it has to be effective, yet, reasonably safe from seed injury in case of over dosage. It must also be economical, readily available, easily applied, chemically stable, and not overly poisonous or disagreeable to operators or corrosive to metal.

Seed treatment may be divided into three categories depending upon the nature and purpose of the treatment. They are designated here as follows:

1. **Seed Disinfection.** This refers to cases where treatment is directed toward eradication of the fungus which has infected the seed and is established within the seed coat or in more deep-seated tissues. The pathogen has penetrated, infected and thus has become established within the seed. When Jensen reasoned that heat might be more penetrating than chemical ions and less phytotoxic, he suggested for the first time the principle of seed disinfection.

2. **Seed Disinfestation.** When seed are contaminated on the surface by spores or other forms of pathogenic organisms, without being penetrated or infected, we then say that the seed are infested with the pathogen. Chemical dips, soaks, and fungicides, applied as a dust or slurry are eminently successful as seed disinfestants. The early success of copper sulfate against bunt was as a disinfestant.

3. **Seed Protection.** Seed protection is based on the principle of surrounding the seed and the young seedling with a fungicide which will prevent infection and damage by soil organisms, to which the plant is particularly vulnerable during its early period of growth.

Seed protection refers to the treatment of seed, usually with chemicals, neither to kill organisms on the surface of the seed nor to kill organisms which have penetrated beneath the surface of the seed, although there is frequently a combination of killing organisms on the surface and seed protection. Rather, this type of seed treatment is designed to protect the seed and the young seedling from organisms in the soil which might otherwise cause decay of the seed before germination. The first successful use of a seed protectant was by Thaxter in connection with onion smut. He had determined that the smut spores infest the soil and that the seedling is susceptible for a short time after

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germination of the seed. He reasoned that a chemical in close proximity to the seed in the soil might protect the young seedling during this short susceptible period. Chemicals used with this objective are known as "seed protectants."

A given fungicidal treatment may serve in one or more of the categories of seed treatment. Practically all effective seed-treatment materials are disinfectants. Many are also disinfectants and protectants. The formaldehyde and hot-water treatments, however, are disinfectants and disinfestants but are not seed protectants. In fact, seeds that have been treated with formaldehyde or hot water frequently are attacked by soil-borne fungi more severely than are untreated seeds and therefore should be treated with a protectant before planting.

Why Treat Seeds

The application of protective fungicides and insecticides to seed has become an important business to seed treater operators and to farmers. The reason, of course, is that no other agricultural practice produces such vast benefits for a few cents per acre.

1. **Treated Seed is Recommended.** The United States Department of Agriculture and State Experiment Stations recommend that most kinds of seed be treated to destroy seedborne fungi, check soil-borne fungi or insects, establish stronger stands, and produce bigger yields of better quality crops.

2. **Use of Treated Seed is Profitable.** As a commercial treater or seedsman you make money in charges for treating, but the most important reason is the result of the seed in the field. Elevators, ginners, or peanut-shelling plant operators find that treated seed assures them of a better quality crop to market. Seedsmen satisfy their customers with treated seed that will generally assure a better crop.

3. **Treated Seed is Easier to Sell.** Farmers do want treating service. In every case where high quality service has been offered and advertised in areas of good potential the response has been extremely good. Many plants have found it necessary to operate around the clock or turn away customers in the busiest seasons.

Importance of Seed Treatment

In the past several years it has become evident that each new variety of a crop released will sooner or later have a new disease to plague it. For the diseases that are seedborne, this build-up may be prevented or delayed by seed treatment, thus extending the useful life of a variety.

Weathered grain usually carries molds which reduce germination and weaken seedlings even though they produce no specific disease. Seed treatment eliminates these molds, giving better stands and stronger seedlings. Poor lots of seed are likely to show greatest benefits.

Besides controlling diseases carried on the seeds, the proper chemicals have a "residual" or carry-over action, especially on some crop seeds (corn).
This means that the chemical also protects the seeds and very young seedlings against soil organisms which may be damaging where weather conditions are not favorable for plant growth.

Seed treatment does not have to pay off very often to repay the small expense involved. The response to seed treatment varies according to the crop variety, the vitality of your seed, the season, the diseases present on your seed and in your soil, and the type of seed treatment you choose. Therefore, it is impossible to predict exactly how much increase in stand or yield you can expect. But year in and year out, it will pay you to have every bushel of your seed treated with one of the materials recommended by your agricultural college.

When to Treat Seed

1. **When Seed is Damaged.** Seed may be injured by disease, weather, harvesting, or improper storage and handling. Seed treatment will be especially profitable in these instances. Unless this damaged seed is protected by proper seed treatment, it lacks the strength and vitality to fight off the diseases which may be found on the seed or in the soil.

2. **When the Soil is Cold and Damp.** Unfavorable germinating conditions for seed may be favorable germinating conditions for disease or fungus spores. If the seed are protected by a good seed treatment, they are capable of resisting the attack of these enemies until soil conditions become favorable for the seed to begin growth.

3. **When the Soil is Dry.** Seed fail to germinate and continue normal growth in very dry soil. While these seed lie in the dry soil awaiting moisture, some disease spores are able to thrive under this dry condition and are able to attack and damage the seed. Therefore, seed treatment is beneficial under dry conditions.

4. **Under Favorable Conditions.** Even with sound healthy seed and favorable growing conditions, seed treatment is still beneficial. Seed treatment is good insurance and should be practiced in order to cover any conditions which may arise when planting seed.

**Historical**

Seed treatment for the prevention of plant diseases, whether accidental or experimental, dates many years back. At first, in the absence of definite knowledge concerning the nature of plant diseases, preventive measures were of a more or less superstitious nature, such as sowing in the dark of the moon, or sticking branches of laurel in the grain fields "to draw the blighting vapors to them."

Powdery mildews and bunt of wheat are ancient and honorable diseases, presumably because the fungus and its effects are quite prominent. Hence, fungicides for these two diseases were discovered first. The earliest reference so far found to a fungicide is the reference of Pliny to Democritus who reported
around 470 B.C. that amurca of olives should be sprinkled on plants to prevent attacks by blight. Amurca of olives is the press cake left after making olive oil. Martin and E. S. Salmon rediscovered some 2400 years later the fungicidal properties of vegetable oils as fungicides for powdery mildew. Here we find an organic compound as the first fungicide.

Cato in 200 B.C. according to Mason advocated for the vine-fretter (whatever that is!) a fumigation of the plant with a smoke from amurca of olives, sulfur, and bitumen. This shows an early use of sulfur and also a coal by-product -- a substance that was to produce hundreds of fungicides and bactericides by 1945.

Seed treatment for wheat mildew (Could it have been smut?) was recommended by Pliny. Pliny proposed that the seed be soaked in wine plus a mixture of bruised cypress leaves. If Pliny really referred to wheat smut he was several hundred years ahead of Tillet and Prevost in using seed treatments.

Wheat smut has fathered many new fungicides. About 1637, R. Remmant in England suggested an unnamed seed treatment. The treatment was probably sodium chloride (common salt) because at this early date (some say 1650 and some 1670) a sailing vessel loaded with wheat encountered a storm and ran aground near Bristol, England, and the salvaged grain was planted and produced a crop that was relatively free of the dreaded smut disease.

When, where, and how the grain smuts originated we do not know but we do know that they have existed for several hundred years for we find reports of heavy losses from smut in England in the 17th century. Probably one farmer noticed that the wheat produced by the salvaged seed was fairly free from smut, while nearby fields grown from normal seed were heavily smutted. Quite probably he resolved to try soaking his seed wheat in sea water before planting. Whether he followed good experimental practice or not, we do not know but we do know he must have succeeded in proving to his fellow farmers that soaking seed wheat in sea water or sprinkling it with brine helped to grow cleaner crops of wheat. The writings of the next century indicate that the brining of seed wheat was a common practice.

It was not until almost 100 years after the sailing vessel met with disaster that Schulthuss of Germany suggested the use of blue vitriol in place of salt. Thus, for an entire century, men treated seed wheat with salt water before anyone had the curiosity to search for a better way. It must be remembered also that no one knew why treating seed wheat helped to reduce smut. In the case of severely smutted wheat they undoubtedly noticed that the seed coat was darkened with the black powder from the smutty heads, but it did not occur to anyone to connect this black powder on the seed with the smutty crop which such seed produced.

At the beginning of the 19th century, Prevost in France observed the germination of the smut spores in water and found that a small amount of copper sulfate in the water prevented their germination. This observation really
furnished the key to the problem. It was not, however, until 1853 that Anton de Bary, a German botanist, proved that smut was caused by a parasitic fungus living on and at the expense of the wheat plant.

This fundamental discovery by de Bary facilitated the search for more effective means of controlling smut. Scientific workers now understood what was needed to control smut, and why. They could describe the properties a good seed treatment should possess. It must be a chemical or other agent highly toxic to smut spores and yet non-injurious to the seed. Other desirable features were that the method of applying the treatment must be simple, practical and relatively inexpensive.

Other new fungicides were slowly to be acquired, some to be kept, most to be discarded, some to be rediscovered.

We have only mentioned sulfur and copper. They are so commonly in use by civilization that their fungicidal properties could hardly have been missed. Both materials seem to have been discovered and rediscovered several times. Homer mentioned sulfur in about 1000 B.C. Lime soon showed up in the sulfur treatment as it did in copper treatments.

Copper sulfate probably was the first standard fungicide used, and its intelligent application dates back in 1761. It did not come into general use, however, until a century later when Kuhn's experiments established a basis for making definite recommendations regarding its use. Later investigators made other recommendations concerning the use of copper sulfate, the most important of which was that after treatment the grain be dipped in lime-water to prevent injury.

Another seed treatment method of early origin still in use is the hot-water treatment developed by Jensen in 1887. It still is the only known treatment that will kill certain deep-seated fungi like that causing the loose smut of wheat which are not controlled by surface disinfectants.

Formaldehyde was first advocated as a seed treatment in Germany by Geuther in 1895 and in the United States by Bolly in 1897. It still ranks among the foremost liquid treatments because of its cheapness and its general effectiveness, in spite of its tendency to injure the seed.

Copper sulfate and formaldehyde continued as the outstanding seed treatment materials up to about 1914. Mercuric chloride and other materials were tried but not generally recommended. In 1912 organic mercury compounds were introduced as seed disinfectants in Germany. In early experiments, Riehm, along with others found them effective in cereal-disease control. Among the first of these to be marketed was a chlorophenol mercury compound known as "Uspulum", placed on the market in Germany about 1915. Similar compounds under the trade names "Chlorophol" and "Semesan" soon appeared in the United States.

Dust disinfectants first came into prominence as a result of the work of
Darnell Smith with copper carbonate in Australia in 1915. Due to certain apparent advantages, this form of seed treatment met with immediate popularity and started the era of dust fungicides. At first the use of dust fungicides was restricted to the control of diseases due to surface-borne organisms such as bunt of wheat, but experiments soon showed that the more deep-coated organisms, like those causing the smuts of oats and covered smut and stripe of barley, could be reached by certain dust fungicides. From then on liquid fungicides which were applied as a dip lost favor and dust fungicides gained in popularity, not only for treating cereal seeds but also seeds of other crops.

This dry treatment which saved so much time and trouble soon became very popular, and by 1925 one-tenth of all the wheat sown in the United States was treated with the dry copper carbonate powder for the control of the bunt. Attempts were then made to get other seed-disinfectants into powder form. Even the gas formaldehyde was tried. It was absorbed in chalk or talc powder for churning with the seed, but this was not very successful.

The greater interest in and acceptance of seed treatment immediately following World War II is probably due to a number of factors. One was the tremendous increase in the use of hybrid seed corn. In 1936 only 3.1 percent of the total corn acreage in the United States was planted to hybrid seed. In 1946 this had increased to 67.5 percent. Since hybrid seed corn is almost invariably treated before planting, this change did much to popularize seed treatment, especially the organic non-mercurials.

With the advent of the second World War and the urgent need for greater food production, seed treatment was advocated to increase yields by eliminating losses due to plant diseases. Extensive cooperative experiments were undertaken by State and Federal agencies to test different fungicides on the market. The tests provided the basis for crop recommendations and helped eliminate worthless seed treatment material from the market.

Along with this renewed interest in seed treatment materials, interests become directed to new and better methods of applying the recently developed materials. Soon the dust application gave way to the slurry method. This method involves the use of a small quantity of water which is employed to distribute the seed protectant over the surface of the seed and not to soak the seed. The slurry method of applying fungicides became very popular, not because of the ease of application and handling, but because of the relative safe method of applying a seed treatment without causing discomfort or ill effects to workers as had been experienced during dust applications.

Still a later development in the method of applying a seed treatment is the liquid or "quick-wet" method. This method is particularly advantageous when applying the organic mercurials most of which can be formulated as liquids. A concentrated solution of a volatile fungicide is applied to the seed and
thoroughly mixed with it. The dosage may range from one-half to five fluid ounces to a bushel and adds less than one percent of moisture to the seed.

Paralleling the development of the different forms of fungicides has been the development and improvement of equipment for the application of the treatment. Seed treaters used for applying the dust formulations gave way to slurry treaters. Since the most widely used organic mercurials are liquids and the non-mercurials are slurries, the aim of the equipment manufacturers at the present time is to build seed treaters which will treat seed satisfactorily with both the slurry and liquid formulations.

Some of the latest developments in seed treatment consist of treating the seed with hormones. Application of plant hormones or growth promoting materials on seeds indicates that our present knowledge concerning their use in seed treatment needs to be greatly increased before definite recommendations can be made.

The subject of synergism and antagonism between different fungicides and insecticides has received considerable study recently. As early as 1946, experiments were started to study the effect of mixing insecticides with fungicides and then applying this to seed. From the results observed of the few cases tried, information suggests that caution must be used in mixing such materials in farm practice and further work on fungicide-insecticide combinations must be done before large scale recommendations. However, success has been made in treating seed of beans and corn with lindane, aldrin, dieldrin, methoxychlor, or chlorodane in combination with a good non-mercurial fungicide such as thiram or captan. These insecticides cannot be used on seed without seriously injuring it unless a fungicide is first applied to the seed or incorporated with the insecticide.

With the extensive amount of research being conducted by commercial firms and also by State and Federal agencies, on the development of seed disinfectants, disinfestants, and seed protectants for the control of plant diseases, the composition of fungicides will continue to change. Materials not being widely used will either be further improved or will be replaced by other materials that will be more effective, cheaper, less harmful to the seed, or more acceptable in other respects. The constant aim will be to find or develop seed treatments that are highly toxic to parasitic fungi and bacteria but relatively harmless to the seeds and plants which are parasitized by them. Modern science and industry have made great progress in the development of some rather satisfactory weapons in our war with the pathogens and injurious insects. However, with the possibility of systemic fungicides, antibiotics, and other materials yet undiscovered, we hope that we can advance to a still stronger position in this continuing struggle.
Bibliography


