Weeds present in rice crops of southern New South Wales

John Broster and Allison Chambers

Graham Centre for Agricultural Innovation (NSW Department of Primary Industries and Charles Sturt University), Charles Sturt University, Locked Bag 588, Wagga Wagga, NSW 2678, Australia. Email: jbroster@csu.edu.au

Abstract
Weed control in the rice industry has been dependent on very few herbicides. Significant levels of resistance have been reported to one of the major herbicides (bensulfuron or Londax®). Random surveys were undertaken in both 2016 and 2017 in which the densities of the weed species were estimated. Additionally, screenings from rice samples analysed by the AGS Quality Appraisals Centre at Leeton were obtained. These screenings were further sorted to determine the quantity and species of weed seeds in the delivery samples. From the AGS Quality Appraisals Centre samples it was estimated that 150 billion barnyard grass seeds were delivered to silos during the 2017 harvest. This shows that while populations may not be resistant there are surviving plants setting seeds and those seeds not delivered to silos are replenishing the seed bank. In subsequent seasons the plants germinating from this seed bank are placing selection pressure for resistance development on the herbicides used for their control.

Key Words
Barnyard grass, rice, *Echinochloa*

Introduction

Barnyard grass (*Echinochloa* spp.) is a problem weed of rice crops. Previously, about 90% of rice in Australia was aerially sown (Graham *et al.* 1996). However, since the discovery of bensulfuron resistance in the aquatic weeds the proportion of ground sown rice has increased such that only 26% of rice was aerially sown in 2017 (R. Ford personal communication). This change in sowing method has resulted in a change in weed spectrum as ground (dry) sowing favours dryland species (e.g. barnyard grass) over the aquatic species favoured by aerial sowing. In 1999, barnyard grass was the predominant weed species in rice screenings with 86% of 400 samples from the Rice Growers Mill Laboratories at Leeton containing barnyard grass, occasionally accounting for most of the weight of the 30-60 gram screenings sample (Pratley and Broster 2004). It occurred in over 86% of samples.

The threat of barnyard grass infestations is of increasing concern because of increasing levels of herbicide resistance in the aquatic weeds of rice and the risk of resistance developing in barnyard grass. With no guarantees of a herbicide solution in the long term for these aquatic weeds, it may become necessary to revert partially or wholly to drilling of rice prior to permanent water. Two of the herbicides used for the control of barnyard grass in rice, cyhalofop (Barnstorm®) and profoxydim (Aura®), are Group A herbicides which are considered to be high risk for the evolution of herbicide resistance.

Methods

Random field surveys

Two random field surveys were conducted, one in February / March 2016 and the second in March 2017. The second survey was undertaken due to the low rice area in the 2015-16 growing season. Paddocks were selected by driving through the rice growing regions and at specific intervals stopping at the nearest rice paddock and collecting samples. Two people sampled the paddocks with one walking through the middle of the bays and one sampling nearer to the edges and banks. If no weeds were found in the selected paddock this event was recorded. Across the two surveys 122 paddocks were visited.

At the same time as sample collection was undertaken any other species present in the sampled area were identified and an estimate was provided of the density of both the collected and observed species using

categories developed by Llewellyn *et al*. (2009) for annual ryegrass populations and modified by increasing the thresholds for smaller species (e.g. dirty Dora) and decreasing it for larger species (e.g. barnyard grass):

- very low (occasional plants, approx. 1 per 10 m^2)
- low (<1 per m^2)
- medium (approx. 1 per m^2)
- high (>1 per m^2)
- very high (>>1 per m^2, dominating the crop)

AGS Quality Appraisals Centre Samples
From the 2016-17 growing season the screenings (below top sieve and above bottom sieve) of 10% of samples processed by the AGS Quality Appraisals Centre at Leeton were collected, providing 153 samples for analysis. These samples were further processed at CSU to collect and quantify all weed seeds present. As the rice variety was recorded for each sample any relationships between crop variety and weed infestation were evaluated. Rice variety yield and area for the 2016-17 season were obtained from SunRice to assist in this evaluation. Differences in barnyard grass numbers between varieties were analysed using an uneven ANOVA.

Results

Sample collection
Across both surveys, 59 paddocks in the Murrumbidgee Irrigation Area (MIA), 18 in the Coleambally Irrigation Area (CIA) and 45 in the Murray Valley Irrigation Districts (MVID) were visited. Of these, four contained none of the collected weed species, 35 contained only one species, 36 two species, 23 paddocks three of the species, 19 four species, two contained five species and three paddocks contained six of the collected species. Barnyard grass (*Echinochloa crus-galli*) was the most commonly collected species found in 116 paddocks. Dirty Dora (*Cyperus difformis*) occurred in 66 paddocks, starfruit (*Damasonium minus*) in 35 and arrowhead (*Sagittaria montevidensis*) in 27 paddocks. Less commonly found were awnless barnyard grass (*E. colona*) in 12 paddocks, silver top (*Diplachne fusca*) in nine, jerry jerry (*Ammannia multiflora*) in seven, umbrella sedge (*Cyperus eragrostis*) in six and water plantain (*Alisma plantago-aquatica*) in two paddocks.

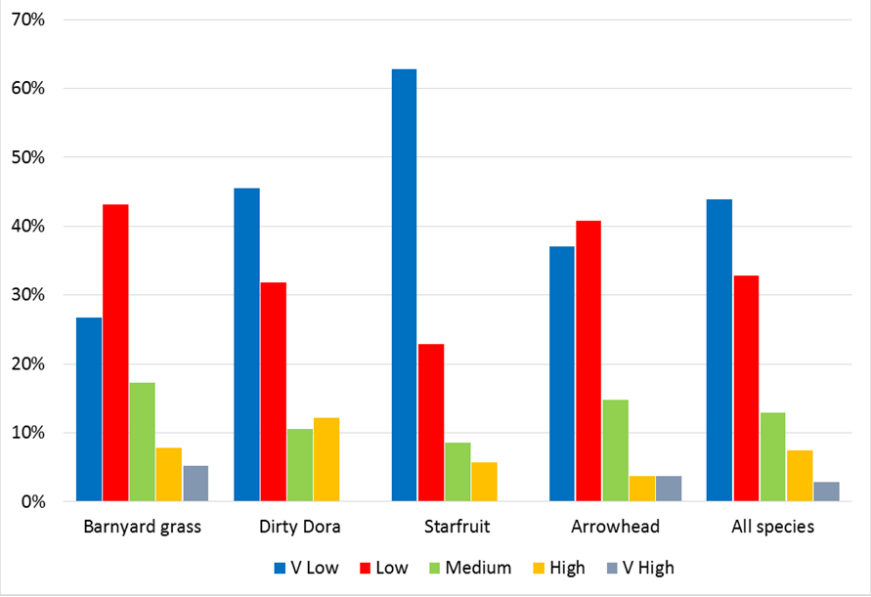

Figure 1: Density of the major weed species collected (percentage of samples for species)

A total of 280 weed samples was collected of which 77% were found at either a very low or low density, with only three percent found at a very high density, outcompeting the crop (Figure 1). Of the four most commonly collected species, dirty Dora and starfruit were most commonly found at very low infestation levels while the most commonly collected species, barnyard grass, was recorded at a low infestation in

nearly 50% of sampled paddocks. Of the eight weed populations that were classed as very high, six were barnyard grass, one was arrowhead and one awnless barnyard grass.

AGS Quality Appraisals Centre samples

Of the 153 samples 94% contained barnyard grass seeds (144), 13 starfruit, eight arrowhead, five silver top and three dirty Dora while only two samples contained no weed seeds. The 94% of samples containing barnyard grass was a higher outcome than the previous collection of screenings from the Rice Growers Co-operative Mill laboratories in 2001. From that collection of 268 samples, 85% (228) contained barnyard grass (Pratley and Broster 2004). Thirty seven other weed species were noted and while not all of these have been identified they include tree hogweed (*Polygonum patulum*), spear thistle (*Cirsium vulgare*), loosestrife (*Lythrum* spp.), dock (*Rumex* spp.), fumitory (*Fumaria* spp.) and nightshade (*Solanum* spp.).

The screenings samples contained an average of 0.7 g of barnyard grass seed, up to a maximum of 18.1 g. There was no statistical difference in the amount of barnyard grass seed present in the samples obtained from Doongara, Topaz, Langi, Opus, Reziq, Sherpa or YRM70 rice crops. Screenings from YRK5 crops contained more barnyard grass than all of these varieties except YRM70 although this findings may be influenced by the low number of screening samples from YRK5 crops (seven) and that one of these samples contained over 10 g of barnyard seed, more than three times the next most for that variety. Samples from Koshihikari crops contained more barnyard grass seed than all other varieties except Illabong but screenings samples were only obtained from one Illabong crop. Even though screening samples were obtained from only five Koshihikari crops, all samples were in the greatest 12% for barnyard grass seed weight.

All of the screening samples were obtained from a 1.2 kg grain sample and the mean weight of the barnyard grass seed was determined to be 0.22 g per 100 seeds. The total rice area grown for the 2016-17 season was 80,100 ha and the yield and percentage of total rice area sown was known for each variety (Table 1).

Table 1: Estimation of barnyard grass seed delivered to silos for 2016-17 season from AGS Quality Appraisals Centre samples

Variety	Area sown			Rice yield		Barnyard grass seed				
	No.	%	ha	t/ha	t (total)	g/ sample	no./ sample	/t rice	/ha	Delivered (000 seeds)
Doongara	6	1.6	1 282	9.8	12 560	0.061	28	23 239	227 741	291 872
Topaz	9	5.3	4 245	8.8	37 359	0.101	41	34 082	299 925	1 273 269
Langi	11	5.5	4 406	8.6	37 887	0.297	123	102 321	879 959	3 876 659
Reiziq	53	38.1	30 518	10.6	323 492	0.340	140	116 735	1 237 386	37 762 675
Opus	10	7.0	5 607	9.9	55 509	0.333	151	126 144	1 248 826	7 002 165
YRM 70	13	5.1	4 085	9.7	39 625	0.772	351	292 494	2 837 194	11 590 221
Sherpa	38	33.0	26 433	10.0	264 330	0.492	212	176 408	1 764 076	46 629 808
YRK 5	7	2.3	1 842	7.1	13,080	2.474	1125	937 262	6 654 559	12 259 694
Koshihikari	5	1.9	1 522	7.2	10 958	5.596	2544	2 119 849	15 262 910	23 228 622
Illabong	1	0.2	160	10.5	1 682	10.106	4594	3 828 106	40 195 113	6 439 257
Mean						0.743	583	264 978	1 877 082	
Total	153		80100		796 482					150 354 246

From the data collected it was estimated that over 150 billion barnyard grass seeds were delivered with the rice grain for the 2016-17 harvest (Table 1). This equates to more than 260,000 seeds per tonne of rice or nearly 1.9 million seeds per hectare.

This number is only an estimation for several reasons:

a) It assumes all samples represent an equal area of rice crop
b) It assumes that each sample attains the overall average yield for that variety regardless of barnyard grass seed numbers
c) The number of samples for each variety is proportional to the percentage of that variety grown

Although these reasons may alter the number of barnyard grass seeds delivered with the rice, the numbers are extraordinarily high. Even if barnyard grass seed numbers estimated were reduced by 50% (unlikely) there would still be an average of nearly one million barnyard grass seeds per hectare delivered to the silos (Table 1).

Not all barnyard grass seed is harvested and delivered with the rice to the silo. Some is shed prior to harvest and falls directly onto the ground while some enters the harvester and exits in either the chaff or straw fractions to be spread across the paddocks. Both options replenish the seed bank. Thus a large number of barnyard grass seeds would be available for germination the following year, providing a large population of plants to be treated with herbicides and the subsequent high level of pressure for selecting resistant plants. The percentage of barnyard grass in each of these three portions is unknown. However, even if 50% of the barnyard grass seed finished in the grain fraction then approximately 190 seeds/m^2 are added to the seed bank. If only 10% are found in the grain fraction then nearly 1700 seeds/m^2 are being added to the seed bank.

Conclusion

Approximately 95% of samples from both the random field survey and the AGS Quality Appraisals Centre contained barnyard grass seed. From the AGS Quality Appraisals Centre samples it was estimated that approximately 150 billion barnyard grass seeds, or 331 tonnes, were delivered in rice samples to the silos for the 2016-17 rice season. This is a cost to the grower in several ways. The presence of barnyard grass in the crop can decrease rice growth and production resulting in yield losses and decreased income to the farmer. Additionally, the cost of removing the barnyard grass seed from the rice during processing is an additional cost that may reduce the price per tonne paid to all growers.

The high number of barnyard grass seed returning to the seed bank results in increased selection pressure for herbicide resistance especially for the higher risk herbicides, cyhalofop and profoxydim. Much of this seed would be from plants that have survived herbicide application and may be resistant. To maintain the long term effectiveness of the current herbicides there needs to be an increase in alternative, non-herbicidal control options, such as harvest weed seed control or allelopathy, for weed control.

References

Graham RJ, Pratley JE, Slater PD, Baines PR (1996) Herbicide resistant aquatic weeds, a problem in New South Wales rice crops. In 'Proceedings of the 11th Australian Weeds Conference'. Melbourne. (Ed. RCH Shepherd) pp. 156-158. (Weed Science Society of Victoria)

Llewellyn RS, D'Emden FH, Owen MJ, Powles SB (2009) Herbicide resistance in rigid ryegrass (*Lolium rigidum*) has not led to higher weed densities in Western Australian cropping fields. *Weed Science* **57**, 61-65.

Pratley JE, Broster JC (2004) 'Influence of species on the efficiency of barnyard grass control.' Project Final Report (UCS-28A) (RIRDC).