The Wizard's Guide to Seed Cleaning

Markael Luterra

February 25, 2025

Author's note

I originally imagined that this might be a published book, complete with illustrations of winnowing divides, screen-shaking techniques, and seed shapes. Perhaps that may yet happen one day, but I find myself pulled in other directions and would prefer to make this information available to folks who will find it helpful. If any readers enjoy publishing and would like to take this to the next level, please reach out.

As of this writing I find myself largely shifting out of the seed world into the realms of local food systems and ecological spirituality. I find that I would like to share my accumulated experience from ten years of seed cleaning at Wild Garden Seed and Adaptive Seeds, through the process developing and optimizing the Winnow Wizard.

Less than half of the magic of the Winnow Wizard is in the machine. The rest is in technique: knowing *when* to winnow in the overall process, where exactly to set the winnowing divide, which screens to pass seeds through, which screens will keep seeds on top, how and when to remove the hulls and husks and fluff. Seed cleaning is a puzzle, and sometimes – with certain seeds – it can be slow and tedious. Most of the time, though, with the right screens and sequence it is possible to go from a chaffy mess to pure seed in a few minutes, to the astonishment of novices and onlookers. With or without a fancy winnowing machine, *you* can become the wizard.

Acknowledgements

I am especially thankful to Frank Morton of Wild Garden Seed, for being willing to share his seed cleaning expertise and especially the trick of using a shop vac for abrasion which was a company secret for many years. I am equally grateful to Andrew Still and Sarah Kleeger of Adaptive Seeds, for being willing to share their accumulated knowledge and for partially supporting this project financially as a seed cleaning manual for their own operation.

Table of Contents

Introduction

I never imagined I would write a guide to cleaning seeds, but then I've also never been one to plan where my life would lead me. My first memories of seed cleaning were of winnowing home-grown popcorn in the frigid winds of Minnesota winter, and of growing wheat in our home garden and then finding myself at a loss as to how to get from the chaffy, hull-covered seeds to something that could be ground into flour.

My path into the seed world started in 2014, when I had just completed a Ph.D. with the goal of engineering photosynthetic bacteria to produce hydrogen and I was ready to be done with pipetting and statistics and bland scientific writing. I had also acquired something of a sense of the futility and hubris in working against evolution, in forcibly re-designing life to serve our objectives, no matter how noble. So I signed on to work with photosynthesis on a larger, more tangible scale, joining the crew at Wild Garden Seed where Frank Morton was guiding evolution with a firm but gentle hand, exploring and selecting the natural diversity in lettuce and kale and quinoa.

That meant that I was cleaning seed, and my engineering mind set to work trying to improve the winnowing process, to match the accuracy of our screens with a precisely-managed airflow. Using the same principle as the laminar flow hoods in my microbiology background – a pressure differential across a grating to create a uniform airflow – I built a prototype winnower that incrementally evolved into the Winnow Wizard now in use at over 100 farms across the US and Canada (with a few as far as Australia).

I have now been cleaning seed for ten years – for five years at Wild Garden Seed, then for various contracts and demonstrations and Winnow Wizard trainings, and most recently at Adaptive Seeds. More than once I have been told, when delivering a Winnow Wizard and offering demonstrations, something along the lines of "that's a nice machine but *you* are the wizard" - which is to say that I have acquired a body of knowledge and experience in seed cleaning that is more valuable to aspiring seed growers than any tool. This book represents an attempt to share that knowledge in an accessible form, to fill a resource niche that has remained oddly empty.

This is specifically a guide to seed *cleaning*. It is not a guide to seed growing or seed saving. Although it includes descriptions of threshing methods I have used, I don't intend it to be a definitive guide to seed threshing as there are many tools and methods available. It includes most commonly grown vegetable, herb, and flower seeds, and the general techniques can be readily adapted to virtually any seed.

If you are just saving garden seed to re-plant, there is no need to get it clean – simply drying it and picking out the seeds is sufficient. On the other extreme, if you are working at the scale of combines and truckloads, there is probably relatively little in this book that will be helpful to you. If you are anywhere in between, from an ounce of lettuce seed for the neighborhood seed swap to ten pounds of home-grown wheat for flour to 100 pounds of chard seed grown on contract to two tons of heirloom beans for the local farmers market, read on.

On the magic of seed cleaning

Seeds are amazing, if we really think about them. Amidst the senescence – the rotting tomatoes, the dry dusty pods, the wilted and faded flowers – these packaged potentialities emerge: beautiful, uniform, each charged with an embryo in stasis, patiently waiting for the right combination of water and light and time and temperature to burst forth.

Too often seed cleaning is regarded as drudgery – a messy and tedious task to be put off until the seed is needed. I prefer to see it as a form of sacred midwifery, of bringing these packaged potentialities into their full being, leaving behind the fragments of dead stem and leaf and petal, the clods of dirt and bird droppings, the hollow seeds borne of incomplete pollination. I did not in any way *make* these forms, in all of their wondrous diversity, but I can steward them into purity, into beautiful bins of beans, into packets that approach 100% germination that can be shared with others.

There is no substitute for a complete set of tools. Lettuce seed *can* be cleaned with 1/8" hardware cloth and a window screen and a box fan, but with a 1/26" slot and a Winnow Wizard it will go much faster and end up cleaner. Each seed has its own unique size and shape, its own specific screens that work best, and a good seed cleaning workshop is like a well-stocked kitchen – it makes the difference between a task that is difficult and tedious with just-OK results and a task that is easy and fun with excellent and replicable results.

A Winnow Wizard and a full set of 50 or so screens will cost just under $10,000. If you're growing seed commercially, this is a worthwhile and reasonable expense alongside a tractor, irrigation system, greenhouse, etc. If you're a gardener or homesteader passionate about seed or just wanting to clean your home-grown grains and beans this won't make sense, but it *can* make sense to build at a community level for shared use. If you have a local food hub or gardening association, consider pooling funds or writing a grant for a shared-use seed cleaning workshop, which also brings a different sort of magic: that of bringing communities together and forging connections through seed.

How to use this book

The first section provides an overview of the seed cleaning process and detailed explorations of the three major operations: winnowing, screening, and abrasion. It introduces specific terminology – some of it probably unique to this book – that is used throughout the later sections so it's worth reading even if you're already familiar with seed cleaning.

The second section provides crop-specific step-by-step guides to seed cleaning, including specific challenges, suggestions, and difficult-to-remove contaminants to avoid during harvest and threshing. Think of it as a collection of recipes. To avoid making this into an encyclopedia, I could not include *every* crop I have ever cleaned, but I tried to include all of the most common ones as well as less-common crops (like sorrel and orach) that require special steps.

The tables at the back offer a quick reference for top and bottom screens for as many crops as I have information for. My hope is that these will also live online in a user-editable "wiki" format and ultimately expand to include hundreds or perhaps thousands of seed varieties.

The Process

All steps in seed cleaning are variations of three operations:

- Threshing/abrasion – to free the seed and remove material attached to the seed
- Winnowing – to separate seed based on density
- Screening – to separate seed based on size and shape

The overall process typically looks like

Thresh -> Field Screen -> Rough Winnow Dry *** Winnow -> Screen -> Winnow -> Screen

In the middle (***) is a stage often described as "rough-cleaned" in which the majority of chaff has been removed by fast initial screening and winnowing steps, and the seed has been dried or checked for adequate dryness. Seed growers will often store seed in this state until later in the fall in order to keep up with fall harvests and field work.

It is important to alternate screening and winnowing steps for maximum efficiency. Seed cannot be effectively winnowed until the coarsest material is removed, but seed also cannot be efficiently screened until the dust and lightest material has been blown away.

Threshing

Threshing methods vary widely, both between wet- and dry-seeded crops and within them. The crop-specific "recipes" will address threshing briefly, but in general it is important to note that threshing is the first step of seed cleaning, and small differences in threshing techniques can have large effects in terms of making seed easier or more difficult to clean.

Dry-seeded crops are generally best threshed at intermediate moisture levels – dry enough that the pods and capsules split open but not so crispy dry that the stems and leaves are pulverized into dust and seed-sized fragments. On summer days in the Pacific Northwest, this is often around 10 am – noon, just after the morning dew has dried. In autumn, crops may only be dry enough to thresh in late afternoon.

In general there are four types of forces that can be applied in order to thresh dry-seeded crops, with the best choices for each crop depending on the way the seeds are attached or enclosed:

- **Crushing**. Brittle pods like brassicas, peas, and beans break open when crushed. On small scales, stomping in bins or on tarps works well. On larger scales, it works surprisingly well to lay

out plants in a single layer on large tarps or landscape fabrics and drive over them, ideally with a higher-clearance vehicle. Work your way slowly across the tarp, forward and back, one tire width at a time. Whether stomping or driving, the intensity of the crushing force is dependent on the hardness of the underlying surface. Beans should be stomped or driven on over grass or soft ground to avoid splitting them, while crops with capsules that are really hard to break – like chicory/radicchio – can be stomped or driven on over concrete or hard gravel.

- **Rubbing/rolling**. Seeds that are directly attached to a stem are often most easily freed by a rubbing or rolling force. On the smallest scales this can involve rubbing plant material over a screen or rubbing it with hands. On slightly larger scales it works to "shuffle" – to dance in a chicken-scratch-like motion – over seed laid out on a tarp. Driving on seed can introduce a rubbing/rolling force if the plants are laid out more thickly such that the stems rub against each other when compressed.
- **Impact.** Impact forces can encourage seeds to fly off of pedicels or out of capsules, and impact can break up resilient structures to free the seed inside. Most conventional "threshing machines" use primarily impact force. On a small scale, hitting plants on a tarp with a stick or a pitchfork can work well. Old "Roto-Hoe" chipper-shredders do a good job of impact threshing, and you can find instructions on modifications to fine-tune them for threshing purposes. Some seeds, especially beans, are easily damaged by impact forces, and excessive impact can create seed cleaning problems by fragmenting stems and flower parts into seed-sized pieces.
- **Agitation.** Sometimes simply moving dried plants around is enough to free their seeds, if their capsules or pods naturally open. In practice this looks like shaking plants (usually upside-down) in bins, or raking material around on a tarp and shaking/hitting it gently. Minimizing the amount of crushing/impact will typically help to minimize the amount of small sticks and heavy debris that is difficult to remove from the seed later. For fluffy-seeded aster-family crops that ripen seed indeterminately, it is often helpful to shake/rattle whole living plants in bins to remove the ripe seed while allowing the plant to continue growing and ripening more seed.

These techniques can be combined in series; a common one is crushing followed by agitation or impact.

Wet-seeded crop threshing is an entirely different process that varies substantially by crop and is discussed briefly in the crop-specific "recipes".

Field Screening

The first step after threshing is to get rid of the whole plants, large sticks and other coarse debris, in effect to make the remaining material winnow-able. With beans, this can be done with manure forks or pitchforks. With smaller seeds a ½" or ¼" hardware cloth screen works well. Some nursery flats and plastic crates have holes in the range of 3/16" to ½" and work well for field screening. With wet seeds, this is typically a process of spraying seed through screens.

Rough Winnowing

At this point you will have a mixture of seed, chaff, and lots of very fine dust. The goal at this step is to blow out the dust without losing any seed, to minimize the amount of dust that gets brought indoors for the final cleaning steps. If you have a location with reliable and steady afternoon breezes, this is fun to do outdoors. If not, you can winnow in front of a box fan or in front of the Winnow Wizard airflow, pointed out the door of a garage or greenhouse. You can run material through the Winnow Wizard hopper at this stage – and this is helpful for small seeds that are easily blown away – but it is often faster to just pour from a bin into a larger bin on the ground. The goal at this stage is not to be accurate or to end up with clean seed, just to blow away the dust and lightest material without blowing away any seed. For wet seeds, this is typically a "water winnow" process, allowing the seed to sink to the bottom and pouring off the lighter material floating or suspended in the water.

Drying

On the seed farms where I have worked, this is the stage at which seed is typically packed away for final cleaning, which may happen several months later. Before it is packed away, it needs to be dry, which can be accomplished by cycling it through a seed dryer or spreading it out on tarps in the shade on dry afternoons. (Seed on tarps in full sun can get overheated, especially in midsummer.) Spreading seed out on cardboard or light-colored fabric in a ventilated greenhouse or high tunnel is a good way to accelerate drying in the summer months, though watch for rodent activity as they love seeds and turds can often be difficult to remove in the cleaning process. Ideally a hygrometer placed in a bin of seed should read under 50%, and closer to 40% is better for long-term storage. Any reading over 60% is a sign of trouble and could result in moldy seed if it is not dried soon. Seed should be fully dried before the final cleaning step, as moist chaff is heavier and does not always winnow out.

Final Cleaning

The order of operations for final cleaning is somewhat less important and will vary by crop. For most crops, I will start with a fast Winnow Wizard run to remove remaining dust and light debris, then screen out material larger than the seed, then complete the fine-winnowing steps to remove light/immature seed and debris just slightly lighter or heavier than the seed, then finally screen out material smaller than the seed while also (if necessary) picking out remaining larger material that did not winnow out.

Exactly how clean to get your seed will depend on what you're planning to do with it. Seed for sale – especially in small-volume packets – is often cleaned to 99.9% or higher purity – no more than one non-seed particle for every 1000 seeds. Grains and beans for eating need to be as clean as possible, especially of dirt and rocks. Commercial seed needs to pass germination tests, requiring that most hollow and immature seeds are removed. On the other hand, if you're just sharing with neighbors or

collecting native seeds for restorations you might get to “good enough” early on and skip the final winnowing and bottom-screening steps.

On Winnowing

I am going to write about winnowing assuming that you have a Winnow Wizard. This is not because I’m trying to sell you one (you can build your own if you prefer – the plans are available) but simply because I’ve done all of my fine winnowing on these machines for the past eight years. If you’re using a box fan or a blower or an entirely different density separator like an aspirator or a gravity table, there are equivalents to the four winnowing operations described here.

That said, I am not going to provide specific Winnow Wizard divider settings in my “recipes.” In part this is because there are different models of machines and different versions of restrictor screens, and settings also vary subtly with elevation and with the operating voltage of the blower, which depends on the length of the circuit and extension cord feeding it. In part it is also because I want you to get a feel for winnowing, for visualizing the spread of good seed as it falls and placing the divider beyond, within, or behind it depending on your objective.

I am also not going to cover specific operating instructions for the Winnow Wizard here. Please refer to the user manual, and for new users I highly recommend watching the 15-minute series of instructional videos on YouTube (linked at luterra.com/winnow-wizard/videos/). As a general pointer, for fine winnowing operations adjust the feed rate, feed tray angle, and feed slot width such that a narrow curtain of seed falls straight down with minimal horizontal momentum (whether forward through a too-wide slot or backward from rolling down the tray too fast and bouncing off of the feed plate). If winnowing by hand, the goal is the same although the achievable precision is lower.

As a curtain of seed falls through flowing air, it experiences a certain amount of random spread – some otherwise-identical seeds deflect farther than others. This spread is a result of three factors: feed (horizontal position and seed bounce), airflow (turbulence and uniformity), and seed shape. The Winnow Wizard minimizes spread resulting from the feed and airflow, leaving seed shape as the major determinant. Round seeds like brassicas spread very little, landing mostly within one horizontal inch, while flat seeds like lettuce and parsnips spread quite a bit, sometimes landing across six horizontal inches or more.

Sometimes it can be challenging to visually distinguish random spread from a genuine difference in density. If you’re unsure, you can re-winnow the heavy and light fractions at the same divider setting. If they mostly stay put – the light fraction blows past the divider on the second run and the heavy fraction falls behind it – then you have separated based on density. If they re-assort, with seeds from both fractions falling almost equally on both sides of the divider, then you have likely placed the divider within the natural spread. You can also inspect the seeds that blow past the divider to determine if they are hollow or damaged.

There are four winnowing operations, defined by where the divider is placed relative to the spread of seed. These are:

- **Clean**. The divider is placed sufficiently beyond the spread such that no viable seed is lost. This is typically used for rough first-pass winnowing, with a high feed rate and wide feed slot as the degree of spread due to the feed is less critical. For all other winnowing operations, the feed slot should be set as narrow as possible with a slower feed rate.
- **Shave**. The divider is placed precisely at the outer edge of the spread, such that a few viable seeds are lost but typically less than 1-2%. This is the final winnowing step for low-spread round seeds or easy-to-clean seeds.
- **Split**. The divider is placed within the spread. Splits are described in the "recipes" section based on the percentage of viable seed that falls behind vs. beyond the divider, e.g. an "80/20 split". Splits are employed to improve precision when winnowing flat, high-spread seeds, and will always be followed by one or more "recover" operations, which is a re-winnowing of the light fraction of the split typically at the same divider setting.
- **Overwinnow**. The divider is placed precisely at the inner edge of the spread, such that 99+% of the seed blows beyond the divider. Although it seldom appears in recipes, this is a useful and often-employed technique to remove heavy contaminants like rocks and dirt clods.

Splits and recoveries

When seed spreads out due to its shape, the effect is random – those seeds that happen to fall face-on to the wind deflect farther than those that happen to fall edge-on. This also means that if, say, 20% of the good seeds land beyond the divider by chance in the first run, 80% of those seeds will stay behind the divider if they are winnowed again. Most problem chaff is roughly in the form of sticks and balls, which don't experience random spread in the same way, and lighter seeds have their own spread curve that is often mostly beyond the divider setting. In this way, the split-recovery strategy is a way to set the divider closer in and effectively winnow out more chaff while avoiding significant loss of good seed.

The number of recoveries required depends on the fractionation of the split, and can be roughly calculated by multiplying probabilities. If 10% of the good seed blows beyond the divider, and upon recovery 10% of the light fraction blows beyond it a second time, the percent of good seed in the light fraction after recovery is 10% of 10% = 1%.

The table below indicates the number of recoveries required to reduce the proportion of good seed in the light fraction to 1% or less.

Split	Recoveries required
90/10	1
80/20	2

70/30	3
60/40	4
50/50	6

I don't recommend this strategy with splits closer in than 50/50, and in practice I always aim to have a majority fall behind the divider on the first run. This also assumes that all of the good seed has an identical density which in practice is never true exactly. When it seems like too much seed is persistently blowing beyond the divider after multiple recoveries, I will sometimes move the divider out another inch or two and continue the recovery cycle, saving the later-recovered seed as a separate lot for further cleaning and germination testing.

I will sometimes recover after a "shave" operation in which less than 5% of the good seed blows beyond the divider. In this case I will usually move the divider a half-inch or even an inch *closer in* such that I recover 50-75% of the good seed but essentially none of the lighter seed and chaff.

On Screening

A few screens can get you started, and if you specialize in a few crops you can get by with a subset of specialty screens, but to be a real seed cleaning wizard, able to adapt to any new seed that comes your way, you will want a well-stocked workshop. The list of 50 screen sizes below represents a good selection, in my experience. The ones highlighted in green get the most use and are a good choice for getting started, or to have in a larger size format.

Most of these screens can be purchased from Quality Custom Screen Company (qcscreen.com), and the round holes smaller than 6/64 that they don't offer can be purchased from Hoffman Manufacturing (https://www.hoffmanmfg.com/products/hand-screens/). You may be able to find other sources as well. You can purchase pre-framed hand screens, typically 12" x 12", or unframed screens cut to a size of your choice.

Building screens

In addition to the specialty screens listed below I recommend building screens with 1/8", ¼", and ½" hardware cloth, typically available by the foot locally. Frames can be built from 1x2 lumber, with solid metal screens nailed on and wire screens stapled on. Once the screen is attached, I recommend filling the holes beneath the frame with wood glue or a non-tacky caulk to cover sharp edges and prevent seeds from getting trapped.

Standard 12"x12" hand screens work well for small lots. If you're regularly cleaning 20+ lbs of certain seeds it can be helpful to have larger screens that fit nicely atop Sterilite or Rubbermaid bins – 14"x20" is a good size for this. Anything larger than that starts to get heavy and awkward to use.

Wire mesh	30x30
	24x24
	20x20
	16x16
Wire slot	6x36
	6x30
	6x26
	6x24
Slotted hole	1/26
	1/23
	1/20
	1/18
	1/16
	1/14
	1/12
	6/64
	8/64
	10/64
	12/64
Round hole	1/24
	1/22
	1/20
	1/19
	1/18
	1/17
	1/16
	1/15
	1/14
	1/13
	1/12
	5.5/64
	6/64
	6.5/64
	7/64
	7.5/64
	8/64
	9/64
	10/64
	11/64
	12/64
	13/64
	14/64
	15/64

16/64
17/64
18/64
20/64
22/64
24/64
26/64

Screening machines are widely available, but they are expensive, noisy, use specially-framed screens that are difficult to use for hand-screening, and are a pain to clean out between lots, almost inevitably resulting in some cross-contamination. Unless you are regularly cleaning seed lots in the hundreds of pounds, I don't recommend going the machine route – investing instead into a large collection of hand screens.

On the art of shaking screens

Hand-screening seed is more of an art than it seems, and I often see novice seed cleaners doing it inefficiently. The most common mistakes are shaking too vigorously, shaking with vertical motion, and placing too much seed on the screen.

When screening seed, all that needs to happen is for each seed to find the nearest hole which is at most a few millimeters away. The slightest vibration is enough for this, and so a gentle but fast shake, moving the screen side to side several times per second and no more than an inch or so per "stroke" is most effective. More vigorous shaking results in fewer shakes per second and tends to accelerate the seeds side to side such that they fly over the holes rather than falling through them.

Most of the time, there are some "sticks" that need to be removed from the seed in the cleaning process – pieces of plant stem or pedicel that are fragmented in threshing. These will pass through screens if they are tipped on their ends but will float on top of screens if laying on their sides. To maximize removal of these, it is important for the screen motion to be entirely side-to-side with no vertical "bounce" component.

Overloading screens increases the shaking time, which consequently increases the amount of just-slightly larger contaminants that pass through the screen. In general, a good rule of thumb is if you have to shake a screen for longer than 15 seconds you are overloading it.

Screening obviously works best if the seed is spread out across the surface rather than in a pile in the middle. Using your hand to spread out the remaining seed partway through shaking can aid efficiency.

Top screening

Following the convention at Wild Garden Seed and Adaptive Seeds, I will call screens with holes larger than the seed "top screens" and those with holes smaller than the seed "bottom screens". Traditional industry standard terms are "scalping" and "sifting".

Round seeds typically require only a single top screen, e.g. 6/64" for most brassicas. Flat seeds often benefit from passing through two different top screens: a round-hole screen to remove sticks and other flat/long debris and a slotted screen to remove smaller round-ish debris.

Passing flat seeds through slotted screens is its own art. The ideal shaking axis is at an angle to the slots; special "herringbone" perforation patterns can be ordered to increase efficiency for screening large lots. In practice, shaking parallel to the slots is usually better than shaking perpendicular, and constantly shifting the shaking axis (side-to-side, front-to-back, angled, etc.) can speed things up. Getting large seeds to pass through narrow slots can be challenging and is aided by tapping on the bottom of the screen to bounce the seeds and tip them such that they fall through the slots. The bouncing/tapping technique is essentially the opposite of the usual method of horizontal movement with no bounce, and it can also be used to pass long narrow seeds through small round holes.

Bottom screening

Not all seeds require bottom screening, although even if not strictly necessary it can be a useful step to put one final set of eyes on the seed, tweeze out any persistent contaminants, and remove the smallest seeds. With corn and beans, bottom screening is typically accompanied by picking out moldy or split seeds if the goal is high-value food or seed to be sold in small quantities.

Bottom screening is necessarily slower and often comprises at least half of the total cleaning time. In order for small debris and undersized seeds to fall through, the seed on the screen surface should be at most a few layers thick, and for larger seeds ideally just one layer thick. That means the amount of seed that can be loaded on the screen at one time is often 4-5x less than with top screening, and the total amount of screening time is increased by that same factor. For the most common bottom screens (e.g. 1/18" round), it is helpful to have a larger-format screen to allow more seed to be loaded and spread out over a wider area.

Flat seeds typically require bottom screening to remove small round debris. For many seed types, bottom screening with a 1/18" screen will remove pigweed seeds which are a very common contaminant in this region.

Bottom screening is typically done with a round-hole screen, or a square mesh screen for the smallest seeds. Perfectly round seeds like brassicas and quinoa will tend to clog round hole screens, and for these it is preferable to use a square mesh bottom screen to remove the smallest seeds. On special occasions, a slotted screen can be used to "bottom out" flat contaminating seeds.

"Screening" without screens

There are a few other tricks that can be used to separate material by size and shape. An "indent cylinder" is a slowly rotating drum lined with thousands of tiny pockets that are just the right size to pick up certain seeds and drop them into a collector as it turns. This is particularly useful for carrot seed which often has tiny sticks that cannot be entirely removed by screening or winnowing. A variation based on this principle has a series of rotating disks with indents of increasing size and separates

material by length. A “drape” is a stationary or moving inclined surface that separates material based on how readily it rolls downhill. This can be especially helpful for removing sticks-with-seeds-attached from beets and chard. A “spiral separator” separates material based on how fast it rolls – effectively how spherical it is – and can be useful as a final step for brassicas though this is seldom necessary to pass quality standards.

Unless you are producing large amounts of a particular seed commercially, it is unlikely that any of these machines will pencil out. However, if you find them cheap at auction or sitting around an old barn unused they can be helpful additions to a seed cleaning toolkit.

Dealing with Dirt

Dirt clods are a very common contaminant, and unlike weed seeds or mouse turds they come in every possible shape and size. The best way to deal with dirt is to avoid getting dirt into the seed in the first place, but this is not always possible particularly for crops that are pulled up by the roots like beans.

With lighter seeds, it is usually possible to overwinnow the seed out of the dirt, and the combination of a slotted top screen and round-hole bottom screen will effectively remove 99+% of dirt from flat seeds like lettuce. With heavy round seeds from teff and amaranth up to peas and beans, dirt clods cannot be readily removed by screening and winnowing.

In many regions, dirt and rocks are slightly magnetic due to iron content, allowing for magnetic removal. The magnetic hopper gate accessory for the Winnow Wizard uses this principle to deflect dirt and rocks to fall in front of the divider while the seed falls behind; see the user manual for instructions and precautions.

If you don’t have a magnet or your soil isn’t magnetic, intense abrasion (like vacuuming, see below) can sometimes grind dirt clods into smaller bits that screen and winnow out – provided your seed can tolerate the abrasion. Finally, as a last resort seed can be briefly soaked (for less than 10 minutes) to soften the clods then washed over a bottom screen and dried, and any rocks that remain can usually be removed by overwinnowing. Or you can just decide that some amount of dirt and rocks in your seed is acceptable.

On Abrasion

Many seeds are not entirely free after threshing and drying. They may be merely stuck together, like tomato seeds, or they may be in doubles, as with many carrot-family seeds. They may have attached sticks, as with spinach and beets and cilantro, or attached pappus or petals, as with many seeds in the aster family. They may be covered in fine papery “angel wings”, as with squash, or encased in husks or packets, as with wheat, quinoa, orach, and sorrel.

Getting these seeds fully clean requires freeing and singulating them, which in general calls for some form of abrasion. There are four levels of abrasion, ranging from gentle to harsh, that will be included in the "recipes" section of this guide. The first three use tools that most folks should have access to; the last requires specialized equipment.

1. **Rubbing**. A gentle rubbing is all that is needed to free lettuce from its fluff, or to separate tomato and pepper seeds that have stuck together in drying. The Winnow Wizard hopper agitator performs this function reasonably well. Small volumes can be rubbed between two hands, and larger volumes can be "rubbed" between two pieces of lath held close together and moved rapidly back and forth through a bin of seed.
2. **Tumbling**. Tumbling is not much more intense than rubbing but of a longer duration. One method for tumbling, which works quite well, is simply to load up to 10 lbs or so of seed into a heavy duty pillowcase, tie the end shut, load two evenly-weighted pillowcases into a clothes dryer, and run it with no heat for 20 minutes. A second 20-minute cycle is sometimes necessary. Tumbling is very effective for removing angel wings from squash and pappus from aster-family seeds.
3. **Vacuuming**. I'm not sure if Frank Morton was the first person to attempt sucking seeds through a shop vac, but for many years it was a signature seed cleaning method at Wild Garden Seed and something of a company secret. Air velocity through a shop vac hose exceeds 150 mph, creating fairly high-intensity abrasion when seeds rub against the corrugations of the tube and the deflector shield. Abrasion intensity can be increased by using a more powerful motor, a smaller-diameter tube (= higher velocity), or a longer tube, and also by tying the tube in knots and gluing sandpaper to the deflector shield inside the tub. Some seeds can be damaged by too much abrasion, and Wild Garden Seed maintains a large-tube vacuum for gentle abrasion and a small-tube vacuum for harsher abrasion. Vacuuming works very well to de-husk quinoa and epazote and goosefoot and wheat, and to get sorrel and orach seeds out of their papery packets.
4. **Dehulling/belt-threshing.** A few seeds, like globe amaranth/gomphrena and statice and some hulled grains, are so firmly entrenched in their containers that no amount of vacuuming will free them. If you want to grow these commercially, you will need to build or invest in a de-hulling, de-bearding, or equivalent abrasion machine that aggressively rubs each seed between two surfaces. The companies where I have worked do not have such machines, and we have mostly chosen not to grow these varieties.

The Recipes

Each recipe contains four parts:

1. *Problems to avoid.* These include weed seeds that are difficult or impossible to remove and other issues to watch out for during harvest and threshing to avoid damaging seed or creating headaches in the final cleaning steps.
2. *Threshing notes.* While this is not intended to be a definitive guide to seed threshing, I am including notes on how we have typically threshed each crop at Wild Garden Seed and/or Adaptive Seeds.
3. *Final cleaning workflow.* The equivalent of "sauté onions for five minutes, then add garlic, etc.", this is the sequence of steps that I or others have used to clean each type of seed. This is written in a shorthand referencing the various cleaning operations discussed in the previous pages. Optional steps are in parentheses. A quick reference to these operations is below.
4. *Cleaning notes.* Notes on different screen sizes for different varieties, variations on standard operations, how to distinguish good seed from light/hollow seed, etc.

Cleaning operations glossary:

Clean: Winnow with divider set well beyond seed spread.

Shave: Winnow with divider set right at outer edge of seed spread.

Split 80/20: Winnow with divider set within the seed spread such that 80% of seed falls behind and 20% blows beyond.

Recover 3x: Winnow the light fraction at the same setting 3 times, adding more seed to heavy fraction bin each time.

Overwinnow: Winnow with divider set right at inner edge of seed spread to remove heavier material.

TS 6/64: Top screen with a 6/64" round hole screen

TS 6/64 slot: Top screen with a 6/64" x ¾" *slotted hole* screen

BS 1/18: Bottom screen with a 1/18" round hole screen

BS 16x16: Bottom screen with a 16x16 wire mesh screen

BS-pick or BS-tweeze: Manually pick out or tweeze out bad seeds, dirt, remaining sticks, etc.

Rub: Hand rub seed, or equivalent.

Tumble: Tumble in pillowcase in clothes dryer (with no heat!)

Vacuum: Suck seed through shop vac

As with any recipes, these are intended as a guide rather than a formula to follow every time. Some varieties of quinoa or lettuce have larger or smaller seeds. Some lots will have more difficult debris to remove, so you might decide to split rather than shave, or even to throw away a significant portion of the good seed if you know you have more than you need and want to have the highest quality while saving time on cleaning.

These recipes assume that the seed has been field-screened to remove large debris. If starting with really coarse material, the first step should be a fast screening through ~1/4" or ~1/2" hardware cloth.

The recipes, and the tables that follow, are arranged alphabetically as Vegetables, Grains and Beans, Herbs, and Flowers. Dual purpose crops – or crops with different edible and ornamental varieties – are placed in one category or the other – if you can't find yarrow under "flowers", check under "herbs".

Vegetables

Beets and Chard (*Beta vulgaris)*

Problems to avoid

Beet seeds are larger than most weed seeds. Field bindweed seeds can be a problem, especially the unbroken seed capsules which are very similar in size and density. Vetch and cereal grain seeds are a similar size but are heavier and can usually be removed by overwinnowing. Bulbils of wild garlic and buckwheat seeds are the most challenging contaminants to remove, so if possible avoid including them at harvest. Avoid overheating the seed or drying plants.

Threshing notes

Method: Rubbing. If crushing (e.g. driving) stack thickly so that stems rub against each other. Avoid impact which tends to break stems into small pieces with seeds still attached. Avoid threshing when stems are extremely dry and brittle, as fragments of stem with attached seeds are challenging to remove.

Cleaning workflow

Airflow: M

Vacuum -> Clean -> TS 12/64 -> Shave* multiple times -> (BS 8/64) -> BS 6.5/64 (-> Drape)

Cleaning notes

Beet and chard seed continuously releases dust, as the tiny leaflets and corky material surrounding each composite seed particle breaks down. High-intensity vacuuming does not damage the seed and helps to break seeds off of sticks. Depending on the lot, multiple passes through the vacuum may be beneficial. Beet seed should be fully dry before cleaning, to allow seeds to more readily break off of sticks in the vacuum and small sticks to more readily winnow out.

*A large proportion of hollow seed is common, and it is only marginally lighter than the filled seed given that each “seed” is actually a composite particle containing multiple much-smaller seeds. When shaving, I like to do a “hammer test” in which I take 10-20 seeds from beyond the divider and smash them with a hammer. Filled seeds show up as a bright white powder. Keep shaving and moving the divider slightly closer in until 30-50% of the particles blowing past the divider contain viable seeds.

Bottom screening with a 1/8” hardware cloth screen or 8/64 round hole will split the lot into large and small seed, both of which are viable. This can be useful for uniformity.

Dirt and similar-sized contaminating heavy seed (like bindweed and vetch) can be readily removed by overwinnowing.

If there are still a lot of seeds-with-attached-sticks left at the end, a drape process can be useful to remove them. A manual drape can be constructed easily by tilting a large flat surface (like a seed-drying

screen or a piece of plywood) to an angle such that free seeds roll off but seeds with attached sticks (or sometimes bindweed seed capsules with attached stems) don't roll far and remain on the surface to be brushed off. Pour seed in small batches across the entire width in small batches and brush off the sticks that don't roll.

Brassica spp.

Brassica oleracea (cabbage, broccoli, Brussels sprouts, kohlrabi, cauliflower, lacinato kale), *Brassica napus* (rutabaga, kale), *Brassica rapa* (turnips, mild mustard greens), and *Brassica juncea* (spicy mustard greens) all have similar spherical seeds, although they vary in size with *juncea* seeds being typically smallest and *oleracea* seeds largest.

Problems to avoid

Climbing geranium seeds are nearly identical and should be avoided at all costs by pre-harvest weeding or careful removal at harvest. Grass seeds are frequent contaminants and can usually be removed by screening and winnowing but should be minimized if possible.

Threshing notes

Method: Crushing, followed by agitation. Stomp it, drive on it, hit it with sticks. Brassicas are straightforward to thresh when fully dry, most effectively threshed with a compression/crushing force, and all threshing debris readily winnows out.

Cleaning workflow

Airflow: M

Clean -> TS 6/64" -> Shave -> (BS 16x16)

Cleaning notes

While a 6/64" top screen will work for most brassicas, this can be adjusted from 1/12" up to 6.5/64" for varying seed sizes. Similarly, the smallest *juncea* seeds will require a smaller bottom screen, if this step is included. Bottom-screening brassicas is less about quality and more about uniformity, for buyers that prefer evenly-sized seed. Brassicas produce relatively few hollow seeds; problem lots may have a lot of insect damaged seed or less-round, lighter seed from plants that died early due to disease. In these cases, repeat the shave and move the divider just slightly further in until you start to see a few good, undamaged round seeds blowing beyond it.

Carrot (*Daucus carota*)

Problems to avoid

Carrot seed is relatively light and the small stems and pedicels are comparably heavy, so it is not possible to separate these "sticks" from the seed by winnowing. If at all possible, thresh carrot seed in a way that minimizes the production of small sticks.

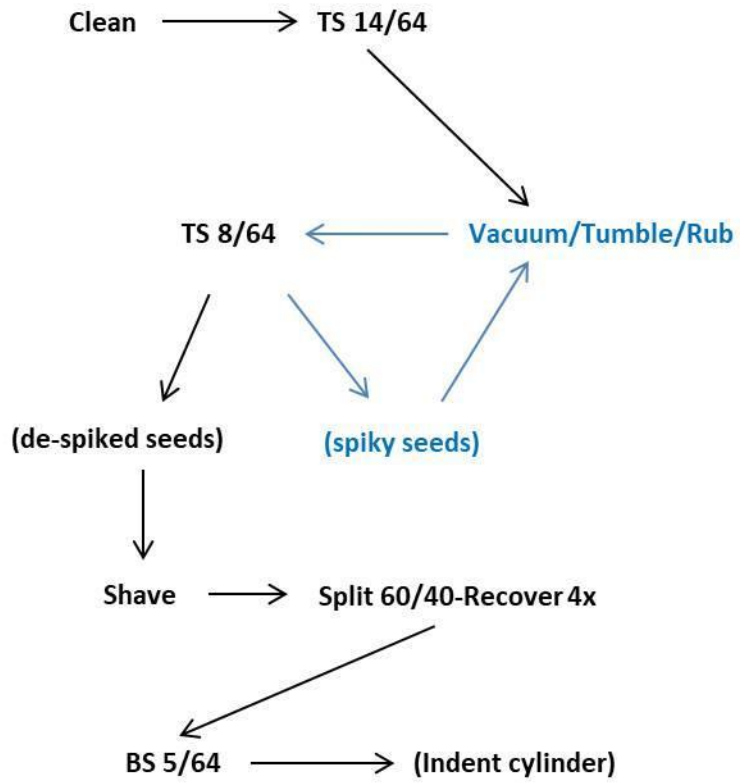
Threshing notes

Method: Rubbing

For small lots this can be done by hand on a hardware cloth screen. For larger lots a light stomping is good. It is recommended to thresh when plant material is not super brittle to limit sticks and discs.

Cleaning workflow

Airflow: L



Cleaning notes

It's important to screen out the larger sticks before the abrasion step, which will tend to break sticks into shorter lengths that are more difficult to remove.

An indent cylinder is very helpful if you will be cleaning large amounts of carrot seed and need it to approach 100% purity with no sticks.

The spines attached to the seeds are not especially brittle and so are only partially removed by each vacuuming or tumbling step. An intense rubbing motion is more effective. A drill-powered paint-mixing paddle in a bucket can be helpful on a small to medium scale.

Celery/Celeriac (*Apium graveolens*)

Problems to avoid

Biennial and slow-growing celery and celeriac seed crops are in the ground for a long time and tend to become weedy. Quite a few small weed seeds can be difficult-to-remove contaminants, so try to minimize weeds and avoid cutting weed seedheads during harvest.

Threshing notes

Method: Rubbing/agitation.

Ripe celery seed falls off very easily with a rubbing or agitating motion when plants are fully dry. Try banging on the inside of a trash can, hitting with sticks, or stepping lightly on dried plants. Threshing less vigorously and when plants aren't crispy dry will lead to less plant debris and hollow seed in seed lot.Seed that stays attached to the plant tends to be immature and less viable.

Cleaning workflow

Airflow: L

Clean -> TS 1/16 -> Shave

Cleaning notes

Celery seed is typically fast and straightforward to clean. Seed can be tumbled if needed to break off tiny attached sticks. Don’t be afraid to blow away the light and immature seed.

Chicory/Radicchio/Endive/Escarole (*Cichorium spp.*)

Problems to avoid

Chicory seeds have size overlap with a wide array of weed seeds – keep the crop weeded and avoid weed seedheads at harvest. Ripe chicory seeds are also a favorite of birds, and bird poop fragments can occasionally be difficult to remove. Covering plants before and after harvest is a good idea.

Threshing notes

Method: Intense crushing/impact.

Seed capsules are very solid and difficult to open. A chipper/shredder is an effective threshing tool, and it can also work to drive over plants repeatedly on a solid (gravel/paved) surface. Driving on plants to loosen seed and then chipping them can maximize extraction if yields are low. Foot stomping accomplishes very little.

Chipping or intense driving generates a large amount of material with a very small proportion of seed. Field winnowing this in a gentle breeze can reduce the volume and greatly speed the cleaning process.

Cleaning workflow

Airflow: L

Clean -> TS 1/8 -> Clean -> TS 1/13 -> Shave -> Split 80/20-recover 2x -> BS 1/18

Cleaning notes

The 1/8 screen removes whole seed capsules freed by the threshing process. These may be re-threshed to increase seed yield if desired.

These crops produce a very high proportion of hollow seed – often more than 50%. The horizontal spread of good seed should be no more than 5-6" – any seeds that blow farther are usually hollow. Hollow seeds can be indented with a fingernail as a quick test. Repeat the shave until most hollow seeds have been removed.

In some varieties, good seeds tend to be dark gray in color while hollow seeds are beige-tan, but color alone is not a reliable indicator of viability.

Adjust TS from 1/14 to 1/12 as needed; seed size varies slightly between crop types and varieties. If too much seed goes through the 1/18, recover some by pouring the small fraction back through the screen one or two times.

Cucumber (*Cucumis sativus*)

Threshing notes

Method: Slice and scoop

Cucumbers must be fully ripe, generally entirely orange or yellow with no hint of green. Slicing fruits with a slightly dull machete damages few seeds and is the quickest way to open them. Seeds scoop out easily with hands into a bucket.

Ferment seeds and pour off pulp, then spray over 1/8" hardware cloth to collect and rinse.

Cleaning workflow

Airflow: M

(Tumble) -> Clean –> Split 80/20-recover 2x -> BS 8/64

Cleaning notes

Some cucumber seeds have small sharp spikes attached that are readily removed by tumbling.

It can help to use the "wiggle wire" attachment for the hopper agitator – the standard agitator wand tends to lock cuke seeds together and rotate the entire mass which is hard on both seeds and motor.

Truly hollow seeds blow away easily. The split/recovery step removes thin and partially-filled seeds.

Low-germ lots can sometimes be improved by a more aggressive split-recovery process.

Eggplant (*Solanum melongena*)

Threshing notes

Method: Chop with smashing action. Agitate in water to separate and sink seeds, then decant multiple times to float and pour off fruit pulp. Spray clean seed in fine mesh strainer.

After-ripening fruit can help some additional seed to mature. However, leaving the fruit too long in storage can lead to unacceptable levels of rot. Avoiding rotten fruit can reduce the need to tweeze discolored seed.

As with ground cherries and tomatillos, eggplant seed is embedded in the fruit and needs to be "squished" free from the pulp. Eggplant are slow to chop and smash and can be more efficiently processed with a "Roto-Hoe" woodchipper or cider press fruit grinder. To limit the amount of pulp that needs to be processed, cut or break the top 1/3 to 1/2 of each fruit prior to chipping.

Cleaning workflow

Airflow: L

Rub to break apart any clumped seed -> Split 90/10-recover 1x -> TS 1/18 slot -> BS 1/13 or 1/14

Cleaning notes

Eggplant may produce underdeveloped hollow or half hollow seed. Be mindful to remove light seeds to achieve a high germination rate. Slotted top screen will remove any remaining clumped seeds which can be re-rubbed to singulate.

Fennel (*Foeniculum vulgare*)

Fennel seeds ripen late in the fall. They can handle quite a bit of frost and rain, though they should ideally be picked before they turn gray with mold and before they begin to sprout following days or weeks of wet.

Problems to avoid

Avoid harvesting too early; immature seeds are not always readily removed in cleaning and can lower germination.

Threshing notes

Method: Impact/rubbing

Sticks can be challenging to remove from fennel seed, so this is a crop that is best threshed when dry but not completely crispy. Crushing is only moderately effective and can damage seed. The best method I have found is to make piles of plants and hit them repeatedly with sticks or pitchforks until all of the seed flies off. It sounds primitive but it works surprisingly well.

Cleaning workflow

Airflow: L

Clean -> TS 12/64 -> Tumble -> Clean -> TS 1/12 slot* -> Split 70/30-recover 3x -> BS 6/64 -> BS 1/23 slot

Cleaning notes

Tumbling helps to break apart doubles and remove attached sticks. Vacuuming is too aggressive and can damage the fragrant oil veins on the outside of the seed, reducing viability and seed life.

*The 1/12 slot separates doubles from singulated seed. The doubles can be hand-rubbed to singulate them if desired, but persistent doubles tend to be immature.

The two different bottom screens remove small, shrunken-but-heavy unfilled seeds that are not readily removed by winnowing.

Ground Cherry (*Physalis* sp.)

Problems to avoid

Seeds blackened by rot are not readily removed. Fruits are ripe when they fall off of the plant and last without rotting for a surprisingly long time in dry weather. Harvest before prolonged rain.

Threshing notes

Method: Smash. Agitate in water to separate and sink seeds, then decant multiple times to float and pour off fruit pulp. Spray clean seed in fine mesh strainer.

Tip: Save husks after first decanting, add water, agitate and decant again. This effectively re-threshes the fruit and recovers most of the seeds that were stuck in the husks.

Cleaning workflow

Airflow: L/VL

Clean -> TS 6x26 -> Split 90/10-recover 1x -> BS 1/20

Cleaning notes

The 6x26 top screen removes seeds that are stuck together; these can be rubbed to singulate them and then re-screened.

Leeks (*Allium ampeloprasum*)

Problems to avoid

Like onions, leek seed sprouts readily on the plant, so pick ahead of rain and keep rain-exposed lots separate to check for sprouting.

Threshing notes

Method: Rubbing/impact.

Seedheads should be starting to open before they are picked and should be thoroughly dried prior to threshing. Like onions, leeks are threshed most readily by a grinding or shaking motion – a crushing force like stomping or driving tends to just lock seeds in their capsules. Leeks require more vigorous grinding than onions to extract a majority of seeds, but over-threshed seeds with a damaged seed coat

have a shorter lifespan. Smaller lots are readily threshed by grinding them over a 1/8" hardware cloth screen by hand. Leeks can be more difficult to fully thresh this way than onions; for larger lots a chipper/shredder can be a better option.

Cleaning workflow

Airflow: L

Clean -> TS 7/64 -> Split 70/30-recover 3x -> BS 1/18 (->float -> dry)

Cleaning notes

Although very similar to onions, leek seed is typically more difficult to clean. The seeds are slightly lighter and the pedicels are slightly heavier, creating a finer density separation. A split-recovery strategy and a willingness to sacrifice some good seed can still yield excellent results.

If there are still too many pedicels to tweeze out, a floating process can help. Pour a small volume of seed into a large volume of water in a clear vessel. Swirl, allow most of the seed to sink, then pour off the pedicels and lighter seeds suspended in the water. Repeat until clean enough, then dry quickly.

Lettuce *(Lactuca sativa)*

Problems to avoid

Wild lettuce/sow thistle seeds are impossible to remove and so these weeds should not be allowed to set seed near the crop. Canada thistle and false dandelion (*Hypocharis*) seeds can also be challenging to remove so should be avoided if possible. Small sticks created during threshing can also be difficult to remove.

Lettuce seed is easily induced into dormancy by exposure to temperatures around 100ºF for any period of time. Avoid laying seed on tarps in the sun on hot days or leaving seed in a greenhouse during heat waves, and set dryer thermostats to 90ºF or lower when drying lettuce seed.

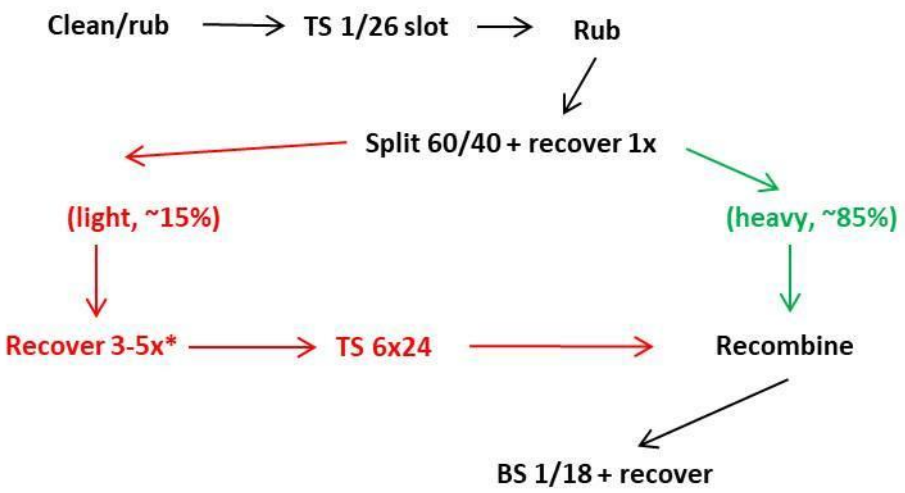
Threshing notes

Method: agitation/light impact, or crushing + agitation. Avoid heavy impact.

Lettuce can be threshed by tipping whole plants into bins and banging the ripe seed off, or by cutting/pulling up whole plants when most of the seed is ripe and laying them out to dry and after-ripen. Seed threshed off of green plants is typically easier to clean. If whole plants are dried, it is best to thresh them in slightly moist conditions (~10 am) rather than when they are crispy-dry on hot afternoons to avoid breaking the smallest stems into short sticks that are difficult to remove. A combination of crushing (usually with feet) and light impact (hitting plants with sticks or pitchforks) works well on the scale of a few bed feet up to 500 bed feet or so.

Cleaning workflow

Airflow: L



Cleaning notes

Rubbing is necessary to remove the pappus/fluff from the seeds, and if the seed is at all moist after threshing it should be dried before cleaning. The Winnow Wizard agitator does a good job with this rubbing on the first pass, but some quick rubbing prior to the final winnowing step is often helpful to remove the last fluff.

Splitting the lot into two fractions minimizes the amount of seed that needs to pass through the slow 6x24 wire screen, which also rejects a few of the thickest seeds.

*Keep recovering (re-winnowing the light fraction) until you are happy throwing the light fraction away – the remaining seed looks green/immature and is a very small proportion of the whole lot. If a lot of good seed is persistently blowing past the divider, the divider can be adjusted farther out by an inch or so for the last recoveries (with the caveat that this will result in slightly less clean seed).

If there are a lot of small sticks, one or more passes through a 6/64 round hole top screen can help to remove them. This may only be necessary for the lighter lot prior to recombining.

Some good seed will fall through the 1/18 bottom screen. This can be recovered by pouring it back through the screen with a very light screen loading and shaking briefly until all of the small debris has fallen through and only seed remains on top. This recovery step can be repeated 2-3x or more if desired so as to minimize loss of small seed (which is typically viable).

Lettuce generally does not produce much hollow seed; the remaining light fraction after multiple recoveries typically contains greenish-tinted seeds that were immature at harvest. After cleaning germination rates are frequently in the 95-99% range.

Melons (*Cucumis melo*)

Threshing notes

Method: Slice and scoop

Melons must be fully ripe – generally past eating stage and it's fine if they're starting to rot, although there should not be visible mold in the seed cavity or discolored seed. A dull machete works well to open them without damaging seeds. Scoop seeds by hand into buckets.

Ferment for 2-3 days, stir, and spray through a screen to remove large pulp pieces. Collect and rinse over 1/8" hardware cloth.

Cleaning workflow

Airflow: M

Clean –> Split 80/20-recover2x -> BS 9/64

Cleaning notes

Melon seeds are very straightforward to clean and often appear 100% clean after being washed and dried. The main goal is to remove hollow, partially-filled, and undersized seeds to maximize germination.

Use the "wiggle wire" attachment for the hopper agitator – the standard agitator wand tends to lock melon seeds together and rotate the entire mass.

Okra (*Abelmoschus esculentus*)

Threshing notes

Method: Impact/crushing

Dried okra pods are still a bit leathery and thresh more readily with impact in a Roto-Hoe or equivalent thresher/chipper, but crushing can work as well. Remove any moldy pods before threshing.

Cleaning workflow

Airflow: H

Clean -> TS 14/64 -> Shave -> BS 11/64

Cleaning notes

As uniformly-sized, large, heavy round balls, okra seeds are among the easiest to clean. Use maximum airflow and set the divider close in on the shave, as there will be some hollow or partially-filled seeds to remove. Adjust TS and BS sizes as necessary such that ~99% of the seed is sized between them.

Onions *(Allium cepa, Allium fistulosum)*

Problems to avoid

Onion seed sprouts very readily on the plant once it is ripe, and sprouted seed is not readily removed in cleaning. Pick seedheads as they ripen, and keep potentially rain-sprouted seed separate to check for sprouting before combining it with earlier harvests. Care must be taken to not crack or crush seeds during threshing. Fractured seeds have short storage life and it is difficult to see when this has happened.

Threshing notes

Method: Rubbing/impact.

Seedheads should be starting to open before they are picked, and the seed that falls out naturally after harvest ("box fall") is very easy to clean. Onions are threshed most readily by a grinding or shaking motion – a crushing force like stomping or driving tends to just lock seeds in their capsules. Smaller lots are readily threshed by grinding them over a 1/8" hardware cloth screen by hand. A roto-hoe chipper may also be used, but gentle threshing results in longer seed viability.

Cleaning workflow

Airflow: L/M

Clean -> TS 7/64 -> Split 80/20 + recover 2x -> TS 1/12 slot -> BS 1/14-tweeze

Cleaning notes

Onions always produce some completely-empty seed that blows away with the chaff in the first winnowing step. Fear not!

Onion seed is jet black and so any light-colored debris is very obvious. Some amount of tweezing is usually necessary to achieve visual purity. If the amount of this debris is large enough to make this an onerous process, a floating process can help. See the description under "Leeks".

Onion seed varies in size between varieties, and *Allium fistulosum* seed tends to be a little smaller. Adjust TS and BS screen sizes as necessary, and if all of the seed will pass through a 1/14" slot that will reduce the amount of tweezing required at the end.

Onions usually produce a small proportion of seed – around 5-10% of the total – that is noticeably thinner and persistently blows farther in winnowing. Tossing this – or setting it aside for non-commercial use – will save substantial cleaning time and result in seed with 95%+ germination. When recovering the light fraction, the new split will not be 80/20 but will be closer to 50/50.

Orach (*Atriplex hortensis*)

Orach makes two types of seeds: small round-ish black seeds that have high dormancy and very low germination and larger disk-shaped tan seeds that have low dormancy and high germination. Most of the seeds are also held in flying-saucer-shaped papery packets, from which they must be removed. For many years, Wild Garden Seed was a leading producer of this relatively obscure seed and Frank's cleaning methods were a closely-guarded secret.

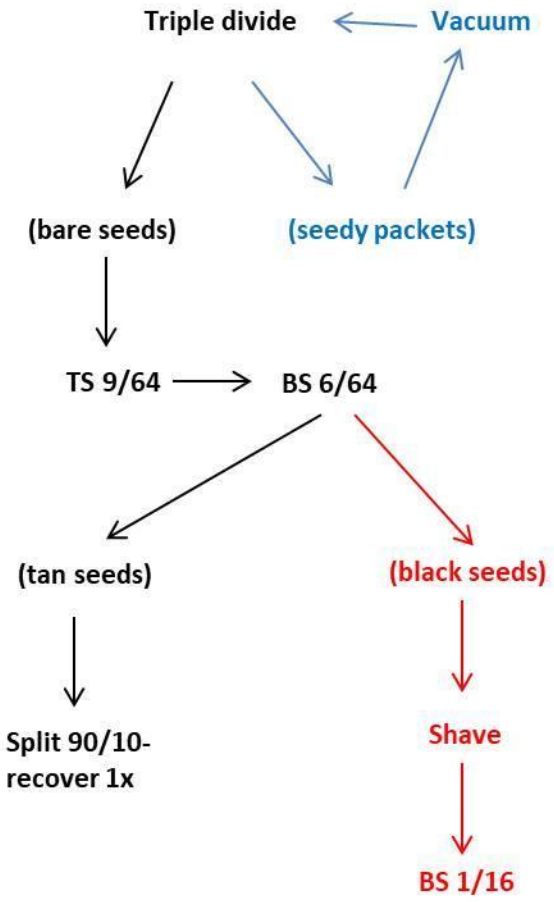
Threshing notes

Method: Impact

The best method we have found to thresh orach seed on a small scale is to set up coarse wire panels (like chain link fence) over a large tarp and then slam mature seedheads against them in a swinging, log-splitting motion. The seeds fly off upon impact, and some of them fly out of their packets.

Cleaning workflow

Airflow: M



Cleaning notes

For the triple divide, set the divider such that all of the naked seed falls behind and all of the packets blow beyond. Then place a couple of bins beyond the divider to catch the packets, and find the second divide beyond which all of the packets are empty. Re-vacuum the seeds-in-packets and repeat this process. Avoid vacuuming naked seed, as this can lead to damage.

A 6/64 screen will allow all of the black seeds to pass through while keeping the vast majority of the tan seeds on top. If desired, some of the remaining small tan seeds can be teased out of the black seeds using slotted screens.

Due to the high and difficult-to-break dormancy of black seeds, I have typically not cleaned them and have instead focused exclusively on the tan seeds. Removing most of the black seeds will result in a much higher germination rate.

Parsnip (*Pastinaca sativa*)

Problems to avoid

Immature seeds can be difficult to remove; harvest when most seed is ripe. It is also challenging to remove all sticks from these light seeds, so avoid threshing too aggressively or in extra-crispy conditions. Parsnip seed is extremely easy to produce in large volumes, so it's a reasonable strategy to accept a significant loss of seed in threshing and cleaning to improve efficiency and end up with higher-quality seed.

Parsnip sap and seed oil can cause photodermatitis in some people.

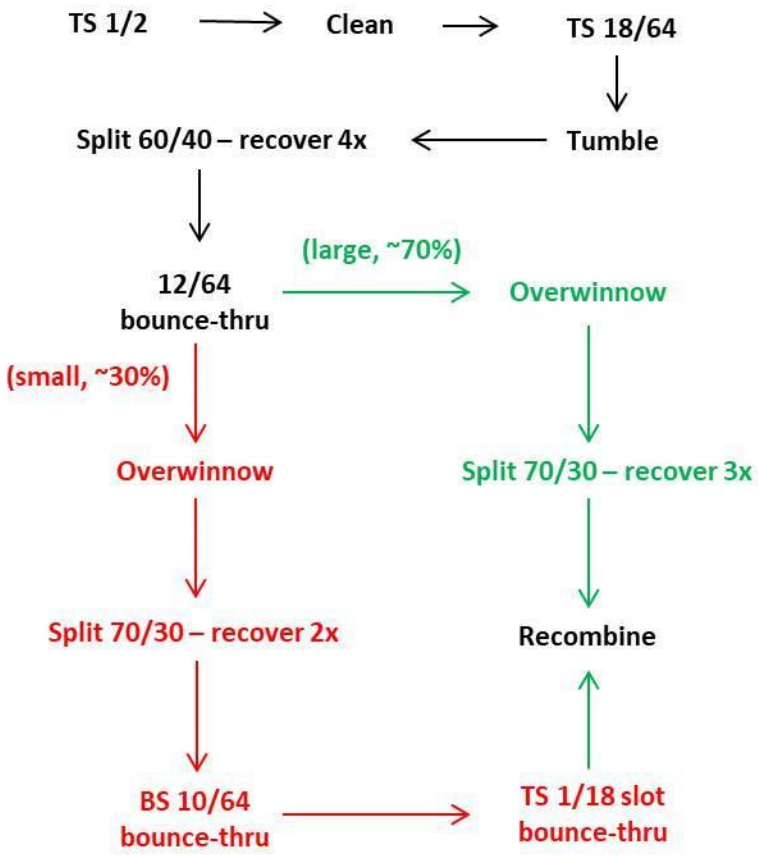
Threshing notes

Method: Agitation/light impact.

On small to medium scales, it works well to place whole dry plants inside a large barrel or garbage can and hit them gently against the walls. Avoid crushing or vigorous impact which creates many small sticks.

Cleaning workflow

Airflow: VL



Cleaning notes

Field-screening is important (with a ~1/2" screen) to remove sticks and plants *before* pouring into the Wizard hopper with the agitator running. If field screening is omitted, the agitator will break stems and leaves into smaller bits that are difficult to remove from the seed.

Tumbling is optional but helps to remove attached sticks and to break apart double seeds. The Winnow Wizard hopper agitator is also somewhat effective in this regard.

Some parsnip varieties will require a larger top screen, up to 20/64.

Bouncing the 12/64 and 10/64 screens vigorously up and down (contrary to standard screening wisdom) will allow sticks to fall through while the round disc-shaped seeds will remain on top.

The 1/18 slot screen separates singulated seed from remaining doubles, many of which are immature and hollow. This is a very slow step, and it is helpful to tap on the bottom of the screen to tip the seeds such that they fall through. Slightly wider slots are faster but much less effective at removing doubles. Typically these immature doubles are also small, so splitting the seed into two sizes allows this slow step to be used only on a fraction of the lot.

An aggressive split with multiple recovery helps to remove most of the light sticks from the papery flat seeds. To remove *all* of the sticks some amount of tweezing will be necessary while bottom-screening.

Parsnips produce a significant fraction of hollow seed, which can be challenging to remove completely because good seeds are also very light and catch the wind. The three winnowing steps (an initial rough clean followed by two split-recovery sequences) will remove the vast majority of hollow seeds, with loss of up to 5-10% of good seed which is usually acceptable given high parsnip seed yields.

Peppers (*Capsicum spp.*)

Problems to avoid

Blackened/discolored seeds are generally not removable in cleaning except by hand-picking or a color sorter machine which is beyond the reach of most small-scale growers. Avoid extremely rotten peppers, and for larger peppers it can be helpful to break the bottom off the pepper prior to threshing in order to visually inspect the seeds. (This also allows for saving the fruit for food use, if desired.)

Threshing notes

In large quantities peppers can be threshed with a chipper/shredder, but this produces lots of small pulp to clean out. The chipper method works better for smaller hot peppers with a high seed to flesh ratio. For large bell/roasting peppers, it works well to break most of the flesh off and then stomp the receptacles in water in a bin to free the seeds.

Spray pepper seeds through a ¼" screen and collect them on a window screen (1/16") – or a 1/8" screen can work for larger-seeded peppers.

Good seeds *usually* sink but floating seeds are often mostly viable. In most cases it is worth saving and cleaning both floaters and sinkers.

Wear goggles, respirator, and long rubber gloves when working with hot peppers, especially if using a chipper.

Cleaning workflow

Airflow: L

Clean -> TS 1/18 slot* -> Split 90/10-recover 1x – BS 6.5/64-tweeze

Cleaning notes

The slotted top screen removes seeds that are stuck together or that are stuck to bits of pulp. *Adjust this from 1/18 up to 1/14 depending on the thickness and "waviness" of the seeds.

If there are a lot of light or discolored seeds, a more aggressive split/recovery cycle can remove more of them.

Adjust the bottom screen based on seed size – up to 7/64 or 7.5/64 for larger peppers.

To quickly pick out larger quantities of discolored seeds, it can be helpful to use a “waterfall method”, sliding seeds from a flat plate (or a bin tipped on its side) into a bin, and quickly flicking away any discolored seeds.

Radishes (*Raphanus sativus*)

Threshing notes

Method: Impact

Radish seeds are borne in large, foam-filled pods. Crushing them is not the most effective method, though driving and stomping can work. More aggressive chippers and impact threshers do a better job of pulverizing the pods and freeing the seeds.

Cleaning workflow

Airflow: M

Clean -> TS 12/64 -> Shave -> BS 1/12 -> BS 1/14 slot

Cleaning notes

Radish seed covers a wide range of sizes. For problem lots (e.g. those with a lot of insect-damaged seed) it can be helpful to split the seed into 2-3 size lots using intermediate screens like 9/64 and 6.5/64. These can then be shave-winnowed separately, which allows the larger-damaged seeds to be removed without also blowing away the smaller good seeds. Some buyers also prefer uniformly-sized seed.

Scorzonera (*Scorzonera hispanica*)

Threshing notes

Scorzonera flowers puff out like dandelions, and the seed needs to be gathered by hand before it blows away. In this way it is effectively hand-threshed.

Cleaning workflow

Airflow: L

Tumble -> Clean -> TS 8/64 slot -> Split 90/10-recover 1x -> BS 1/20 slot -> BS 8/64

Cleaning notes

Tumbling magically reduces a pile of fluff into bare seeds and dust that blows away.

Scorzonera produces a lot of light/hollow seeds that blow away. Fear not, and you can easily check whether they are filled by breaking them open.

Shungiku (*Glebionis coronaria*) – Edible chrysanthemum greens

Threshing notes

Method: Crushing

Dried flower heads crush easily and release their seeds.

Cleaning workflow

Airflow: L

Clean -> Vacuum -> Clean -> TS 11/64 -> TS 6/64 slot -> Split 70/30-recover 3x -> BS 1/17

Cleaning notes

Shungiku seeds often require some abrasion/scarification before they will germinate – vacuuming helps with this while also breaking off any remaining attached flower structures.

Hollow seeds are quite common, and germination may still be low after cleaning. Germination can sometimes be improved by further scarification (vacuuming/tumbling) or further winnowing to remove smaller/lighter seeds.

Sorrel (*Rumex acetosa*)

Problems to avoid

Dock, a common weed, has leaves that look like sorrel, and it produces very similar-looking seedheads with rather similar seeds. Watch for dock when harvesting.

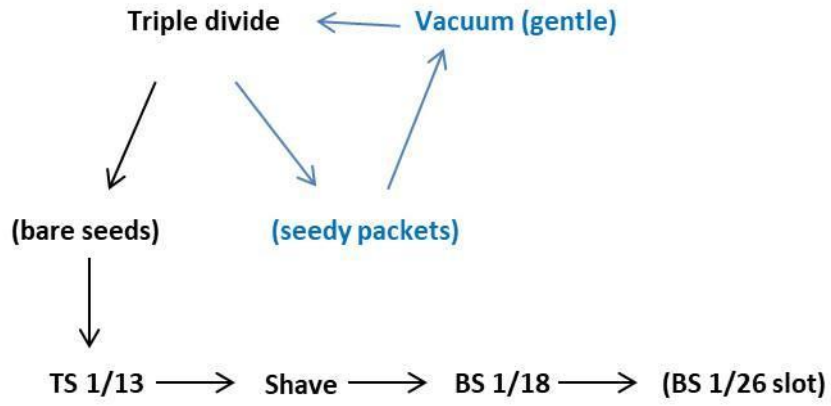
Threshing notes

Method: Rubbing

Foot-shuffling over sorrel on a tarp is an effective threshing method. Crushing is rather ineffective.

Cleaning workflow

Airflow: L



Cleaning notes

Sorrel dust is allergenic for some folks – masks are a good idea.

For the triple divide, set the divider such that it separates the naked seed from the packets. Place two bins beyond the divider. The first will catch all of the packets that still have seeds inside. The second should catch only empty packets, but you can check and recover seed from there if necessary.

Vacuuming is very effective at getting the seeds out of their packets, but it can also remove the seed coat, leaving the smaller orange-red kernel inside. Use a gentle vacuum if possible: large tube, lower HP motor, no sandpaper or tying the tube in knots.

Repeat the vacuum – triple divide winnow cycle until there are no more seedy packets.

The 1/18 bottom screen will remove most of the seeds that have lost their seed coats. The 1/26 slot bottom is optional to remove small grass seeds if they are present.

Sorrel is one of my favorite seeds, silky smooth with its glossy bronze-black triangular prisms.

Spinach (*Spinacia oleracea*)

Threshing notes

Method: Rubbing/crushing

Spinach is easy to thresh, by foot or vehicle.

Cleaning workflow

Airflow: M

Clean -> Vacuum -> Clean -> TS 12/64 -> Shave -> (BS 8/64) -> BS 6.5/64

Cleaning notes

Spinach seed is most similar to beets and chard, in terms of the cleaning process. Like beets and chard, it can also produce a large amount of hollow seed that is only marginally lighter.

Vacuuming helps to break seeds off of attached sticks and to break up clusters of multiple seeds. Multiple passes through the vacuum may be required.

As with beets and chard, use a hammer test to check whether seeds blowing past the divider are hollow, and keep shaving and moving the divider slightly closer in until 30-50% of the seeds blowing past the divider are filled.

The 8/64 bottom screen is optional and pass a substantial amount of smaller seed that is also viable. The 6.5/64 screen will remove the smallest seeds and most weed seeds.

Squash (*Cucurbita spp.*)

Although there are differences in seed size between the three commonly-grown species of squash (*C. pepo, C. moschata, and C. maxima*), there are also differences between varieties within each of these, so I have chosen to present one overall squash "recipe" with plenty of room for adjustment.

Problems to avoid

Compost any rotten squash with mold or rot that has come in contact with the seed. This seed usually will have germination problems or will need to be removed later individually by hand due to serious discoloration.

Threshing notes

Absent a vine threshing machine, most squash is best threshed by some variation of "crack and scoop". Most winter squash and pumpkins are nicely brittle and will crack in half if thrown downward onto a tarp, or onto a concrete paver placed on a tarp. Some, like zucchini, are better broken with a sledgehammer or even driven over with a tractor to crack them. Short fermentation may help with separating pulp, but more than a day or two can reduce germination. Spray the seeds through a top screen (usually ½") and collect and rinse over a bottom screen (usually ¼", sometimes 1/8" for small-seeded varieties).

Cleaning workflow

Airflow: M

Tumble -> Clean -> Split 80/20-recover 2x -> BS-pick

Cleaning notes

Tumbling is useful to remove "angel wings". Hull-less "naked seeds" should not be tumbled – or only for 5 minutes or less – as they are easily damaged.

Hollow or partially filled seeds are a problem in some lots. When there are a lot of hollow seeds, a "shave" step can be helpful and it's easy to check whether seeds blowing past the divider are hollow by cracking them open.

As with beans, select a bottom screen based on seed size, which can range anywhere from 12/64 up to 20/64 or larger.

Tomatillo (*Physalis philadelphica*)

Threshing notes

Method: Removing husks will speed seed separation but is not required. Smash. For large lots, running through a Roto-Hoe works well. Agitate in water to separate and sink seeds, then decant multiple times to float and pour off fruit pulp. Spray clean seed in fine mesh strainer.

Tip: Save husks after first decanting, add water, agitate and decant again. This effectively re-threshes the fruit and recovers most of the seeds that were stuck in the husks.

Cleaning workflow

Airflow: L

Clean -> TS 7/64 -> TS 1/23 slot -> Split 90/10-recover 1x -> BS 1/14

Cleaning notes

Tomatillo seed is generally easy to clean. Adjust bottom screen size based on seed size such that 1% or less falls through.

Tomato (*Solanum lycopersicum*)

Problems to avoid

To avoid cleaning hassles, remove calyxes when harvesting. Some amount of rot is OK but remove any hardened material, such as blossom end rot. To avoid sprouted seed, do not over-ferment fruit, then dry clean seed quickly with lots of airflow. be especially careful with pre-fermented (rotting) fruit and varieties with less germination-inhibiting gel.

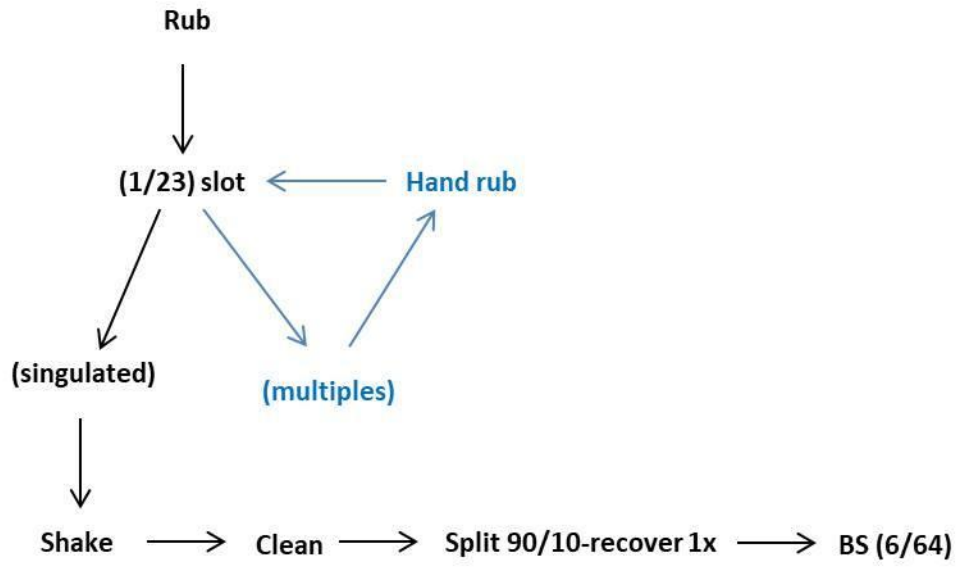
Threshing notes

Method: Smash and agitate, spray through a screen to remove skins and some pulp. Ferment for 3-7 days. Agitate in water and decant, finish by spraying in a fine screen, wash away all remaining pulp and gel.

Smaller lots can be stomped in bins, larger lots can be run through a Roto-Hoe chipper or a specialized wet-seed extractor (e.g. Millett).

Cleaning workflow

Airflow: L



Cleaning notes

Tomato seeds tend to stick together when dried. Drying in mesh bags with regular "massaging" results in less adhesion than spreading out seed on trays in a dryer. Typical small-scale seed volumes are a pound or less, so hand-rubbing seems to be the best approach to singulation. Re-rub the remaining multiples that stay on top of the 1/23 slot, and repeat this cycle until nearly all of the multiples have been singulated.

Tomato seeds are covered in very fine hairs. It's possible to remove most of these by filling a one-quart yogurt container about half-way and shaking vigorously for 30 seconds or so. Larger lots can be tumbled to remove fuzz and separate most clumps.

Most tomato seeds are viable; only a few light/hollow seeds typically blow away.

Tomato seed size is usually proportional to fruit size. Adjust the top and bottom screen sizes accordingly. Very large tomatoes may require a 1/20 slot, and cherry/grape tomato seed will fit through a 1/26 slot. Bottom screen size can range from 1/18 up to 6.5/64.

Watermelon (*Citrullus lanatus*)

Problems to avoid

Watermelons produce a continuum of seed densities from hollow/immature to fully filled. Harvest large, fully-ripe fruit to minimize the amount of light seeds.

Threshing notes

Method: Smash and scoop

Fruit can store for several months with no loss of seed quality, and overripe fruit thresh much easier as the pulp begins to naturally break down. Toss ripe fruit onto a tarp gently such that they break roughly in half, and scoop the seeds and flesh into buckets. Ferment briefly and collect/rinse over a 1/8" screen.

Cleaning workflow

Airflow: M

Clean -> (TS 6/64 slot) -> Split 70/30-recover 3x -> BS 11/64

Cleaning notes

Watermelon seed size varies substantially by variety – adjust screen sizes accordingly.

After splitting and recovering, assess the amount of hollow/partially-filled seeds in the light fraction, and if it's a lot consider additional shave or split-recovery steps.

Beans and Grains

Amaranth

Problems to avoid

Pigweed (wild amaranth) seeds obviously can't be removed, so amaranth patches must be pigweed-free. Lambsquarter seeds also have a size overlap and should be avoided.

Threshing notes

Method: Crushing/rubbing/agitation

Amaranth is easy to thresh by driving/shuffling over dry plants, followed by raking/agitation.

Cleaning workflow

Airflow: L

Clean -> TS 1/18 -> Shave

Cleaning notes

Amaranth is very easy to clean. Some larger varieties may require a 1/17 top screen. Bottom screening is not typically necessary.

Amaranth has very small spread in winnowing, so don't be afraid to do a close shave and remove all of the smaller/lighter seeds.

Amaranth seed often has initial dormancy, which it evolved so it won't sprout in early fall rains and then die with the first frost. If it fails its first germ test, just wait six months and try again.

Beans (*Phaseolus spp.* and *Cicer arietinum*)

Problems to avoid

- Dirt clods the same size as beans cannot be winnowed or screened out, and magnetic removal only works in the most highly-magnetic soils. If plants are pulled up by the roots, some amount of picking out dirt at the end becomes inevitable.
- Nightshade berries don't always winnow or screen out – especially from smaller beans – and they can get crushed and stuck to beans.
- Moldy or water-damaged beans are difficult to remove; minimize overhead irrigation once beans are ripening and try to harvest beans before significant fall rains.
- Beans are easily split/cracked – see threshing notes.

Threshing notes

Method: gentle crushing

The biggest challenge with beans is not splitting them. Although splits can be removed, whenever you see splits there are also inevitably some cracked or chipped or internally-damaged beans that won't be removed but still won't germinate. Most stationary threshers and "bean combines" split a lot of beans.

On a small scale, stomping on beans on a soft surface works well, and driving on beans on a soft surface works almost as well. If driving, each bean should only be driven on once, and the same bare ground should ideally not be used twice – once compacted more beans will split the second time. Grassy ground provides more cushion and can be used for multiple driving passes.

Once the plant material has been raked off, beans should ideally be field winnowed – or lacking steady wind, manually winnowed in front of the Winnow Wizard's strongest airflow. This is a very dusty process for which I strongly encourage masks and goggles if doing hundreds to thousands of pounds.

Cleaning workflow

Airflow: H

Clean -> Shave -> (dirt magnet) -> BS-pick

Cleaning notes

Most pods and coarse material will not feed through the Winnow Wizard hopper. Once all the beans have fed through, shut off the agitator and pull the remaining pods and plants out of the hopper. (If most of these pods still have beans you can save them for re-threshing.)

Most beans are so heavy that even on the highest airflow setting they are only deflected 2-3". This means that the divider setting for the shave operation is extremely sensitive, with horizontal shifts as small as 1/8"-1/4" resulting in cleaner beans, or more good beans blowing past the divider. In general, set the divider such that less than 1% of the good seed blows away. If there are a lot of splits, sometimes I will do a closer shave that removes 1-5% of the good seed followed by a recovery, moving the divider further in (say, from 4" to 3.5") for the recovery so as to minimize the number of splits in the recovered beans.

The shave step will remove beans still in pods. For filet beans and garbanzo beans this can be a significant amount, worth re-stomping and re-winnowing.

If there is a lot of dirt in the beans, the normal agitator attachment will grind some of it to dust and leave a film of dust on the beans. To avoid this, you can try using the "wiggle wire" attachment instead though this is less effective at feeding pods and coarse debris.

Beans vary greatly in shape and size, which means the ideal bottom screen also varies. In general it will range from around 12/64 up to 20/64, though 10/64 and 12/64 slotted screens can be used to remove undersized beans and splits. Tiny beans like "rice beans" will of course require much smaller screens. I have found 16/64 to be the most adaptable bottom screen for beans, and if you're doing a lot it is very helpful to have a larger-format screen of this size to cover a bin.

Bottom-screening and visually inspecting/picking through beans can easily make up two-thirds of the total cleaning time, depending on your standards and the amount of dirt clods, splits, and water-damaged beans in each lot.

Cereal Grains (Wheat, Barley, Oats, Rye)

Problems to avoid

Field bindweed, vetch, and buckwheat all produce large heavy seeds that are difficult to remove after harvest and so should ideally be weeded from the field.

Threshing notes

Method: Impact/rubbing

Impact-based threshing machines were designed for cereal grains, and they excel at this purpose. Threshing cereals by driving or foot-shuffling is possible but is relatively slow and requires repeated passes.

Cleaning workflow

Airflow: H

Vacuum (cycle) -> Clean -> Shave -> BS (8/64)

Cleaning notes

A shop vac works to de-hull wheat, rye, and the "naked" varieties of barley and oats, but it is not the best tool for this purpose. Some varieties may require up to 4-5 passes through the vacuum to approach 100% de-hulled seed. Cereal grains can handle multiple vacuum passes without damage. If you grow a lot of cereal grains, a purpose-built "de-huller" or "de-bearder" is a good investment.

Setting the shave as close in as possible will remove some of the remaining seeds with hulls, but hull-covered and de-hulled seeds cannot be completely separated by winnowing.

Adjust the bottom screen size as necessary to match the seed size – to remove fragmented seeds and contaminating small weed seeds.

Corn (*Zea mays*)

Problems to avoid

Corn grows mold very easily, and moldy kernels are not readily removed in cleaning. Unless you have the privilege of harvesting fully-dry cobs, plan on husking and drying within a few days of harvest.

Threshing notes

Method: Specialized impact/rubbing (corn shellers), or small amounts by hand

Corn shells most easily when fully dry. Kernels are easily split/damaged by many mechanical shellers, and this is especially true for sweet corns. Whatever technique you are using – even if just a hand-twist or hand-crank metal sheller – clean a small batch first to check whether the amount of damage is acceptable. Most corn shellers are designed for food/feed applications in which kernel damage is less of a concern. Simply twisting in opposite directions wearing sturdy leather gloves or rubber oven mitts can be an efficient method for threshing small quantities or particularly delicate varieties.

Cleaning workflow

Airflow: H

(TS ½") -> Clean -> Shave -> BS (16/64")

Cleaning notes

The first top screen is a field-screening step, which just removes any large cob pieces that would otherwise clog up the Winnow Wizard feed. A smaller top screen is typically not necessary as remaining cob bits are lighter than kernels and will winnow out.

Winnowing at least twice, with some rubbing such as is introduced by the Winnow Wizard hopper agitator, helps to minimize the amount of papery "bees wings" still attached to the kernels.

A close shave will remove most split/insect-damaged/thin kernels. If there are a lot of these, a second shave is helpful.

Sweet corns have flatter seeds and a wider spread in winnowing. For these I will often do a 90/10 split with one recovery instead of a shave as the final winnowing step.

Bottom screen size can range from 12/64" for popcorns up to 18/64" for the large kernels of flint and flour corns.

Quinoa (*Chenopodium quinoa*)

Problems to avoid

Lambsquarter is a close relative of quinoa with slightly smaller black seeds that can be difficult to remove.

Lygus bugs can frequently wipe out crops in the Pacific Northwest – the plants appear healthy but produce little or no seed as the bugs suck the sap from the developing seedheads.

Quinoa seed sprouts very readily once it is ripe. Ripe seed should not be allowed to remain wet for more than 24-48 hours; crop loss due to a prolonged rainy spell is not uncommon in some climates.

Threshing notes

Method: Rubbing

Foot-threshing or driving on quinoa works well, though it is the rubbing motion rather than crushing that frees the seed. A shuffling motion with the feet is much more effective than stomping.

Cleaning workflow

Airflow: M

Vacuum -> Clean -> TS 6.5/64 -> Shave -> BS 16x16

Cleaning notes

Vacuuming removes husks from quinoa seeds. A second pass through the vacuum will minimize the number of remaining seeds with husks.

Quinoa dust is rich in bitter saponins and can be irritating. Masks are recommended.

The top screen removes most remaining seeds with husks. Smaller-seeded varieties can use a 6/64 top screen.

Set the shave close in to remove small seed, light seed, and remaining seed with husks. To get a feel for the right position, you can shave repeatedly, moving the divider slightly closer in each time until good seeds start to blow past it.

Bottom screening is usually optional but will remove the smallest seeds. Bottom screening will also remove all pigweed seeds and most lambsquarter seeds.

Cleaning quinoa to eat

Unless you live somewhere with high lygus bug pressure or soggy Septembers, quinoa is an easy and fun crop to grow for food at a home/community scale. Yields can match wheat or barley, and it is easier to

harvest and thresh than cereal grains on a home scale and does not require milling. The main challenge is removing enough of the bitter saponin coating on the seeds to make it palatable.

De-bittering quinoa seeds requires rinsing/agitating them in running water, or in about four changes of water. The best way that I have found to do this on the scale of pounds to tens of pounds is – credit to Frank Morton – to put the seed in sturdy pillowcases, tie them shut, and then run them through four consecutive cold water rinse cycles in a washing machine before re-drying the seed in the sun or in a seed dryer. Winnow the seed once more after drying, and a final rinse prior to cooking is helpful to remove any remaining bitterness.

Teff (*Eragrostis tef*)

Problems to avoid

It's easy to get dirt in teff, as the panicles drape and often lay on the soil. Small weed and grass seeds can be difficult or impossible to remove.

Threshing notes

Method: Rubbing/agitation

Teff panicles are soft and light. Rubbing them together, as by stacking them rather thickly and driving or foot-shuffling over them, is an effective threshing method. A second step of raking up the plants and rolling/shaking them will release more seed.

Cleaning workflow

Airflow: L

Clean -> TS 1/22 -> Shave -> (Dirt Magnet)

Cleaning notes

Teff is rather easy to clean, provided it doesn't have much in the way of dirt or small weed seeds. Some varieties may fit through a 1/24 top screen.

Most lots will have some level of dirt contamination. If your soil is at all magnetic, the magnetic hopper gate accessory for the Winnow Wizard can effectively remove this.

Herbs

Basil (*Ocimum spp.*)

Problems to avoid

Basil stems branch close to the ground, so some dirt clods are often included with harvest.

Basil seeds overlap in size/shape with a number of weeds; keep patches well weeded.

Basil seeds have a mucilaginous coating that swells when wet to give the seeds a “fish eye” appearance. These “basil eyes” stick to everything – stems, tarps, bins, etc. – and once re-dried can be more difficult to fully clean. If at all possible, harvest basil on a dry day and avoid any rain/dew during drying and threshing.

Threshing notes

Method: Impact/agitation

Basil seeds are held in leathery capsules that they must be shaken out of. Hitting dry plants with sticks or pitchforks is much more effective than crushing them. Driving on basil can work by weakening the capsules, but some amount of impact/agitation will still be necessary.

Cleaning workflow

Airflow: L

Clean -> TS 1/15 -> Shave -> BS 1/19 (-> Dirt Magnet)

Cleaning notes

Basil seed varies substantially in size by variety – adjust top and bottom screens accordingly. The listed sizes are for most Italian types; Thai basil seed is smaller and Sacred Basil (*Ocimum tenuiflorum*) has the smallest seeds and requires a 1/18 top screen and 1/22 bottom screen.

Basil often produces a high proportion of hollow seeds that are visually identical (though they may be slightly lighter in color). Don’t be afraid to blow these away – in some cases it can be over 50% of the volume. Good basil seeds have a very small spread in winnowing, so if you’re unsure keep repeating the shave and moving the divider closer in.

If your soil is at all magnetic, the magnetic hopper gate for the Winnow Wizard will remove dirt clods from basil seeds, and basil is one of the crops that most regularly needs this.

Chamomile (*Matricaria spp.*)

Threshing notes

Method: Crushing/impact

Stomping in a bin works just fine at small scales

Cleaning workflow

Airflow: VL

Clean -> TS 24x24 -> Split 90/10-recover 1x -> BS 6x36 (-> TS 1/22)

Cleaning notes

Chamomile produces a great deal of hollow seed – usually substantially greater in volume than the good seed. The divide when winnowing is beautifully clear, with no overlap between the good and hollow seed. Fear not when blowing the hollows away – the seeds are tiny and you will still have far more than you need.

Chives (*Allium schoenoprasum*)

Threshing notes

Method: Rubbing/agitation

Chives are similar to onions, and can be threshed through a chipper or rubbed across a ~1/8" hardware cloth screen.

Cleaning workflow

Airflow: L/VL

Clean -> TS 6/64 -> Split 80/20-recover 2x -> BS 1/18

Cleaning notes

Chives seed is a lot lighter than onion seed, so be cautious about blowing good seed away. Like onions, chives produce a lot of hollow seed. Use a split-recovery winnowing strategy to identify the cutoff between good and hollow seed and recover most of the good seed.

Cilantro/Coriander (*Coriandrum sativum*)

Threshing notes

Method: Impact

Hit plants with sticks or pitchforks on a large tarp to break the seeds free. Avoid crushing forces; coriander seeds are relatively easy to crush.

Cleaning workflow

Airspeed: M

Tumble -> Clean -> TS 13/64 -> Shave -> BS 8/64

Cleaning notes

Coriander seeds are often still attached to small sticks. Tumbling breaks most of these off. Vacuuming works too but can damage or split the seeds.

Hollow seeds are only subtly lighter. Being perfectly spherical, coriander seeds have a very small spread, so don't be afraid to set up a close shave and blow away some of the lighter seeds. Often the lighter seeds have a small exit hole from an insect that has hollowed out the embryo inside.

Dill (*Anethum graveolens*)

Threshing notes

Method: Agitation/light impact

Bang/shake dry plants inside of garbage cans, or tap seedheads lightly when not too crispy. Small sticks can be difficult to remove from these light winged seeds.

Cleaning workflow

Airspeed: L

Clean -> TS 10/64 -> Split 60/40-recover 4x -> TS 1/26 slot -> BS 1/12

Cleaning notes

Dill produces abundant seed, so it's usually OK to winnow away some of it. Shaking the 1/26 slot perpendicular to the slots can be helpful to encourage the curved dill seeds to dive through.

Epazote (*Dysphania ambrosioides*)

Epazote is extremely aromatic, and its volatile oils may cause headaches and minor burns from prolonged exposure. Masks are helpful, and work in well-ventilated areas.

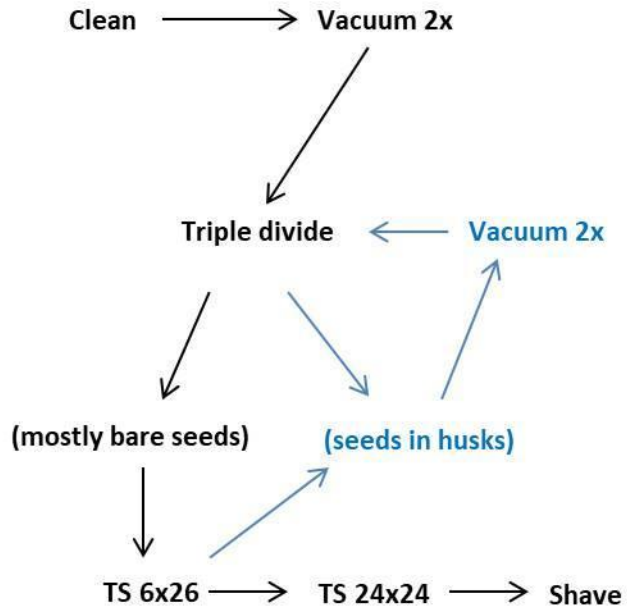
Threshing notes

Method: Rubbing

Tiny seeds are borne directly on small stems, and rubbing these stems together (by shuffling or driving) will free the seeds.

Cleaning workflow

Airspeed: L/VL



Cleaning notes

Vacuuming – depending on the various factors that influence abrasion strength – is usually about 50% effective at de-husking epazote seeds in a single pass. So getting to fully de-husked clean seed is an iterative process.

The triple divide aims to separate the post-vacuum seed into naked seed, seed-with-husks, and empty husks/dust. Any seeds with husks that end up with the naked seed after winnowing will be removed by the 6x26 screen.

A nearly identical cleaning process works for cleaning goosefoot/"magenta spreen" seed, which is slightly larger so uses a 6x24 top screen to separate the naked seeds from those with husks.

Lovage (*Levisticum officinale*)

Threshing notes

Method: Rubbing/impact

Along with other carrot-family herbs like angelica and alexanders, lovage has large-ish, relatively-light seeds that are difficult to separate from small sticks in seed cleaning. If at all possible, thresh at intermediate moisture levels – not crispy dry – to minimize the creation of small sticks.

Cleaning workflow

Airflow: L

Clean -> TS 10/64 -> Split 60/40-recover 4x -> BS 7/64-tweeze

Cleaning notes

This overall recipe also applies to alexanders and angelica, which have larger seeds and therefore larger top and bottom screens. See the tables for recommendations.

Hollow seeds are only marginally lighter; when setting the divide in winnowing, break seeds open to check if there is an embryo inside.

Some tweezing of sticks is typically necessary to reach 100% clean seed; for larger lots an indent cylinder may be useful, as with carrot seed.

Parsley (*Petroselinum crispum*)

Threshing notes

Method: Impact/rubbing

Hitting plants with sticks/pitchforks works well to knock seeds off; on a larger scale driving also works.

Cleaning workflow

Airflow: L/M

Tumble -> Clean -> TS 1/14 -> Shave 2x -> BS 1/22

Cleaning notes

Parsley seeds are set in pairs; the 1/14 screen passes singles but not unbroken pairs. If the quantity is large, these pairs can be vacuumed or rubbed to singulate them so that they will pass through the 1/14 screen.

Occasionally, parsley seed lots may have poor germination, with the dead seeds being only about 5% lighter than the good seeds. In these cases, it is possible to increase germ by winnowing with a repeated split strategy. For example, if aiming to remove 30% of the seed, start with an 80/20 split and then re-run the heavy fraction at the same divider setting to shave off another 10% or so.

Perilla/Shiso (*Perilla frustescens*)

Threshing notes

Method: Agitation (no crushing!), light impact

Perilla seed is extremely soft and can't be stomped or driven on. Thresh these aromatic plants by shaking them upside down inside buckets, trash cans or bins.

Cleaning workflow

Airflow: M

Clean -> TS 8/64 -> Shave -> (BS 1/18 slot)

Cleaning notes

Perilla seed is spherical and easy to clean, and the gentle threshing method results in relatively little debris.

Sage (*Salvia officinalis*)

Threshing notes

Method: Rubbing and/or impact: Shuffle stomp or banging in totes. Roto-hoe also works. Crushing seals seed inside capsules and should be avoided.

Cleaning workflow

Airflow: M

Clean -> TS 8/64 -> Shave -> BS 1/12

Cleaning notes

Sage seed is spherical, heavy, and easy to clean.

Thyme (*Thymus vulgaris*)

Threshing notes

Rubbing and/or impact: Shuffle stomp, rub on screes, or bang in totes. Roto-hoe is also works.

Cleaning workflow

Airflow: L/VL

Clean -> TS 1/24 -> Shave (-> Dirt Magnet)

Cleaning notes

Although very small, thyme seed is round and heavy and generally easy to clean. Soil particles, if present, can often be removed with the magnetic hopper gate.

Yarrow (*Achillea millefolium*)

Threshing notes

Method: Impact/crushing

Hitting seedheads with sticks or pitchforks will cause the seeds to fly out. Some stomping/crushing can help as well.

Cleaning workflow

Airflow: VL

Clean -> TS 16x16 -> Clean -> TS 6x36 -> Split 80/20-recover 2x

Yarrow is not the smallest seed but it is one of the lightest and thinnest that is commonly encountered. The Winnow Wizard divider settings will be right at the end of the rails or perhaps slightly beyond.

The 6x36 screen is the secret sauce for yarrow cleaning; cleaning yarrow is the best reason to add this screen to your collection.

Flowers

Flowers don't easily fall into major categories, and their seeds cover an immense range of shapes and sizes. Sweet Annie and Sweet Pea are next to each other in the table, but it takes about 2,000 Sweet Annie seeds to equal the weight of a single Sweet Pea seed. The cleaning recipes here are a somewhat arbitrary subset, intended to include the most common flowers – like zinnias and snapdragons – but also those for which the cleaning process is somewhat unique or involved.

Many flower seeds are attached to some form of pappus or dried petal, so some form of abrasion – rubbing, tumbling, or vacuuming – is often a part of the cleaning recipes.

Ageratum (*Ageratum houstonianum*)

Threshing notes

Method: Impact/agitation

Ageratum flowers "puff out", at which point the tiny seeds are easily released from the plants. Shaking plants upside down in a bin, or hitting the seedheads, both work well.

Cleaning workflow

Airflow: VL

Tumble -> Clean -> Rub -> Clean -> TS 6x26 -> TS 30x30 (bounce through) -> Split 80/20-recover 2x

Cleaning notes

Ageratum seeds are among the smallest and lightest; the divider settings will be near or even slightly beyond the ends of the rails. Once clean though they often have impressively high germination rates.

Aster, China (*Callistephus chinensis*)

Threshing notes

Method: Impact/agitation

China asters are one of the last seeds to ripen in the fall – if the weather is turning they can be pulled up by the roots and laid out in a greenhouse to keep after-ripening their seeds. The plants thresh easily with gentle impact or foot threshing.

Cleaning workflow

Airflow: L

Tumble -> Clean -> TS 6/64 -> Split 80/20-recover 2x -> BS 1/17-recover -> (TS 1/12 bounce through)

Cleaning notes

Aster pappus is easily detached in tumbling.

Some seeds will fall through the 1/17 bottom screen; most of these can be recovered by a second or third bottom screening.

Late-harvest lots can have issues with heavier debris, like collapsed, hardened, moldy petals. In this case the seed can be slowly bounced/tapped through a 1/12 screen which will remove most debris.

Bachelor Buttons (*Centaurea cyanus*)

Threshing notes

Method: Impact/crushing

Seeds are held fairly tightly but they are readily dislodged by hitting and/or stepping on dry seedheads. Plants are indeterminate and will continue to flower even as the first ripe seed shatters, so choosing the best harvest time can be challenging.

Cleaning workflow

Airflow: L/M

Vacuum -> Clean -> TS 7/64 -> Split 90/10-recover 1x -> BS 1/16

Cleaning notes

Vacuuming breaks off most of the attached pappus from the seeds.

Bachelor button seeds are fairly straightforward to clean. They do, however, tend to find their way into other crops being grown nearby.

Bee Balm (*Monarda spp.*)

Threshing notes

Method: Agitation

Seeds are held in capsules that naturally open as the plants dry. Once the capsules are open the seed will fall out with mild agitation.

Cleaning workflow

Airflow: L/VL

Clean -> TS 1/22 -> Shave

Cleaning notes

Bee Balm and other mint-family flower and herb seeds are generally easy to clean, being very small but spherical and heavy.

Blanket Flower (*Gaillardia spp.*)

Threshing notes

Method: Crushing

Step on the seed heads to break them apart and release the individual “badminton birdie” seeds.

Seed cleaning workflow

Airflow: VL

Clean -> TS 12/64 (rub through) -> Shave 3x -> Overwinnow (-> BS 8/64)

Cleaning notes

The vast majority of the “birdies” are hollow. Don’t be afraid if you see 80% of them blowing past the divider. The ones with viable seeds are surprisingly heavy.

For top screening, the birdies will get stuck in the holes of the 12/64 screen but will go through if you rub the *bottom* of the screen. This works well once you get the hang of it.

The multiple shave steps help to peel off remaining hollow seeds – they don’t all blow out in one pass as the birdies sometimes stick together as they fall.

Bottom-screening these is a pain and best avoided if possible, since the birdies fall partway through even small screens and clog the holes. Overwinnowing – blowing the seed past the divider while heavier debris falls behind – can be an effective alternative as a final step.

Calendula (*Calendula officinalis*)

This four-purpose plant (edible, medicine, dye, beauty) produces three types of seeds, making cleaning them something of a challenge.

Problems to avoid

Heavy green/immature seeds and stem-fragment sticks.

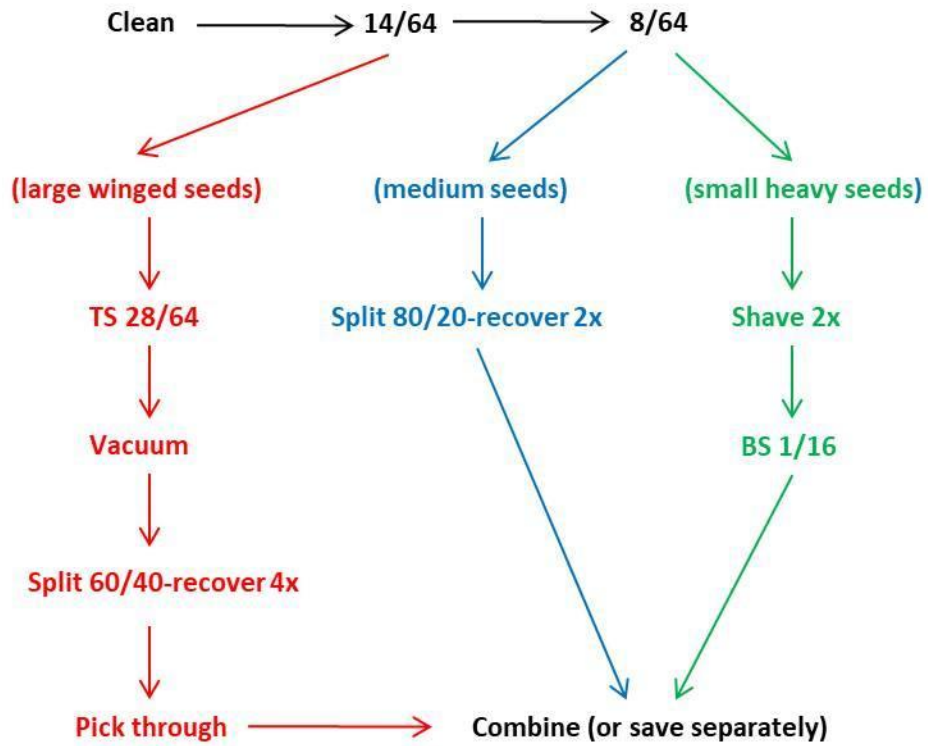
Threshing notes

Method: Crushing/impact.

Stepping on dry seedheads readily releases the seeds. Calendula is highly indeterminate, flowering long into fall and winter, and green immature seeds are not readily removed. A good threshing strategy is to tip a row of still-rooted plants onto the edge of a tarp and stomp/hit them lightly to release the ripe seeds while leaving the firmly-attached green seeds behind. Sticks can be difficult to remove, so avoid hitting too hard or threshing in extremely dry conditions.

Cleaning workflow

Airflow: L (large seeds) or M (small/medium seeds)



Cleaning notes

The largest winged fraction is the most difficult to clean and also has a high proportion of hollow seeds. If your harvest greatly exceeds your need, you might consider not cleaning the large fraction, or cleaning it to a lower standard and keeping it separate from the combined smaller fractions.

The vacuuming step helps to break up soft parts from the core of dried seedheads that are otherwise the same size and weight as the large seeds. Vacuuming will also break up large sticks into smaller, harder-to-remove sticks, so it's best to screen out the sticks first.

Most immature seeds will be in the small fraction. Don't be afraid to shave off greenish-tinged seeds when winnowing.

Celosia *(Celosia spp.*)

Celosia seeds are perhaps my favorite – each one is a round, slightly flattened, shiny jet black jewel. They are also easy to grow, harvest, and clean.

Threshing notes

Method: Impact/agitation

Celosia is largely self-threshing as the seed ripens and dries. Hitting or shaking seedheads will release the seeds. "Crested" types produce relatively little seed, mostly at the base of the crests, and require more aggressive threshing to release the seeds.

Cleaning workflow

Airflow: L

Clean (-> Tumble) -> TS 1/15 -> TS 1/23 slot -> Shave -> BS 1/19

Cleaning notes

The 1/23 slot screen will remove most seeds still in their husks. Tumbling will remove husks, but celosia seeds have a relatively fragile seed coat so tumble for shorter periods if needed. Do not vacuum celosia seeds.

Coreopsis *(Coreopsis spp.*)

Threshing notes

Method: Crushing/agitation

Thresh by stepping on seedheads, but do so gently and avoid crispy dry conditions to avoid creating small debris that is difficult to remove.

Cleaning workflow

Airflow: VL

Clean -> TS 1/8 -> Clean -> TS 1/26 slot -> TS 1/16 -> Split 60/40-recover 4x -> BS 30x30

Cleaning notes

Coreopsis has light, flat, rather small seeds that are challenging to separate from tiny plant parts. Repeat the 1/16 top screen if necessary, and use a split-recovery winnowing strategy to blow out most sticks. You may need to discard the lightest 5-10% of seed.

Cosmos (*Cosmos spp.*)

Threshing notes

Method: Agitation

Cosmos flowers and ripens indeterminately and ripe seed shatters onto the ground. Ripe seed can be hand threshed from ripe flowers, or plants can be tipped and shaken in bins to dislodge ripe seed. Whole plants can be harvested to after-ripen at the end of the season, with threshing by agitation/light impact.

Cleaning workflow

Airflow: M

Clean -> TS 6/64 slot -> Shave 2x -> BS 8/64-recover

Cleaning notes

Cosmos seed is surprisingly heavy and easy to clean despite its shape. Some will fall through the 8/64 round bottom screen but will stay on top when screened a second or third time. The combination of a 6/64 slot top screen and large 8/64 round bottom screen will remove pretty much everything not shaped like a cosmos seed, and light/hollow seeds readily winnow out.

Dianthus (*Dianthus spp.*)

Threshing notes

Method: Crushing

Crush ripe seedheads to release the seeds, but do so as gently as possible as dianthus seed is challenging to clean.

Cleaning workflow

Airflow: VL

Clean -> TS 8/64 -> Clean -> TS 1/26 slot -> Split 60/40-recover 4x -> BS 1/17

Cleaning notes

Dianthus is one of the most challenging seeds to clean to 100% purity, and in most cases it is necessary to accept some amount of inert plant matter.

Flax (*Linum spp.*)

Threshing notes

Method: Crushing/rubbing. Easily threshed by driving on dried plants.

Cleaning notes:

Airflow: L

Clean -> TS 8/64 -> Clean -> TS 1/26 slot -> Split 80/20-recover 2x -> BS 5/64

Cleaning notes

The combination of a narrow-slot top screen and a much larger round-hole bottom screen effectively removes everything not shaped like a flax seed.

Globe Amaranth (*Gomphrena spp.*)

Gomphrena seed is one of those that requires specialized equipment – essentially very intense rubbing – to produce commercially, although there is one trick described below that works well on a home or community scale.

Gomphrena seeds are held in tough leathery packets, which are covered in white fluff, which are enclosed in a fine papery covering. Removing the papery covering, such as by vacuuming, produces a mess of fluff that cannot be readily winnowed, and the tightly-attached fluff prevents vacuuming or tumbling from being effective for further cleaning.

Commercially, the fluffy seeds are fed through a machine that individually rolls/rubs the seeds to remove the fluff, and they are sold still contained in their leathery packets.

Threshing notes

Method: Rubbing/agitation

A gentle rubbing or shuffling motion readily removes the packets from stems.

Cleaning workflow (very small scale)

Airflow: M

Vacuum -> Soak 4 hrs -> Immersion blender -> Dry -> Clean -> TS 5.5/64 -> TS 1/20 slot -> BS 1/18

Cleaning notes

This process takes something like 12 hrs per pound of finished seed, so I don't recommend it if you're growing it as a contract or for more than packet sales.

Soaking the seed loosens it inside of its leathery packets, and the impact from the immersion blender blades opens these packets so that the heavy free seed falls to the bottom. The unthreshed packets float while the free seed sinks, so I recommend doing this process in a tall bucket such that the free seed falls away from the blender. It takes about 30 minutes to process a gallon or so of fluffy material into less than an ounce of naked brown seeds that look a bit like quinoa seeds.

Most home immersion blenders are not designed for this intensity of use – allow it to cool for a bit after each 10 minutes or so and clean the blade assembly frequently so that it doesn't get clogged.

Once most of the floating fluffy packets are empty, pour off the packets and water and it's very easy to collect and dry the seed at the bottom.

Hollyhock (*Alcea spp.*)

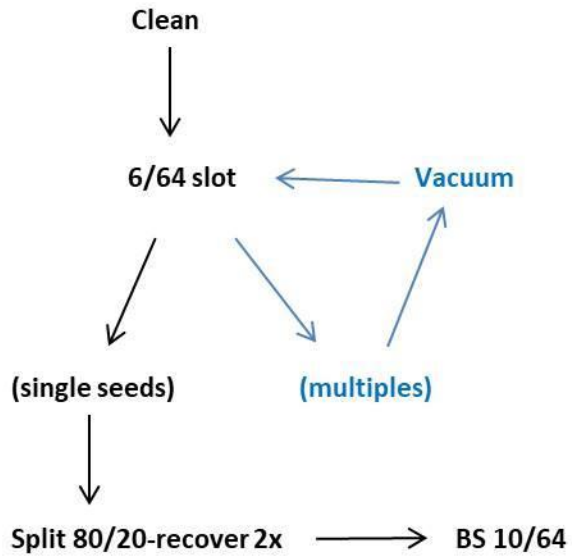
Threshing notes

Method: Crushing

Flat seeds are tightly stacked horizontally into donut shapes. A crushing motion – stomping or driving – releases these donuts and begins to individuate them.

Cleaning workflow

Airflow: L



Cleaning notes

Tightly-packed stacks of hollyhock seeds need to be singulated, which is readily accomplished by vacuuming.

Once singulated, the combination of a narrow slot top screen and large round bottom screen effectively removes most debris.

Hollyhocks produce quite a bit of hollow seed, and good seeds can be hollowed out by weevils that leave a signature exit hole. Don't be afraid to blow some seed away, and watch for weevil holes when winnowing. Additional shave or split-recovery steps may be helpful to improve germination.

Larkspur *(Delphinium spp.*)

Threshing notes

Method: Crushing

Larkspur pods naturally open, and most seeds fall out if they are shaken upside down. Crushing the pods readily releases all seeds.

Cleaning workflow

Airflow: M

Clean -> TS 6.5/64 -> Shave -> BS 1/15

Cleaning notes

Larkspur seeds are round-ish, heavy, and generally easy to clean.

Marigold (*Tagetes spp.*)

Threshing notes

Method: Crushing

Stepping on dried seedheads readily releases the packed columnar seeds inside.

Cleaning workflow

Airflow: VL

Clean -> Tumble -> Shave -> TS 1/23 slot -> Split 80/20-recover 2x

Cleaning notes

Tumbling removes attached petals and flower parts. Be sure to use a sturdy pillowcase made of tightly-woven fabric. Hypoallergenic pillowcases work best. The needle-shaped seeds will poke through lesser pillowcases resulting in a pincushion effect.

The 1/23 slot screen magically cleans marigold seed and is usually the only screen required. Marigold seeds will not readily pass through any round-hole screens.

Marigolds produce a lot of hollow seeds. Hollow seeds are flexible and fold/bend readily while good seeds are more rigid and snap when bent.

Milkweed

Threshing notes

Pick pods just before they puff out and release their seeds, and dry them under screens or fabric so that the seeds don't blow away when the pods open. On smaller scales, milkweed seeds can be threshed by placing opened pods in a covered bin with some small pieces of wood and shaking the bin vigorously. Open the bin and blow away the loose fluff, and repeat until most of the seeds have been de-fluffed. It is recommended to wear a hooded cape while doing this, under the light of the full harvest moon. And definitely have an audience.

Cleaning workflow

Airflow: VL

Clean -> TS 1/18S -> Split 60/40-recover 4x -> BS 8/64

Cleaning notes

Milkweed seeds will readily fit through a 1/18 slot, but getting them to fall through requires some bouncing and tapping on the bottom of the screen. Using a slightly larger slot will go faster while getting the seed a bit less clean.

These winged seeds blow a long way for their size – use a gentle wind when winnowing, and a split-recovery strategy is helpful for removing chaff and hollow seeds.

Nicotiana (*Nicotiana spp.*)

Threshing notes

Method: Crushing

Nicotiana/tobacco is largely self-threshing as the ripe capsules release their seeds. Gentle crushing will release all seeds.

Cleaning workflow:

Airflow: VL

Clean -> TS 24x24 -> TS 24x24 -> Shave

Cleaning notes

Although tiny, the seeds are heavy and round-ish and quite easy to clean. A second pass through the top screen will remove some additional debris.

Nigella (*Nigella spp.*)

Threshing notes

Method: Crushing

Nigella is very easy to thresh by crushing the pods. ("Transformer" nigella has an entirely different seed shape and should be threshed very gently or simply shaken out of its opened pods, as it is much more difficult to clean.)

Cleaning workflow

Airflow: M

Clean -> 6.5/64 -> Shave -> BS 1/15

Cleaning notes

Although nigella and larkspurs are entirely unrelated, they both have black seeds of nearly identical size, and they share the same cleaning recipe. Culinary nigella ("black seed") and most "love-in-a-mist" ornamental nigellas are very easy to clean. Some nigella seeds have an interesting "artificial grape" aroma.

Some nigella species have smaller seeds; adjust top and bottom screen sizes accordingly.

"Transformer" nigella (*N. orientalis*) produces flat seeds with an entirely different cleaning recipe. See the table for details.

Phacelia (*Phacelia tanacetifolia*)

Problems to avoid

Phacelia seed overlaps in size and weight with quite a few different weeds. The sprawling plants are difficult to keep weeded, but try to avoid weed seed contamination as much as possible.

Threshing notes

Method: Crushing/agitation

Plants ripen indeterminately – harvest once the earliest pods have begun to shatter. Phacelia is a good candidate for driving on plants on large tarps, although foot threshing works well on smaller scales.

Cleaning workflow

Airflow: M

Clean -> TS 5.5/64 -> Shave -> BS 1/18

Cleaning notes

Phacelia is a dusty seed – masks are recommended.

In the case of weed seed contamination, it is often possible to concentrate the weeds into a minority of the seed, either by a winnowing split or by using an intermediate-size screen like 1/17 or 1/16.

Poppies (*Papaver spp.*)

Threshing notes

Method: Crushing

Stomping the dry pods readily releases all seed. If you want to save the pods for art, many varieties naturally open at the top and can simply be turned upside down and dumped out.

Cleaning workflow

Airflow: L

Clean -> TS 1/22 -> Shave

Cleaning notes

Poppy seed is very easy to clean. Seed size varies by variety and species. Adjust top screen size accordingly.

Rudbeckia (*Rudbeckia spp.*)

Threshing notes

Method: Impact

A Roto-Hoe chipper does a great job of threshing rudbeckia. The somewhat supple seedheads are not readily crushed in a way that releases the seeds; repeated impacts work much better.

Cleaning workflow

Airflow: L

Clean -> TS 1/8 -> Shave -> TS 1/18 -> Split 80/20-recover 2x (-> BS 30x30)

Cleaning notes

Rudbeckia seed is surprisingly heavy for its size and typically easy to clean. Bottom screening is often not necessary.

Scabiosa (*Scabiosa atropurpurea*)

Threshing notes

Method: Crushing

Crushing the seedheads – with feet or tires – works well to free the individual "birdies" that hold the seeds.

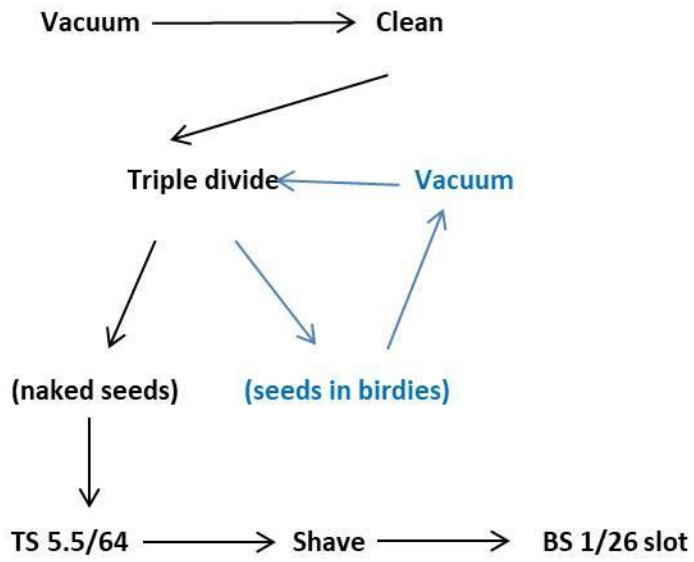
Cleaning workflow (to birdies)

Airflow: L

Vacuum (gentle) -> Clean -> TS 16/64 -> Shave 3x -> BS 8/64

Cleaning workflow (to bare seed)

Airflow: L/M



Cleaning notes

The "spike" has to be broken off by vacuuming gently before seeds can be effectively winnowed.

Cleaning to naked seed is more effort but results in higher-germ seed that is easier to handle for planting.

Each pass through the vacuum typically pulls about 25% of the seeds out of their birdies. As an alternative, grinding the birdies through a 6/64 slot screen (using another slot screen on top as a "driver") is much more effective but is slower and does damage some seed. Perennial scabiosa (*S. caucasica*) cannot be cleaned to naked seeds, and it requires a larger top screen for its larger "birdies".

Snapdragon (*Antirrhinum spp*.)

Threshing notes

Method: Crushing

Snapdragons are very readily foot-threshed by crushing the dry pods.

Cleaning workflow

Airflow: VL

Clean -> TS 1/22 -> Shave -> BS 30x30

Cleaning notes

Snapdragon seed is typically easy to clean, although caterpillar frass is sometimes an issue requiring smaller top screens to remove.

Strawflower (*Xerochrysum bracteatum*)

Threshing notes

Method: Agitation/Impact

Strawflowers need to be picked before they fully fluff out and release their seeds. Once picked and dried, vigorous shaking will release the seeds. A woodchipper is overkill but effective.

Cleaning workflow

Airflow: VL

Tumble -> Clean -> Rub/Tumble -> Clean -> TS 1/17 -> Shave -> BS 24x24

Cleaning notes

For the “clean” steps, set the divider conservatively so that seeds still attached to their pappus don’t fly away.

Although vacuuming works well for de-pappusing, it also shells some of the seeds, so tumbling is a better option.

Strawflower seed is light for its size; similar-sized contaminants can often be removed by overwinnowing – blowing the seed away from heavier material.

Sunflower (*Helianthus annuus*)

Threshing notes

Method: Impact

Threshing sunflowers on a small scale is surprisingly difficult. Stepping on the heads doesn't do much. Rubbing them against a coarse hardware cloth screen can work but is slow and also damages seeds. The best method I have found is to run them through a modified Roto-Hoe woodchipper, which effectively knocks the seeds free. Seedheads shouldn't be overly dry when run through the roto-hoe, as they can be shredded into a million pieces. For smaller seeded sunflowers this material can be difficult to separate from the seed. Regular "burping" of the roto-hoe is recommended to allow threshed seedheads to exit the machine without being shredded.

Cleaning workflow

Clean -> TS 10/64 slot -> Shave -> Split 80/20-recover 2x -> BS 10/64

Cleaning notes

Sunflowers produce quite a few hollow or partially-filled seeds – don't be afraid to winnow some away, and it's easy to check by breaking them open.

Sunflower seeds vary widely in size by variety – adjust top and bottom screen sizes accordingly.

Sweet Annie (*Artemisia annua*)

Threshing notes

Method: Crushing/impact

Sweet Annie ripens late and benefits from after-ripening. Stomping on the soft seed capsules, followed by hitting them with sticks or pitchforks, works well to release the tiny seeds.

Cleaning workflow

Airflow: VL

TS 8/64 -> Clean -> TS 1/16 -> Clean -> TS 30x30 -> Shave 2x

Cleaning notes

Sweet Annie is one of the tiniest seeds you will probably encounter. Set the divider way out at 20" or so for the initial runs so as to avoid losing seed. Once the coarser material has been screened out it will be clearer where the seed is falling.

Chances are you will have far more seed that you need, so don't be afraid to blow some away in order to achieve higher purity and germ.

Sweet Peas (*Lathyrus odoratus*)

From the smallest flower seed to the largest; it takes 2,000 Sweet Annie seeds to equal one sweet pea seed in weight.

Threshing notes

Method: Crushing

Sweet peas are largely self-threshing, in that the pods split open and release their seeds as they dry. Harvest timing is critical, ahead of splitting. Driving or stomping on plants will open pods that have not yet split.

Cleaning workflow

Airflow: H

Clean -> TS 17/64 -> Shave -> BS 10/64

Cleaning notes

Sweet peas are easy to clean. When winnowing, use a low tray angle so that they don't roll down and bounce off of the feed plate.

Zinnias *(Zinnia elegans)*

Zinnias are one of the more challenging seeds to clean. They make two different sizes/shapes of seed from ray and disk flowers, and the ray seeds remain attached to the dried petals. The seeds are flat, relatively light, and frequently hollow – and hollow ray seeds have a similar density to good disk seeds.

Small flowered or Mexican zinnias (*Z. haageana*) have much smaller seeds – the process is similar but move down one or two notches on all of the screen sizes.

Problems to avoid

Method: Rubbing/gentle impact. Avoid crushing!

Don't smash the cones! The receptacle or "cone" to which the seeds are attached can shatter into fragments that are identical in size and density to zinnia seeds and that effectively cannot be removed except with tweezers. This informs threshing methods and those that involve stomping/crushing should be avoided.

At least on smaller scales zinnia flowers are typically harvested individually which alleviates most contamination concerns. Flowers picked late into the fall after days of rain may develop hard fungal bodies (sclerotia) on petals that add weight and create a seed cleaning challenge. It's best to resist the urge to harvest in November for this reason.

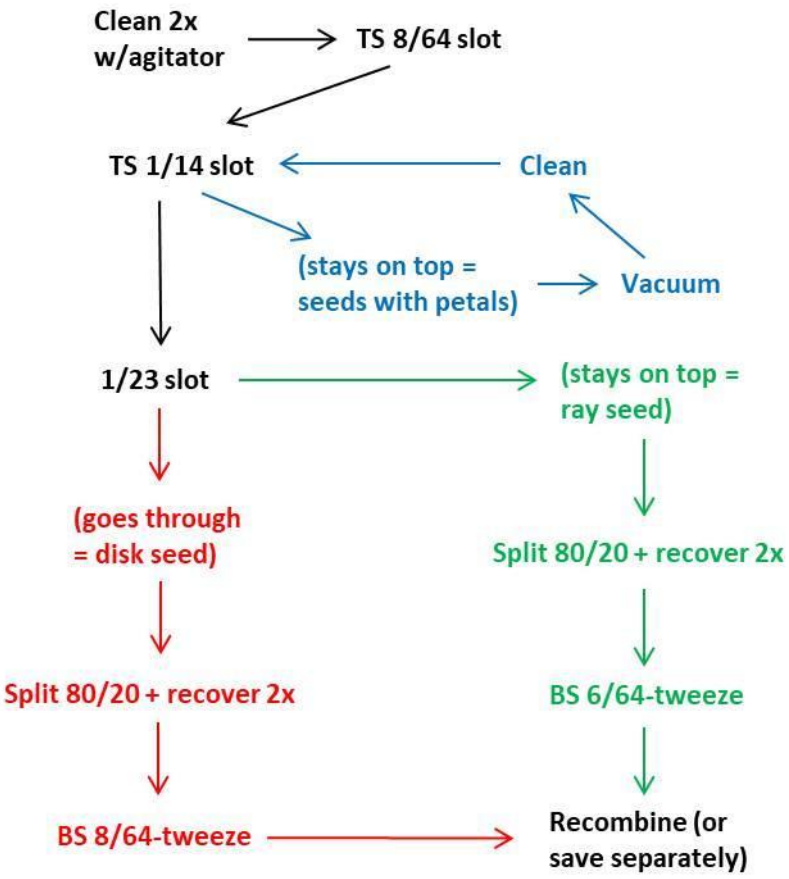
Threshing notes

Zinnia heads should be dry but not completely crispy when threshed. Threshing zinnias straight out of a seed dryer results in more fractured cones. Sucking whole dry flower heads through a large-tubed shop vac works surprisingly well as a threshing method. A modified Roto-Hoe chipper works too provided that the cones are not crispy dry – it's fine if they break in half as long as they don't break into small fragments.

Once the seed is threshed and field-screened it should be fully dried to allow the petals to break off of the ray seeds during final cleaning.

Cleaning workflow

Airflow: VL (or L for ray seeds only)



Cleaning notes

It's not always easy to see the rear edge of the seed spread in the first winnowing steps, and the seeds with petals still attached fly farther, so set the divider conservatively. Lower the agitator close to the bottom of the hopper to provide maximum rubbing action, which helps to break most of the petals off of the ray seeds.

Vacuuming *all* of the seed after the first TS step is an option, but may damage some of the disk seeds.

Repeat the vacuum cycle until all of the ray seed goes through the 1/14 screen. Very small volumes can be rubbed vigorously by hand.

Load the 1/23 slot screen lightly and use the bottom-tapping method to encourage all of the thin disk seed to fall through. This is the slowest step of the process. Disk seeds that remain in the ray seed lot may get winnowed away.

When setting the divider in winnowing, you can check if seeds are hollow by bending them – hollow seeds will bend easily, good seeds will be rigid until they snap. For the final split, set the divider where

about 20% of the *good seed* falls beyond it, it can be helpful to do a "shave" step first to blow away most of the hollow seed to getter a better sense of the true spread.

Different varieties may require different bottom screen sizes.

The Tables

These quick-reference tables represent the combined experience of Wild Garden Seed, Adaptive Seeds, and my own personal and contract-cleaning endeavors. That said, there is no guarantee that your seed will match ours exactly – seed size, shape, and weight often varies by variety and sometimes even in response to growing conditions. These can serve as a guide, but allow your seed to lead you.

Each of these recipes includes:

- Threshing method
- Winnowing wind speed. These are referenced as Winnow Wizard settings and are approximately:
    - H (high) = 12 mph
    - M (medium) = 8 mph
    - L (low) = 4 mph
    - VL (very low) = 2 mph
- Top screens. Screens that all of the seed will pass through.
- Splitting screens. Screens that will divide the seed into different types, or large and small lots.
- Bottom screens. Screens that all (or most) of the seed will stay on top of
- Abrasion needed, in the form of vacuuming, tumbling, or rubbing
- Notes

Parentheses () indicate a step that is often optional.

Slotted screens are indicated with an S, e.g. 1/26S, 6/64S

Crop	Threshing method	Airspeed	Top screens	Split screens	Bottom screens	Abrasion	Notes
Alexanders	Impact	L	16/64		9/64		
Beet/Chard	Rubbing/crushing	M	12/64	8/64	6.5/64	Vacuum	Drape helpful for sticks
Brassica carinata (Texsel greens)	Crushing	M	5/64		(1/18)		
Brassica (napus/rapa/oleracea)	Crushing	M	1/12 - 6.5/64		(1/18)		
Brassica juncea	Crushing	M	1/15 - 1/13		(1/20)		
Burdock	Crushing/agitation	M	8/64		1/14		
Cardoon	Crushing/impact	M			7/64, 1/14S		
Carrot	Rubbing/impact	L	8/64		1/18	Vacuum	Indent cylinder helpful for sticks
Celery	Rubbing	L	1/16				
Chicory/Radicchio	Intense crush/impact	L	1/13		1/18		
Claytonia	Agitation/impact	L	1/18, 6x24	1/22, 1/24	24x24		Use 1/24 or even 1/22 to remove chickweed s
Corn salad, small-seeded	Crushing/agitation	L	1/12				
Cress	Crushing/impact	M	5.5/64		1/18		
Cucumber	Slice & scoop	M			1/8	Tumble	Use wiggle wire in agitator
Doucette d'Alger	Agitation	L	16/64		7/64		
Eggplant	Roto-hoe	L	1/18S		1/14		
Endive/Escarole	Intense crush/impact	L	1/13		1/18		
Fennel	Impact	L	12/64, 1/12S		6/64, 1/23S	Tumble	
Goosefoot	Rubbing	L	6x24			Vacuum	
Ground Cherry	Smash	L	6x26		1/20		
Leeks	Rubbing/impact	L	6/64-7/64		1/16		Float if necessary
Lettuce	Crushing/agitation	L	1/26S, (6x24)		1/18	Rub	Use 6x24 on recovered portion if needed
Malva crispa - vegetable mallow	Crushing	M	7/64				
Melon	Slice & scoop	M			9/64		
Okra	Crushing/roto-hoe	H	14/64		11/64		
Onion	Rubbing	L	6.5-64-7.5/64, 1/12S		1/15-1/14		Float if necessary
Orach	Impact	M	9/64	6/64	1/16	Vacuum	Black seeds less viable
Parsnip	Impact/rubbing	VL	17/64, 1/18S		10/64	Tumble	
Pepper (annuum)	Wet stomp or roto-hoe	L	1/18S - 1/14S		6.5/64 - 7/64		
Pepper (chinense)	Roto-hoe (goggles!)	L	1/18S		6.5/64		
Plantain, buckshorn	Crushing/agitation	VL	1/22				
Purslane	Impact/agitation	L	1/26S, 6x24, 1/19		24x24		
Radish	Intense impact	M/H	12/64	9/64, 6.5/64	1/12,1/14S		
Salad burnet	Crushing/agitation	M	14/64		7/64, 1/12S		
Salsify/Scorzonera	Hand-pick	L	8/64S		1/20S, 8/64	Tumble	
Sculpit	Crushing	L	1/17				
Shungiku	Crushing	L	11/64, 6/64S		1/17		
Sorrel	Rubbing	L	1/13		1/26S, 1/18		
Spinach	Rubbing/crushing	M	12/64	1/8	6.5/64		
Squash	Crack & scoop	M			14/64 - 18/64	Tumble (angel wings)	
Tomatillo	Smash	L	1/23S, 7/64		1/15-1/14		
Tomato	Smash	L	1/26S - 1/23S		1/16 - 6/64	Rub (multiples), shake (remove hairs)	
Watermelon	Crack & scoop	M	6/64S		11/64		

Crop	Threshing method	Airspeed	Top screens	Split screens	Bottom screens	Abrasion	Notes
Amaranth	Rubbing/Impact	L	1/17-1/18				
Beans, Adzuki	Crushing	H			10/64		
Beans, most dry/snap	Crushing	H			16/64		
Beans, Garbanzo	Crushing	H			16/64		Re-thresh filled pods
Beans, Soy	Crushing	H			14/64		
Camelina	Crushing	M	1/15				
Cereals (wheat, rye, oats, barley)	Impact	H			8/64	Vacuum	
Corn	Special	H			12/64 - 18/64		
Flax	Crushing	M	7/64, 1/23S		1/12		
Millet	Crushing/impact	M	1/14 - 7/64		1/18 - 1/17	Tumble	Seed size varies between varieties
Quinoa	Rubbing	M	5.5/64 - 6.5/64		1/16 - 1/15	Vacuum	
Quinoa, Taiwanese	Rubbing	L	1/18				
Sorghum	Rubbing/impact	H	12/64		7.5/64 - 8/64		
Teff	Rubbing/impact	L	1/24 - 1/22				

Crop	Threshing method	Airspeed	Top screens	Split screens	Bottom screens	Abrasion	Notes
Angelica	Impact/rubbing	L	8/64S		8/64		
Ashwagandha	Smash (wet)	L	1/26S, 6/64		16x16		
Basil	Impact/crushing	L	1/16 - 1/12		1/22 - 1/19		Keep dry!
Basil, sacred	Impact/crushing	L	1/18		1/24 - 1/22		Keep dry!
Borage	Agitation	H	10/64		7/64		
Caraway	Impact/rubbing	M	1/12		1/18	Tumble	
Catnip	Impact/agitation	L	1/18				
Chamomile	Crushing	VL	24x24, 1/22		6x36		
Chervil	Impact	L	1/20S, 16x16 bounce				
Chives	Impact/rubbing	VL	6/64		1/18		
Cilantro	Impact	M	14/64		7/64 - 8/64	Tumble	
Dill	Agitation/impact	VL	10/64, 1/26S		1/12		
Epazote	Rubbing	VL	6x26, 24x24			Vacuum	
Horehound	Crushing/agitation	VL	1/18		1/24		
Hyssop	Impact/agitation	L	1/17				
Lemon Balm	Impact/agitation	L	1/19		30x30		
Lovage	Impact/rubbing	L	10/64		6/64 - 7/64		
Marshmallow	Crushing	M	6/64, 1/23S		1/15 - 1/16	Rub	
Mugwort	Crushing/impact	L	1/20				
Mullein	Crushing	VL	1/22				
Parsley	Impact/rubbing	L	1/14		1/22	Tumble	Vacuum doubles to split
Perilla	Agitation	M	8/64		1/18S		Soft seed, don't crush!
Sage	Agitation/impact	M	7/64 - 8/64		1/12		
Stinging Nettle	Rubbing	VL	1/24				
Thyme	Impact/crushing	L	1/24				
Valerian	Impact/crushing	L	1/14, 1/26S		1/19	Hand rub	
Yarrow	Impact/crushing	VL	6x36, 1/20				

Crop	Threshing method	Airspeed	Top screens	Split screens	Bottom screens	Abrasion	Notes
Ageratum	Crushing/agitation	VL	6x26, 30x30 bounce			Tumble	
Ammi	Impact/rubbing	L	1/17		1/22		
Aster (China)	Crushing/agitation	L	6/64, 1/12 bounce		1/17	Tumble	
Bachelor Button	Crushing/agitation	L	7/64		1/16	Vacuum	
Balloon Flower	Crushing	L	1/17				
Bee Balm	Impact/agitation	VL	1/22				
Bells of Ireland	Crushing/agitation	M	10/64		7/64		
Blanket Flower	Crushing	VL	12/64 rub-through		(8/64)		
Blazing Star	Rubbing/crushing	VL	1/14S		1/16	Tumble	
Calendula	Crushing/agitation	L/M	28/64	14/64, 8/64	(1/16)	Vacuum large	Split into three sizes, see text
Camas	Crushing	M	7/64				
Campanula	Crushing/agitation	VL	1/22				
Celosia	Impact/agitation	L	1/15, 1/23S		1/19		
Chocolate Flower	Agitation	L	1/12S				
Columbine	Crushing	L	1/14				
Coreopsis	Crushing/agitation	VL	1/16, 6x26		30x30		
Cosmidium	Crushing/agitation	L	6/64S		6/64		
Cosmos	Agitation	M	6/64S		1/8 (recover)		
Dahlia	Crushing/agitation	VL	1/12S		7/64		
Dianthus	Crushing/agitation	L	1/26S, 6.5/64		1/17		
Didiscus	Impact/rubbing	L	1/14S		7/64		
Echinacea	Crushing/impact	L	9/64		1/13		Harvest after weathering to softer
Evening Primrose	Crushing	L	1/18		30x30		
Flax	Crushing/impact	L	1/26S		5/64		
Foxglove	Crushing	VL	1/20				
Godetia	Crushing/impact	VL	1/18		30x30		
Gomphrena	Rubbing	L	5.5/64, 1/20S		1/18		Difficult; see text
Hollyhock	Crushing/impact	L	6/64S		10/64	Vacuum	
Iberis	Rubbing/impact	L	1/26S, 7/64		1/16		
Klip Dagga	Impact/crushing	L	1/13				
Larkspur	Crushing/agitation	M	6.5/64		1/15		
Lobelia	Crushing/agitation	VL	30x30				Smallest seed in this guide
Maltese Cross	Agitation/crushing	L	1/17				
Marigold	Crushing	VL	1/23S			Vacuum	
Milkweed	Impact/agitation	VL	1/18S		1/8		
Nicotiana	Crushing	VL	24x24				
Nigella	Crushing	M	6.5/64		1/15		Seed size varies; adjust accordingl

Nigella (transformer)	Agitation	L	6/64S		10/64		
Penstemon	Crushing/agitation	M	6.5/64		1/18		
Phacelia	Crushing/impact	L	5.5/64		1/18		
Phlox	Crushing	L	6/64, 1/20S				
Poppy	Crushing	VL	1/22				
Rose Campion	Crushing/agitation	L	1/18				
Rudbeckia	Impact	L	1/18				
Salpiglossis	Crushing	VL	1/22		30x30		
Salvia farinacea	Agitation/impact	L	1/15		1/19		
Scabiosa (atropurpurea)	Crushing	L	5.5/64		1/26S	Vacuum	For naked seed; see text
Schizanthus	Crushing/impact	L	1/17		1/22		
Silene	Crushing	VL	1/24				
Skullcap (baikal)	Crushing/agitation	M	1/12		1/22		
Skullcap (mad-dog)	Crushing/agitation	L	1/19				
Snapdragon	Crushing	VL	1/22		30x30		
Strawflower	Agitation/impact	VL	1/17		24x24	Tumble	
Sunflower	Impact/rubbing	M	17/64, 10/64S		8/64 - 10/64		Variable seed size; adjust accordin
Sweet Annie	Crushing/impact	VL	30x30				One of smallest seeds
Sweet Pea	Crushing	H	17/64		10/64		
Tithonia	Impact/crushing	L	6/64S		4.5/64		
Verbena	Crushing/impact	L	7/64, 1/14S		1/17		
Veronica	Crushing/agitation	VL	24x24		6x36		
Wallflower	Crushing/impact	L	7/64				
Winged Everlasting	Crushing/impact	L	24x24, 1/22 (bounce through)		1/18 (no bounce, recover)		
Zinnia elegans	Rubbing/impact	VL	6/64S, 1/14S	1/23S	6/64 - 8/64	Vacuum	See text, don't break the cones!
Zinnia haageana	Rubbing/impact	VL	1/14S	1/26S	1/14 - 6.5/64	Vacuum	