Basic Concepts of Seed Production and Seed Regeneration

Seed Production and Regeneration: The basics for producing and harvesting seed from plant material for the purpose of distribution, storage or sale.

In order to produce seed which is true to type, one must become knowledgeable in the variety’s reproductive process, as well as, the techniques used for maintaining genetic diversity and identity, seed harvesting, seed cleaning and seed storage.

Plant Reproduction 101:

Plants can be broken down into 2 main reproductive categories...Self-Pollinating and Cross-Pollinating.

- Self-Pollinating Plants (“selfers”): transfer of pollen from the male anther to the female stigma within the same flower or on the same plant.
  
  o These plants usually require smaller minimum population sizes (minimum number of plants needed to ensure genetic diversity) and shorter isolation distances (distance needed between same species varieties to ensure no crossing) than crossers.
  
  o Examples: beans, tomatoes, barley, lentil, oat, rice, soybean, wheat.

- Cross-Pollinating Plants (“crossers”): transfer pollen from the anther of one plant to the stigma of another plant. This process is usually accomplished naturally by wind and insects or can also be accomplished manually by hand-pollination.

POINTS TO REMEMBER:

- Cross-pollinating plants evolve under conditions of constant gene recombination and suffer from “inbreeding depression” (symptoms of decreased vigor and the appearance of negative recessive genes when inbred).

- When breeding cross-pollinating plants one must be cautious to prevent crossing varieties of the same species. This can be accomplished through various methods of isolation.

- Genetic diversity must be maintained. High genetic diversity ensures that all possible genes (characteristics) are being represented in the variety.
Examples of cross-pollinated: onion, beets, corn, cucumber, cole crops, squash, radish, celery, rye, and buckwheat.

Means of Pollination:
1. **Wind:** These species require the largest isolation distance (pollen can travel for miles depending on the strength of the wind and the presence or absence of barriers). Varieties that are wind pollinated should be planted in dense blocks to ensure total pollination. Wind pollinated species can either be self-pollinated (wheat or oats) or cross-pollinated (corn or beets).

2. **Insects:** These plants have flowers that encourage insects to travel from flower to flower. For plants that prefer insects as pollinators, it is important to find out which pollinators (flies, bees, etc.) that the plant prefers. Insect pollinated species require less isolation distance than the wind pollinated species but still require up to a mile of separation from same species varieties to ensure no crossing within species.

3. **Self-pollinating species:** Self-pollinated plants (for example: beans, tomatoes, and potatoes) have flowers that are evolved to self-pollinate with no assistance. Although self-pollinating species are designed to reduce/eliminate cross pollination within species, crossing can occur. For example, certain heirloom varieties of tomato have long, protruding styles which can encourage cross-pollination. If you attempt to produce seed from these varieties, you must treat them as a cross-pollinating species and isolate them from other varieties in their species.

**Annual Crops:** Annual crops require only one growing season to produce seed and complete their lifecycle. But because you are growing the crop for seed rather than fruit, you may have to plant the crop earlier than usual and harvest much later.

**Biennial Crops:** Biennial crops require 2 growing seasons to produce seed and complete their lifecycle.
- These crops generally require a period of vernalization (exposure to cold) in order to flower. [Tip: Before exposing the vegetable to the cold (less than 45 degrees Fahrenheit), they should be partially developed].
  - Cabbage stems should be at least as large as a lead pencil in diameter.
Average chilling temperature should be less than 45 degrees Fahrenheit and chilling should continue for at least 1 – 2 months.

**Photoperiod Response:** Some crops require a specific day length in order to initiate flowering.
- Short day plants require a day length shorter than a specific period.
- Long day and intermediate day plants require a day length longer than a specific period.

**Plant Genetics 101:**

**Genetic Integrity:** To prevent varieties from crossing, seed producers must use some means of isolation (cages, distance isolation, time isolation, or hand pollination) during periods when pollination can occur. Genetic diversity within a variety is maintained by including a minimum number of randomly selected parents into the breeding population. This number will vary by crop species (See appendix page 2).

**Ways to protect a varieties genetic integrity:**

1. Properly identify and label plants.
2. Plant on clean land which has not been used to grow the same crop in the past cycle.
3. Isolate plants from cross-pollination.
4. Plant at least 200 plants for cross-pollinated crops and 50-100 plants from self-pollinated crops (this number varies dependant on who you talk to).
5. Rogue off-types.

**Rogue:** A rogue is a plant which is “off-type” (different from the variety) or is otherwise undesirable. Rogue plants should be removed as soon as possible in order to protect the genetic integrity of the variety.

**Reproductive Isolation:**

1. **Isolation strips:** plot of a crop which separates seed plots, preventing crossing and mechanical mixtures.
   - This strip would theoretically catch windblown pollen and distracts insects from visiting the plots on either side of it.
2. **Distance Isolation:** Try to follow this general rule, selfers should be isolated by at least 150 feet AND an isolation strip. Wind pollinated crossers should be separated by at least 1 mile (but up to 5 miles), insect pollinated crossers should be separated by at least ¼ mile AND some other barrier (or 1 mile in open land).
Once again these figures vary depending on the source of your information.

3. **Caging and Artificial Barriers:** Cages can be constructed with PVC and fabric row covers. Brown paper or fine meshed bags can also be used. Non-porous bags are not recommended because they can lead to rot.
   - When these methods are used it is required that either plants are hand-pollinated or pollinators must be introduced into the caged/bagged environment.

4. **Time Isolation:** You can plant different varieties of the same species in the same year as long as the times they flower do not overlap. For annuals, this could mean starting one variety early in the season and then starting another several weeks later. For biennials, you could have multiple varieties of the same species (such as onions) growing in the same place but only one that is in it’s second year and going to flower.

**Hand-pollinating:**
Basically, you are transferring pollen from one flower to the stigma of another and then you must cover the pollinated flower to isolate it from being pollinated by a different variety.

1. The flower to be pollinated is emasculated (stripped of anthers or male parts).
   - This should be done BEFORE the male parts begin to release pollen (typically just before the flower opens).

2. To transfer the pollen, either...
   - Remove the entire flower and touch the anthers to the stigma.
   - Place a bag over the flower heads and shake to collect the pollen and then transfer the pollen with a feather or fine brush.

3. After pollination has occurred, the flower should be covered with a bag or taped (squash flowers and other large flowers).

4. Remove the bag or tape after approximately one week.

**Minimum Population Size:** This refers to the smallest number of plants that can be grown of one variety to ensure genetic integrity. There is a more in-depth minimum population size sheet at the end of this section.

- In general,
  - 200 plants for cross-pollinated varieties.
  - 60-80 plants for self-pollinated varieties.
  - These figures often vary depending on who you talk to.
**Seed Harvesting:**

- **Labels and Records:** Label seeds and seed lots! Labels should be affixed to whatever the seed is being stored on or in during processing.
- **Harvesting Methods:**
  - Dry Seeds: Let the plant material completely dry either in the field or after you harvest in mesh bags or on mesh tarps (turn frequently to ensure proper drying).
  - Harvest when the seeds begin to rattle in their pods but, keep a daily check to ensure the pods don’t open and you don’t waste any seed.
  - Wet Seeds: Harvest entire fruit and scoop out seeds and place in container.
  - Most fruits should be allowed to slightly over-ripen (but before decay) before you harvest for seed.
- Seeds should be harvested from as many plants as possible throughout the growing season to help ensure genetic integrity.

**Seed Cleaning:**

When seeds come out of the field, they may contain many types of particles (the desired seed, weed seed, plant material, etc.). In addition to the many different types of particles, the desired seed may have broken or other unviable seed mixed in to the lot. By removing these undesirable seeds and particles, you will improve the vigor and germination rate for your lot.

When removing the undesirable seed from your seed lot, there are many differences in the seed used to make separations.

1. **Size** (large vs. small and length, width, and thickness). The most popular way to separate particles of different sizes is by scalping (using a screen which allows the desired seed fall through the screen holes while removing the larger particles) or sifting (dropping out smaller particles by using a screen in which only the particles smaller than the seed are allowed to pass). Both of these separations can be made manually by using separating boxes or mechanically using devices like the Clipper Office Tester (see equipment section). Making length separations can be done by using an indented cylinder or disc machine.

2. **Weight** (heavy vs. light and differences in specific gravity and surface area). This separation is best done with a box fan, an air column or aspirator (see equipment section). These work by
passing a stream of air past the seed allowing the light (often unviable) seed to be blown out of the seed lot. This method will also remove any light chaff that remains within the seed lot.

3. **Shape** (round vs. non-round). This separation can be done with a spiral separator (round seeds will roll faster than flat or non-round seeds).

4. **Surface Texture** (rough, smooth or pointed). A flat piece of roughed-up cardboard works well for this separation. Round seed will roll to the bottom when placed at a slight angle while flat seed will be “caught” on the roughed cardboard. Also a velvet roller works well (see equipment section).

5. **Color**: This separation is most often done by hand-picking although there are color separation devices; they are not commonly used by small-scale seed producers.

Other things to keep in mind when cleaning seed:

- **Labels, Records and Mechanical Mixing**: Affix labels to all seed containers and spaced far enough apart to ensure there is no mechanical mixing of seed lots.
- **Cleaning Supplies**: Dry seed should be free of seed pods, hulls, and stalks by being smashed in a tarp, bag or mechanical thresher (clipper mill, belt thresher, brush mill, etc.) and then screened. Screens are used to separate out material that is larger or smaller than the seed being cleaned. Wet vegetable seed cleaning supplies include buckets for fermenting, hand mashers (4 x 4 with a handle), a wet vegetable seed separator (See Seed Cleaning Equipment section) and sieves and colanders.
- **Always dry seeds completely before storing!**

**Cleaning Dry Seed:**

- Seed pods can be dried then smashed in a number of ways...stomping and smashing in a threshing box, or using a mechanical thresher is common. Once all the seeds are released from the pods, you can separate the seeds from the pods by using handscreens or a “Clipper Mill” (See Equipment section).
  - A threshing box can be built by making a 3 x 3 box (without a top) and placing a corrugated plastic mat at the bottom of it.
- Once the larger pods are removed, lighter chaff can be removed by winnowing or using an air column (See
Equipment section). Finer removal of chaff can be accomplished by using a velvet roller (See Equipment section).

- Once all chaff has been removed, seeds should be stored in a dark, clean, dry, pest-free environment.

**Wet Seed Cleaning:**

- Seeds can be removed from fruit by cutting the fruit open and scooping out the seeds or by using a "Wet Vegetable Seed Separator" for tomatoes, peppers, and cucumbers. (See Equipment section).
- After seeds are removed, some species (tomatoes, for example) can benefit from a fermentation process.
  - Fermentation Process: Place seeds (covered with pulp/gel) into a container and cover seeds with an equal amount of water for approximately 2 days. You should stir this mix at least twice a day.
- Once the fermentation process is finished (there will be a pungent odor and layer of mold growing on the top of the bucket), seeds should be rinsed thoroughly. Strainers and fryer baskets come in handy during this step.
- After seeds are rinsed, they can be dipped in a 20% Clorox solution (this process protects the seed from Tobacco Mosaic Virus) and then rinsed again with clean water to protect the seeds against certain viruses.
  - The seeds only need to be dipped for enough time to ensure that all the seeds have contacted the bleach solution.
- Once seeds are treated, they should be dried completely prior to storing.

**Drying Seeds:**

- Drying seeds at 10 – 25 degrees Celsius (50 – 77 degrees Fahrenheit) and at 10 – 20 % relative humidity using either some type of desiccant (silica gel or activated alumina) or a dehumidified drying chamber (set at the lowest heat setting or no the "no heat" setting) is ideal but air drying is common as well. Desiccants should be replaced every 3 to 5 years and dehumidifiers should be carefully watched so that seeds are not damaged by the heat.
- Seeds should be dried as soon as possible after harvest to avoid fungal and viral growth.
- Drying time is variable depending on the seed and the conditions in which the seed is being dried.
• If you can push your nail into the seed, it is probably not dry enough to store!!!
• Ovens are not recommended for drying seeds since heat can damage many seeds

**Seed Storage:**
• Optimal storage is airtight, low humidity, and low temperature.
  ◦ Except for peas and beans which like some “open air”.
• Containers should ideally be moisture proof and sealable (keep in mind that most plastics are not moisture proof).
• Metal, foil-lined heat sealable envelopes are often used at seed banks.
• Cold storage in a chest type deep freezer is invaluable for extending the lifespan of seeds. Low temperatures slow the process of seed decay. But be careful, most seeds can tolerate freezing but, it may damage others. Test a small sample of seeds first before putting the whole seed lot into freezer storage.
• Leak, onion, corn and parsnip seed is short-lived, the seed will most likely only last 1 – 2 seasons.
• Always remember that **before** opening any seed container that has been in a freezer, let the container acclimate to room temperature! If you just open the container straight from the freezer, condensation will form on the interior walls of the container and you will have to dry the seed again (possibly damaging it).

**Germination Testing:**

• Germination testing is important to both the seed regenerator and the seed producer.
• Always try to germinate a random sample of the seeds you are wanting to plant.
• For long term storage, initial germination should be at least 85% for cereals, and 75% for vegetables.
• Wild species often have lower germination rates.
• See Germination testing section of workbook for more information about the New York State Seed Testing Laboratory.

If you have any questions regarding what you have read in this workbook, please feel free to contact any project coordinator from the PSI project.