

# *The Winnow Wizard*

## *Seed Cleaning Strategies*

*Thresh*

*Screen*



*Winnow*

*Winnow*



*Screen*

*Winnow*

Aside from the use of the Winnow Wizard, I take no credit for developing these methods; they were developed by Frank Morton and his team at Wild Garden Seed over years of processing seed by hand. I would like to thank Hank Keogh and the Wild Garden crew - especially Victor Sauvie - who have together created the seed cleaning "bible" with protocols for every type of seed that Wild Garden has ever grown.

This guide is aimed at beginner to intermediate seed cleaners. It is not so much a recipe book with instructions for each variety as a strategic framework that can be applied to almost any seed. While threshing techniques vary widely across different species, once the seed is free the steps to clean it are remarkably universal.

For wet seeds, the first screening and winnowing steps may be performed in water. For seeds from a combine/threshing machine - or those collected free of chaff (e.g. poppies), it may be possible to skip directly to the final winnowing stage.

Following an overview of the the Wild Garden seed cleaning process (p. 3), this guide provides a summary of the way the Winnow Wizard has improved the process (p. 4), an overview of some of the more useful screen sizes (pp. 5-6) and a collection of approximate Winnow Wizard settings (p. 7) for a wide range of seed sizes. The last two pages provide complete examples of the Wild Garden seed cleaning process for an easy-to-clean seed (kale, p. 8) and a more difficult-to-clean seed (lettuce, p. 9).

This guide is designed to accompany the Winnow Wizard operating manual, which is available for download at: [luterra.com/winnow-wizard/](http://luterra.com/winnow-wizard/)

## *Winnowing Math*

The distance that a particle will blow as it falls through a uniform wind is proportional to the wind speed and inversely proportional to its size and density (proof on p. 10).

For a given wind speed and particle size, less dense particles will blow farther than denser particles: the magic of winnowing. However, for a given wind speed and particle density, smaller particles will blow farther than larger particles.

Therefore, the Winnow Wizard can remove:

- lighter particles the same size as the seed or smaller, and
- smaller particles the same density as the seed or lighter,

but not:

- lighter particles substantially larger than the seed, or
- smaller particles substantially heavier than the seed.

The Winnow Wizard must be combined with screening as part of a seed cleaning strategy. The trick is to alternate screening and winnowing; too much light chaff clogs screens, and too much large debris reduces the accuracy of winnowing.

## *The Process*

*In the field:*

1. **Thresh** the seed off the plant, out of its pods and packetses, by the method of your choice.
2. **Screen** out large debris using a screen that allows all seed and light chaff to flow through rapidly.
3. **Winnow** away light dust and leaf bits on a breezy day in the field, to reduce volume and minimize indoor dust. (This step can be skipped for very light seed that can't be safely winnowed in natural wind - or for any seed if appropriate wind is lacking.)

(Once dry, seed can be stored indefinitely in this state, until there is time for further cleaning.)

*Indoors, in a well-ventilated space:*

4. **Winnow** rapidly with the Winnow Wizard (wide slot, hopper gate 50-100% open) with the splitter set conservatively to avoid losing seed. If seed is too dirty to flow, use the hopper agitator or manually winnow (pour from bin to bin) in the Wizard wind.
5. **Screen** the seed using a screen just large enough to pass all of the desired seed while removing all larger chaff and weed seeds. If you have a Clipper or similar machine, this is the place to use it. In our experience, unless we are working with seed lots over 100 lbs, it often takes longer to clean the machine than to simply screen by hand.

(If your seed has a range of sizes or multiple forms - e.g. disk and ray seeds - try to separate them with screens before final winnowing.)

6. **Winnow** slowly and precisely with the Winnow Wizard (slot as narrow as possible, hopper gate 10-25% open) with the splitter set as close in as possible. If there are hollow or green seeds, repeat and keep moving the splitter closer in until a few good seeds start to winnow out (Wizard manual p. 11). If winnowing flat seeds, use a shrinking-middle three-bin system (manual pp. 12-13) or set the splitter to collect the heaviest ~60% of the seed and re-run the light fraction several times at the same setting (manual p. 14) to achieve optimum separation without losing good seed.

7. Inspect your seed; it is often clean enough at this point. If you have small seeds or heavy debris smaller than the seed, choose a sifting screen that leaves the desired seed on top. If you have chunks of dirt the same size as the seed, try the magnet separator (manual p. 15) or try blowing the seed away from the heavier dirt (manual p. 10). If you have weed seeds or persistent chaff, experiment with different screens. If screens don't work, try splitting the seed in half with the Winnow Wizard to check if the problems can be concentrated in the light or heavy fraction.

## *The Winnow Wizard Difference*

Since its introduction in 2015 and refinement in 2016 the Winnow Wizard has streamlined and improved the Wild Garden seed cleaning process in multiple ways:

### **50% time savings on final cleaning**

In pre-Wizard days, we would spend 50% of our indoor seed cleaning time manually winnowing behind fans, with the remaining time spent screening. Now winnowing time is closer to 10-20%. Furthermore, by increasing the accuracy of winnowing and concentrating the “problems” into a small portion of a seed lot (see manual p. 14), we have been able to reduce or eliminate some of the more time-intensive screening steps for additional time savings.

### **Improved consistency**

With manual winnowing, the cleanliness of a seed lot depends in large part on the person doing the cleaning, and it is challenging to see the divide exactly from a standing vantage point while pouring seed. With the Wizard, it is easy for multiple people - even those with less experience - to achieve a uniformly clean seed lot with minimal loss of good seed, and the dividing point can be observed closely and finely tuned during operation to optimize separation.

### **Seed lot “rescue”**

Nearly as significant as its time savings, from a financial perspective, is the ability of the Winnow Wizard to perform fine-scale density separations to remove slightly-lighter hollow and immature seed. In numerous cases, the Wizard has allowed us to bring unsaleable seed lots in the 40-60% germination range up to 80-90% or higher germination. It can, in effect, substitute for a gravity table at a fraction of the cost.

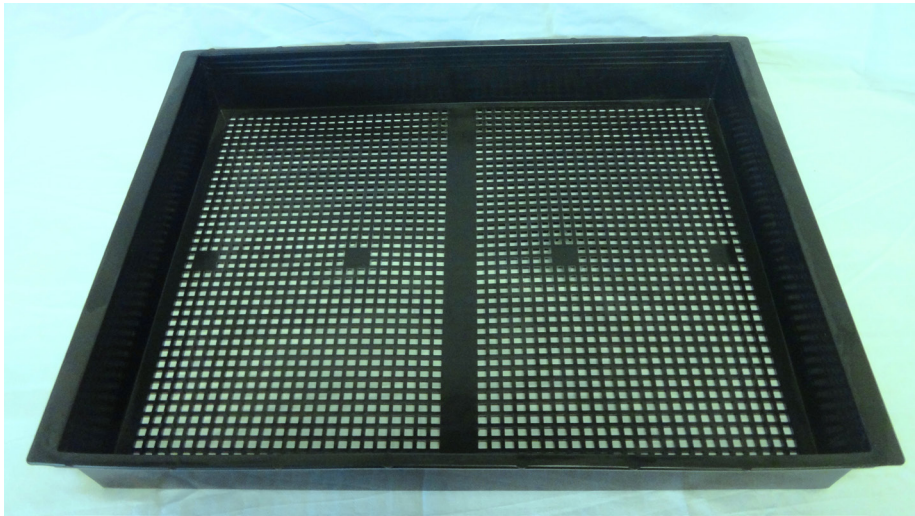
### **Reduced repetitive stress**

I originally developed the Winnow Wizard after winnowing a 300 lb lot of cress seed behind a fan. My wrist was getting sore, and I was holding too much tension in my body trying to maintain the exact pouring position - within an inch or so - for hours at a time. The Wizard eliminates the need for precise manual winnowing; as a result a greater proportion of time is spent screening which tends to be more ergonomic and less stressful as precise body positioning is not required.

## *Screens*

### *Field screening:*

Field screens should be rugged and framed with a box that can hold a substantial amount of material. They can be built with 1" welded wire and hardware cloth in 1/2" and 1/4" sizes. At Wild Garden Seed we use primarily found plastic vegetable crates with ~3/4" square holes that we call "box screens" and nursery trays with ~3/16" holes that we call "black screens" (image below, <http://www.andersonpots.com/products/anderson-flats/, #2400B>).



### *Fine screening:*

For every seed, there is a magic screen that is just large enough to pass the seed. At Wild Garden, we have at least 75 screens - round, square, and slotted, in increments of 1/128 of an inch. This is rather like having a well-stocked kitchen; when cleaning a new seed or attempting to remove a new contaminant, we can experiment until we find the best screen "recipe."

If you don't yet have any screens, I recommend starting with the following:

- 1/4" hardware cloth
- 1/8" hardware cloth
- 6/64" (3/32") round hole
- 1/16" (window screen)

The Winnow Wizard air diffuser screens can be removed and used for seed screening. Their sizes are 3/16", 1/8", 1/16", and 3/64" (~1/21"). However, this precludes screening and winnowing at the same time, so I don't recommend it as a long-term solution.

If you are ready to invest in a larger set of screens, the following (from large to small) are some of the more useful:

Hardware cloth/window screen:

1/2" - rough screening and beans

1/4" - cereals, rough screening

1/8" - many things

1/16" - amaranth, basil, bottom screen for brassicas, quinoa

Round hole:

10/64" - peppers

9/64"

7/64"

6.5/64" - large-seeded kale and quinoa

6/64" - brassicas and quinoa

5/64" - phacelia and cress

1/18" - celery, bottom screen for lettuce

Slot:

6/64" x 1/2"

1/16" x 1/2"

1/22" x 1/2"

1/26" x 1/2" herringbone pattern - the magic screen for lettuce

Wire screens (sized as wires per inch in each direction):

6 x 24: final lettuce polishing

20 x 20

24 x 24 - yarrow

30 x 30 - Sweet Annie, smallest flower seeds

Specialty screens can be purchased from Quality Custom Screen Co. ([qcscreen.com](http://qcscreen.com)) and other sources, either pre-framed as 12" square hand screens or unframed and cut to the size of your choice.



## *Wizard Settings*

I hesitate to provide a prescription for Winnow Wizard settings because every seed lot is different. When I winnow, I am always moving the splitter forward or back by a quarter inch or half inch to optimize the division, and I encourage you to develop your own eye for it. That said, the following table, arranged from largest to smallest seed, provides a good starting point.

<b>Seed</b>	<b>Wind speed (manual p. 7)</b>	<b>Splitter setting</b>	<b>Magic screen</b>
Beans	High	2 1/2" - 3"	~1/2"
Peas	High	3"	1/4-1/2"
Corn	High	3 1/2"	1/4-1/2"
Cereals	High	3 1/2" - 4"	1/4"
Spinach	Standard	4" - 5"	3/16"
Beets/Chard	Standard	5" - 6"	3/16"-1/4"
Round brassicas	Standard	5" - 7"	6/64"-6.5/64"
Quinoa	Standard	5" - 6"	6/64"-6.5/64"
Cress & Phacelia	Standard	7" - 10"	5/64"
Amaranth	Low	6"	1/18"-1/16"
Lettuce (pp. 12-14)	Low	(1) 6" - 8", (2) 10"-13"	1/26" x 1/2" slot
Celery	Low	~10"	1/18"
Yarrow	Very Low	~14"	24 x 24 or ~1/36" slot
Sweet Annie	Very Low	~20" (beyond rails)	30 x 30

## *Example: Kale*

*Easier than pie*

<b>Step</b>	<b>Objective</b>	<b>Approx. % seed</b>	<b>Minutes per 50 lbs</b>
Thresh and rake		~15%	
Black screen	Remove large debris and some pods to allow winnowing.	40%	60
Field winnow	Remove dust and most pods	70%	20
Wizard rough winnow	Remove remaining pods and chaff	95%	15 (5)*
Magic screen 6/64"	Remove dirt clods and heavy seed-filled pods	98%	30
(Optional) Size split 1/16"	Separate small-but-viable seed to avoid winnowing it away	--	120
Wizard fine winnow	Remove light and insect-damaged seed  If two size lots, winnow them separately with different splitter settings.	99.9%+	30 (5)*

\*Wizard times are listed as machine runtime with actual operator time in parentheses - the operator can screen and do other tasks while the machine is running.



## *Lettuce*

*More difficult than pie*

Typically we end up with a heavier (~80% of total) and lighter (~20% of total) lot after the fine winnowing step (see manual p. 14), and we can limit some of the final time-intensive screening steps to the lighter lot if the main lot is clean enough.

<b>Step</b>	<b>Objective</b>	<b>Approx. % seed</b>	<b>Minutes per 50 lbs</b>
Thresh		~10%	
Box screen in a light breeze	Remove large debris and fluff	15%	15
Black screen	Remove stalks and leaves	25%	45
Field winnow	Remove dust, fluff, and leaf bits	50%	45
Wizard rough winnow	Remove remaining light debris	75%	20 (5)
Magic screen 1/26" x 1/2" herringbone slot	Remove sticks, buds, and any debris larger than seed	95%	45
Rub seed vigorously	Detach remaining pappus from seed	---	10
Wizard fine winnow, shrinking-middle (manual pp. 12-13) or repeat-recapture (p. 14)	Remove small sticks, immature green seed, remaining tiny flower buds, and leaf bits	99% +	60 (15)
(if necessary, useful for most lots) Bottom screen 1/18"	Remove small heavy balls of crystallized lettuce latex	99.5% +	180
(if necessary, often light fraction only) Stick removal 5.5/64"	Remove few remaining long narrow sticks	99.7%+	90
(light fraction only, if necessary) Wire slot 6 x 24	Remove last few round particles (dirt, tiny immature buds, crystallized orange latex) - some seed loss (stays on top)	99.9%+	240

\*Wizard times are listed as machine runtime with actual operator time in parentheses - the operator can screen and do other tasks while the machine is running.

# *Winnowing Math - Proof*

*(assuming a spherical seed/particle for ease of calculation)*

a = horizontal acceleration of a seed

v = wind speed

$\rho_a$  = air density

V = seed volume

m = seed mass

$\rho_s$  = seed density

A = seed cross-sectional area

D = seed diameter

In a winnowing context:

Force (accelerating a seed) = Force (applied by the wind)

From physics:

$$ma = \frac{1}{2} \rho_a v^2 A$$

Solving for horizontal acceleration a:

$$a = \frac{\rho_a v^2 A}{m}$$

Cross sectional area = area of circle with diameter D

$$A = \frac{1}{4} \pi D^2$$

Seed mass = seed density \* seed volume (volume of sphere with diameter D)

$$m = \frac{1}{6} \pi \rho_s D^3$$

Substituting for m and A and simplifying yields

$$a = \frac{3}{4} \frac{\rho_a v^2}{\rho_s D}$$

So horizontal acceleration during winnowing is proportional to:

- Wind speed squared (particles blow farther in stronger wind) and
- Air density (settings may require slight adjustment at high altitudes)

And inversely proportional to:

- Diameter (smaller particles blow farther) and
- Particle density (lighter particles blow farther)

## *Questions? Conundrums?*

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