Harvest weed seed control: is there a role in northern region farming systems?

Michael J. Widderick[1], Michelle D. Keenan[1] and Michael J. Walsh[2]
[1] Agri-Science Queensland, Department of Agriculture, Fisheries and Forestry Queensland, PO Box 2282, Toowoomba, Qld 4350, Australia
[2] Australian Herbicide Resistance Initiative, University of Western Australia, 35 Stirling Highway, Crawley, WA 2009, Australia
(michael.widderick@daff.qld.gov.au)

Summary Harvest weed seed control (HWSC) is a new approach which targets weed seed removal and/or destruction during the crop harvest operation. The success of HWSC is dependant upon weed seed retention at harvest. To identify and define the potential value of HWSC in northern farming systems, we conducted a field survey. In total 1400 transects across 70 paddocks assessed weed distribution, density and seed production at harvest time in wheat, chickpea and sorghum crops. Seventy weed species were identified, of which many had large seed numbers retained at crop harvest. The most prevalent included common sowthistle, flaxleaf fleabane, awnless barnyard grass, wild oat, and African turnip weed. Our field survey has shown there is a role for HWSC in the northern farming system. Therefore the efficacy of specific HWSC systems on problematic weeds should be evaluated in the northern region.

Keywords Harvest, weed seed, northern region.

INTRODUCTION

Stopping seed bank replenishment is important for effective management of annual weeds. Weed seeds produced in crop increase the weed seed bank and contribute to weed problems in future crops and fallows.

HWSC is a system targeting the collection and/or destruction of weed seeds during crop harvest in order to minimise replenishment of the seed bank (Walsh *et al*. 2013). There are various HWSC systems available including chaff carts, narrow windrow burning and the Harrington Seed Destructor (HSD) (Walsh *et al*. 2012, Walsh *et al*. 2013). HWSC is commonly used in Western Australian farming systems and has been effective in reducing populations of annual rye grass (*Lolium rigidum* Gaudin) (Walsh *et al*. 2013).

In the northern crop production region of northern New South Wales (NSW) and southern and central Queensland, herbicides are heavily relied upon for in-crop weed control (Osten *et al*. 2007). Rarely do in-crop herbicides provide 100% control of in-crop weeds. These uncontrolled weeds set seed, replenish the seed bank and cause future weed problems. In addition, there are limited in-crop herbicide options for some crops and the increasing incidence of herbicide resistant weed species is further reducing the in-crop herbicide options in this region (Heap 2014, Preston 2014). Therefore, additional tactics are required in-crop to reduce weed seed bank replenishment and future weed pressures.

At present, HWSC is rarely practiced as a weed control option in the northern crop production region. This is in part because the need for this approach has not been assessed and in part because there is poor understanding of how this approach fits with the regions cropping systems and weed species.

The potential efficacy of HWSC is based upon the proportion of total seed production retained at crop maturity (Walsh and Powles, in press). To assess the potential for HWSC in the northern crop production region, in-crop weed surveys were conducted in northern NSW, and southern and central Queensland summer and winter crop production zones.

The surveys were conducted to identify weed species with upright seed bearing plant parts that will potentially be collected during the harvest of the major crops wheat (*Triticum aestivum* L.), chickpea (*Cicer arietinum* L.) and sorghum (*Sorghum bicolor* L.) in these regions. These surveys allow the determination of the potential for successful use of HWSC in the northern crop production region.

MATERIALS AND METHODS

A random survey was conducted in 2011/2012 on 70 paddocks of wheat, chickpea and sorghum in the four main cropping zones of the northern grain region (Table 1).

Within each paddock, weed populations were assessed along 20 representative transects of 10 m^2 (1 m × 10 m) selected in a zigzag pattern. In each transect the weed species present, the density of each weed species (using a rating scale of 1 = 1–9 plants, 2 = 10–49 plants, 2.5 = 50–100 plants, and 3 = >100 plants per 10 m^2) and a visual estimation of the percentage of each species seeding, were assessed.

For seeding species, three representative samples were collected from each paddock. For each sample, a visual estimation of the percent of seeds or seed heads above potential harvest height (nominated as 5 cm for chickpea, 15 cm for wheat and 30 cm for sorghum) and of the percent of total seed retained at time of sampling, was made. Also, the number of seed heads per plant above harvest height was counted and seed production determined based upon counting the number of seeds in five representative seed heads.

The visual assessments and counts were used to determine total seed production, number of seeds retained at harvest time and the percent of seed available for potential harvest management.

RESULTS

The in-crop weed flora was very diverse, 70 different species were found, 37 species in chickpea crops, 33 in wheat, and 38 in sorghum (Table 1). Fifteen species were found in all three crops with 70% of these species retaining seed at harvest time.

Table 1. Extent of survey and occurrence of weed species.

Region and crop	Number of paddocks	Number of species at harvest	Number of species retaining seed at harvest
Central Highlands, Qld			
Chickpea	5	8	6
Wheat	5	5	4
Sorghum	10	12	11
Darling Downs, Qld			
Chickpea	5	11	7
Wheat	5	12	10
Sorghum	10	15	11
South-West Downs, Qld			
Chickpea	5	15	11
Wheat	5	8	3
Sorghum	10	25	19
Liverpool Plains, NSW			
Chickpea	5	22	16
Wheat	5	18	12
Sorghum	–	–	–

Eight weed species were commonly found across the cropping zones and crops (Table 2). The most prevalent were species with wind-blown seed–common sowthistle (*Sonchus oleracues* L.) and flaxleaf fleabane (*Conyza bonariensis* (L.) Cronquist). There were three grasses–awnless barnyard grass (*Echinochloa colona* (L.) Link), wild oat (*Avena* spp.) and feathertop Rhodes grass (*Chloris virgata* Sw.); two brassicas – turnip weed (*Rapistrum rugosum* L.) and African turnip weed (*Sisymbrium thellungii* O.E. Schulz); plus bladder ketmia (*Hibiscus trionum* L.).

Common sowthistle seed production was much greater in chickpea than either wheat or sorghum, but average seed retention at crop maturity was similar across crops, averaging 55% (Table 2). For flaxleaf fleabane, average seed production was greatest in sorghum (111,205 seeds/plant), but the seed retention was least in sorghum (35%). For both common sowthistle and flaxleaf fleabane, the majority of seeds were present above harvest height, especially in wheat and chickpea. Thus, these weeds may be a priority for harvest weed seed management.

Barnyard grass was the third most prevalent weed with a substantial number of seeds produced per plant in all three crops (Table 2). While more seed was produced in sorghum (11,320 seeds/plant), a lower proportion was retained at crop maturity in sorghum (47%) and very little was retained above sorghum harvest height (Table 2). A substantial portion of feathertop Rhodes grass seed was retained in both chickpea (71%) and sorghum (79%) at crop maturity and much of this was present above harvest height, especially in sorghum (Table 2). Several hundred seeds were produced/plant for wild oat in both wheat and chickpea. Much of this seed was retained at crop maturity and all of the retained seed was above harvest height (Table 2). The grass weeds may also be a priority target for HWSC, especially feathertop Rhodes grass and wild oat.

The brassica weeds produced substantial numbers of seeds in chickpea (10,055 and 65,140) but much less in wheat (0 and 995) for turnip weed and African turnip weed respectively. The majority of seeds (95–100%) was retained at harvest time and were above the potential harvest height. Thus these weeds are a priority for harvest weed seed management, especially in chickpea crops.

For bladder ketmia, small seed numbers were produced in wheat and not much of the seed that was retained was above harvest height (Table 2). While a larger number of seeds were produced in sorghum, a reduced number were retained at crop maturity and many were below harvest height.

Table 2. The most common weed species seeding at harvest time in wheat, chickpea and sorghum, and data on average total seed production and percentage retained per plant at crop maturity, and percentage of remaining seed above potential harvest height (averaged across each of 4 cropping zones) for each species. Seed data for each species are listed in order of wheat, chickpea and sorghum.

Weed	Number of paddocks infested	Number of paddocks seeding	Average total seed production/plant *(range)*	Average % seed retained per plant *(range)*	% above harvest height
Common sowthistle	45	38	**7,430** *(920–13,260)*	**53** *(12–84)*	80–100
			19,990 *(15,235–24,915)*	**54** *(19–87)*	100
			6,185 *(2,660–12435)*	**58** *(40–70)*	65–85
Flaxleaf fleabane	28	17	**9,715** *(4,885–17,130)*	**93** *(81–100)*	40–100
			32,900 *(18105–53850)*	**86** *(60–100)*	90–100
			111,205 *(58,920–163,490)*	**35** *(20–49)*	55–60
Awnless barnyard grass	20	17	3,785	95	100
			2,845	100	60
			11,320 *(4,250–18,390)*	**47** *(17–76)*	20–25
Bladder ketmia	19	15	55	84	25
			–	–	–
			395 *(265–500)*	**55** *(34–79)*	30–100
Wild oat	14	13	**325** *(210–405)*	**69** *(51–82)*	100
			215 *(185–240)*	**93** *(90–96)*	100
			–	–	–
Turnip weed	10	9	–	–	–
			10,055 *(150–28,170)*	100	95–100
			480	95	20
African turnip weed	9	8	995	100	100
			65,140 *(33,130–112,080)*	100	100
			–	–	–
Feathertop Rhodes grass	7	7	–	–	–
			12,185 *(2,850–21,515)*	**71** *(54–87)*	100
			33,310 *(13,640–52,975)*	**79** *(59–100)*	60–75

DISCUSSION

The survey of northern region wheat, chickpea and sorghum crops at maturity identified high frequencies of in-crop weeds bearing large numbers of seed. It is clear that there is an urgent need for northern region growers to manage in-crop weeds better to prevent large annual seed bank replenishment.

The survey has identified key weed species which may be potential targets for HWSC. However, further work is required to assess the effect of HWSC tactics on weeds including common sowthistle, flaxleaf fleabane, wild oat, feathertop Rhodes grass and the brassica weeds.

Both common sowthistle and flaxleaf fleabane have wind-dispersed seed which are produced indeterminately. Therefore, the question remains as to how much of this seed actually enters the harvester and then if it is susceptible to HWSC. In contrast brassica weeds retained large amounts of seed above harvest height at crop maturity and are key potential targets for HWSC.

The survey has identified the potential for HWSC to be used in the northern crop production region. However more survey work is required to cover a wider cropping area and other cropping seasons and years. In addition, the different HWSC tactics should be evaluated in the region and changes in weed population assessed over time.

ACKNOWLEDGMENTS

Funding for this research was provided by the Rural Industries Research and Development Corporation and the Grains Research and Development Corporation. The surveys were undertaken as a collaborative effort between Queensland's Department of Agriculture, Fisheries and Forestry and the Australian Herbicide Resistance Initiative. Many thanks to the agronomists and farmers who helped to coordinate the survey and who willingly allowed us to enter their properties.

REFERENCES

Heap, I. (2014). The international survey of herbicide resistant weeds. Available from URL: http ://www.weedscience.org (cited 14 May 2014).

Osten, V.A, Walker, S.R., Storrie, A., Widderick, M., Moylan, P., Robinson, G.R. and Galea, K. (2007). Survey of weed flora and management relative to cropping practices in the north-eastern grain region of Australia. *Australian Journal of Experimental Agriculture* 47, 57-70.

Preston, C. (2013). Australian Glyphosate Resistance Register. Available from URL: http://www.glyphosateresistance.org.au (cited 14 May 2014).

Walsh, M.J., Harrington, R.B. and Powles, S.B. (2012). Harrington seed destructor: A new non-chemical weed control tool for global grain crops. *Crop Science* 52, 1343-7.

Walsh, M., Newman, P. and Powles, S. (2013). Targeting weed seed in-crop: A new weed control paradigm for global agriculture. *Weed Technology* 27, 431-6.

Walsh, M.J and Powles, S.B. (in press). High seed retention at maturity of annual weeds infesting crop fields highlights the potential for harvest weed seed control. *Weed Technology*.