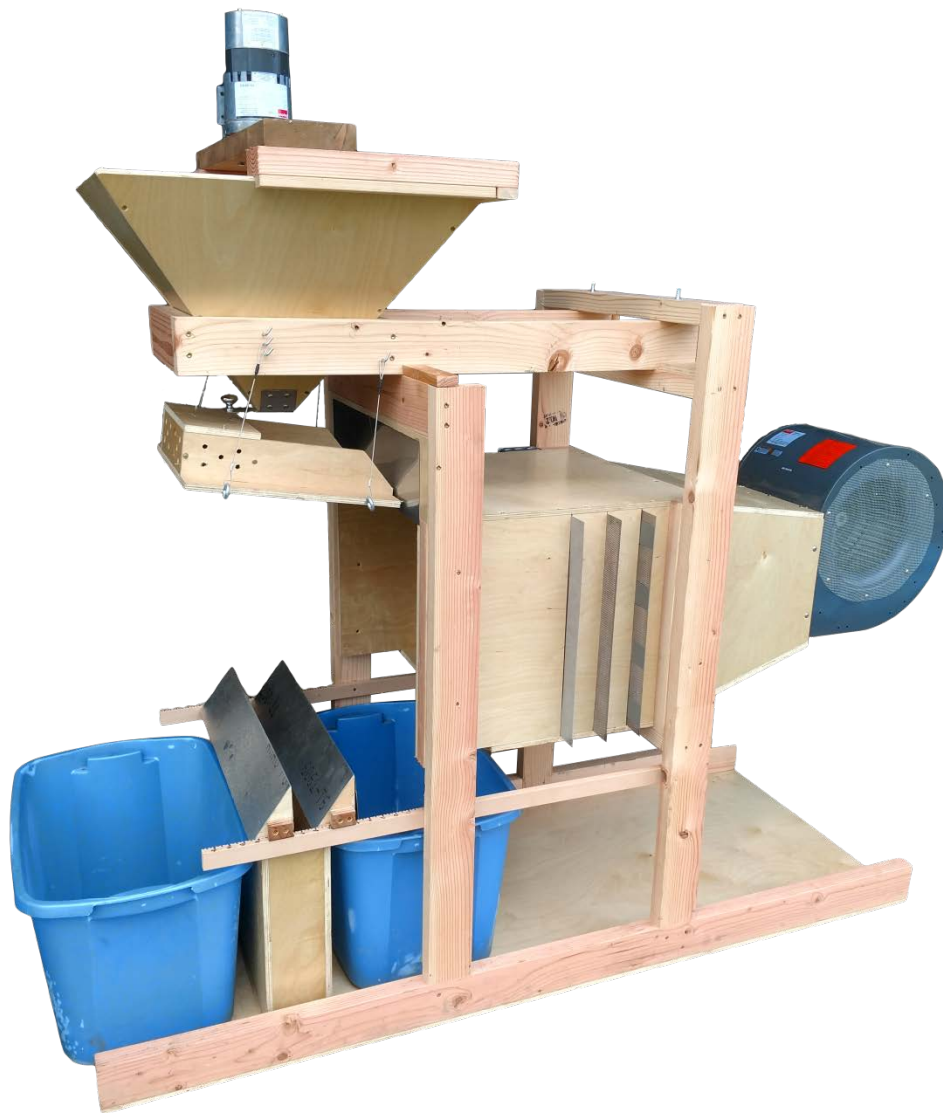


# The Winnow Wizard

## Operating Instructions and Techniques

### (1 HP)



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## **Acknowledgements**

I would like to thank Frank Morton, renowned plant breeder and owner of Wild Garden Seed, for believing in me, trusting me with engineering projects at the edge of my expertise, and giving me the freedom to tinker with innovations on company time. Hank Keogh, then crew manager for Wild Garden Seed, first taught me how to winnow and provided numerous design suggestions and proposed improvements from the first prototype. Hank first suggested the hopper and designed a functional prototype hopper agitator. Victor Sauvie, master of flower seed cleaning and talented artist, created the wind drawing. Thanks to the rest of the 2015-2018 Wild Garden crew – Karen Morton, Helen Dziuba, Zoe Frost, and James Young – for suggestions, support, and enthusiasm along the way.

Thanks to my wife, Elizabeth Records, for her excitement with my tinkering even when it meant less time for hiking and gardening together.

Finally, a special thanks to Petra Page-Mann of Fruition Seeds, who convinced me – at the 2016 Organic Seed Growers conference – that this was an invention worthy of sharing.

## The Story

When I arrived at Wild Garden Seed, we cleaned our seed from threshing to final product using hand screens and hand winnowing in constructed “wind tunnels” behind fans. We owned a few Clipper-type machines, but with our small lots we spent more time cleaning the machines than using them. We didn’t have a gravity table, and many of our lots would have been too small anyway to completely cover the table.

It didn’t take long, my first season of seed cleaning in 2014, for me to start looking for a better way. I wanted to match the precision of our size separation screens – exactly 1/17” or 6.5/64” – with a similarly precise method of density separation. Inspired by the laminar flow hoods in my microbiology background, which used a pressure differential across a grate to create an even airflow, I set about building a winnowing machine.

Over the next three years, a single grate in front of a box fan evolved to two grates and a 1/3 HP blower, and eventually up to five sequential grates in front of a 3/4 HP blower, in pursuit of less wind variability and a greater range of adjustable speeds. I added a half-octahedral hopper and a vibrating feed tray, eliminating the need to stand and pour seed thereby cutting our seed cleaning time by nearly 50%.

In a world where seemingly everything useful and many things of limited use have been invented and modified to death, I have so far been unable to find a similar device. Perhaps I ought to have patented it, but that ship has sailed and I am really more interested in contributing something useful than in profiting from intellectual property. If you find your Winnow Wizard useful, please share your stories and put in a good word to friends and neighbors who could use a Wizard of their own.

## Acquiring a Winnow Wizard

Winnow Wizards are available for purchase from Luterra Enterprises. Contact [mark@luterra.com](mailto:mark@luterra.com) if you are interested, or visit [www.luterra.com/winnow-wizard](http://www.luterra.com/winnow-wizard) and fill out an order form. Each machine is custom hand-built to order, signed and dated, and adorned with an original line-art design by Victor Sauvie. The hopper agitator and magnetic dirt-removal hopper gate are optional accessories.

If you would prefer to build your own Winnow Wizard, plans are available at [www.luterra.com/winnow-wizard](http://www.luterra.com/winnow-wizard). Unless you really enjoy tinkering and fabrication or you live outside the continental United States, I recommend purchasing. With multiple compound angles, <1/32" tolerance on some dimensions, and many components to assemble, this is an advanced-level 50+ hour DIY project with high potential for frustration if things don't line up correctly.

## Precautions

- Plug the Winnow Wizard into a properly grounded electrical outlet.
- Do not store, operate, or transport in wet conditions. In addition to possible motor damage, air diffusion screens will rust if exposed to moisture for prolonged periods.
- Do not operate unattended; turn motors off when not in use.
- Do not operate without blower intake screens in place.
- Keep hair, loose clothing, and necklaces away from blower intakes and hopper agitator.

## Maintenance

- Keep blower intake screens clean.
- Monthly, or more often in dusty conditions, remove and clean the two permanent screens nearest the blower.
- Annually, or more often in dusty locations, remove intake screens and feed tray motor cover. Clean blower motor, shaker motor, and blower blades with compressed air. If equipped with a hopper agitator, clean motor whenever significant dust buildup is detected. Dust buildup reduces efficiency and is a possible overheating/fire hazard.
- **Lubricate shaker motor sleeve bearings every 50-100 hours** with 3-in-1 or other electric motor oil. Inspect mounting bolts and tighten nuts if necessary. Remove top (8 screws) to access.
- Fuse (1A) on shaker motor may blow if rotational resistance increases due to dust/wear. If this occurs, clean/oil motor and replace fuse.

## Transport

- With all detachable components removed, the base unit can be carried by three people: one in front and one on each side under the blower. Lift by the bottom frame rails only.
- If the machine needs to be moved frequently on a level surface (e.g. from storage to operating location), six casters can be added under the frame rails (front, center, rear on each rail)
- For highway travel, remove and secure all detachable components and stuff a towel/sweater into the blower from the inside to prevent it from spinning in the wind.
- If the Wizard will be subjected to especially rough handling (e.g. mobile installation on a trailer), add a 2x4 brace under the blower.

## Operating Instructions

### *Siting*

The Winnow Wizard needs to be level and located away from ambient winds. Dust and chaff will land 10-20 feet in front of the machine, so this area should be open and ideally covered with a tarp.

### *Seed preparation*

Seed needs to be field-cleaned before running through the Winnow Wizard. Too much fine chaff will prevent seed from flowing out of the hopper, and large debris will clog the hopper outlet and feed slot. In general, it is sufficient to do one field winnow followed by one screening using a screen no larger than twice the diameter of the seed. If equipped with a hopper agitator, this precleaning requirement can be relaxed, but most seed lots will still require a coarse screening to remove large debris that may clog the agitator, hopper gate, and feed slot.

### *Sizing*

Aerodynamic density is proportional to seed diameter, so smaller seeds will blow farther than larger seeds. If viable seeds have a wide range of sizes, it is helpful to size them first with screens before a fine winnowing step.

### *Slot width*

The feed slot width needs to be wide enough to pass the largest chaff in the lot, but in general should be made as small as possible. The smaller the slot width, the more uniform and vertical the trajectory of the seed falling into the airflow. The slot width needs to be matched to the feed rate from the hopper to avoid filling up the feed tray. In general, a slot width of approximately 1/16"-1/8" wider than the largest dimension of the seed is ideal for fine winnowing.

### *Feed tray adjustments*

Seeds should move down the feed tray toward the slot when vibration is turned on. The slower their horizontal motion, the less they will bounce off the vertical feed plate and the less random spread will be introduced. A steeper angle setting is best for soft or flat seeds, while round seeds like brassicas, peas, and beans benefit from a shallower angle to avoid excessive horizontal bounce. The tray can be shaken manually to feed the last seed in a lot.

- If seed moves to one side of tray (and machine is level), rotate cable-attachment eye screws to level feed tray and equalize cable tension.

### *Feed rate*

To a point, the slower the throughput, the more accurate separation will be. With fewer seeds dropping, there is less scatter from collisions in the feed slot and less wind interference from nearby falling seeds. For maximum accuracy, select the smallest hopper opening that maintains a steady flow across the full width of the feed tray. In our practice, we usually start with a fast-feed, wide-slot "rough winnow" to remove 90% of the chaff, run the seed over scalping/sifting/sizing screens, then do a final winnow with a slower feed, narrower slot, and shorter divider setting.

## Wind speed

Wind speed should be adjusted so that most of the good seed is deflected between 3" and 13", though it is possible to winnow light seeds by setting the divider beyond the rails. With too little wind, random seed bounce predominates over air separation. With too much wind, turbulence becomes noticeable as the air stream interacts with ambient air. Some screen combinations create more even airflow than others; the table below is based on empirical testing. Feel free to experiment with different combinations, within the constraints listed below.

Blower speed: H (high), L (low)

Restrictor screens: O (open – no screen in slot), S (3/64" holes),

M (1/16" holes), R1 (50% obstructed), L (1/8" holes)

Screen slots: 1 (closest to exit), 2 (middle), 3 (closest to blower)

Setting	Slot 1	Slot 2	Slot 3	Blower	Wind speed (mph)	Power (watts)	Sample Applications
High	S	O	L	H	11	1800	Grains, beans, peas, removing rocks
Medium	S	M	L	L	8	1280	Brassicas, beets, quinoa
Low	S	M	R1	L	5	960	Amaranth, teff, lettuce

## Notes

- Never operate without screen S in Slot 1. Without sufficient static pressure the blower motor may overload, and airflow will be too turbulent for effective winnowing.
- Do not use high blower speed with screens M or R1 in place. With the airflow restricted, high speed will increase noise and power consumption with no winnowing improvement.
- Do not use an R2 screen (included with the ¾ HP model) in a 1 HP Winnow Wizard. Excessive static pressure results in unsteady blower performance and may damage blower motor.
- Insert screens so that the labels appear as shown below. Due to minor imperfections in the perforation process, orientation can affect airflow evenness left-to-right and top-to-bottom. Each machine is tested and screen orientation optimized for best performance.



## Electrical specs

16.3A, 1950W, 120V, 60Hz (20A circuit and outlet required)

Aux. outlets: 400W max

Feed tray: 0.2A

Agitator: 1.1A

Blower @ top speed: 15A

## Hopper Agitator (optional)

### *Setup and operation*

1. Ensure hopper is oriented with gate pull facing forward (away from the blower).
2. Install desired attachment using 5/32" hex wrench on shaft set screw.
3. Place agitator on hopper with cord above switched outlet and dust/seed shield facing forward.
4. Plug agitator into top switched outlet. Motor will start when machine is switched on.
5. Set feed tray to the middle or upper angle setting, and set the feed slot wide enough for the largest chaff/debris.
6. **Start agitator motor before pouring seed into hopper, especially with lots containing abundant sticks or awns. Starting torque is lower than torque at operating speed.**
7. Motor casing will be hot to the touch (~130°F) in normal operation. Keep motor air intake/exhaust free of dust and rogue seeds.

### *Attachment selection*

- The "triangle twist" attachment is most useful for dirty/dusty/stick-filled seed lots. It can be used with any amount of gate opening. Use caution with soft/fragile seeds (e.g. zinnias, marigolds, cucurbits) – run a small sample first and inspect for seed damage.
- The "wiggle wire" attachment is most useful for large/fragile seeds that don't naturally flow well, e.g. zinnias, cucurbits. It creates less abrasion/rubbing than the triangle twist but is less effective with especially dirty/stick-filled seed.

### *Triangle Twist*

- Adjust shaft up or down (using set screw) so that wire is ~1/4" above hopper gate and does not rub against hopper walls when rotating. Bend wire to center if necessary.
- Screen seed to remove large debris (>1") and long sticks (>3-5") before pouring into hopper. Large debris may stall agitator and cause damage to agitator paddle or hopper opening.
- Keep hands, long hair, and dangling clothing out of hopper when agitator is operating.
- **Do not allow agitator to slow or stall. Motor may overheat. If slowing/stalling occurs, either perform additional screening/threshing steps before winnowing, or add material to hopper in smaller amounts.**

### *Wiggle Wire*

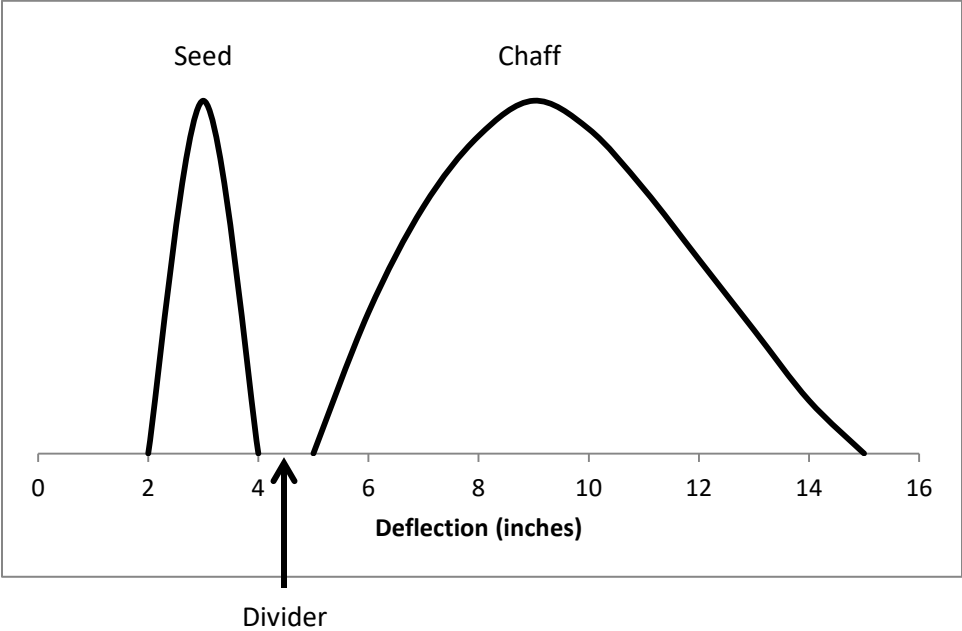
- Open hopper gate fully before installing. Wire should stick through gate slightly. Do not close gate fully during operation.
- Bend wire such that it sweeps through an arc but does not rub excessively against hopper opening when rotating.
- Performance may decrease if hopper is more than ½ full.



# Winnowing Techniques

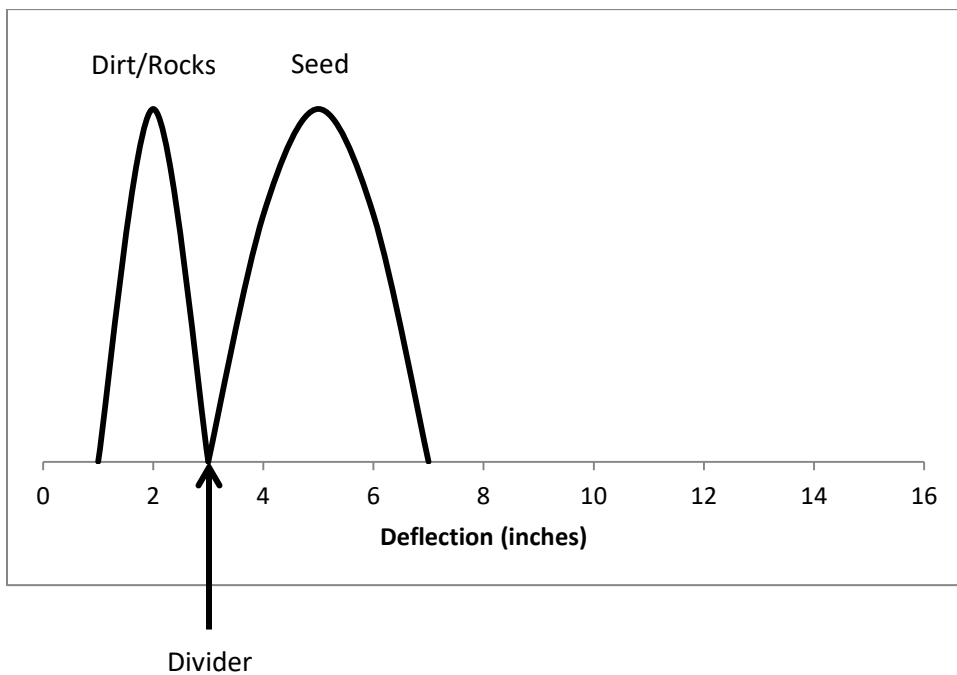
## Single-pass split

For heavy round seeds – including most brassicas – it is possible to set a division point that retains 99% of the good seed while removing 99% of the chaff. Fill the hopper, watch it run, pack up the clean seed, pat yourself on the back for growing easily-cleaned seeds, and grab a beer...



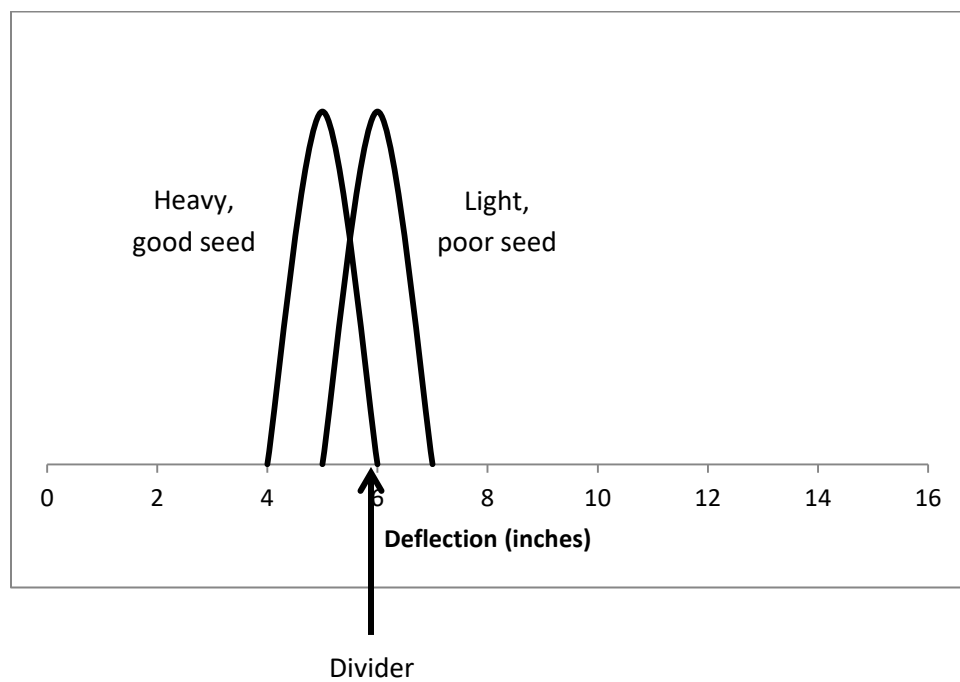
### *Overwinnowing dirt/rocks*

If your seed contains heavy debris (usually dirt clods and rocks), it is sometimes possible to blow the seed away from the dirt with maximum airflow. I have done this often to get chunks of dirt out of beet seed. Set the divider in a location such that ~99% of the seed lands beyond it, then re-winnow the dirt fraction at the same setting to recapture that 1% of seed. Heavy seeds like basil, quinoa, and brassicas are not readily separated from dirt by winnowing; in those cases the magnetic separator attachment may be helpful.



*“Shaving” to increase germination*

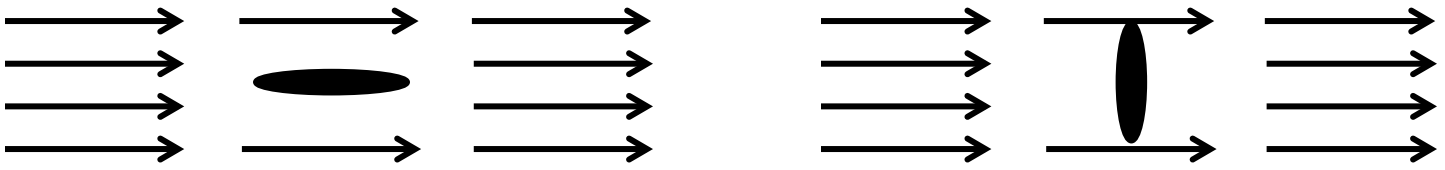
In general, lighter seeds are less viable than heavier seeds, so it is usually possible to increase germination by winnowing away the lightest seed. At Wild Garden Seed we have had great success using the Winnow Wizard to raise germination from 50-70% up to 85% or higher. The trick is to winnow away the correct proportion. If a seed lot tests at 66% germination, aim to shave away 1/3 of the seed. Because there is always some random spread, it is best in this example to set the divider to remove about 20% of the seed, then re-run the heavy fraction once or twice until about 1/3 of the seed has been winnowed out. If possible, run a germ test on both the heavy and light fractions to confirm success before throwing away the light seed.



### Winnowing flat seeds: the shrinking middle

Winnowing is a probability game. Let us assume that we have a perfectly uniform population of round seeds, all the same size and density. For these seeds, all spread will be due to the machine itself: slight bounces off of the feed plate, slight turbulence in the airflow, and airflow interference caused by seeds falling close together. This random spread should be less than 2" horizontal at a 6" deflection, which is to say that 99% of our theoretical identical seeds would land between 5" and 7".

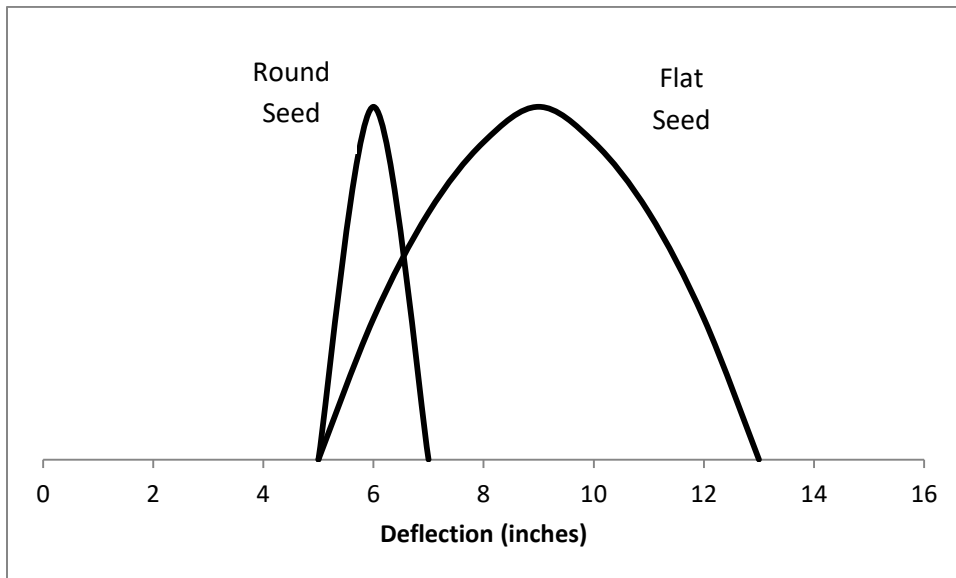
If we take our uniform collection of round seeds and smash them to form an equally uniform collection of flat seeds, then run them through the Wizard, we will find that the horizontal spread increases substantially. This occurs because a seed falling edge-on to the wind will be deflected less than a seed falling face-on to the wind; in effect aerodynamic density is now dependent on orientation.



Flat seed falling edge-on

Flat seed falling face-on

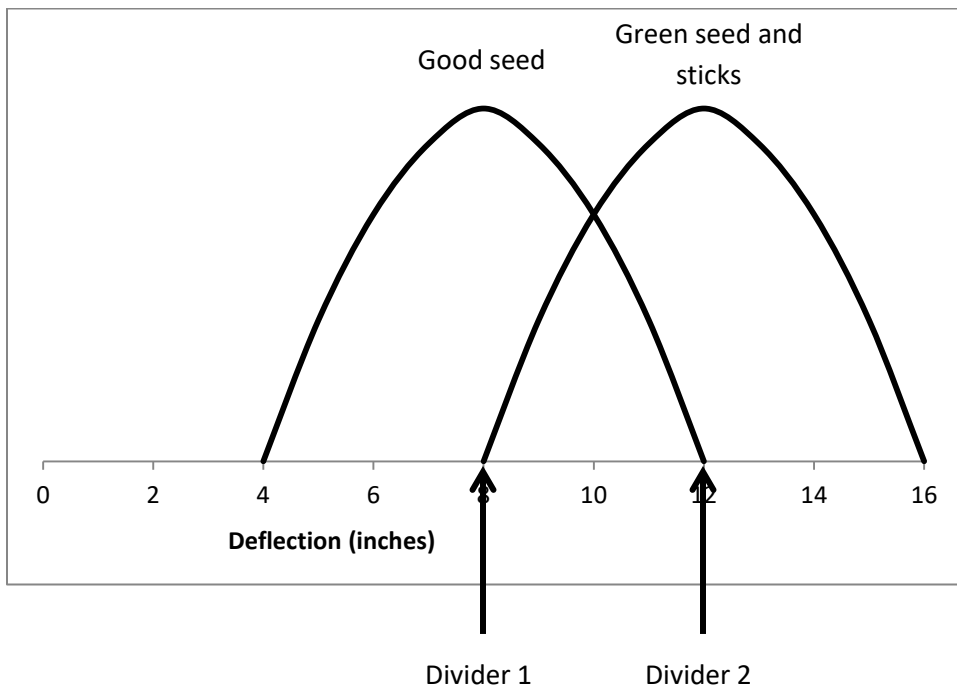
If we graph the spread curves of our round and flattened seeds, they will look something like this:



The important thing to note is that this spread is entirely random, as all of our flat seeds are identical. One particular flat seed may land at 6" in one pass, 12" in the next, and 9" in a third, depending on how it is oriented as it falls. The spread curve can be viewed equally as the positions at which 1000 identical seeds will fall, or the positions at which one single seed will fall if it is dropped 1000 times.

The challenge with winnowing flat seed is that the tail end of the spread – the seed that happens to fall face-on to the wind – overlaps with chaff, small sticks, and light seed. The solution is to take advantage of the fact that with enough passes, any given good seed will eventually fall edge-on and land closer in, while sticks and light seed will always be deflected past a certain point. This is the theoretical basis for the Wild Garden lettuce seed winnowing strategy, which has dramatically reduced the time required to clean lettuce – less screening – while also producing a cleaner finished seed.

The curves look something like this:



Using a narrow central bin and two dividers set at 8" and 12", we split the stream into three fractions. The close fraction is almost 100% good seed with no sticks. The farthest fraction is almost 100% light seed and sticks with no good seed. The middle fraction is a mix. The middle fraction is then re-winnowed, and the stream fractionates a second time along the same probability curves. With each pass, the volume of the middle shrinks by about 50%, and about 50% of the good seed in the middle falls in front of the first divider and is recovered. If we continue to re-winnow the middle five times, we can recover over 98% of the good seed while removing nearly all of the sticks and light seed.

# of passes	% of good seed recovered
1	50%
2	75%
3	87.5%
4	93.8%
5	96.9%
6	98.4%

In reality, there is usually less overlap than in the example, and it is sufficient to re-winnow the middle fraction 3-4 times. When the volume of the middle fraction is small and it appears to be mostly green seed and chaff, then we add it to the chaff bin and call it done.

#### *Winnowing flat seeds with one divider*

One problem with using a two-divider system is that a few seeds (less than 1%) are unlucky enough to bounce off the top of the first divider, over the second, and into the trash bin. To avoid this, or to winnow lots that are too large for the narrow bin, we have often adopted a different strategy.

1. Set the divider at position 1 in the above diagram (at which 50-70% of the good seed stays in and all of the sticks/light seed winnow out). Winnow the whole lot, then re-run the light fraction, collecting the heavies in the same bin as before. Set these heavies aside as Lot 1 – this should be around 75-85% of the total seed.
2. Set the divider at position 2 in the diagram (at which everything that winnows out is trash) and winnow the “2x light” fraction. Discard the trash. Continue to the next step with the heavier fraction.
3. Set the divider back at position 1, or a little back from position 1 if you want to save lighter-or-smaller-but-still-good seed. Winnow the seed from Step 2, then re-winnow the light fraction 2-6 times until you are content to discard the remaining light fraction. The combined heavies from this step – usually 15-25% of the total seed – are Lot 2.
4. If necessary, perform additional screening/cleaning steps on Lot 2 until it is clean enough to combine with Lot 1.

## Magnetic Dirt and Rock Removal (optional)

### Notes:

- Magnetic properties of rocks and soils vary widely locally and regionally; while this has worked well in the Willamette Valley of Oregon I cannot attest that it will work as well elsewhere. If you use the dirt removal attachment please report on its efficacy in your area. Organic matter and debris (e.g. bird and rodent feces) are nonmagnetic and cannot be magnetically removed.
- Effectiveness decreases with increasing seed size, as slot width necessarily increases (some dirt falls farther from the magnets) and larger dirt clods are not as readily deflected. Only the most magnetic soils can be effectively removed from beans.
- Seed should be as clean as possible before this step, to optimize flow through a narrow slot.
- Winnow the seed first to remove very small dirt particles. If not removed this magnetic dust tends to collect on the magnet surface and reduce effectiveness.

### Caution!

**These neodymium magnets are extremely powerful and will attach to an iron/steel surface with a force exceeding 150 lbs, potentially causing finger pinching. Keep away from metal surfaces and loose metal e.g. nails and screws. Keep away from pacemakers, credit cards, and sensitive electronics. Do not attempt to separate the two stacked magnets. Magnets are brittle and may shatter explosively, ejecting sharp fragments at high velocity, if dropped or allowed to attract other strong magnets. Store in a dry sealed container. Magnets will eventually rust if stored in a humid environment.**

### Directions:

1. Remove the feed tray, turn off blower; no airflow required.
2. Remove the stainless steel hopper gate and replace with the magnetic gate.
3. Adjust magnets to approximately 1/8" from front edge of gate.
4. Set divider so that it shaves the rear edge of the seed stream, with 99+% of seed falling in front. This is typically around 7.5-8".
5. Open gate as little as possible so that a steady stream of seed falls. Dirt particles and rocks will be deflected toward the magnet and will fall behind the divider.
6. Adjust magnet forward or backward as necessary; periodically clean off dirt particles that adhere to magnet.
7. Repeat if necessary. With sufficiently magnetic soil each round removes ~75-90% of the dirt particles, and extremely dirty lots may require 3-4 passes.

Helpful tip: For larger seeds like peas and beans, use the wiggle wire on the hopper agitator to allow seeds to flow through a narrower slot. Plug it into the top unswitched outlet, and if necessary trim the wire so that it only protrudes ~1/4" through the gate and doesn't contact the magnet surface. The triangle twist attachment also works, but it tends to grind dirt into dust which then accumulates on the magnet, reducing effectiveness.

## Troubleshooting

### *Airflow decreasing*

Clean blower intakes and wind tunnel screens. Examine blower wheel blades and clean if necessary.

### *Airflow uneven left to right*

Clean blower intakes and wind tunnel screens. Use only screen combinations specified on p.7. Try other orientations of "S" screen. If persistent, dividers may be angled slightly to compensate.

### *Excessive blower noise*

Avoid using high blower speed with more than a single screen in place – and especially with partially obstructed screens. If rubbing/scraping noise, remove intake screen opposite motor and check blower wheel clearance. Adjust blower wheel on shaft (5/32" hex wrench) if necessary.

### *Excessive/very annoying noise when shaking feed tray manually*

Wipe a small amount of oil onto the feed plate where the magnets make contact.

### *Excessive seed bounce*

When splitting excessively bouncy seeds (e.g. cilantro) into heavy and light fractions, it can be helpful to place a sheet of folded paper over the divider.

### *Excessive horizontal spread/poor separation precision*

Reduce feed tray angle to reduce bounce off of feed plate. Reduce slot size as small as possible. Reduce feed rate. If winnowing flat seeds, use probability-based winnowing strategies (pp. 12-14).

### *Too little vibration/seeds vibrate to one side of tray without falling off.*

1. Rotate eye screws to level tray and equalize tension in all four suspension cables.
2. Increase feed tray angle and/or decrease feed rate to reduce seed weight in tray.
3. Remove feed tray cover and oil vibration motor bearings. Motor may start slowly in cold (<45°F) conditions.
4. If persistent, add an additional nut to the vibration bolt. Do not exceed three nuts.

## Replacement Parts

Available online, or contact [mark@luterra.com](mailto:mark@luterra.com)

Blower (1 HP, motor only): Dayton #2JFF8 (Low = speed 1, High = speed 3)

If motor fails, try replacing capacitor before replacing entire unit. Ask at a local HVAC shop.

Blower (1 HP, entire assembly): Dayton #1XJY3 (Low = speed 1, High = speed 3)

Shaker motor: Dayton #4M068 or #4M070, or Fasco #K130

Agitator motor: Dayton #1LPL6 or #4Z521

Spacer magnets: Applied Magnets #ND011 (1/16" thick), #ND012 (1/8" thick)

All other components: Contact [mark@luterra.com](mailto:mark@luterra.com)