**Seed Germination**

**Overcoming dormancy**

In the nursery, dormancy prolongs tree production time. Therefore, various treatments are often applied to shorten dormancy to accelerate planting stock production. A thick, impervious seed coat can prevent water or oxygen reaching the embryo, so one of the simplest techniques to break dormancy is to cut away a small piece of the seed coat with a sharp knife or nail clippers. For smaller seeds, gently rubbing them with sandpaper can be equally effective. These techniques are called scarification. During scarification, care must be taken not to damage the embryo within the seed. Acid treatment is another form of breaking down seed covering, but since acid can kill the embryo, seeds must be soaked in acid only long enough to soften the seed coat, without penetrating to the embryo. When germination is inhibited by chemicals, soaking seeds in water to dissolve the chemical inhibiters can induce germination.

**How should seeds be sown?**

Sow seeds in germination trays, filled with a suitable medium, except for large seeds, which can be sown directly into plastic bags or other containers. Seed trays should be 6¬10 cm deep, with plenty of drainage holes in the bottom. The germination medium must have good aeration and drainage and provide support for germinating seedlings.

**Dormancy and germination defined**

**Dormancy** is a period during which viable seeds fail to germinate, despite favourable conditions. It can originate in the embryo or in the tissues that surround it (endosperm, testa or pericarp). Dormancy originating in the embryo can be due to i) a need for further embryonic development (after-ripening); ii) chemical inhibition of metabolism; iv) a block on mobilization of food reserves or v) insufficient plant growth hormones. Dormancy, due to the seed coverings, can be caused by i) restricted water or oxygen reaching the embryo; ii) mechanical restriction of embryo expansion or iii) chemical inhibitors (e.g., abscisic acid). In many plant species, dormancy results from a combination of several such mechanisms.

**Germination** consists of three overlapping processes. Absorption of water causes swelling of the seed and splitting of the seed coat. Food reserves are mobilized (from the endosperm) and transported to the embryonic root (radicle) and shoot (plumule), which begin to grow and push against the seed coat. The final stage (and most precise definition of germination) is emergence of the embryonic root through the seed coat. In germination trials, this can be difficult to observe for buried seeds, so emergence of the embryonic shoot can also be used to indicate germination.

Mix forest soil with coconut husk 2:1, or for very small seeds, forest soil:sand 1:1. Including forest soil in the medium provides a source of mycorrhizal fungi, required by most tropical forest tree species. Sow small to medium-sized seeds just below the surface of the medium, to a depth of approximately two to three times their diameter. If rats or squirrels are a problem, cover germination trays in wire mesh. Space the seeds at least 1-2 cm apart (more if the seeds are large) to prevent over-crowding. If seeds are sown too closely together, seedlings may be weakened and more susceptible to diseases such as damping off. Water the germination trays lightly, immediately after sowing the seeds and regularly thereafter. Use a spray bottle or a watering can with a fine rose to prevent compaction of the medium. Watering too frequently encourages damping off diseases.

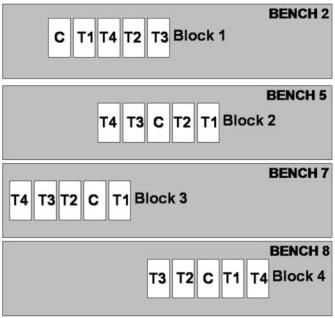
**Germination trials**

Collect fruits when they are fully ripe but just before they are dispersed or consumed by animals. Label each seed tree with a unique number and fill in a seed collection data sheet.

Germination trials can answer two basic questions: i) how many seeds germinate (per cent germination) and ii) how quickly or slowly they germinate. Both of these parameters can be manipulated to grow tree saplings for a specific planting time.

**What treatments should be tested?**

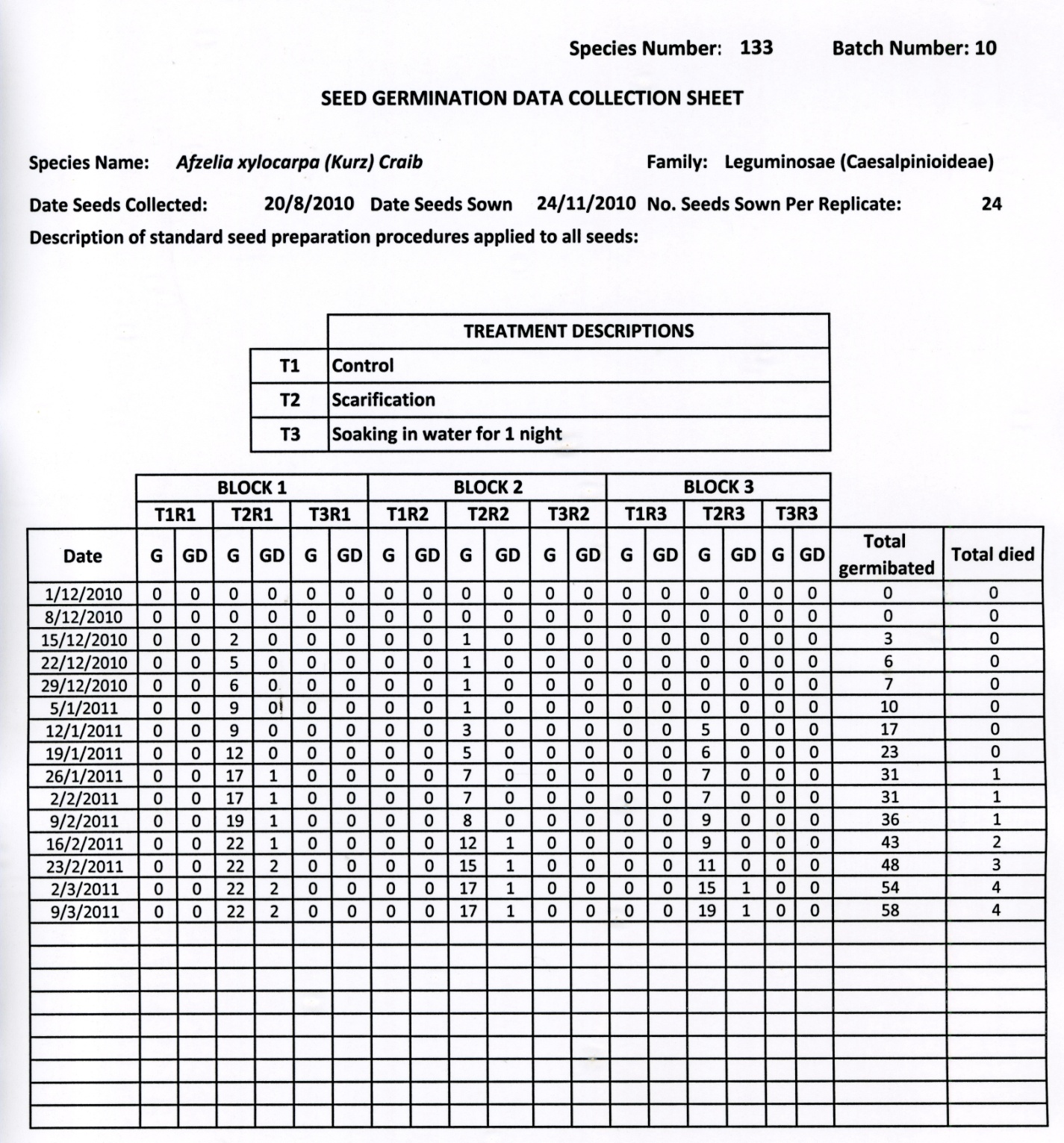
To accelerate and maximize germination, seed treatments should aim to overcome dormancy mechanisms, which may be present, e.g. scarification, acid treatment, soaking etc. Design treatments that change only one factor, although this can be difficult to achieve in practice. For example, putting seeds into hot water has two simultaneous effects i.e. soaking and heating.

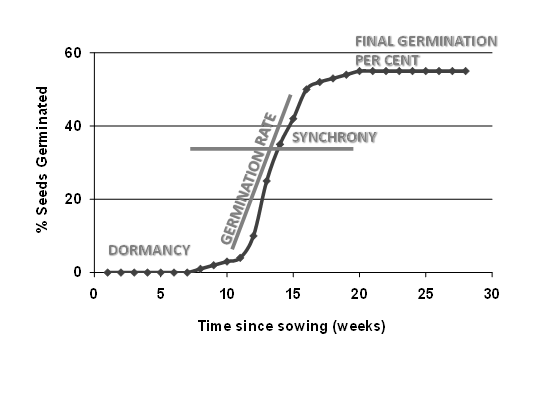
**Experimental Design**

Use a randomized complete block design (RCBD) to test different treatments or to compare germination among species. Place a control germination tray (with seeds prepared in a standard way) and several treatment trays (each one containing seeds subjected to a different pre-sowing treatment) adjacent to each other on a nursery bench as a “block”. Replicate the blocks several times on different benches and represent each treatment equally in every block (i.e. the same number of seeds subjected to each of the treatments and in the control tray). Within each block, allocate the positions of the control and the treatment replicates randomly. The typical design shown here has 4 treatments and a control, replicated in 4 blocks. Fill modular germination trays with the regular germination medium used in the nursery. Then, sow a single seed into each module. Clearly label the trays with the species number and treatment. A similar design can be used to compare among species replace T1, T2 etc. with Species 1, Species 2, etc.

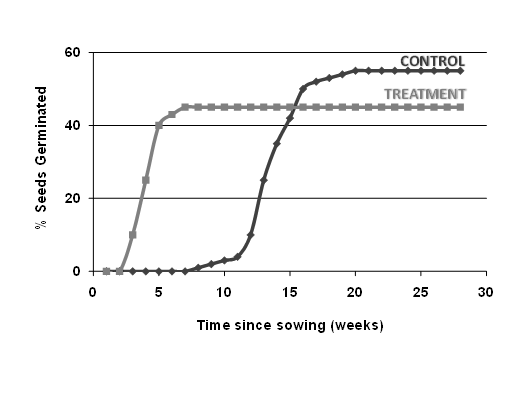
**Data Collection**

Inspect all seed germination trays at least once per week. For each seed that has germinated, use a white marker pen to place a waterproof white dot on the rim of the module. Count the total number of white dots and record the result on the data sheet. Recording early seedling mortality is also a useful to help to calculate the number of trees that can be generated from a given number of seeds collected. To record early seedling mortality, count the number modules with white dots, but containing no visible seedling or an obviously dead one

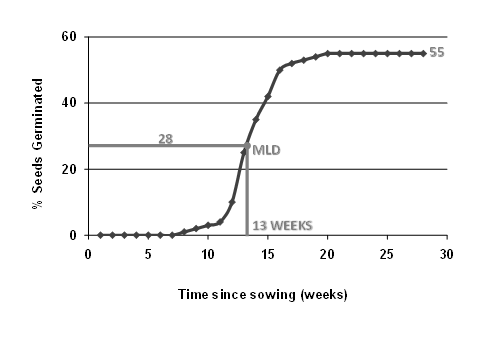


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**Germination curves**

The germination curve combines all germination parameters into a single graphic, including length of dormancy period, rate and synchronicity of germination, as well as final percent germination. Decisions can be made even without the need for complex statistical tests. In the example here, a pre-sowing seed treatment accelerates germination but reduces the germination per cent, compared with the control. Faster germination may mean the difference between achieving a crop of saplings ready to plant by the first rainy season after seed collection or having to maintain saplings in the nursery until the second rainy season after seed collection.

**How is dormancy measured?**

Dormancy is time between sowing a seed and emergence of its radicle (embryonic root). It varies among the seeds. Median length of dormancy (MLD) for a seed batch is the length of time between sowing and germination of half the seeds which eventually germinate. In the above example, MLD would be the time between sowing and germination of the 5th seed, i.e. 50 days.

**Treatment comparisons**

For each treatment and for the control (or to compare among species), sum the final number of seeds that germinate from all replicate blocks and divide the result by the number of blocks to calculate the mean value and then repeat the calculation for the MLD values. Then apply a “two-way ANOVA (without replication)” to test for significant differences among the means (i.e. among the treatments and control). If the ANOVA shows significant differences, then perform pair-wise comparisons between each treatment mean and the control mean to determine which treatments increase or decrease germination and/or dormancy. Both these tests are easily done using the Data Analysis Tool Pak of MS Excel. For full details see the appendices of “[Research for Restoring Tropical Forest Ecosystems: A Practical Guide](https://www.forru.org/library/0000156?t%5B0%5D=47)”. <https://www.forru.org/library/0000156>.

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