Seed Quality Testing for Range and Wildland Species

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The seed bag label provides assurance as to the identity and quality of the seed. Each lot of seed offered for sale is required by law to be properly and truthfully labeled. Label information comes from two sources. The seed producer or dealer provides the common and scientific name, variety, and class (such as foundation, breeder, certified, registered) designations where appropriate, lot number, seed origin, date of harvest, and name and address of the seller. The laboratory performing the seed quality test provides the seed quality information.

People who buy seed for range, wildland, and disturbed land restoration often use nontraditional species that present problems in seed quality evaluation. The seed may be sold at low purity or may not be readily germinable under commonly used test conditions. Seed of nontraditional species is often expensive, making an accurate evaluation of quality even more important.

Government, commercial and private seed-testing laboratories in the United States and Canada are required to use standard procedures as outlined in Rules for Testing Seeds, published by the Association of Official Seed Analysts (AOSA 1988). State seed laboratories perform standard seed tests on request and can answer questions (Table 1).

Quality evaluation for agricultural crop seed is usually a straightforward process. Rules for testing crop species have been standardized and in place for many years. This is not the case for many species used in range and wildland rehabilitation. Accurate and repeatable seed quality evaluation procedures have only recently become available for many of these species.

When a laboratory receives a seed sample of a species not in the AOSA Rules, the analyst uses procedures developed from experience and best judgement. Under these circumstances, results can vary substantially from one laboratory to another, resulting in confusion as to the actual meaning of the label information. This problem is worsened by the fact that standard purity and germination procedures often do not work well on wild-collected native seed, and labeling conventions do not permit adequate explanation. The seed buyer must be educated to understand the implications of label information.

A survey of Intermountain range and wildland species in Rules for Testing Seeds showed that some of the grasses and most of the forbs and shrubs commonly used in rehabilitation were without official procedures for seed quality evaluation. In 1985, the Utah Department of Agriculture, the Utah Division of Wildlife Resources, and the Forest Service, Intermountain Research Station, U.S. Department of Agriculture initiated a project to develop seed quality evaluation procedures for significant species. The project researchers have cooperated with the AOSA in securing adoption of the procedures as official Rules. Official testing procedures for 21 species have been developed to date (Table 2). The project has also generated insight into some communication problems in the wildland seed marketplace that are better addressed through education than through regulation.

Seed-testing is generally a two-step process. The first step, the purity test, determines what fraction of the sample, by weight, consists of pure seed (species being sold), other crop seed, weed seed, and inert material. The second step, the viability test, determines what percentage, by number, of the pure seed is viable.

Purity Testing

The AOSA Rules define the weight of approximately 2,500 seed units as the minimum sample for purity analysis. A major problem in purity testing is obtaining a representative subsample for analysis. Mechanical seed sample dividers are used to assure that the bulk sample is adequately mixed for subsampling. This works well only for free-flowing seed. In general, the lower the sample purity, the more difficult it is to obtain a representative subsample.

Seeds and seed units are not always synonymous. For example, if intact one-seeded fruits (whether or not they contain a seed) are defined as the seed unit, all unfilled fruits must be included as pure seed. This results in an increase in purity values but an accompanying decrease in viability percentage. If only visibly filled fruits are included as pure seed, purity values decrease but viability percentages increase. These changes in purity and viability are not necessarily proportional. Unfilled fruits are lighter than filled fruits, so then tend to "count" more in the viability test (based on numbers) than in the purity analysis (based on weight).

From the point of view of the seed analyst, high purity is always desirable because it improves the accuracy and ease of testing. Most agricultural crop seed is sold at high purity. This is not the case for many wildland seed crops (Table 2). The cost of cleaning seed of many wildland species to high purity is not justified, because the seeds

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Table 1. Official state seed-testing laboratories in the Western States.

State	Address	City/Zip code	Phone Number
California	1220 N St., Rm. 340	Sacramento 95814	(916) 445-4521
Colorado	E-10 Plant Science Bldg. Colorado State Univ.	Ft. Collins 80523	(303) 491-6406
Idaho	2240 Kellogg Lane	Boise 83712	(208) 334-2368
Montana	Montana State Univ.	Bozeman 59717	(406) 994-2141
Nevada	P.O. Box 11100	Reno 89510	(702) 789-0180
New Mexico	P.O. Box 3190	Las Cruces 88003	(505) 646-3407
Oklahoma	2800 N. Lincoln Blvd.	Oklahoma City 73105	(405) 521-3864
Oregon	Farm Crops Annex, Oregon State Univ.	Corvallis 97331	(503) 754-4464
Texas	P.O. Box 629	Giddings 78942	(409) 542-3691
Utah	350 N. Redwood Rd.	Salt Lake City 84116	(801) 538-7182
Washington	2015 S. 1st St.	Yakima 98903	(509) 575-2750
Wyoming	University Station P.O. Box 3333	Laramie 82071	(307) 766-5225

are very small and must then be "diluted" with a carrier (such as rice hulls) for low seeding rates. Also, cleaning procedures that produce high purity without damage to the seed are not available for many species. The seed analyst is faced with time-consuming and difficult purity analysis procedures for many wildland species. Without official seed unit definitions agreed upon and in place, it is not surprising that purity results vary among laboratories.

The Seed Unit Controversy

Seed unit definitions recently adopted for some wildland shrub species have affected values obtained in quality evaluation. For example, a winterfat *(Ceratoides lanata)* seed unit is defined as the fruit with attached hairy bracts intact, the form in which the seed is usually sold. Both filled and unfilled fruits must be included, because there is no reliable way to separate the two. This results in relatively low viability percentages even though fruits that actually contain seeds may have high viability (Allen et al. 1987). An alternative method is arbitrary selection of obviously filled fruits for the viability test. A buyer might reject a lot based on the standard test but accept the lot based on the less repeatable method, which gives higher viability percentages overall. All analysts need to under-

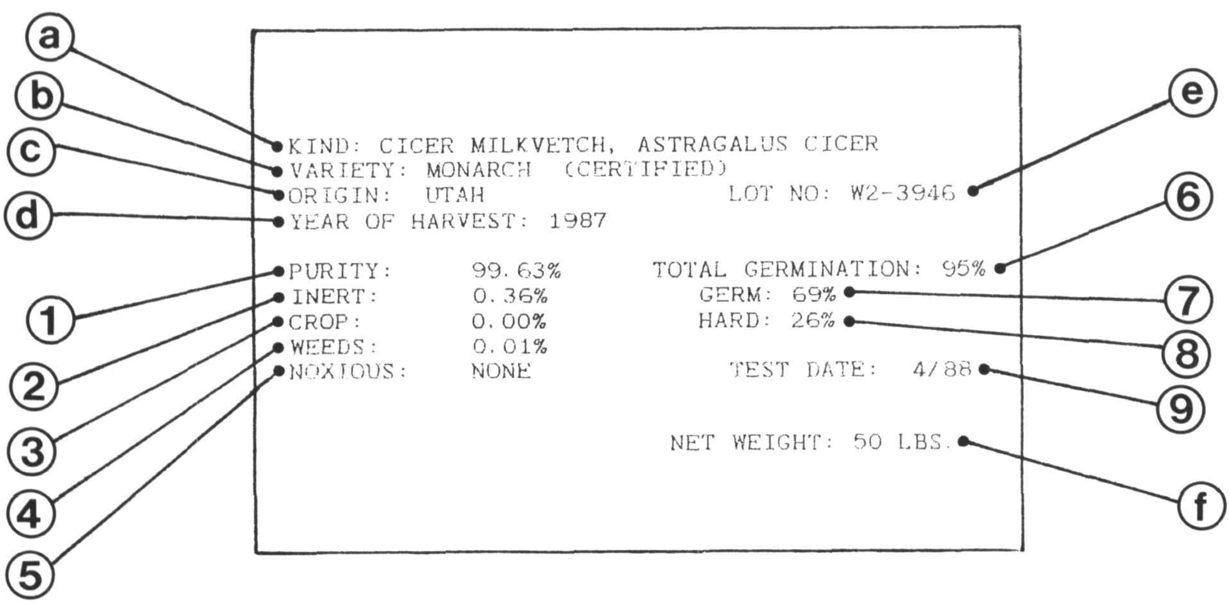

Diagram of a typical seedlot label (dealer's name and address deleted). The seed dealer provides information on: (a) common and scientific name, (b) variety and class, (c) seed origin, (d) date of harvest, (e) lot number, and (f) net weight. The testing laboratory provides information on results of the purity analysis: (1) pure seed percentage, (2) inert material percentage, (3) percentage of other crop seed, (4) percentage of weed seed, and (5) presence of noxious weed seed, and on results of the viability test, (6) total viable seed percentage, (7) total germination percentage, (8) total hard or dormant seed percentage, and (9) test date.

Table 2. Seed quality testing standards status for some important Intermountain species.

Species[a]	Status of Seed Quality testing Standards[b]	Seed Unit[c]	Acceptable[d] % Purity	Acceptable[d] % Viability
Grasses:				
Brome, Meadow *Bromus biebersteinii*	3	Floret*	90	85
Brome, Smooth *Bromus inermis*	1	Floret	95	90
Orchardgrass *Dactylis glomerata*	1	Floret	90	85
Rye, Mountain *Secale montanum*	2	Caryopsis	95	85
Squirreltail, Bottlebrush *Sitanion hystrix* *Elymus elymoides*	2	Spikelet with or without awns attached	90	85
Wheatgrass, Fairway *Agropyron cristatum* *Agropyron cristatum*	1	Floret	95	85
Wheatgrass, Siberian *Agropyron sibericum* *Agropyron fragile*	3	Floret*	95	85
Wheatgrass, Streambank *Agropyron riparium* *Elymus lanceolatus*	3	Floret*	95	85
Wheatgrass, Thickspike *Agropyron dasystachyum* *Elymus lanceolatus*	3	Floret*	95	85
Wildrye, Altai *Elymus angustus* *Leymus angustus*	3	Floret*	95	85
Wildrye, Basin *Elymus cinereus* *Leymus cinereus*	2	Floret	95	85
Wildrye, Russian *Elymus junceus* *Psathyrostachys juncea*	1	Floret	95	85
Forbs:				
Alfalfa *Medicago sativa*	1	Seed	95	85
Burnet, small *Sanguisorba minor*	1	Achene	95	90
Flax, Lewis *Linum perenne*	1	Seed	95	85
Milkvetch, Cicer *Astragalus cicer*	2	Seed	95	85
Penstemon, Firecracker *Penstemon eatonii*	2	Seed	95	70
Penstemon, Palmer *Penstemon palmeri*	2	Seed	95	80
Penstemon, Rocky Mountain *Penstemon strictus*	2	Seed	95	70
Penstemon, Wasatch *Penstemon cyananthus*	3	Seed*	95	70
Sagewort, Louisiana *Artemisia ludoviciana*	2	Achene	80	80
Sweetvetch, Northern *Hedysarum boreale*	2	Seed, loment (hull) removed	90	60
Yarrow, Western *Achillea millefolium*	1	Achene	95	80
Shrubs:				
Bitterbrush, Antelope *Purshia tridentata*	2	Seed, pericarp (hull) removed	95	90

Species[a]	Status of Seed Quality testing Standards	Seed Unit[c]	Acceptable[d] % Purity	Acceptable[d] % Viability
Cliffrose *Cowania mexicana*	2	Achene with style (tail) removed	95	85
Ephedra, Green *Ephedra viridis*	2	Seed	95	85
Kochia, forage *Kochia prostrata*	2	Utricle with and without appendange (star-shaped wing) retained on a 1mm opening square sieve. Utricles that pass through are considered inert.	70	50
Mahogany, Curlleaf Mountain *Cercocarpus ledifolius*	2	Achene with style (tail) removed	90	80
Mahogany, True Mountain *Cercocarpus montanus*	2	Achene with style (tail) removed	90	80
Rabbitbrush, Low *Chrysothamnus viscidiflorus*	3	Achene with or without pappus removed*	10 to 15	75
Rabbitbrush, Rubber *Chrysothamnus nauseosus*	2	Achene with or without pappus removed*	10 to 15	75
Sagebrush, Big *Artemisia tridentata*	2	Achene (with pericarp) or seed (without pericarp)	8 to 12	80
Sagebrush, Black *Artemisia nova*	2	Achene (with pericarp) or seed (without pericarp)	8 to 12	80
Sagebrush, Silver *Artemisia cana*	3	Achene (with pericarp) or seed (without pericarp)*	8 to 12	80
Saltbush, Fourwing *Atriplex canescens*	2	Utricle, filled and unfilled, appendanges (wings) removed	95	45
Saltbush, Shadscale *Atriplex confertifolia*	3	Utricle, filled and unfilled appendages (wings) removed*	95	30
Serviceberry, Saskatoon *Amelanchier alnifoia*	2	Seed, flesh removed	95	85
Winterfat *Ceratoides lanata*	2	Utricle, filled and unfilled, includes hairy bracts	75	40

[a] = Seed quality testing rules are established for species only. All subspecies, varieties, ecotypes, strains, and cultivars use rules for the species. Hybrids follow rules of one parentage. Common names are from Plummer et al. (1977). Scientific names are first from Plummer et al. (1977) and Holmgren and Reveal (1966), followed by Barkworth and Dewey (1985).
[b] = Rules for testing seed quality
1. have been established and published for some time (examples).
2. have been established through work accomplished jointly by the Utah Dept. of Agriculture, Utah Division of Wildlife Resources and the Intermountain Research Station, Forest Service, USDA.
3. are in various stages of being developed.

[c] = Reproductive structure that is marketed as a seed
* Seed units followed by an asterisk represent most common reproductive structure marketed as seed. Seed unit definition is being developed.
[d] = Purity and germination percentages that can be expected using established seed quality testing rules on seed of commercial quality.

stand a method and agree to use it, so that buyers and sellers will have a common basis for interpretation of test results.

In cases where commercial cleaning consistently results in removal of fruit parts, such as the wings of a fourwing saltbush *(Atriplex canescens)* fruit, the cleaned fruit (without wings) may be defined as the seed unit. In sagebrush *(Artemisia)* species, the fragile fruit wall is often partially or wholly removed in cleaning. In this case, either the intact fruit or the naked seed may be considered the seed unit. Similarly, the umbrella or pappus on a rabbitbrush *(Chrysothamnus)* fruit may or may not be removed in cleaning; if it remains attached to the fruit it is considered part of the seed unit. In forage kochia *(Kochia prostrata)*, tiny fruits are consistently nonviable and are removed by a standard screen procedure; fruits that pass through the screen are considered inert matter and not part of the pure seed component.

The seed unit definition can also affect the estimated number of seeds per pound. If appendages such as the wings of fourwing saltbush or the feathery styles of cliffrose *(Cowania mexicana)* and mountain mahogany *(Cercocarpus)* were left intact, the number of seeds per pound would be substantially reduced.

Viability Testing

According to AOSA definitions, a viable seed (or seed unit) is one that is capable of germinating to produce a viable seedling under favorable conditions. For agronomic crops, laboratory germination test results correlate well with seedling emergence under favorable field conditions. Seed dormancy, the ability to remain ungerminated under conditions suitable for the growth and survival of seedlings, has been largely eliminated in crop plants, whether by design or not. Agronomic crops are normally sown at a time suitable for emergence and survival, so that a delay between sowing and emergence is neither necessary nor desirable.

Rangeland seedings in the Intermountain area present a different situation. Late autumn to early winter seedings are generally the norm, and the seeds are expected to experience winter in the ground prior to spring emergence. Fall seeding maximizes use of early spring moisture and avoids problems involved with equipment handling on saturated ground. Mechanisms such as seed dormancy that prevent premature autumn or winter germination are desirable under these conditions. Most native shrub and forb species possess such safeguards against premature germination. Seed dormancy may be regarded as a problem by seed analysts and even by some range scientists, but from the plant viewpoint it represents a necessary insurance.

Seed Dormancy

When testing species with appreciable seed dormancy, laboratory germinability and viability are definitely not the same thing. There are several options when testing such species. A good example is antelope bitterbrush *(Purshia tridentata)*, whose seeds are completely dormant when tested under conditions suitable for seedling growth. One option is to determine viability by some criterion other than germinability. A commonly used procedure is tetrazolium staining. In this procedure, seeds are soaked in a tetrazolium chloride solution, which stains actively respiring (living) embryo tissue bright red. Stain patterns are then interpreted to determine whether the embryo could have produced a normal seedling. Tetrazolium staining is a reliable measure of seed viability when adequate information from correlative studies is available. It has the advantage of giving quick results and has been used extensively for many dormant wildland species.

Another option is to apply a dormancy-breaking pretreatment prior to the germination test. Four weeks of moist chilling will break dormancy for most seeds in most lots of antelope bitterbrush. For ungerminated seeds remaining at the end of the prescribed germination test period, viability can be determined by tetrazolium staining or other methods. Seeds determined to be viable are reported as dormant seed percentage.

For species with varying dormancy levels, a common procedure is to perform the germination test without pretreatment and to report ungerminated viable seeds as dormant. Hardseeded legumes are an example. The germinable seed percentage plus the hard seed percentage equals the total viable seed percentage. For these species, seeds that fail to take up water (hard seeds) have a high probability of being viable. Hardseededness is only one type of dormancy. Most dormant seeds take up water freely and are not considered hardseeded.

Sometimes a dormancy-breaking pretreatment is prescribed in the Rules; lots may be retested with pretreatment if a standard germination test yields a high percentage of dormant seeds. In this case, the retest results, with lower dormancy level, would be reported. The germinable seed percentage reported is very much a function of the test procedure used. Alternative procedures are often prescribed as part of a Rule, and different lots may have different germination requirements. Seed dormancy levels can also change spontaneously in dry storage, so that the germinable seed percentage changes from one test date to another.

Seed viability may decrease in dry storage, a process that happens faster in some species than others. But total viable seed percentages obtained on the same lot at the same time by different laboratories are usually in much closer agreement than total germinable seed percentages, especially for native species. From a seed quality standpoint, it is the total viable seed percentage, not the germinable seed percentage, that counts. Because the total viable seed percentage can change over time, each State and Province has regulations specifying the length of time that results of a seed test remain valid, or at what point retesting is required.

Abnormal Seedlings

Another aspect of the viability test is the classification of abnormal seedlings. Seeds that produce abnormal seedlings as defined in the Rules are not considered viable, because abnormal seedlings would have low survival chances. For agronomic crops, abnormal seedling classification has been worked out in great detail. When testing range and wildland seed, this important aspect is left largely to the discretion of the individual analyst, and results may vary considerably among laboratories. A high proportion of abnormal seedlings may result if the seed is harvested green, damaged in threshing or cleaning, or stored improperly. Older seedlots in the process of losing viability also tend to have higher abnormal seedling counts. The abnormal seedling percentage is not reported on the label and is excluded from the viable seed percentage.

The Pure Live Seed Concept

Agronomic crop seed is usually sold on a bulk weight basis, because it is almost always of high purity and viability. But seed for range and wildland seedings is more commonly marketed on a pure live seed basis. The results of seed tests become more important when the pure live seed method is used. The laboratory purity and viability percentages are used directly in calculating the dollar value per bulk pound of a particular lot.

To arrive at a pure live seed value, the bulk weight is multiplied by the pure live seed percentage (percentage purity times percentage viability). For example, if a seedlot has a purity value of 50% and a viability of 80%, its pure live seed percentage would be $.50 \times .80$, or 40%. A 100-lb bag of this seedlot would contain 40 lb of live seed. Another lot of the same species might be at 40% purity and 70% viability, giving a pure live seed value of 28%, or 28 lb of live seed per 100-lb bag. The 100-lb bags of the two lots are clearly worth different dollar amounts. In the wildland seed market, relatively low viability percentages and especially purity percentages are acceptable for some species (Table 2). The purpose of the seed test is to determine what these percentages are, so that a corresponding dollar value can be assigned. This places considerable responsibility on the seed-testing laboratory and underscores the need for accurate and repeatable testing procedures.

Using PLS to Set Seeding Rates

The pure live seed percentage is also useful in setting seeding rates in terms of bulk pounds per acre. For example, suppose a seeding rate of 1 lb pure live seed (PLS) per acre is desired for fourwing saltbush in a mixture. If the lot has a purity of 90% and a viability of 50%, then 45% of the bulk seed by weight is pure live seed. This means that 1 lb divided by 0.45 or 2.22 lb of bulk seed per acre would be needed to attain the desired rate.

One major source of error in determining seeding rates is the estimate of number of seeds per pound. For example, the weight of a fourwing saltbush seed unit can vary over at least a fivefold range. If an exceptionally small-fruited lot is planted, the actual seeding rate in terms of number of seeds per unit area would be much higher than estimated, while the opposite would be true of an exceptionally large-fruited lot. One solution is to set the seeding rate based on a determination of seed weight for the lot that is actually going to be planted. The weight per 100 seeds could easily be included as part of the seed-testing procedure. Or the purchaser could make the determination and adjust seeding rates accordingly.

Future Prospects

As demands for quality seed of a wide variety of native and introduced species continue to increase, the range and wildland seed industry can be expected to keep growing. Mined land reclamation, conservation reserve planting, range and wildlife habitat restoration, and roadside landscaping all present challenges to the seed industry and the people involved in development of appropriate plant materials for use in these applications. We need accurate and consistent seed quality testing procedures. We hope to continue our efforts to improve communication among collectors, producers, sellers, testers, and buyers of wildland seed.

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CURRENT LITERATURE by Dr. Vallentine will be back in the next issue.