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Harvest Weed Seed Control

Authored by Michael Flessner, Associate Professor and Extension Weed Science Specialist, School of Plant and Environmental Sciences, Virginia Tech; Eli Russell, Graduate Research Assistant, School of Plant and Environmental Sciences, Virginia Tech

Introduction

Combine harvesters can disperse weed seed, spreading them within a field and from field to field (Figure 1). Harvest Weed Seed Control (HWSC) is a method of weed control that concentrates, removes, or kills weed seeds that are retained on weed plants at the time of crop harvest (Walsh et al. 2018; Shergill et al. 2020). HWSC can be used to 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 have escaped herbicidal control. HWSC is not a stand-alone weed management tactic and must be used in an integrated weed management system. Additionally, since HWSC is reducing inputs into the soil seed bank, it is important for growers to implement HWSC for multiple seasons. HWSC also eliminates crop seeds and thus volunteers which can make harvest losses can be 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 that have shattered or fallen off the plant before harvest or seeds that are in the soil. Research indicates that many of our troublesome and herbicide-resistant weed species are good candidates for HWSC. These include Palmer amaranth (*Amaranthus palmeri*), common ragweed (*Ambrosia artemisiifolia*), Italian ryegrass *(Lolium perenne* ssp. *multiflorum*), and others (Table 1; Walsh et al. 2018; Schwartz-Lazaro et al. 2021). However, species that have wind-dispersed seeds, such as horseweed/marestail (*Conyza canadensis*) and perennial species, are likely not good candidates for HWSC. Also, seeds with long lifespans in the soil seedbank, such as common lambsquarters (*Chenopodium album*), jimsonweed (*Datura stramonium*), common cocklebur (*Xanthium strumarium*), and velvetleaf (*Abutilon theophrasti*) could be less impacted by HWSC if it is not implemented for multiple seasons (Burnside et al. 1996). Regardless of weed species, a timely harvest is key. The longer the harvest is delayed, the more weed seeds are shed, and less weed control is achieved.

Figure 1. Common ragweed (top) and Italian ryegrass (bottom) emergence in rows as a result of combine harvesting. (Photos by Michael Flessner.)

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/yard²	--------plants/yard²--------	
88	5	11
---------------Million seed/acre---------------		
37.5	56.0	257.6
-----------------lbs seed/acre-----------------		
168	258	504

Techniques

HWSC can be achieved through various techniques and combine modifications. All techniques are limited to crops harvested with a grain header such as small grains and soybean. Corn and cotton are not current options for HWSC. Limited research has directly 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.

For HWSC to be successful, the combine needs 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. However, 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). Research at Virginia Tech has indicated that less than 5% of weed seeds exit the combine in the straw fraction if your combine is adjusted so that you have clean grain entering the grain tank and minimal grain loss out of the back. To increase the amount of weed seeds entering the combine, harvest low to the ground for all techniques.

Table 2. Seed kill of common and problematic weeds in soybean and wheat production systems by two different seed impact mills from research conducted at Virginia Tech.

Species	Redekop SCU	iHSD
Soybean	Seed kill (%)	
Palmer amaranth	99.6	99.9
common ragweed	99.7	99.8
barnyardgrass	99.3	99.8
morningglory	99.8	99.7
redroot pigweed	99.4	99.3
giant foxtail	98.6	98.3
giant ragweed	99.8	100
waterhemp	99.8	99.8
johnsongrass	99.9	99.8
velvetleaf	99.5	99.5
Wheat	Seed kill (%)	
Italian ryegrass	93.6	91.4
canola	99.9	99.8
hairy vetch	99.6	99.8
annual ryegrass	95.8	94.1
wild mustard	99.8	99.8
cereal rye	99.2	99.7

Seed Impact Mills

are aftermarket modifications that are integrated into the back of the combine. These mills process the chaff fraction, killing more than 90% of the seeds contained therein (Table 2; Schwartz-Lazaro et al. 2017). All harvest residue is then spread across the field as in conventional harvest operations, eliminating potential subsequent planting issues or nutrient concerns. The Redekop Seed Control Unit (SCU), integrated Harrington Seed Destructor (iHSD), and Seed Terminator are three seed impact mill options that attach to and are powered by a combine (Figure 2).

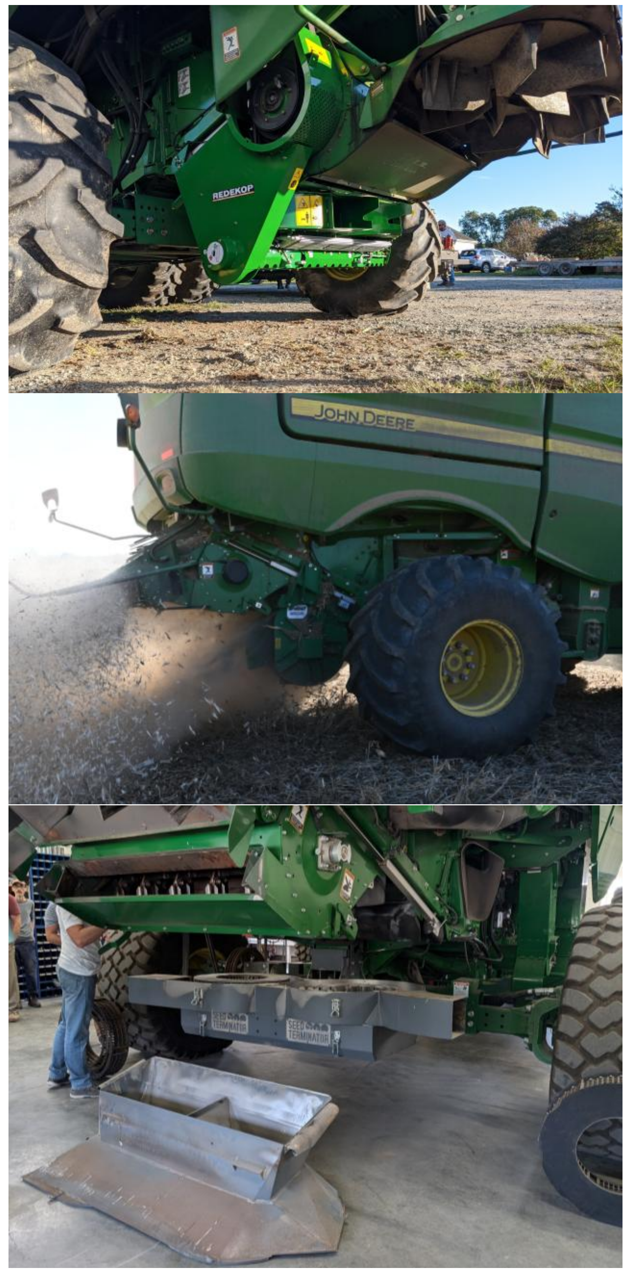

Figure 2: Three seed impact mills on the market. Redekop Seed Control Unit (SCU) (top), integrated Harrington Seed Destructor (iHSD) (middle), and Seed Terminator (bottom). (Photos by Michael Flessner and Claudio Rubione, GROW.)

Seed impact mills are a one pass system, since the mill actively kills the weed seeds during harvest. However, since these mills are powered directly by the combine, using them can result in higher horsepower usage by the combine. This in turn results in more fuel usage. Additionally, some growers reported reduced speeds during harvest to accommodate for the additional horsepower draw. Seed impact mills are not recommended below class 8 combines.

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 (Figures 3 and 4). 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 (Figures 3 and 4). 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.

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 Walsh and Newman 2007). Our research indicates that Italian ryegrass and Palmer amaranth are effectively killed (>95%) by burning wheat and soybean windrows, respectively (Spoth et al. 2022).

Figure 3. Narrow windrow burning of soybean residue during (left) and after (right). (Photos by Michael Flessner.)

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

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 (Walsh et al. 2018). Chaff lines should not be disturbed (i.e. tilled) for best results.

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 while chaff lining is less expensive.

Research Results

Several studies have been conducted at Virginia Tech to evaluate the effectiveness of HWSC. Additional research targeted the effectiveness of chaff lining and seed impact mills for use in soybean and wheat systems (Beam et al. 2019).

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

HWSC in Wheat and Soybean

Studies were conducted in 2017 and 2018 targeting Italian ryegrass in wheat and common ragweed and Palmer amaranth in 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). In wheat, HWSC reduced Italian ryegrass tillers 29% and 69% at two locations compared to a conventional harvest. 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. There were no significant differences at any locations for Palmer amaranth.

Seed Impact Mills

Two experiments were conducted to test seed impact mills in soybean and wheat. The first experiment tested the percentage of seeds that the seed impact mill killed during a commercial harvest. The results indicate that >99% of problematic soybean weeds were killed, and >89% of problematic wheat weeds were killed during harvest when those seeds made it to the mill. Another experiment evaluated common ragweed density in soybean and Italian ryegrass density in wheat following a successful harvest with a seed impact mill. Results indicated that common ragweed density was reduced by 26% at POST herbicide application timing and 77% at harvest timing when compared to a conventional harvest. Additionally, Italian ryegrass density was reduced by 48% in the spring when compared to a conventional harvest.

Chaff lining

Testing at Virginia Tech evaluated the ability of chaff lines to suppress weed emergence in Palmer amaranth and common ragweed in soybean and Italian ryegrass and wild mustard in wheat. These experiments involved adding weed seeds to chaff lines and tracking the emergence of those species. Results indicated that chaff lines in wheat were able to reduce weed emergence by 43-54% at a field scale in the subsequent year after harvest. In soybean, chaff lining decreased Palmer amaranth emergence by 81% in 6 out of 7 field locations and common ragweed by 85% in 2 of 3 locations.

Research Conclusions

HWSC shows promise as a tool to reduce weed populations with both seed impact mills and chaff lining reducing weed emergence in the following seasons. Reductions in weed density and subsequent seed production can help reduce weed populations. However, these studies did indicate that differences between HWSC and conventional harvest were not detected or hard to detect when weed densities were low or where weeds were well controlled with other tactics, indicating that HWSC may only become

Table 3. Comparison of Harvest Weed Seed Control (HWSC) techniques.

Technique	Pros	Cons
Seed Mills	Complete residue return One pass system 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 Lining	Very low up-front cost One pass system Ease of adoption	Weed seeds remain in the field Little data on effectiveness Residue buildup over time Planting into chaff lines potentially problematic

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://growiwm.org/how-harvest-weed-seed-control/

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