Native seeds in commerce: more *Frequently Asked Questions*

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ABSTRACT

To make intelligent choices in the marketplace, customers should have a working understanding of 1) the diversity of products that are available in the seed trade; 2) how they move in the market; 3) how they are regulated for purity and germination; 4) how they are certified to assure genetic identity; and 5) how they are legally protected as intellectual property. Options for seed certification have greatly increased over the last several years. Two complementary certification mechanisms are currently being used to deliver native plant materials, one facilitating the traditional cultivars and the other directed toward the novel pre-variety germplasms. Both accommodate natural and genetically manipulated plant materials.

KEY WORDS

seed prices, release, cultivar, pre-variety germplasm, genetic shift, pure live seed, seed certification, variety, germplasm, plant variety protection

NOMENCLATURE

USDA NRCS (2004)

This paper answers a set of 9 frequently asked questions related to native seeds in commerce, continuing a series that began in the spring 2005 issue of *Native Plants Journal* (Jones 2005).

10. Why do native seed prices fluctuate so widely, and why are they so expensive in general?

The native seed industry is highly competitive, and fluctuating seed prices are driven by imbalances between supply and demand. Because of weather conditions, the amount of wildland-collected seeds harvested is notoriously cyclical, and establishment and production of a seed field of perennial native species is often tenuous. This leads to greater supply-and-demand imbalances than would be the case for many annual agronomic crops, for which planting decisions are made each year (Dunne and Dunne 2003). In the arid and semi-arid western US, demand may be driven by unpredictable events like wildfires on public lands or announcements of government incentives like the Conservation Reserve Program. As with agronomic crops, supplies are short relative to demand when a new release is introduced. Therefore, prices are high relative to established items of the same species. As a plant material becomes better established over time, additional acreage is planted and the material becomes better known and more widely used. Consequently, prices drop relative to previously established items.

Seed companies typically "hedge" when bidding on government-contracted seed buys, offering portions of their crop at different prices. In this manner, they are not locked into an "all-or-nothing" scenario when competing with other bidders. Because lower-priced bids are accepted in preference to higher-priced bids, hedging increases the likelihood that the bidder will obtain at least a portion of the government's business (Dunne 2005).

Average price of native seeds is often higher than that of comparable introduced plant materials used in land reclamation. There are several reasons why this is so. Seed yields of introduced materials are oftentimes innately higher than for native seeds, thus their production costs are lower because of "economy of scale." In addition, native species may pose processing difficulties, exhibit a high degree of seed shattering due to natural seed dispersal mechanisms, and feature high seed dormancy. While these traits are advantageous in the wild, they are a disadvantage in terms of agricultural production. Our widely used introduced species do not have good agronomic performance by accident. The introduced species in use today proved to be the most promising of the many nonnative species that were originally evaluated for utility in North America.

Another issue influencing price is the size of the market niche the plant material is intended to occupy. Materials of introduced species are typically intended to be widely adapted and to have as large a niche as possible. This implies that only a few materials are needed to satisfy demand. In contrast, market demand for natives is increasingly for regionally and locally specific materials, particularly for those species that are highly ecotypic. This implies that several materials may be needed to fill a variety of market niches. Because demand for individual such materials may be relatively low and highly inconsistent, prices for such materials are higher than if demand were higher and more consistent.

11. How do I know that my seeds are of good purity and germination?

All seeds sold, whether certified or noncertified, must conform to federal and state seed laws that limit weed seed content and require purity (crop seed percentage, inert matter percentage, percentage of weed and other crop seeds) and germination to be correctly labeled on the seller's seed label (Copeland and McDonald 1995). Each state has lists of "prohibited noxious weeds" and "restricted noxious weeds." Prohibited noxious weeds are forbidden in any seedlot sold in that state because they are considered to be a threat to agriculture. Restricted noxious weeds are permissible only below a designated number per pound of seeds.

Seeds for the reclamation market are typically sold on a pure live seed (PLS) basis. Pure live seed is the product of the purity (the percentage of the lot by weight that consists of the crop seed) and percentage germination as performed by an official germination test (Copeland and McDonald 1995). For example, a 50-pound bag of seed with 90% purity and 90% germination has a PLS percentage of 81 ($0.9 \cdot 0.9 = 0.81$), hence it amounts to 40.5 pounds of PLS ($50 \cdot 0.81 = 40.5$).

For species with seed dormancy, there is usually a difference between germination and viability, the latter being the total percentage of seeds that are living. Dormant seeds are viable but do not germinate on the date of test. A tetrazolium test, or "TZ" test, is used to determine if seeds are respiring and therefore viable (Copeland and McDonald 1995). Though the TZ test is labor intensive and requires considerable experience to interpret seed staining pattern, it can be completed within a day or two rather than in the matter of weeks required for actual germination results. It is, however, somewhat more expensive than a germination test. If sufficient time is available, a practical approach for species with seed dormancy is to conduct a germination test followed by a TZ test on only nongerminating intact seeds. These results can be expressed as germination percentage (germination) + dormancy percentage (TZ minus germination) = viable seed percentage. Tetrazolium results are often noted as TZ on the seller's label.

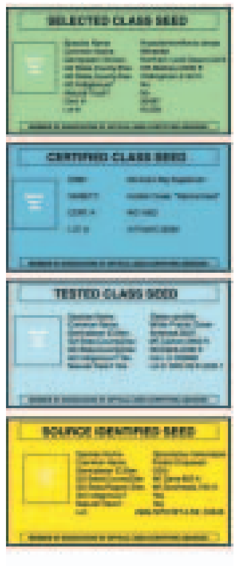

Figure 1. Pre-variety germplasm and variety/cultivar seed tags (Young and others 2004).

SEED CERTIFICATION NOMENCLATURE AND LABELING FOR PLANT GERMPLASM TYPES

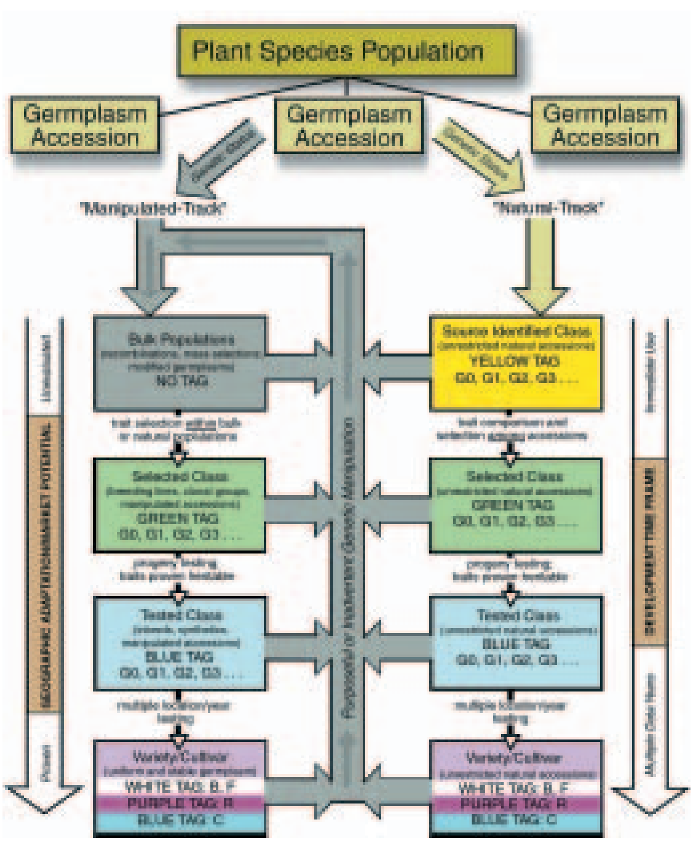

Figure 2. Pre-variety germplasm development flow chart (Young and others 2004).

12. How can I be sure I'm buying seeds with the genetics I want?

To assure genetic integrity of seeds, official seed certification agencies have protocols and standards that must be adhered to in order for the product to be sold as certified seed. Certification, as defined in the Federal Seed Act of 1939, is the field inspection and "paper trail" process by which genetic identity is assured (McDonald and Copeland 1997). This is a quality assurance option. Therefore, not all seeds for sale are certified. Bags of certified seeds are marked with colored tags (Figure 1) by the state's seed certification agency. Without certification there is no regulatory assurance for the buyer regarding genetic identity of seeds in the bag. Most states employ a two-tag system in which the colored certification tag is separate from the seller's label that displays purity and germination data, but some states employ a one-tag system in which the colored certification tag includes these data. In the case of noncertified seeds, the seller's label includes purity and germination data alone.

In accordance with the Federal Seed Act, noncertified seeds in the US may be sold as "variety not stated" (VNS), that is, "common" seeds (McDonald and Copeland 1997). Such seeds are often an older release (see FAQ 14) or material of unknown origin that happens to be a good seed producer, making it a relatively inexpensive seed source. Alternatively, a seller may list a cultivar (see FAQ 13) name or pre-variety germplasm (PVG) (see FAQ 16) identification on his label for a noncertified seedlot. In this case, truth-in-labeling is required by the Federal Seed Act (McDonald and Copeland 1997), but in practice the accuracy of this claim is difficult to enforce. Therefore, the name or identification of a noncertified seedlot is merely what is claimed by the seller. An exception to the right of the seller to place a cultivar name on a tag of a noncertified seedlot is when the cultivar name is legally restricted to only certified seeds (see FAQ 18).

13. What's the difference between a cultivar and a variety?

The word "variety" has two very different definitions, one for use in plant taxonomy and the other to describe a particular type of released plant material (see FAQ 5 in Jones [2005]). It is important to convey which definition you intend when you use this word.

In taxonomic usage, "varietas" (Latin for "variety") is the botanical nomenclature division ranked below "subspecies" but above "forma" (Greuter and others 2000). A botanical variety is a more-or-less morphologically recognizable entity that is not genetically isolated from other varieties of the same subspecies, that is, no genetic barriers preclude their hybridization with one another. A variety is added to the specific binomial and preceded by "var." (nonitalicized), such as *Aster adscendens* var. *ciliatifolius.*

Of greater interest to us is the meaning of this word in a plant materials context. In common usage, a variety is a released plant material (see FAQ 14) intended for commercial production exclusive of pre-variety germplasm. The word "variety" is used synonymously with "cultivar," a practice in accordance with the International Code of Nomenclature of Cultivated Plants (Trehane and others 1995). A "cultivar" (contraction of "cultivated" and "variety") is a named plant material propagated in a cultivated setting. Because of the ambiguous meaning of "variety," the word "cultivar" is preferred when referring to specific named, released, and cultivated plant materials.

It is important to note that not all plants in cultivation are cultivars because a cultivar must be formally released; and, not all cultivars are in cultivation because a cultivar may be archaic. A nonexhaustive list of types of plants that are eligible for release as cultivars is as follows:

- materials of deliberate hybrid origin (either within or between species)
- inadvertent hybrids arising in cultivation
- materials selected from within existing cultivated stock
- unselected wildland-origin materials
- selections within wildland-origin materials
- materials resulting from hybridization or amalgamation among wildland-origin materials.

When the full scientific name for a particular cultivar is given for the first time in a document, the part of the name that indicates the cultivar itself either follows "cv." or is set off by single quotation marks but not italicized, for example, *Pascopyrum smithii* cv. Rosana = 'Rosana' western wheatgrass = *Pascopyrum smithii* 'Rosana' (LH Bailey Hortorium 1976). After first mention in a document, the cultivar is referred to without single quotation marks or "cv.," for example, Rosana = Rosana western wheatgrass. A complementary type of plant material, the pre-variety germplasm (PVG) (see FAQ 7 in Jones [2005]), is referred to by an identifier without quotation marks, not to be equated with a cultivar name, followed by the word "Germplasm" and common name, for example, Sand Hollow Germplasm big squirreltail.

14. What exactly is a release?

Releases include cultivars and pre-variety germplasms (PVGs) (see FAQ 16) that have been made available to the public through a formal approval process. Cultivars are always released, while this is not a requirement for PVG. In the public sector, the decision whether to release is made on merit as specified by the sponsoring organization, typically represented by a designated committee. Releases are initiated by the developer of the plant material by submission of a release document to the designated committee for consideration. This document may include information about the species obtained from the scientific literature, data pertaining to any wildland collection site(s) from which the material originated (passport data), breeding methodology used to develop the material, if any, and data collected on the material in comparison with other materials of the same species, for example, relating to adaptation, yield, or disease resistance, at one or more locations over one or more years. After considering the data, the committee makes a recommendation to the releasing organization whether to release the plant material.

To be eligible for seed certification, specification must be made limiting the number of generations of seed increase, the frequency of off-types for either plants or seeds, and the age of the stand (in the case of perennials). These are intended to protect the material's purity, identity, and origin, which may become compromised over time. The geographic area in which the material is adapted and will be marketed must be supplied, and the limitation of geographic area within which seeds may be increased, if any, must be delineated. Undesirable genetic shift may be a factor when seeds are reared in a different environment than that in which they will be used, especially for materials with high genetic heterogeneity (Rincker and others 1978, 1982; Rumbaugh and Johnson 1983; Meyer and Monsen 1993). In other words, the seed production environment may favor a shift toward genotypes that are less desirable in the area of intended usage. As an example, production of seeds in a locale with mild winters may favor genotypes that are susceptible to extreme winter conditions.

Following release, the developer may take the optional step of registering the material by publishing a registration article (Jones and others 1998, 2002). The purpose of registration is to provide a written description of the cultivar to the scientific community. The journals *Crop Science* and *HortScience* regularly publish registration articles. The developer may also submit an application for intellectual property rights (see FAQ 18).

15. How far removed are the seeds I buy from what was originally released ?

Propagation of certified seeds (see FAQ 12) of a cultivar is accomplished through a limited number of generations of seed increase (Copeland and McDonald 1995). The original seeds provided by the developer are termed "breeder seed" and are marked with an official white tag. The seed increase after one generation is termed "foundation seed" (white tag). Foundation seed is used, in turn, to produce "certified seed" (blue tag), which is the generation intended for direct use rather than primarily for propagation purposes. Furthermore, with the agreement of the developer and oversight authority, an additional generation of seed increase termed "registered seed" (purple tag) may be inserted between foundation and certified generations. This may be necessitated when the need for seed volume is greater than can be provided with foundation and certified generations alone. Generations of PVG are also designated, but generation numbers (starting with zero) are employed instead of the terminology used for cultivars.

To prevent genetic contamination by pollen, seed production fields of different releases of the same or closely related species must be isolated by distance (McDonald and Copeland 1997). The isolation distances required are progressively less strict (shorter) for each generation of seed increase, with the goal of providing seeds of as high an assurance of genetic purity as is practically possible (AOSCA 2005).

16. What's the difference between a "traditional" germplasm, a pre-variety germplasm, and a cultivar ?

First of all, the term "germplasm" has at least 3 meanings. It may refer to any or all genetic material of a taxon or any subdivision of a taxon, whether wildland-collected or developed by plant breeding, including cultivars. Second, it may refer to genetic material released and registered as a germplasm analogous as to what was described above for a cultivar. Typically, these "traditional" germplasms, not to be confused with pre-variety germplasms (PVGs), have traits of value to a plant breeder or geneticist for research and development purposes, but they have negative characteristics that preclude them from having direct commercial value (CSSA 2005). Third, it may refer to PVG, which is material lacking the extent of data evaluation required for cultivar release, as described above, yet may have commercial utility.

Pre-variety germplasms may be preferred when existing commercial sources of a species are inadequate, propagation material of specific ecotypes is needed for ecosystem restoration, a high potential exists for immediate use, or commercial potential beyond specific plant community sites is limited (Young 1995). Because some or all of these conditions commonly hold for the application of native plants for restoration purposes, many PVGs intended for restoration usage have been released in recent years. Indeed, the trend is toward PVGs and away from cultivars (Kujawski and Ogle 2005).

Sometimes it is stated that PVGs are preferable to cultivars, or vice versa. Such attitudes are symptoms of bias. Each plant material should be judged on its own merits for the use intended. Cultivars do not necessarily possess a wider or narrower genetic base than PVGs. A common misconception is that cultivars are genetically manipulated and PVGs are natural, that is, not genetically manipulated. Genetic manipulation procedures are typically used to develop cultivars of agricultural crops (Fehr and Hadley 1980; Fehr 1987a, b), and cultivar as originally defined (LH Bailey Hortorium 1976) assumes origination in cultivation. Nevertheless, for seed certification purposes **both cultivars and PVGs may be either natural or genetically manipulated.** Probably the majority of cultivars of native grasses released to date are “natural.” For example, ‘Rimrock’ Indian ricegrass, a cultivar, is a natural population originating at Billings, Montana (Jones and others 1998). In contrast, P-7 Germplasm bluebunch wheatgrass, a selected class PVG, is a genetically manipulated multiple-origin polycross developed from materials originating at 25 wildland sites (Jones and others 2002).

The most important technical distinction between a cultivar and PVG is that more data (multiple locations and years) characterizing plant traits must be divulged to justify a cultivar release as compared with a PVG release (Young and others 2004). A cultivar must also be judged to be “distinct, uniform, and stable” (see FAQ 18). In this sense, then, cultivars are superior to PVGs. For PVG material, the point-of-origin with its associated climate and soil parameters (presumed to be reflective of adaptation) is used to substitute for performance data that prevail in a cultivar release, particularly in the less rigorous classes (see FAQ 17). Another distinction, noted previously, is that cultivars must be released, while release is optional for PVGs. For a nonreleased PVG, its class (see FAQ 17) is determined jointly by the plant material developer and the official seed certification agency.

17. What about misperceptions concerning pre-variety germplasms? What do I really need to know?

Pre-variety germplasm (PVG) is a relatively new, but useful, innovation offered by official seed certification agencies to provide a format for orderly native plant seed production (Young and others 2004). **To describe a PVG seed source, one must state its origin, class, track, and generation** (Figure 2). Class, track, and generation are 3 independent descriptors. This means that a particular PVG of said origin may be categorized by a combination of class and track, and a particular seedlot of said PVG can be further described by its generation number, beginning with G0. The number of generations permitted is typically limited by concurrent decision of the PVG developer and official seed certification agency. Information on origin, class, track, and generation can be found on the certification seed tag.

Origin

Required origin data are state, county, and elevation of the original (G0) collection (Figure 1). This may be a single location or multiple locations, as defined by the PVG developer. If the seed generation is beyond G0, county and elevation data are also given for the location at which the seeds were actually produced. Additionally, the seed tag may indicate whether the G0 seeds are indigenous to the G0 site. For example, seeds could be tagged as “G0 non-indigenous” if planting rows are visible at the field site where the seeds were originally collected, if there is a record of previous planting of the species at that site, or if the species is not believed to be native to the vicinity. The rationale for source-identifying such material is that it is presumed to be adapted to the site (and similar sites) despite not being indigenous to the site.

Class

A PVG may be offered as any one of 3 classes: source-identified (yellow tag), selected (green tag), and tested (blue tag) (Figure 2). **These demand increasing degrees of data, and this is the primary criterion distinguishing them.** To be certified as source-identified, only the state, county, and elevation need be specified. Source-identified seed sources are typically sold by individual businesses that have a proprietary knowledge of the specific site where the seeds were collected. Therefore, for their protection, the specific location is not divulged on the seed tag. Source-identified materials are less likely to be released than materials of selected or tested classes (Kujawski and Ogle 2005). To be certified as selected class for natural track (see below), data are required comparing the candidate population with other populations of the same species. For genetically manipulated track (see below), data must be presented for selected class materials describing the criteria for: 1) selecting individuals out of individual population(s); and (or) 2) hybridizing or otherwise genetically manipulating individual plants or populations. To be certified as tested class, such comparative data are required plus additional progeny-testing data showing that distinguishing trait(s) selected is (are) heritable in the next generation.

Track

Like a cultivar, a PVG may be one of either of two tracks: natural or genetically manipulated. The genetically manipulated track implies hybridization, bulking of disparate seed sources, and (or) artificial selection. Natural track implies the absence of all of these. Natural materials may be either source-identified, selected, or tested, whereas genetically manipulated materials may be only selected or tested, because by definition any plant material that has been genetically manipulated has achieved at least selected class status. Choosing among discrete wildland-collected accessions permits natural-track designation, while selection within or hybridization among such accessions defaults to genetically manipulated track.

Generation

Instead of the terminology used for generations of cultivars, that is, breeder, foundation, registered, and certified seed (see FAQ 15), generations of PVG materials are numbered. Seeds of a PVG collected at the original wildland site are designated G0, and subsequent generations of seed increase under cultivation are numbered starting with G1. As with cultivars, a maximum number of generations permitted may be stated in the release document for selected and tested PVGs.

18. What do I need to know about intellectual property rights of seeds?

In some cases, the developer may wish to seek legal protection for a cultivar as intellectual property at the time of release (McDonald and Copeland 1997). For seed-propagated materials this is facilitated by the Plant Variety Protection (PVP) Act of 1970. Only cultivars, not PVGs, are eligible for protection under PVP, and an extensive process is required to secure such status.

In order to qualify for PVP, data must be presented to demonstrate the proposed material meets cultivar standards for being "distinct, uniform, and stable" (DUS) (McDonald and Copeland 1997), as well as "new." It must be distinct, or novel, in the sense that it can be differentiated by one or more identifiable morphological, physiological, chemical, or cytological characteristics from all other cultivars of public knowledge. It must be uniform in the sense that variations in essential and distinctive characteristics are describable, predictable, and within commercially acceptable limits. It must be stable in the sense that it will remain unchanged in its essential and distinctive characteristics when increased, as determined for a specific mode of reproduction (see FAQ 3 in Jones [2005]). In 1994 the PVP Act was amended, requiring that a protected cultivar be new in addition to DUS, meaning that it must not have been sold or distributed for a given time period prior to the date of filing for protected status (USDA AMS 1997).

As a provision of Title 5 of PVP, sale of noncertified seeds for a particular release may be prohibited (McDonald and Copeland 1997). Cultivars qualifying for PVP are protected for 17 y before entering the public domain. For clonally propagated materials, the Plant Patent Act of 1930 offers intellectual property protection. Although these laws protecting intellectual property do not apply to PVGs, these may be offered a degree of civil protection by trademarking a PVG identification term.

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