Seed Condition

Seed condition refers to the physical and physiological state of being and health of seeds. Seeds are a living biological end-product of genetic and environmental interaction and their behaviour cannot be predicted with certainty (Ben Wang, pers. comm., May, 2000). Seed condition explains the large variability we observe between species and seedlots, and even within seedlots.

Seed condition may be characterized **qualitatively** through visual observation (e.g., cutting tests or x-rays) or **quantitatively** through seed testing (e.g., moisture or germination tests). Within the seed handling system, seeds are removed from cones, dewinged, separated from foreign debris and culled if non-viable, prior to being termed a seedlot. As this processing advances, the seeds begin to appear more streamlined, cleaner and no longer mixed with extraneous material. Seeds ready for storage carry little if any debris with them.

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Seeds—even clean seeds—can be passive carriers of pathogens that can kill or mummify them. Even after planting, these pathogens can emerge under suitable environmental conditions and be further transmitted. Fungi, insects, bacteria, viruses, and nematodes are associated with and can be carried with, on, and in all seeds. Of these organisms, insects and fungi are most important for conifer seeds. They are discussed in the chapters "Cone and Seed Insects" and "Seed Fungi."

Visual Observation

The visual observation of seeds is an important step in assessing condition and determining if a problem exists. The technique requires no special tools and provides an instantaneous assessment of seed condition. While evaluation based on observation will always be subjective, it is through experience gained from repeated observation, assessment, and follow-up, that the full benefits of observations can be realized. Discussion of observation techniques will cover basic external and internal seed characteristics. A more complete coverage of seed characteristics is available in *Anatomy and Morphology of Conifer Tree Seed* (Kolotelo 1997).

Morphology

The exterior of a seed is comprised of the seed coat, which is composed primarily of dead cells and acts as a protective covering to the inner living tissues. The appearance of the seed coat can be quite variable (Figure 2). Lodgepole pine and interior spruce seeds are similar in size, are both completely dewinged during processing and do not possess resin vesicles.

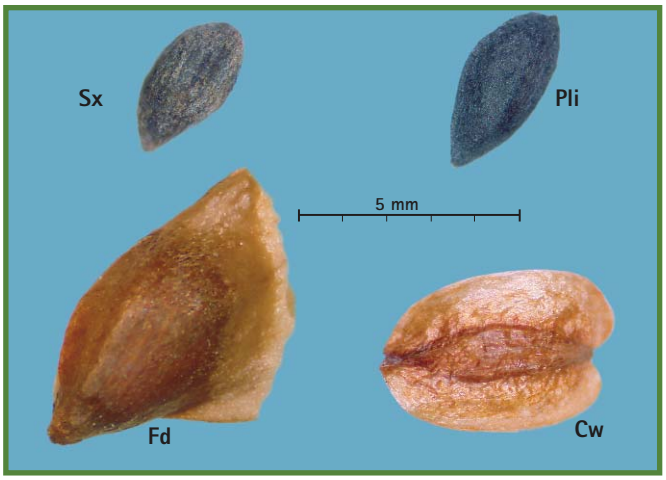

Figure 2 A comparison of the exterior appearance of interior spruce (Sx), interior lodgepole pine (Pli), Douglas-fir (Fd), and western redcedar (Cw) seeds.

These species can usually be differentiated based on seed size and seed coat colouration. Douglas-fir seeds do not possess resin vesicles, but the seed wings are not completely removed due to their integral connection with the seed coat—a small remnant of the wing can usually be seen following processing. Western redcedar seeds are quite distinct as the seed wings are not removed and resin vesicles are present on the seed surface.

Resin vesicles are present in all species of *Abies*, *Thuja*, and *Tsuga*. Although their role is unclear, studies have confirmed that damage to resin vesicles will result in decreased germination (Kitzmiller et al. 1973; Gunia and Simak 1970). Removal of the outer seed coat layer during handling can greatly change the appearance of seeds and predisposes the vesicles to damage (Figure 3). Seeds that have had their resin vesicles damaged can be identified by one or more of the following characteristics: a distinct odour, a tacky or pitchy feel to the seed, a greyish coloration, or a smoother, duller appearance to the seed (Figure 4). Damage to vesicles will occur as a result of rough handling of cones and seeds at any stage in the seed handling system.

...damage to resin vesicles will result in decreased germination

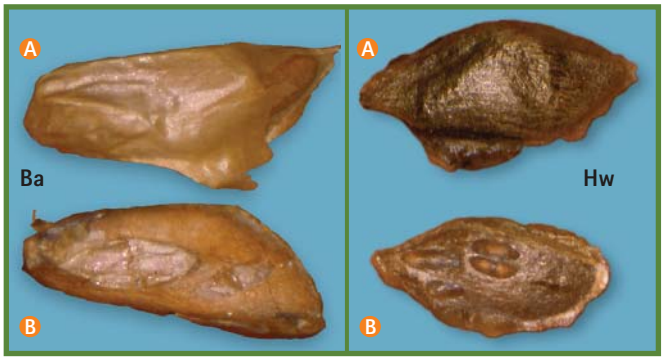

Figure 3 The appearance of Amabilis fir (Ba) and western hemlock (Hw) seeds that are a) intact or b) with the outer seed coat layer removed exposing the resin vesicles to potential damage.

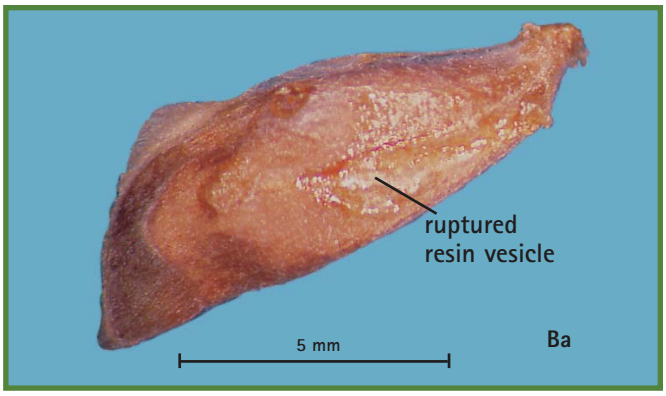

Figure 4 Resin vesicle damage in Amabilis fir (Ba).

The moisture status of the seed coat is an important visual attribute used to gauge surface drying of seeds. Once the inner components of the seed have been fully hydrated in preparation for stratification or sowing, surface drying is generally used to remove excess moisture. This drying minimizes potential fungal buildup, allows increased oxygen levels to reach the embryo and ensures that the seed is easy to sow mechanically. When excessively moist, seeds of many species appear dark compared to seeds which have had their surface moisture removed (Figure 5).

Figure 5 Interior spruce seeds showing imbibed seeds with (darker) and without (lighter) surface moisture.

Anatomy

...an assessment of the internal components of seeds is required for a complete picture of seed condition

Observations of the seed coat can provide some insight into seed condition, but an assessment of the internal components is required for a complete picture of seed condition. The internal components of seeds can be viewed by cutting a seed and examining it under magnification. These seed **anatomy** or cutting tests provide basic information on the quality of seeds at different times in the seed handling system. During collection, cutting tests indicate the proportion of viable seeds and their degree of maturity. During cone processing, cutting tests are used to assure all viable seeds are removed from cones. During seed processing, cutting tests are used to fine tune equipment settings and ensure viable seeds are being retained and non-viable seeds are being removed from a seedlot. Cutting tests can also be used to assess a seedlot following a germination test if it is below the species average in quality. To obtain the best results from the cutting test, ensure that the seed is **imbibed** first (fully hydrated) in a water bath (see "Seed Testing" chapter, Table 5, page 46, for soaking times). As the components swell, tissues become more differentiated making it easier to identify viable seeds in the hydrated condition. Cut the seed on its longest axis through its thinnest dimension (Figure 6). Seed anatomy can be best

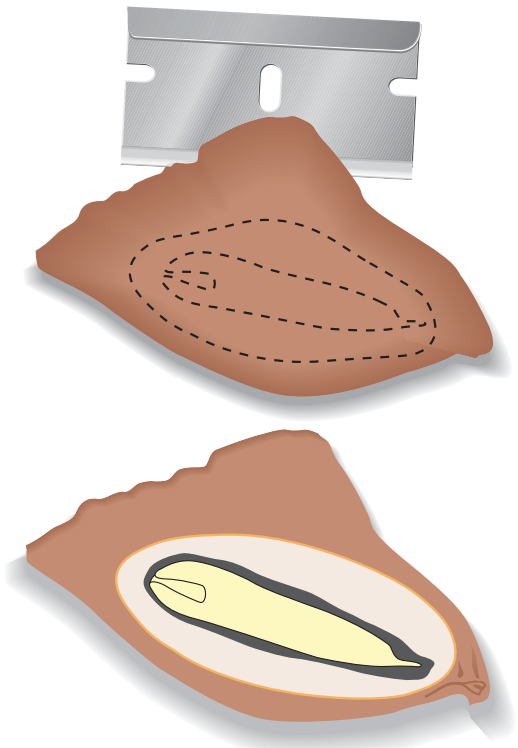

Figure 6 When performing cutting tests, cut the seed longitudinally through its thinnest dimension.

viewed when the cut has been made exactly through the middle of the side. The anatomical detail is reduced as the cut moves off-centre. For some categories (i.e., rotten contents) it is not as important to perform a 'perfect' cut, but slight differences in anatomy (i.e., obtaining an accurate estimate of embryo length) require a centred cut. Cutting tests generally become more challenging as seed size decreases (i.e., more difficult to get good sections in western hemlock as compared with ponderosa pine). While a hand lens is sufficient, a dissecting microscope will greatly increase your power of observation.

The cut seed is classified into categories based on the observed anatomy. A random and representative seed sample is key to properly assessing a seedlot. An assessment of the number or proportion of seeds in each category will allow the seedlot to be characterized to estimate germination capacity and provide guidance about what procedures can be used to improve seed quality throughout the seed handling system. The categories used will depend on the stage in the seed handling system, level of detail required, and types of seeds observed. For example, a cutting test on seeds just extracted from the cones should include a group for empty seeds, but this category is usually absent from fully processed seeds of most species. The number of seeds to use is also debatable and depends on the level of detail required, but sample sizes of between 25 and 50 seeds are most commonly used.

The three main components of the seed, **seed coat**, **megagametophyte**, and **embryo**, can all be viewed within the cut seed (Figure 7). The seed coat in conifers is generally found to have three distinct layers and is mainly composed of dead cells. The seed coat protects and insulates the inner tissues from damage. The megagametophyte tissue serves as the food reserves for the embryo and may also be implicated in seed dormancy. The major portion of the megagametophyte is composed of **lipids**, which are **water insoluble** and efficient at storing energy for the demands of germination. The third component is the embryo which will give rise to the future seedling. Structures within the embryo include the **cotyledons** (sometimes called seed leaves) which will function in harnessing energy for growth through photosynthesis immediately after germination; the **shoot apical mersitem** which through cell division will give rise to all subsequent vegetative tissues; the **root apical meristem** which will give rise to all below-ground structures; a **rootcap** to protect the root apical meristem, and the **procambium** which will give rise to the vascular tissues important in translocating water, sugar and minerals within the plant. The **pith** is found inside, and the **cortex** on the exterior, of the procambium, but both tissues are composed of **parenchyma** cells.

It is usually relatively easy to identify seeds that can be considered potentially viable, but classifying or determining the cause of a problem can be more challenging

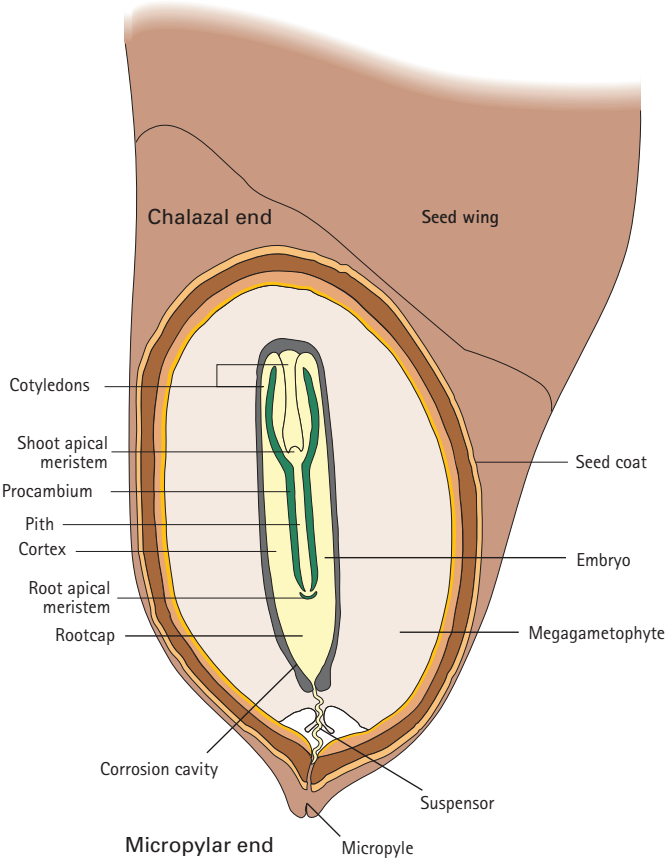

Figure 7 The anatomical details of a generalized conifer seed in longitudinal section.

It is usually relatively easy to identify seeds that can be considered potentially viable, but classifying or determining the cause of an aberrant condition can be more challenging. Representative cut seeds of the four major reforestation species in BC are illustrated in Figure 8.

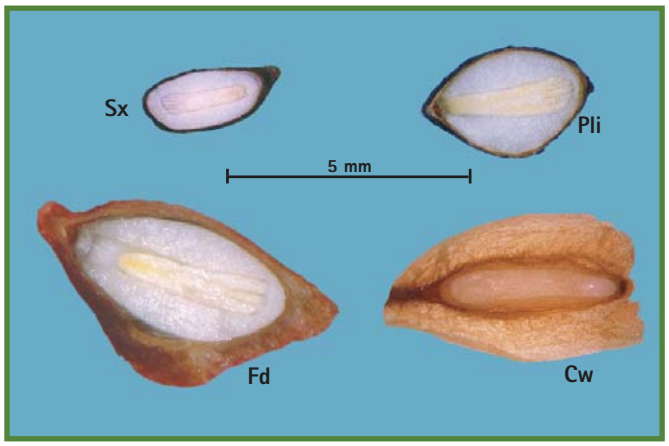

Figure 8 A comparison of longitudinal sections of interior spruce (Sx), interior lodgepole pine (Pli), Douglas-fir (Fd), and western redcedar (Cw) seeds.

In Figure 9, a key is presented showing one method for classifying seeds. Seeds described as having rotten contents generally have a loose, unorganized and discoloured appearance (embryo may or may not be identifiable). These seeds are easy to identify and, due to an advanced state of deterioration, will not germinate. Some activities that can increase deterioration are physical damage (bruising); overheating (post-collection storage or in transport); prolonged storage of moist seeds (>10% moisture content); and the presence of micro-organisms. The most commonly observed categories are described, but it should be appreciated that seed condition is continuous and these categories are created for our convenience.

Seeds with developmental problems can be defined, for simplicity, as seeds with immature components. An immature embryo is the most readily identified component as it occupies only a fraction of the **corrosion cavity** which forms within the megagametophye. A cone crop is generally considered morphologically mature when its embryo occupies more than 90% of the corrosion cavity. Immature seeds may contain a normal looking megagametophyte and may germinate if they have matured sufficiently. While the threshold between germination and continued deterioration varies, it probably lies between 60 and 75% of the length of the **corrosion cavity**. Seeds with embryos between 75 and 90% have a high probability of germinating, but germination rate, vigour, and storability may be reduced compared to mature seeds. Immature seeds that contain a deteriorated megagametophyte probably will not germinate.

Potentially viable seeds possess all essential structures including a mature embryo and a uniform, firm, white megagametophyte without any signs of deterioration (Figure 7). These seeds will germinate promptly, with appropriate dormancy breaking treatments, and will likely store quite well. Seeds with a slightly deteriorated megagametophyte will probably germinate if provided with 'good' germination conditions. The practical impact of deterioration can be profound if germination is slowed, through unsuitable germination conditions, to the point where insufficient storage reserves are available to fuel germination. As deterioration of the megagametophyte worsens, the probability of germination decreases.

This is but one example for classifying seeds and many other methods may work well for your situation. An example of a cutting test scoresheet is presented in Figure 10 (page 9). The use of imbibed seeds in cutting tests is strongly recommended. When assessing developing or soon-to-be-harvested crops, moisture content may be sufficient and thus, seed imbibition not required. In judging collection timing, one can allow cut seed to dry overnight—if the megagametophyte does not shrink from the seed coat, the seeds are ready to be collected (Eremko et al. 1989).

X-ray radiographs offer another method for visually assessing and preparing a permanent point-in-time record of a seedlot. X-rays are generally performed on seeds at storage moisture content between 5 and 10% as details about seed anatomy are clearly visible (Figure 11). Problems such as insect-infested seeds and cracks in the seed coat are readily visible on x-rays, but difficult to detect by other means. Film choices include options for instant development, great for immediate decision-making, or negative film for a higher quality, archival record of seedlot quality.

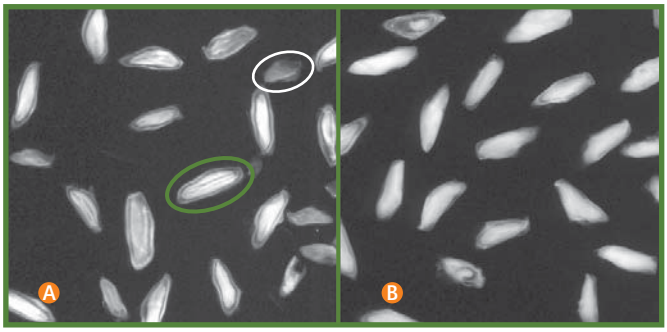

Figure 11 Examples of x-ray radiographs on a) seed at storage moisture content and b) soaked seeds at approximately 30% moisture content. The seed in the green ellipse (a) illustrates a viable seed; the seed in the white ellipse is a non-viable empty seed.

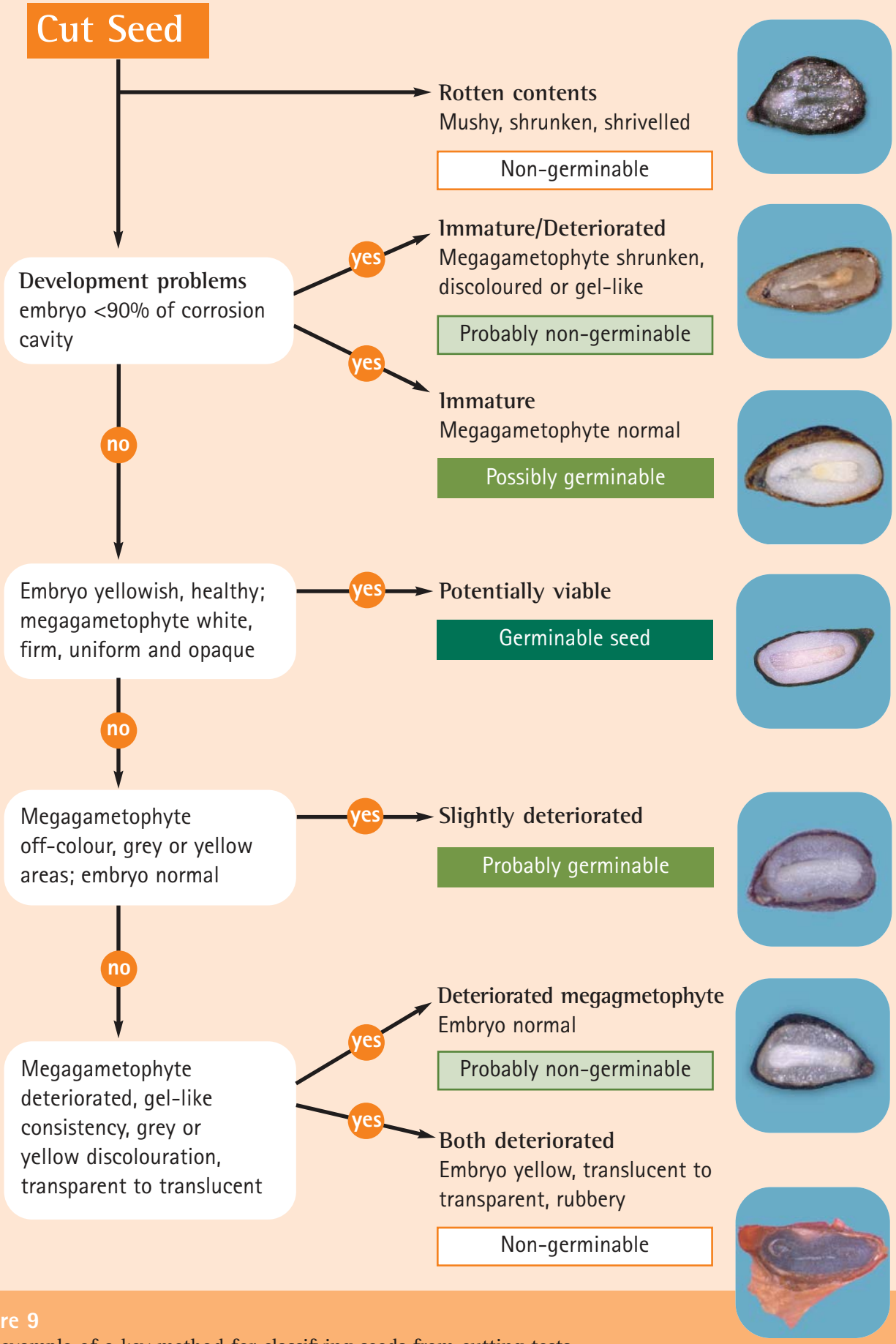

Figure 9
One example of a key method for classifying seeds from cutting tests.

Date of Tests		Viable	Questionable Viability			Immature		Non-viable	
					EMBRYO				
Tests Performed by:		Good	Normal	Normal	Deteriorated translucent rubbery	Development problems	Development problems	Rotten	Comments/other
Seedlot/ Sample	# of seeds				MEGAGAMETOPHYTE				
		Good	Slight discolouration	Grey/Yellow deteriorated	Grey/Yellow deteriorated	Normal	Shrunken/ discoloured	Rotten	

Figure 10
A cutting test sheet for classifying seeds and recording comments.