Oregon State University have developed a microscopic inspection station, as well as a vibrator-separator to help purity analysts in making their separations. This type of equipment is used in several North American seed laboratories.

NOXIOUS WEED SEED EXAMINATIONS

Each state has established an official list of noxious weed seeds. In general, the plants from these seeds are particularly troublesome and objectionable. Such lists are a part of the state seed law (or regulation) and are usually defined in two categories, *primary* (or *prohibited*) and *secondary* (or *restricted*) noxious weed seeds. Sale of seed lots containing primary (or prohibited) noxious weed seeds is prohibited), while the sale of lots containing secondary (or restricted) noxious weed seeds is permitted, but their number per pound (of crop seed) is limited. Since each state has its own seed law, the weed seeds listed as noxious are not necessarily the same from state to state.

The noxious weed seed examination is an attempt to provide special information about noxious weed seed content of seed lots. Because of the limited occurrence of noxious weed seeds, a large working sample is used for the noxious weed seed examination-often as much as 500 grams for large-seeded types down to 2.5 grams for small-seeded types. The occurrence of noxious weed seeds in the United States is reported in number of seeds per pound or ounce. Since state seed laws and noxious weed seed lists vary among states, the results of this examination may be reported for only one state, or it may be reported for two or more states. Crop seeds transported in interstate commerce should have an "all-state" noxious weed seed examination.

GERMINATION TESTING

Probably the single most convincing and acceptable index of seed quality is the ability to germinate. Seeds are tested for germination because a seed lot is composed of a population of individual seed units, each possessing its own distinct capability to grow and produce a mature plant. A seed germination test is an analytical procedure to evaluate seed viability and germination under standardized (favorable) conditions. It enables a seed vendor to determine and compare the quality of a seed lot before it is marketed to the consumer. Furthermore, the percent germination can be used to determine the planting value of a seed lot, its storage potential, and labeling information required to provide for standardized marketing of seed lots. Thus, germination testing is perhaps the single most important function of a seed testing laboratory. Since the process of seed germination is covered in Chapter 5, this discussion will cover only the laboratory techniques used for performing the analysis.

Procedures for Germination Testing

The germination test is ordinarily performed on the pure seed of the crop kinds that constitute 5% (or more) of the sample after all inert matter and other crop and weed seeds are removed. Each pure seed kind is germinated and reported separately. A minimum sample of 400 seeds is recommended for a statistically dependable germination test. These are usually planted in four replicates of 100 seeds each, although various other arrangements are sometimes used (Figure 15.6). Each replicate is evaluated separately, but the official germination report is an

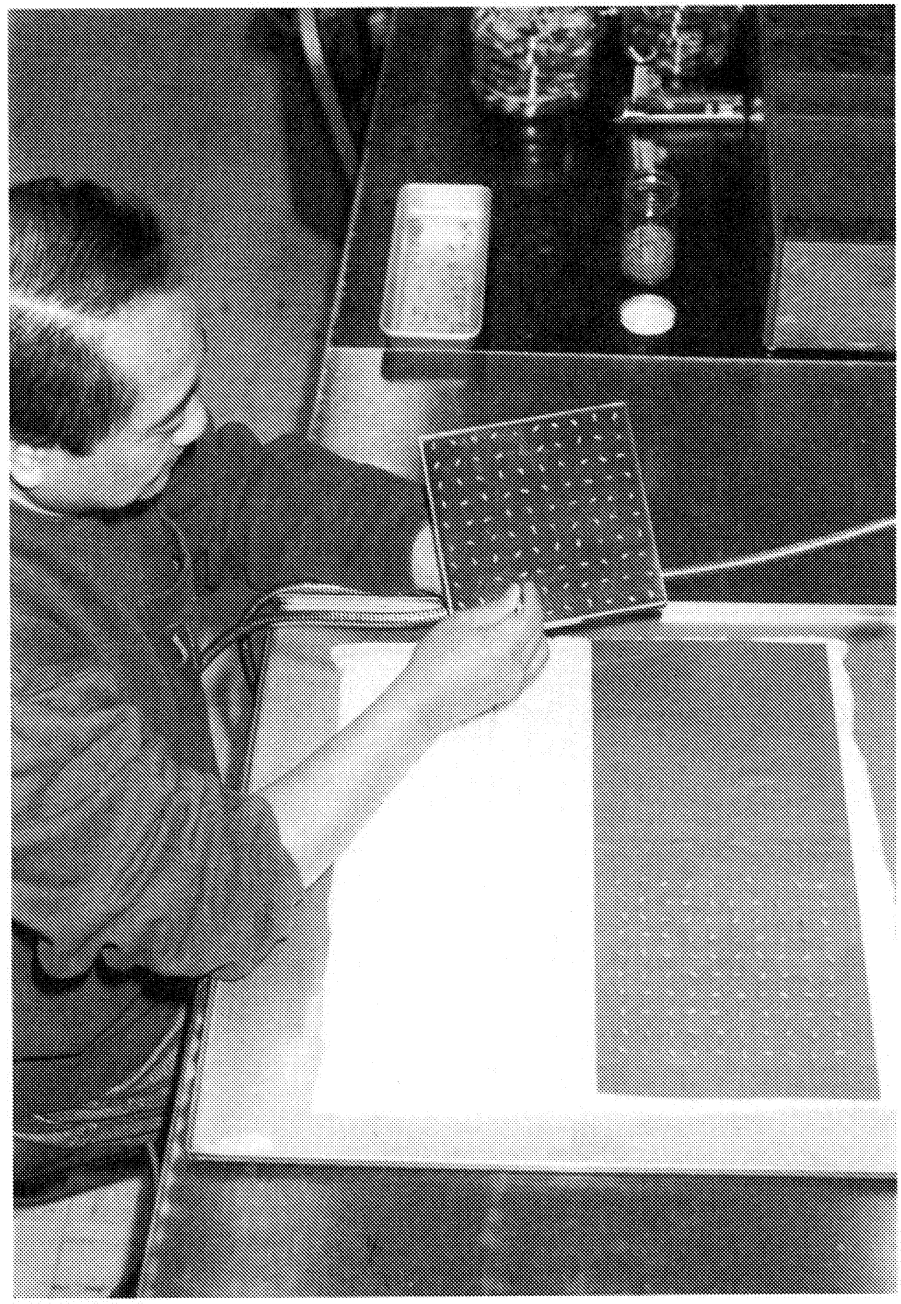

Figure 15.6. Using a vacuum head for preparing 100-seed replicates for germination testing (Courtesy of Bob Neumann).

average of all replicates. The exact procedures and regimes under which different kinds of seeds are germinated have been developed throughout more than 100 years of experience in germination testing and have been augmented during the last 40 years by a systematic program of referee testing involving interchange of samples and results among laboratories. The testing instructions given in the Rules for Testing Seeds include the germination media (substrata), the temperature required, the duration of the test period, and additional suggestions for optimal results (Figure 15.7).

The time required for germination tests varies among species. Some seeds require less than seven days, while others may require a month or longer. The seeds of some trees and woody shrubs are notorious for their long germination requirements. The Rules for Testing Seeds also specify germination requirements for tree, vegetable, woody shrub, and flower species. However, knowledge of germination requirements, especially for wild and exotic species, is not complete.

Evaluation of Germination

At the end of the prescribed germination period, the tests are evaluated; however, it is sometimes desirable to make preliminary evaluations, called first counts. Seedlings that have germinated and are normal are counted and removed from the substrate at the time of the first

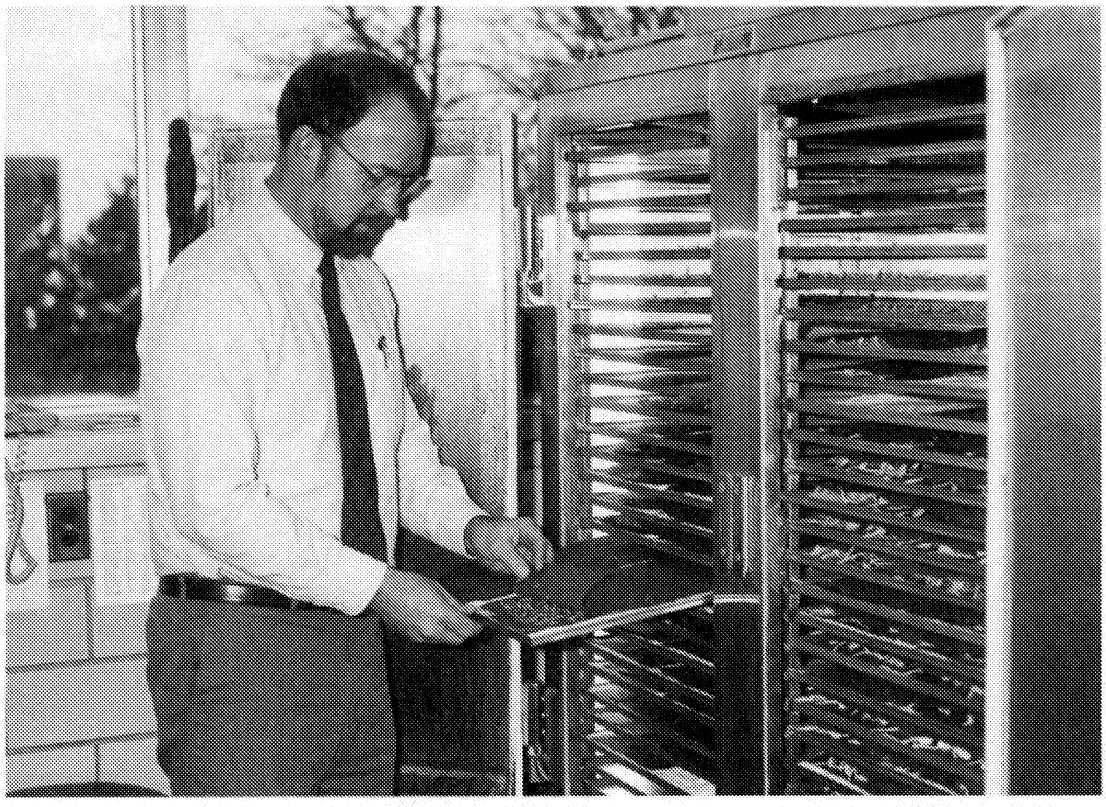

Figure 15.7. A light-equipped seed germinator for testing seeds that require light for best germination (Courtesy of Bob Neumann).

count. This procedure helps subsequent counts, because early-germinating seedlings often tend to grow profusely, causing difficulty in evaluating later-germinating seedlings. Seeds that remain ungerminated at the end of the prescribed period are considered dead or dormant (refer to the discussion on dormant seed in Chapter 7).

The 'Normal Seedling.' The seed analyst has a somewhat different concept of seed germination than the layperson, to whom germination implies the rupture of the seed coat and the emergence of the root and shoot apices. The Rules of the AOSA, which most seed analysts in North America follow, prescribe the following definition of germination, embodying the normal seedling concept: "the emergence and development from the seed embryo of those essential structures which, for the kind of seed in question, are indicative of the ability to produce a normal plant under favorable conditions." Not only does this concept include the layperson's definition of germination, it also reflects the agronomic value of the seed (i.e., capacity to produce normal plants under favorable conditions).

Abnormal Seedlings. Any seedling that is not classified as a normal seedling is considered abnormal. The germination analyst may classify seedlings as abnormal for various reasons; for example, the absence of certain essential structures (such as radicle, epicotyl, twisted, or otherwise abnormal shape, to greatly reduced growth or seedling vigor. The ability of a seed analyst to discriminate between and classify normal and abnormal seedlings is one of the most subjective aspects of seed testing. Therefore, constant education and training are required to assure uniformity in interpretations. To help provide uniformity, the AOSA developed a Seedling Evaluation Handbook in 1992 which is now recognized as a formal component of the Rules for Testing Seeds. The Handbook provides line drawings depicting differences between normal and abnormal seedlings to help analysts in discriminating among questionable seedlings (Figure 15.8).

Firm, Ungerminated (Dormant) Seeds. Seeds other than hard seeds that remain firm (nondecayed) and ungerminated at the end of the prescribed germination period are called firm, ungerminated seeds. This is a type of dormancy commonly found in certain grasses, and should be treated appropriately to stimulate germination.

Hard Seeds. Hard seeds are those that do not imbibe water and therefore remain hard at the end of the prescribed germination period. Hard-seededness is a type of dormancy that prevents germination of viable seeds because they cannot absorb water through their impermeable seed coat. The percentage of hard seeds is reported as part of the total percentage germination.

Laboratory Methods of Breaking Dormancy

Any time a seed fails to germinate in the time specified in the Rules for Testing Seeds, the analyst must determine whether the seed was ungerminable due to lack of viability or dormancy. If the seed does not appear diseased, it is probably dormant. Once it is recognized that dormancy exists, the challenge to the seed analyst is to determine approaches that can break the dormancy. Since seeds have evolved many unique ways to maintain dormancy, the analyst must employ various approaches to break the dormancy-imposing mechanism(s). In some cases, a single treatment may be effective. In others, a combination of techniques may be necessary. The Rules for Testing Seeds specify appropriate dormancy-breaking techniques for species where dormancy commonly occurs. These usually are either by prechilling or the use of KNO_3.

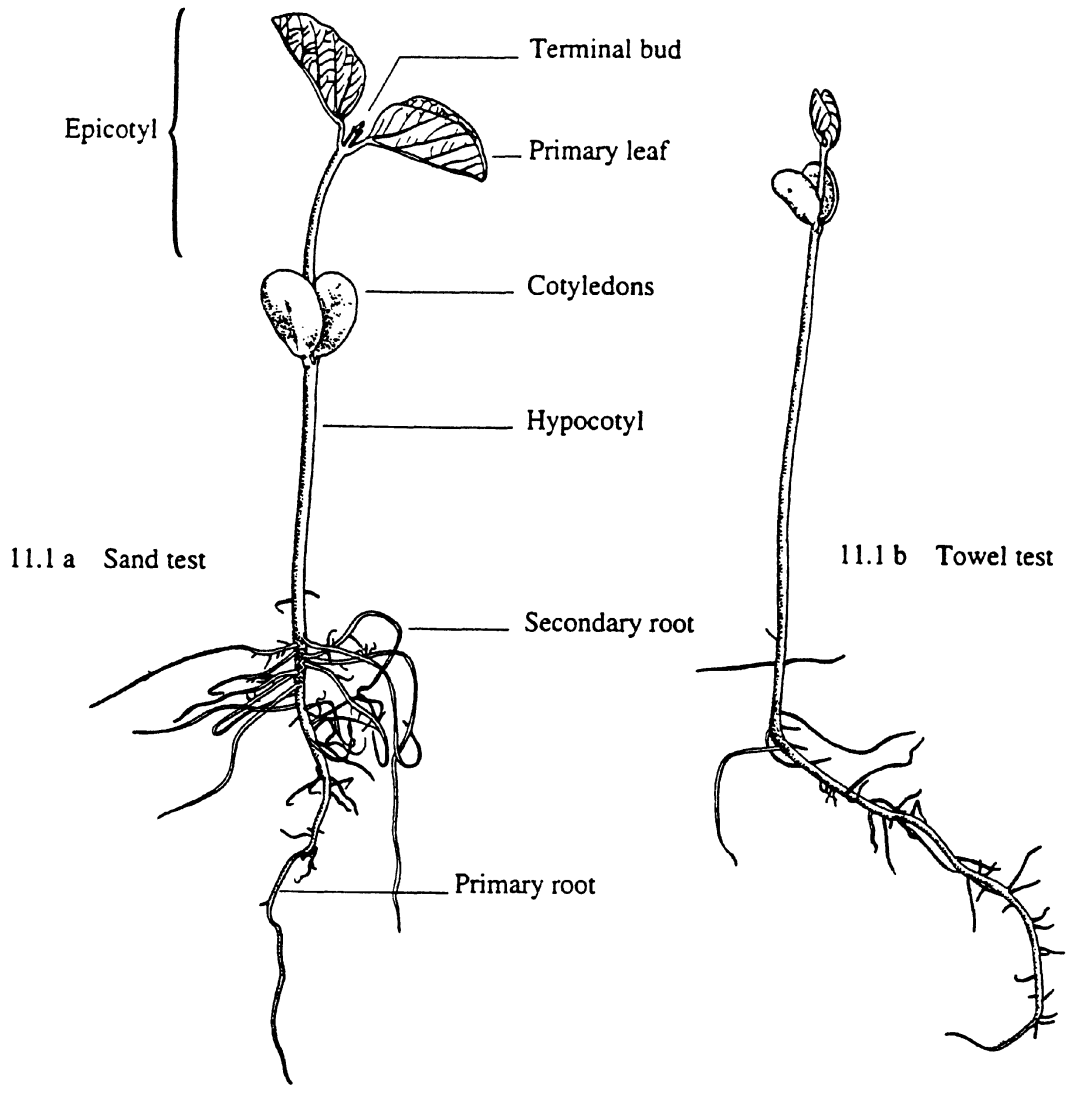

Figure 15.8. Soybean seven-day seedlings, sand test and towel test. (From AOSA Seedling Evaluation Handbook, 1992. Contribution No. 35 to the Handbook on Seed Testing. Association of Official Seed Analysts. 101 pp.).

Prechilling. Viable seeds other than hard seeds can often be stimulated to germinate by a cold treatment of the water-imbibed seeds, commonly called prechilling, or stratification. This is accomplished by placing the seed on or in moist substrata at relatively low temperatures (about 5°C) for a specified time-usually about five days; longer durations may be necessary for the seeds of some species (e.g., woody species). The experienced seed analyst recognizes those species in which dormancy is likely to occur and routinely prechills them as a standard part of the laboratory procedure.

Potassium Nitrate (KNO_3). Seed germination in many species, such as turf grasses, can be stimulated by using a dilute solution (0.1 % to 1.0%) of potassium nitrate as moisture for the germination test. Like prechilling, the use of KNO_3, is a valuable aid in germination of those species benefited by it and has become a routine procedure in the germination testing of many species.

SPECIAL TESTS FOR SEED QUALITY

Although purity, germination, and noxious weed evaluations are routinely performed on almost every seed sample submitted to the laboratory, many additional tests also reflect seed quality. Such special tests are usually performed only when requested; however, they may be done routinely for certain species or for law enforcement or certification samples. These special tests have been developed as byproducts of routine testing procedures in the seed technicians' attempts to learn more about the quality of seed lots. Today, most modern, well-equipped seed laboratories have the capability of conducting such tests.

Genetic Purity Testing

Changes are rapidly occurring in agriculture, many of these at the level of the seed industry. The ability to develop new varieties that differ in all but a single or several genes places an even greater burden on genetic purity testing. It seems certain that seed products developed from molecular biology will become increasingly common because they benefit numerous people. For example, farmers will obtain higher crop yields from improved insect, weed and disease control. Because these controls are obtained without chemical use, less concern will exist about environmental pollution. Farmers will also benefit from lower input costs for pest/weed control and will likely obtain premiums for seeds with selective output traits. Seed companies also will benefit from increased seed premiums that will enhance seed margins. Those companies that are the research and development leaders will likely enjoy a market share advantage from being the first to offer these new products. Finally, gene providers will obtain additional income from per acre technology fees and, in some cases, increased herbicide market share for companies selling seeds of herbicide tolerant varieties.

The continued development of new and improved varieties is the cornerstone of increases in crop yield and agricultural productivity. By definition, a variety of a cultivated crop differs from other varieties of the same species in one or more specific characteristic(s). Such characteristics as maturity, lodging resistance, disease resistance, plant height, and market quality make varieties distinct from one another. More recently, advances in molecular biology have led to the release of new varieties that may differ in as little as one gene for a specific trait such as herbicide tolerance or insect resistance. Farmers and growers are vitally interested in the selection of the variety best suited to their particular field/greenhouse conditions because they recognize that this single decision can have a marked effect on their yields and profit. Genetic purity testing is so important that it has been the subject of a recent book (Wrigley 1995), several reviews (McDonald 1995; 1998; Smith and Register 1998; Cooke 1995; 1998) and specific genetic purity testing protocols have been outlined in the Seed Technologist Training Manual (Society of Commercial Seed Technologists, 2001) and the Cultivar Purity Testing Handbook (AOSA 1991).

When new varieties are developed by plant breeders, a limited amount of seed is increased to quantities sufficient to supply larger grower needs. As this seed is increased, it must be