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Harvest Weed Seed Control

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Introduction

Combine harvesters disperse weed seed, spreading weed seed within a field and from field to field (Figure 1). Harvest Weed Seed Control (HWSC) removes or kills weeds seeds that are retained on weed plants at the time of crop harvest (Walsh et al. 2018). HWSC can reduce the soil seedbank and thus future weed problems. It can also aid in herbicide resistance management, by killing or removing seeds produced by weeds that escape herbicidal control. HWSC is not a stand-alone weed management tactic and must be used in an integrated weed management system. HWSC also eliminates crop seed and thus volunteers, but can make harvest losses difficult to determine.

For HWSC to be effective, weed seeds must be retained on the mother plant at harvest time. HWSC does not affect weed seeds on or in the soil. Research indicates that many of our troublesome and herbicide resistant weed species can be managed by HWSC. These include Palmer amaranth (*Amaranthus palmeri*), common ragweed (*Ambrosia artemisiifolia*), potentially Italian ryegrass (*Lolium perenne* ssp. *multiflorum*), and others (Table 1; Walsh et al. 2018). However, species that have wind-dispersed seed, such as horseweed/marestail (*Conyza canadensis*) and perennial species are not good candidates for HWSC. Seed of some species, such as common lambsquarters (*Chenopodium album*), jimsonweed (*Datura stramonium*), common cocklebur (*Xanthium strumarium*), and velvetleaf (*Abutilon theophrasti*) can survive in the soil seedbank for many years, making HWSC less effective if only used for a couple years (Burnside et al. 1996). Regardless of weed species, a timely harvest is key. The longer harvest is delayed, the more weed seed shed and less weed control is achieved.

Techniques

HWSC can be achieved through various techniques and combine modifications. All techniques are limited to crops harvested with a grain header, so corn, cotton, and other crops are not current options for HWSC. Limited research has compared different HWSC techniques, but data available indicates that techniques are similarly effective for weed control (Walsh et al. 2017). So, choose a technique that fits into your operation and budget. Also keep in mind potential future planting issues, nutrient

Figure 1. Common ragweed emergence in rows as a result of combine harvesting. (Photo by Michael Flessner.)

implications, and overall logistics of removing, burning, or condensing crop residues.

Table 1. Approximate number of plants and amount of seed retained at crop harvest from on-farm research in Virginia.

Italian ryegrass	Palmer amaranth	Common ragweed
Seed heads/yard^2	--------plants/yard^2--------	
88	5	11
----------Million seed/acre----------		
37.5	56.0	257.6
----------lbs seed/acre----------		
168	258	504

All techniques except narrow windrow burning need the combine to be properly adjusted so that weed seeds exit in the chaff fraction (not in the straw). A properly adjusted combine will have over 90% of seed exit in the chaff. But a poorly adjusted combine can have up to 50% of weed seeds exit in the straw fraction, severely reducing the effectiveness of HWSC (Broster et al. 2016). To increase the amount of weed seeds entering the combine, harvest low for all techniques.

Seed Mills process the chaff fraction killing 93 to 99% of weed seeds contained therein (Schwartz-Lazaro et al. 2017). Chaff is then spread across the field as in conventional harvest operations, eliminating potential subsequent planting issues or nutrient concerns. The Vertical Integrated Harington Seed Destructor (Vertical iHSD) and Seed Terminator are two competing pieces of equipment that attach to and are powered by a combine making this technique a one-pass operation. Commercial availability is very limited at this time.

Narrow Windrow Burning is where all field residues and weed seeds contained therein are placed into a windrow (rather than being spread) behind the combine (Figure 2). The windrow is then burned, killing the weed seeds by fire. Combine modifications are inexpensive: remove or disconnect the spreader and/or chopper and construct a chute to direct the residue into a windrow (Figure 3). The windrow width should be 10% or less of the header width, so for a 30 foot header, the windrow should be 3 feet or less (Lyon et al. 2016). After harvest, light the windrow on fire.

Figure 2. Narrow windrow burning of soybean residue during (left) and after (right). (Photos by Michael Flessner.)

Burning windrows increases the heat and duration compared to burning entire fields, making it much more effective at killing weed seed (Lyon et al. 2016). The windrow needs to reach 750 to 930°F for 10 to 30 seconds to kill most weed species, but some weeds such as crabgrass will be killed when exposed to 185°F for 20 seconds (Hoyle and McElroy 2012; Walsh and Newman 2007). Our research indicates that Italian ryegrass and Palmer amaranth are effectively killed by burning wheat and soybean windrows, respectively.

When implementing narrow windrow burning, harvest low so more fuel (that is, crop residue) ends up in the windrow. Make sure conditions are good for burning: check with local authorities, make sure the windrow is dry and dew is not present, drought periods or windy days are risky and should be avoided. Ignite the windrow in a single spot and let the fire move

down the windrow on its own (Figure 2) as this increases the heat and duration of the fire and thus how effective it is. Consider neighbors, organic matter loss, and nutrient issues before implementing this technique. Most nitrogen is lost due to burning but most potassium remains, albeit concentrated in a row.

Figure 3. Example of combine modifications for narrow windrow burning. (Photo by Michael Walsh.)

Chaff Cart is the use of a trailer (Figure 4) behind the combine that collects only the chaff fraction (not the straw fraction) and weed seeds contained therein. Once full, the cart is then dumped in the field or dumped along the field edge, removing weed seeds from the field. Optionally, the dumped chaff piles can be burned to kill the weed seeds. Some Australian farmers are finding value in chaff dumps by grazing them. Be aware that grazing may redistribute weed seeds. A major concern is towing (and sometimes backing) a trailer in small fields.

Figure 4. Example of a chaff cart system. Photo: Evan Collins.

Chaff Lining is where only the chaff fraction, and weed seed therein, is dropped from the combine rather than spread (Figure 5). Combine modifications are inexpensive and include removing the chaff spreader and making a chute to direct the chaff. Chaff lining does not kill weed seeds but condenses them to less than 10% of the field. Placing weed seeds into a chaff line exposes them to rot, reduces germination due to a less suitable environment, and if weeds do germinate, they compete with each other (Condon 2018). Chaff lines should not be disturbed (i.e. tilled) for best results.

Figure 5. Example of combine modifications for chaff lining. (Photo by WeedSmart.)

Economics. Costs depend on how much acreage HWSC is used on. Costs also differ in terms of up-front costs for equipment and delayed costs from things like nutrient replacement. In Australia, seed mills and narrow windrow burning are similarly costly. Chaff lining is the least expensive, and chaff carts are in between.

Table 2. Comparison of Harvest Weed Seed Control (HWSC) techniques.

Technique	Pros	Cons
Seed Mills	Complete residue return Nothing to do after harvest Weed seeds killed	High up-front cost and supply Increased fuel cost Difficult to estimate harvest losses
Narrow Windrow Burning	Low up-front cost All weed seeds entering harvester end up in windrow Ease of adoption	Fire/smoke Nutrient removal Residue removal Requires good burn across all windrows
Chaff Cart	Ability to graze chaff dumps Minimal residue removal	Medium up-front costs and supply Pulling a trailer and other handling of chaff Nutrient removal May need to burn chaff dumps
Chaff Lining	Very low up-front cost Nothing to do after harvest Ease of adoption	Weed seeds remain in the field Little data on effectiveness Residue buildup over time Planting into chaff lines potentially problematic

Research Results

Studies were conducted in 2017 and 2018 targeting Italian ryegrass in continuous winter wheat at three locations in Eastern Virginia as well as common ragweed and Palmer amaranth in continuous soybean at four locations each, in South Side Virginia. Studies were conducted on farm, with all management left to the farmer except harvest treatment in 2017. Studies assessed HWSC (via weed seed removal) on weed populations in the next year's crop compared to conventional harvest (weed seeds returned).

Italian Ryegrass in Wheat. HWSC reduced Italian ryegrass tillers 29% and 69% at two locations in April compared to the conventional harvest, but a significant difference was not observed at a third location, where Italian ryegrass density was the lowest. Of two locations measured at wheat harvest, HWSC reduced Italian ryegrass seed heads to 41 seed heads per square meter from 125 at one location. A significant difference was not observed at harvest at the second location, again where Italian ryegrass density was lowest.

Common Ragweed in Soybean. In soybeans prior to preplant herbicide applications and postemergence (POST) herbicide applications, HWSC reduced common ragweed densities by 22 and 26%, respectively, compared to the conventional harvest plots. By soybean harvest no differences in common ragweed density or crop yield were observed, due to the effectiveness of POST herbicides.

Palmer Amaranth in Soybean. No treatment differences were observed at any evaluation timing for Palmer amaranth or soybean yield, which is attributed to farmer weed management (i.e. effective herbicides) and low weed densities making any potential treatment differences difficult to detect.

Research Conclusions. HWSC shows promise as a tool to reduce weed populations with up to 69% Italian ryegrass and 22 and 26%, common ragweed reductions. Reductions in weed density and subsequent seed production, can help reduce weed populations. However, differences between HWSC and conventional harvest were not detected when weed densities

were low or where weeds were well controlled with other tactics, indicating that HWSC may only become economically appropriate in fields with herbicide resistant weeds or high weed pressure. It should be noted that these results are from a single harvest. As HWSC is successfully implemented over multiple seasons, greater weed control should result. But, one year of poor management can greatly replenish the soil seedbank.

Additional Resources

https://www.diversityera.com/courses/harvest-weed-seed-control-101
https://weedsmart.org.au/
http://integratedweedmanagement.org/
https://agweedsci.spes.vt.edu/extension/presentations.html
https://www.uaex.edu/publications/pdf/FSA-2180.pdf

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