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Harvest Weed Seed Control (HWSC)

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The introduction of harvest weed seed control (HWSC) techniques and associated machinery has enabled the routine use of an alternative weed control technology at a novel weed control timing in global grain cropping fields. The use of HWSC has likely contributed to lower annual ryegrass population densities and thus mitigated the impacts of herbicide resistance as well as slowing further evolution of resistance. In addition, low weed densities enable the introduction of site-specific weed control technologies and the opportunity to target specific in-crop weeds with non-selective alternative weed control techniques.

The introduction of HWSC as an alternative, end-of-season weed control treatment has created the opportunity for routine targeting of the seed production of weed species surviving to maturity in Australian grain production systems. In Australia, the widespread use of HWSC has substantially improved the management of herbicide-resistant weed populations and helped to mitigate their adverse impact on crop production systems (Walsh *et al.*, 2022).

Another challenge would be the length of time seeds remain viable in the soil seedbank, which determines how long best management practices (BMP) must be used to reduce the seedbank and any herbicide resistant seed (Norsworthy *et al.*, 2012). While annual management practices affect the above ground weed species, the soil seedbank is typically slower to respond because of continual input of weed seeds from multiple seasons of escaped weeds (Schwartz *et al.*, 2016). Reducing the weed seed in the soil seedbank is critical to reducing the weed population that farmers will manage in the future.

Narrow windrow method

The narrow windrow burning system is very simple and is the most effective HWSC tactic. The inexpensive system uses a chute mounted on the rear of the combine that concentrates all of the chaff into a narrow row (e.g., a crop row). The base of the chute is generally 16 to 18 inches wide. Immediately following formation, these rows should be burned. Burning the entire field is not as effective in killing the weed seeds as burning the chaff in the windrows. The concentration of the chaff increases the temperature and duration of burning, which leaves less loss of residue versus traditional burning.

Additionally, this method does not slow down the harvest process and produces heat loads far in excess of those with a typical burning of straw in a wheat field. In soybean, narrow windrow burning has been shown to reduce escaped Palmer amaranth by 73 percent and the soil seedbank by 62 percent over three years (Norsworthy *et al.*, 2016). Our recent research has shown narrow windrow burning in soybean killed nearly 100 percent of Palmer amaranth, barnyard grass and johnsongrass seed present in the windrow.

Chaff carts

The simple chaff cart method consists of a chaff collection and transfer mechanism attached to a grain harvester that delivers the weed seed into a bulk collection bin. This method allows for the chaff and the weed seed to be collected and removed from the field. Another option is to dump the chaff material in the field and then burn the chaff piles. A drawback to this method is that the chaff cart attaches behind the already lengthy harvesting equipment, which makes

maneuvering in small fields more challenging (Schwartz *et al.,* 2015).

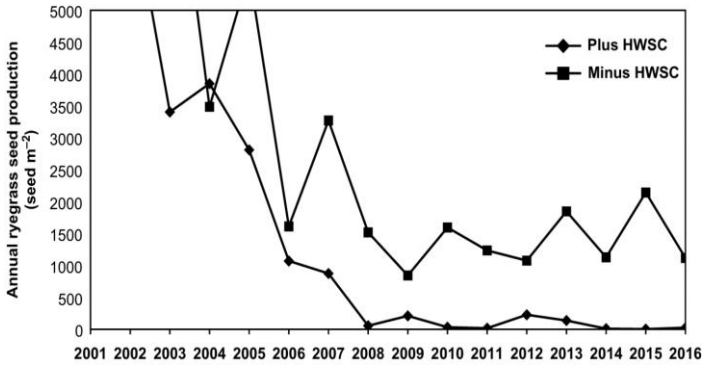
Harrington Seed Destructor

The Harrington Seed Destructor (HSD) was developed by an Australian crop producer, Ray Harrington, in 2005. The HSD is a trailer mounted cage mill with chaff transfer systems. Preliminary research using the HSD has shown that during commercial wheat harvest, 95 percent of annual ryegrass, wild radish, wild oat and bromegrass weed seed was destroyed (Walsh *et al.,* 2013).

Bale Direct system

The bale direct system consists of a large baler directly attached to the combine that constructs bales from the chaff exiting the harvester. This system captures the weed seed, and the bales formed can then be used as feed for livestock. The limitations of this method are that there is a very limited market for the baled product and there is some risk in spreading the resistant weed seeds to other fields through the distribution of the bales (Schwartz *et al.,* 2015).

(Walsh *et al.,* 2022) conducted a study on Influence of herbicide alone and herbicide plus HWSC weed management programs in 25 Western Australian cropping paddocks from 2008 to 2016.



(Bajwa *et al., 2015*) conducted a study on the efficiency and adoption of harvest weed seed control systems in Australia.

System	Weed species	Seed control (%)	Adoption	Extra benefit	Reference
Harrington seed destructor	Annual ryegrass	95	High adoption rate due to high efficiency	Residue retention for soil protection and fertility enhancement	Walsh et al. (2012)
	Brome grass	99			
	Wild oat	99			
	Wild radish	93			
Chaff carts	Annual ryegrass	73 to 86	Less due to problems of subsequent handling of chaff	Alternative use of chaff as feed for the livestock	Walsh and Powels (2007)
	Wild radish	95			
	Wild oat	74			Shirtliffe and Entz (2005)
Narrow windrow burning	Annual ryegrass and wild radish	99 for each	Most widely adopted as economical, simple, and efficient	Relatively ecofriendly as it avoids burning of the whole field	Walsh and Newman (2007)
Bale direct	Annual ryegrass	95	Less due to lack of availability of markets for baled material	Baled feed stock for livestock	Walsh and Powels (2007)

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