Understanding Seed Handling For Germination

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PREFACE

This paper is one of a series published by Volunteers in Technical Assistance to provide an introduction to specific state-of-the-art technologies of interest to people in developing countries. The papers are intended to be used as guidelines to help people choose technologies that are suitable to their situations. They are not intended to provide construction or implementation details. People are urged to contact VITA or a similar organization for further information and technical assistance if they find that a particular technology seems to meet their needs.

The papers in the series were written, reviewed, and illustrated almost entirely by VITA Volunteer technical experts on a purely voluntary basis. Some 500 volunteers were involved in the production of the first 100 titles issued, contributing approximately 5,000 hours of their time. VITA staff included Gerald Schatz as editor, Suzanne Brooks handling typesetting and layout, and Margaret Crouch as project manager.

The authors of this paper, VITA Volunteer Dr. James Young and Raymond Evans are range scientists with the U.S. Department of Agriculture-Agricultural Research Service in Reno, Nevada. Author Jerry Budy , is an Assistant Professor of Forestry at the University of Nevada in Reno. The reviewers are also VITA volunteers. Dr. Charles Suggs is a professor with the Department of Biology and Engineering at the North Carolina State University in Raleigh. Dr. Suggs has worked in India, Australia, Europe and South America. Reviewer Lawrence Yarger is a horticulturalist working with Food for the Hungry in Scottsdale, Arizona. He has worked in Thailand and Latin America.

VITA is a private, nonprofit organization that supports people working on technical problems in developing countries. VITA offers information and assistance aimed at helping individuals and groups to select and implement technologies appropriate to their situations. VITA maintains an international Inquiry Service, a specialized documentation centers, and a computerized roster of volunteer technical consultants; manages long-term field projects; and publishes a variety of technical manuals and papers.

I. INTRODUCTION

Local seed production in developing countries can have important benefits. It can help to reduce dependence on seed and food imports and so increase agricultural production. It can also provide commodities for export (flowers, specialty plants, etc.). It can improve income and well-being of rural populations, enhance self-sufficiency, and stimulate employment.

Depending on the plant and the market, seed may be produced for direct planting, as in typical raising of cereals, or it may be produced for germination and transplantation from seedbeds, as is widely practiced in raising trees, commercial flowers, and some vegetables. These applications have certain. requirements in common, including careful harvesting, handling, and storage, and certain seed tests are widely applicable. Care and appreciation of the seed resource can reduce postharvest loss substantially.

This report notes general considerations in seed harvesting, handling, and storage, and it focuses attention on methods to enhance germination for seeds started in seedbeds. The paper is intended to be especially useful for persons interested in setting up a small business that produces seed for sale or for use in a commercial nursery.

Successful germination of seeds starts with proper collection or harvesting of the seeds. Both the timing of collection and the handling of the freshly harvested seeds are important.

II. BASIC PRINCIPLES

TIMING THE COLLECTION OF SEEDS

If seeds are collected too early, yields will be lowered; immature seeds can be poor germinators. If collection is delayed, seeds may be dispersed and lost on the ground.

Many crop species have been selected for determinate-type flowering, in which all the fruits on a given plant mature at close to the same time. Unless the seed pods of determinate species are collected shortly before maturity, there is the danger of the pods suddenly splitting open and allowing the seed to be lost. Many wild plant species have indeterminate-type of flowering--flowering continues for prolonged periods. This means that some seeds are ripe and falling from the plant at the same time blooming is still occurring at other locations on the same plant. It is difficult to avoid collecting immature seeds in this situation or to prevent mature seed from falling from the plant.

Slightly immature seeds are not necessarily poor germinators, but they may require extensive drying before they can be stored safely. The influence of seed maturity has to be determined through germination trials. To conduct meaningful trials it is necessary to label the seed collections with some detail of the stage of plant development and seed maturity, to record where the seedlot was collected, and to maintain the identity of the seedlot through germination trials.

HANDLING FRESHLY HARVESTED SEEDS

A seed is a living organism in a resting stage. It is alive and for germination must be kept alive. Freshly harvested seeds have too high a moisture content for safe storage. The moisture content of the seed must be reduced, often by artificial means, to permit storage without loss of viability. The relative humidity of the air at a given temperature is directly related to the moisture content of the seed. For safe storage the moisture content of the seed should be 14 percent or less.

In the humid tropics it may be very difficult to obtain a moisture content that permits seed storage without using artificially heated air for drying. In most temperate to arid environments, it is possible to reach a satisfactory moisture content without artificial drying. Artificial drying at high temperatures or drying in direct sunlight are not desirable and can be especially harmful to seed viability.

For freshly harvested seeds to reach a moisture equilibrium with the environment they must be stored in such a manner to allow for free aeration. If the seed heads cannot be hung or tied on strings, baskets or uncoated paper or mesh bags make good storage containers for initial drying. Very shallow trays can also be used. Never use plastic bags for storage of freshly harvested seeds. Seed heads or mesh bags should be hung on racks if possible and spaced apart to allow good air circulation.

Excessive moisture in freshly harvested seeds is often caused by plant parts and other trash that accidentally contaminate the seed collection during the harvesting period. Screening freshly harvested seeds to remove high moisture content trash will reduce drying time.

Freshly harvested fruits require prompt treatment to remove the fleshy material to avoid spoilage or mummification of the fruits. Fleshy fruits are cleaned in macerators. The macerator shreds and dislodges the fleshy portion of the fruit so it can be separated from the seed. Separation is usually done by flotation: The macerated fruit seed mixture is dumped into a container into which water is running; the heavy seeds sink, and the shredded fruit floats over the lip of the container. Drying is required before storage of the seeds.

Seeds are recovered from some fleshy fruits by allowing the fruits to ferment. Tomatoes, cucumbers, and melons are among the fruits that may be treated this way. After the fruit portion is dissolved by the fermentation process the hard seeds are recovered.

The seeds of species collected from marshes and wetlands often require special handling. The technique used depends on the species involved. Often it is necessary to keep the seeds in a cool, wet environment, or actually stored in water, to avoid loss of viability.

Seed Cleaning

Generally, the faster that seeds are cleaned and placed in storage after they reach moisture equilibrium, the less chance there is of predation from birds or small mammals or contamination from insects.

Avoid rough handling of seeds during cleaning. Remember that the seeds are alive, and the embryo can be very fragile. Never use a hammer mill in seed processing unless you have first determined by careful testing that seed-viability is not being adversely affected by the process.

Proper seed cleaning makes subsequent handling of the seeds in the germination process much simpler. If the seedlot contains trash, weed seeds, empty or obviously immature seeds, much time will be wasted sorting the material to find germinable seeds.

Seed Storage

To avoid problems with storage insects start with clean, insect-free storage conditions. Do not introduce pests with the seeds to be stored. Most seed storage insects are of tropical origin. Cool storage conditions such as in the shade of the house or underground lessen the chances of insect problems.

The key to seed storage is maintaining proper moisture conditions so that the seeds remain alive but ungerminated. Remember that the amount of water that the storage atmosphere will hold as a vapor is directly related to temperature. The warmer the air, the more moisture it will hold. When the temperature drops relative humidity will increase. Droplets of water may then condense and form in storage containers.

Storage in paper or mesh bags in a cool, dry location is satisfactory for most seeds. Once the seeds have reached moisture equilibrium, storage in glass jars or plastic boxes is possible to avoid insect contamination. Some seeds can be stored easily in small lots, but suffer losses in viability when larger quantities of seeds are stored together. Some seeds have short storage lives, and seed stocks of these species must be renewed annually.

III. GERMINATION

GERMINATION TESTING

There are two common determinations that are made from seed tests: viability and germinability. Viability simply means that the seed is alive. It does not indicate that the seed will germinate. Viability tests may be as simple as cutting a seed with a knife blade to determine if an embryo is present. More complex viability tests involve the use of a tetrazolium TZ test. After the proper sectioning and preparation of the seed, this chemical helps certain enzymes remove the hydrogen from the seed during the respiration process in viable seeds. Essentially, respiring or living tissue in the seeds is shown by a red color change.

That the seeds contain living tissue does not necessarily mean the embryo will germinate. For seeds of the major crop species, standards have been developed that relate the tetrazolium reaction to potential germination. These standards have not been developed for the seeds of most wildland species.

Germinability is a much more meaningful factor for individuals interested in propagating plants from seeds. To obtain an estimate of germinability, the seeds must be subjected to a germination test. The Association of Official Seed Analysts (AOSA), in Boise, Idaho, prescribes rules for testing seeds of specific plants in the United States. There are corresponding international organizations for seed testing. Unfortunately, for the seeds of most wildland species, no standard germination tests exist. The AOSA has draft standards for about 100 wildland species. Until these standards are accepted and/or developed for the seeds of important wildland species, germination figures as given on their seed tags are meaningless.

AFTER-RIPENING

The seeds of many species will not germinate immediately after they are harvested. They must pass through a period of dormancy before germinating. This dormancy requirement varies with the species and allows for certain physiological changes to occur within the seed that make it capable of germination. This is referred to as after-ripening and has been attributed to immature embryos requiring post-harvest time to mature.

A variant of this type of dormancy is called temperature-dependent after-ripening. In this type, seeds will not germinate at one incubation temperature (usually moderate to high incubation temperature) but will germinate at other temperatures (usually cold incubation temperatures). Other variations include responses to light, stratification, alternating temperatures, leaching of growth inhibitors, and other conditions. As a practical matter, the after-ripening requirement means the farmer has to wait to obtain germination with the seeds of certain species.

HARD COAT SEEDS

If seeds do not germinate soon or after a reasonable after-ripening period, the first germination factor to check is whether the seeds take up water. This check can be made by pressing the seed with a thumbnail or by cutting. If the interior of the seed appears chalky and hard, water has not been imbibed through the seed coat. Seeds that have imbibed water should be soft and easily squashed with the thumb. Seeds with coats that do not freely allow the passage of either water or oxygen are termed "hard seeds."

SCARIFICATION

To break the hard seed coats some form of scarification is required to make the seed coat permeable to water. This scarification can be accomplished with mechanical, thermal, or chemical treatments. If the seeds are large enough, scarification may be accomplished by filing a notch in the coat or clipping so as not to injure the embryo. Smaller seeds can be mechanically scarified by mechanically abrading them in some manner. This may be as simple as rubbing the seeds between sheets of sandpaper.

Mechanical scarifiers have been developed, such as those with rotating drums lined with an abrasive material in which the seeds are tumbled. Hammer mills may be used (with care), and the clearance between the concave bars in threshing machines can be set to just crack the seeds of legumes to obtain increased germinability. Any mechanical scarification that increases germinability results in decreased viability. In other words, you pay a price: the mechanical process that gets some seeds to germinate, fatally injures other seeds. Great care must be taken not to injure seeds excessively with these treatments.

Thermal scarification is obtained by dropping seeds into boiling water and then allowing the water to cool. Such treatment may have many other influences, such as thermal shock to the embryo or leaching soluble inhibitors. In areas that have freezing winter temperatures, thermal cracking of seed coats can also be obtained by fall seeding at shallow depths.

One chemical method of scarification is to use concentrated sulfuric acid to remove hard seed coats. This is a very tricky treatment, with many side effects. The duration of treatment has to be determined for individual seedlots. Heating from the acid reaction along with rinse water and the resulting hydrolysis of the seed tissue may induce germination rather than simply increasing the intake of water as intended.

Always try to control the temperature of the acid-treated seeds in a water bath, rinse a small amount of acid and seed in a large volume of water, and use a neutralizing solution after the treatment.

STIMULATING THE GERMINATION OF SEEDS

A seed's after-ripening time cannot be shortened, but the germination of seeds following the after-ripening period may be stimulated by any of a variety of methods.

Stratification

Seeds that imbibe water but fail to germinate are good candidates for stratification--placing of seeds in a wet environment at temperatures that normally are not conducive to germination. Such treatments are termed cool-moist stratification. The duration of stratification requirements can range from a few days to many months. For prolonged stratification, a substrate must be furnished to retain moisture. Peat is often used, but other common materials include sand and vermiculite.

Naked stratification has proven effective for seeds of some species of conifers. This is accomplished by soaking the seeds overnight in water and then placing the damp seeds in plastic bags that are sealed for the duration of the stratification.

Seeds of other species require specific stratification temperatures. Their seeds are very difficult to germinate without prolonged experimentation.

Nitrogen

The most influential factor in enhancing germinations of seeds is the supply of nitrogen, usually in the form of potassium nitrate ([KNO.sub.3]).

In the field or nursery bed, lush growth in spring or after the rains may be associated with the availability of nitrogen in the seedbed. Farmers or nursery operators should have their soil or growing medium tested for nitrogen content if possible. Nitrogen fertilizer can be added if necessary.

Gibberellic Acid

Scientists don't know exactly how gibberellic acid, a growth regulator, works in seed germination, but they do know that very low concentrations of it can greatly enhance germination. Concentrations of from 1 to 250 parts per million (ppm) are commonly used to improve germination. Combinations of gibberellic acid and potassium nitrate are often more effective than either material alone. These materials can be obtained from chemical suppliers. The potassium nitrate is more easily obtained than gibberellin.

Good measuring equipment is needed for preparing the minute concentrations of gibberellic acid. A solution with a concentration of 1 ppm of gibberellic acid consists of 0.001 grams of gibberellic acid dissolved in 1,000 milliliters (ml) of water. Gibberellic acid is sold as a 10-percent active-ingredient preparation, which makes the weighing simpler. One alternative is to prepare higher concentrations than needed and dilute to the desired concentration. For example, 1,000 ppm would be 1g in 1,000ml. It is best not to mix too large a batch at once, however, for gibberellic acid is relatively expensive and breaks down very rapidly at warm temperatures.

Hydrogen Peroxide

Germination of the seeds of several species, especially members of the rose family, is enhanced by soaking the seeds in hydrogen peroxide solutions. Dramatic germination enhancement has been obtained with seeds of bitterbrush (Purshia tridentata) and curl-leaf mountain mahogany (Cercocarpus ledifolius). A wide range of concentrations from 1 to 30 percent is effective. Generally, the higher the concentration, the shorter the soaking time, but the greater the risk of damaging the seed. Hydrogen peroxide is a very reactive chemical. Concentrations greater than 3 percent are particularly dangerous to handle. Hydrogen peroxide, however, has an advantage in that it is generally available and inexpensive.

Other Chemicals

Many other chemicals have been used to enhance germination. These include various sulphydryl and ethylene-producing compounds.

Light

Many seeds are sensitive to light during germination. Both light intensity (candlepower) and light quality (color or wave length) can influence germination. The light intensity requirement varies with the type of seed from a few foot candles, such as that from moonlight, to strong daylight. Germination is enhanced or inhibited by the color or wave lengths of light. Orange to red wave lengths (660-700 nanometers) stimulate germination while far red or infra-red (700 or more nanometers) inhibits germination. The impact of light rays on seed is also affected by other factors such as the age of the seed, temperature, and chemicals present in the germination medium. Cool-white fluorescent light enhances germination, and incandescent light should be avoided. Seeds that require light for germination have to be placed virtually on the surface of the seedbed. The seeds should be pressed into the seedbed for optimum moisture transfer.

SEEDBED REQUIREMENTS

Seeds must absorb moisture from the germination medium faster than they lose it to the atmosphere. In a well-firmed seedbed, optimum germination conditions can occur with proper water management. Planting small seeds on the surface of a firmed seedbed and covering them lightly with fine vermiculite can produce an ideal germination environment. Moisture loss can be reduced by shading the seedbed with large leaves or, if excess temperatures are not generated, by covering with plastic film. These should be removed after germination occurs to give the plants light or, in the case of clear plastic, to prevent temperature build up.

Seeds with low germination percentages can be established satisfactorily if a sufficient number of seeds are planted in a well-prepared seedbed.

III. SUMMARY

Seed production can contribute substantially to local and national rural economies. It depends more on care than on investment, and the equipment required may be improvised easily. Simple seed dryers and storage facilities, for examples, are illustrated in numerous publications worldwide. Like any seed-production industry, seed handling for germination and transplantation requires proper timing and care in harvest and storage, to reduce postharvest losses and to realize the greater value from seed crops. Germination of seeds can be stimulated by special treatments, some of which use chemicals that may be relatively expensive but are used in very small quantitites. These techniques are well worth considering if sufficient markets for the seed are identified to make them cost effective.

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