Emergence and persistence of barnyard grass (*Echinochloa colona* (L.) Link) and its management options in sorghum

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Summary A general trend of decreasing emergence of barnyard grass (*Echinochloa colona* (L.) Link with increasing soil burial depth was found in this study. Barnyard grass emerged primarily at the soil surface (0–2 cm), while little emergence was found at the burial depth of 10 cm. Three major flushes of emergence were identified during late spring and early summer. Seed persistence decreased rapidly with increasing burial depths and duration. Research showed that wider sorghum row spacings resulted in higher weed biomass. Soil incorporation of atrazine mixed with metolachlor at sorghum planting provided effective seasonal control of barnyard grass. Further studies on barnyard grass biology and integrated weed management strategies are necessary in improving control efficacy and in reducing the risk of developing herbicide resistance.

Keywords Barnyard grass, seed persistence, seed emergence, row spacing, weed suppression.

INTRODUCTION

Barnyard grasses (*Echinochloa* spp.) are important weeds in cotton, sorghum, maize, rice, and many other field and vegetable crops in Australia. In recent surveys across the northern grain region, barnyard grass was reported to be the most common weed in sorghum and summer fallows (Walker *et al.* 2004). The weed was also rated as having a high risk of developing resistance to glyphosate. Globally, biotypes of barnyard grass have evolved resistance to a number of chemically distinct groups of herbicides (Heap 2004).

Only limited data on the biology and management of barnyard grass were available under dryland conditions. *E. colona* (L.) Link can produce up to 42,000 seeds plant^{-1} (Mercado and Talatala 1977), and the minimum, optimum and maximum germination temperatures were 15, 30 and 40°C (Uremis and Uygur 1999). The aims of this study were to investigate:

(1) the seed emergence pattern and persistence of barnyard grass under dryland field conditions; and

(2) chemical and agronomic options in managing barnyard grass.

MATERIALS AND METHODS

Plant materials Seeds of barnyard grass (*E. colona*) were collected at maturity from a sorghum paddock in southern Queensland in March 2003. Seeds were air-dried outdoors, cleaned and stored in darkness in a cool room at 10°C. Japanese millet (*Echinochloa crus-galli* (L.) P.Beauv.) was purchased commercially.

Seed emergence study Seed persistence was examined in a heavy textured vertosol near Toowoomba in southern Queensland. Five hundred and forty seeds of barnyard grass were buried at 0–2, 5 and 10 cm depths in in-ground pots in June 2003. The pots were maintained in the field and were not irrigated. The experimental design was a randomised complete block with three burial depths (0–2, 5, and 10 cm), seven exhumation periods (2, 4, 6, 12, 18, 24, and 36 months after burial), and three replicates. Emerged seedlings were counted and removed for a period of 36 months. Rainfall data were collected throughout the trial.

Seed persistence study The treatments and experimental design were the same as the emergence study mentioned above. After the burial of barnyard grass seeds for the specified exhumation period, the seeds from the three burial depths were extracted, counted, and subjected to a germination test. Fifty extracted seeds were placed into a 9 cm Petri dish and incubated in a growth cabinet at 20°C in 12 h light. Germinated seeds were counted daily. After 14 days of incubation, seeds that did not germinate were dissected and subjected to a tetrazolium viability test.

Sorghum agronomy experiment Sorghum cv. MR Buster was planted in early November 2003 near Toowoomba. Treatments were three row configurations, which were 1 m row (solid), single skip (third row missing), and double skip (third and forth row missing), with and without weeds. A randomised complete block design with three replications was used. Weed-free plots were manually hoed. Weedy plots were sown with Japanese millet as a model weed similar to barnyard grass. The millet was sown immediately before the sorghum planting, and an average population of 72 plants m^{-2} of Japanese millet was established. Weed biomass and seed production, and sorghum populations and yields were determined.

Sorghum atrazine efficacy experiment This experiment was conducted on a farm near Millmerran in southern Queensland in October 2003. Barnyard grass was one of the dominant weed species in the field. Sorghum MR Buster was sown at approximately 60,000 plants ha^{-1}. A randomised complete block design with three replications was used. Ten atrazine-based herbicide treatments were studied, including atrazine with and without metolachlor, fluroxypyr, and bromoxynil, applied at different weed growth stages, with and without soil incorporation.

Data analysis All data were subjected to analysis of variance using Genstat 6 (Release 6.1) and the treatment means were tested for least significant difference at a 5% level of probability.

RESULTS

Seed emergence The surface 0–2 cm was the most active soil layer for seed dormancy loss and emergence. The fresh barnyard grass seeds were 100% dormant when sown, based on a germination test. A tetrazolium test showed that 80% of the initial seeds were viable. Seed dormancy was lost rapidly within the first four months of burial, resulting in the first major flush of barnyard grass emergence in October 2003 (Figure 1). Emergence of the buried seeds was highly dependent on the available soil moisture. After the burial of seeds in June 2003, three peaks of emergence were identified, with 6.4%, 7.2%, and 3.6% emergence in October, December 2003, and January 2004, respectively. These three flushes of emergence correlated well with the amount of rainfall received during that period, such as 90, 141 and 140 mm in October, December 2003, and January 2004, respectively. However, the emergence did not correspond well to amount of rainfall between February and March 2004, which was 76 and 77 mm and should have provided sufficient soil moisture for barnyard seeds to emerge. However, only a very limited number of barnyard grass seedlings emerged during these two months, at 0.2% and 0.1%, respectively, indicating that barnyard grass seeds might have experienced induced dormancy.

Table 1. Seed persistence of barnyard grass (*Echinochloa colona)* at three burial depths and three exhumation periods, expressed as a per cent of the original number of sown seeds.

Exhumation (months after sowing)	Burial depth (cm)		
	0–2	5	10
		Viable seeds	
2	59	53	75
4	50	34	54
6	19	23	46
		Dormant seeds	
2	37	11	37
4	18	14	19
6	9	7	15

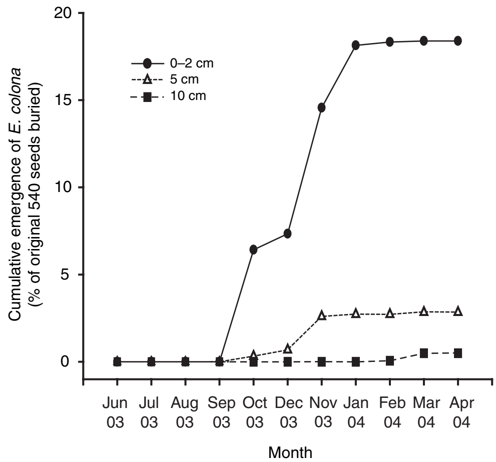

Figure 1. Cumulative emergence of barnyard grass (*Echinochloa colona*) sown in June 2003 at burial depths of 0–2, 5 and 10 cm.

Emergence of barnyard grass decreased significantly with increasing soil depth. For example, 6.4% of the original buried seeds emerged in October 2003 at the depth of 0–2 cm, while only 0.3% and 0% emergence was found at the burial depths of 5 and 10 cm, respectively (Figure 1). Little emergence was found at the burial depth of 10 cm during the experimental period.

Seed persistence The number of viable seeds in the soil was significantly influenced by the burial depth and duration (Table 1). Persistence (viability) declined steadily during the first six months of burial, irrespective of the burial depths. Percentage of viable seeds decreased from the initial 80% to 19% after six months of burial at 0–2 cm, and to 23% and 46% at soil depths of 5 cm and 10 cm, respectively. Compared with 0–2 cm and 5 cm burial depths, seeds buried at 10 cm depth were able to maintain a higher percentage of viability irrespective of exhumation periods, indicating that seeds buried deeply in the soil would persist longer than those near the soil surface.

Similarly, the number of dormant seeds declined significantly after six months of seed burial at the three soil depths examined (Table 1). Seeds buried at 10 cm depth contained a higher percentage of dormant seeds. Irrespective of the duration of seed burial, the percentage of dormant seeds at 5 cm soil depth was significantly lower than at burial depths of 0–2 cm and 10 cm, indicating that seeds at the soil surface or at deeper soil might experience induced dormancy under unfavourable conditions.

Effects of row configurations on weed suppression and sorghum yield Sorghum growing conditions were ideal in the summer season of 2003/04. During the early establishment stage, two light irrigations were also applied to achieve optimum sorghum and millet emergence. Sorghum planted in the traditional 1 m solid row configuration had significant yield advantages, as yield declined by 40% for single skip, and 50% for double skip (Table 2).

Sorghum planting configurations also had significant effects on weed growth. The wider row spacings were associated with higher weed populations, weed biomass (Table 2) and effective tillers. Weeds had substantial effects on sorghum yield, resulting in 27%, 23%, and 7% yield reduction in solid, single skip, and double skip, respectively.

Table 2. The impact of sorghum row spacing and presence of weeds on weed biomass and yield.

Treatment		Weed biomass	Sorghum yield
Row spacing	Weeds	($g\ m^{-2}$)	($t\ ha^{-1}$)
Solid	+	933	7.4
	–		5.4
Single skip	+	1400	5.4
	–		4.1
Double skip	+	2008	3.3
	–		3.1

Atrazine efficacy in sorghum The soil incorporated treatment of atrazine at 4 L ha^{-1} + metolachlor at 2 L ha^{-1} at planting provided the most effective seasonal control on barnyard grass. This treatment gave 96% control at 50 days after treatments (DAT), and 88% at 95 DAT. The other treatments did not provide satisfactory control, ranging from 0 to 74%.

DISCUSSION

The emergence of barnyard grass decreased significantly with increasing burial depth. This trend has also been observed by Sumiyoshi (2000) and Benvenuti and Macchia (2001). Barnyard grass rapidly lost dormancy after a few months of burial in the field. Frequent thunderstorms in the summer season of southern Queensland will result in a number of barnyard grass flushes as reported in this study, thereby creating difficulties in the effective control of this weed. Seasonal dormancy of barnyard grass seeds was found in this study, which was similar to the dormancy dynamics reported in other weeds (Baskin and Baskin 1985, Benech-Arnold *et al*. 2000).

Seed persistence of barnyard grass was influenced by soil burial depth and duration of the burial. The number of viable and dormant seeds decreased rapidly with the increasing burial depths and duration. Seeds buried deeper in the soil are able to persist longer, thereby providing a potential seed source of further infestation.

The success of barnyard grass is attributed to prolific seeding, seed dormancy, emergence patterns, and its ability to grow rapidly and flower in a range of photoperiods. The best long-term management strategy for barnyard grass is to integrate both chemical and non-chemical options to manage survivors and prevent the replenishment of new seeds into the soil seedbank. This study showed that wider row spacings in sorghum provided an ideal open canopy for weed growth, resulting in higher weed populations and biomass, and seed production. However, the weed can be effectively controlled by soil incorporation of atrazine and metolachlor at sorghum planting. Experimental data on the effects of sorghum density and cultivar competitiveness on barnyard grass have also been collected and are being analysed. Manipulation of sorghum agronomy can provide a non-chemical means in managing barnyard grass.

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