# Pasture legumes offer promise to control barnyard grass in delayed permanent water systems in rice

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## Abstract
Australian rice growers endeavour to reduce water use in their rice crops due to high competition for scarce water resources. One method increasing in popularity is to drill sow rice and delay the application of permanent water. This water saving method however, provides an opportunity for the global weed barnyard grass to proliferate. Farmer anecdotes have suggested that the resultant barnyard population is determined to some extent by the lead-in crop or pasture. This paper considers the impact of particular pasture legumes on the barnyard grass seedbank and seedling establishment. Data show that there is some validity in the farmer experience with barnyard grass being inhibited by legume species as the lead-in 'crop'.

## Key Words
Pasture legume-rice rotation, water saving strategies, seed mortality

## Introduction
The decline in water availability and the impelling effort towards increasing water productivity are the major drivers for the adoption of water saving strategies such as drill sowing of rice with delayed application of permanent water (DPW) until late tillering for rice crop production. However, weeds such as barnyard grass are considered a major threat to sustaining water productivity gains in these water-saving strategies. Direct drill sowing of rice prior to DPW results in the concurrent establishment of rice and barnyard grass, and favours the increase in barnyard grass densities (Bajwa and Chauhan 2017). This increases the competitiveness of barnyard grass against rice (Ampong-Nyarko and De Datta 1991). Moreover, the biggest risk involved with DPW is insufficient herbicide residual control for barnyard grass (Dunn and Ford 2018).

Barnyard grass [*Echinochloa crus-galli* (L.) Beauv.] is an annual summer terrestrial grass weed. It has been reported across 61 countries and grows as a weed in 36 different crops (Holm *et al*., 1991). In rice it has been reported to cause 30-100% rice yield reduction (Chauhan and Johnson 2011) and cause rice seed contamination during harvest (Pratley *et al*. 2008). It is recognized as a major weed species in Australian rice (Bajwa and Chauhan 2017) and is reported to have evolved herbicide resistance to nine herbicide modes of action, in 20 countries and in 4 crops including rice (Heap 2018). Therefore it is imperative to find effective alternative means to manage this problem weed.

According to Lattimore (1994), pastures in rotation with rice may help to manage weeds. The role of the pasture legumes for weed management in rice rotations in Australia has long been recognized, but the nature of the suppression in this system is poorly understood. Hence, this study aimed to determine the effects of the pasture legumes on barnyard grass seed mortality, emergence and growth during and after the winter cropping season.

## Methods
*Effect of pasture legumes and winter crops on barnyard grass seed mortality, emergence and growth.*
A glasshouse pot trial and associated field trial were conducted to determine the effects of the different species of annual pasture legumes and selected winter crops on the seed mortality of barnyard grass. The trials were conducted at the Charles Sturt University Horticulture field bay and glasshouse from May 2018-January 2019.

Pasture legume species (balansa clover cv Border, Persian clover cv Shaftal, and subterranean clover cv Antas were sown at 10 kg ha$^{-1}$ and winter crops (canola cv AV Garnet and barley cv Hindmarsh) were sown at 4 kg ha$^{-1}$ and 110 kg ha$^{-1}$ seeding rates, respectively. Fertilizer was applied as follows; basal application of single super phosphate (45% $P_2O_5$) at the rate of 200 kg ha$^{-1}$ in all pots/plots, and side dress application of urea (46%N) at the rate of 100 kg ha$^{-1}$ in the control (no crop), canola, and barley pots/plants at 21 days after sowing (DAS). Pots were initially sprinkler irrigated and then sub-irrigated during the entire growing period while the field plots were initially flooded and sprinkler irrigated as needed. The soil used in the pot trial was collected from the Charles Sturt University Horticulture field bay. The soil had been under fallow condition from previous year, brown in colour, clay texture and with pH ($CaCl_2$) of 5.3. Freshly harvested barnyard grass seeds from 2017-2018 drill-sown rice crops were placed inside packets (100 seeds per packet) and buried at different depths (0, 5, and 10 cm) in pots and in field plots sown with the different pasture legumes, crops and control (nil sown) pots/plots. The barnyard grass seed germination rate at the time of burial was 1%.

During retrieval, the total mortality and total remaining viable barnyard grass seeds placed inside the packets at different burial depths were recorded. The retrieved seeds were tested for feel method (decayed or intact), germination, and viability. In the feel/pressure method, barnyard grass seeds that were weak and broke under little pressure using fingers were recorded as decayed. Seeds which germinated inside the packets were added to the mortality. The other retrieved weed seeds were tested for germination. All seeds which did not germinate were tested for viability using tetrazolium chloride (TZ) at 1% (1 mg TZ per 100 mL distilled water). All seeds which tested as not viable were considered as dead barnyard grass seeds.

*Effect of pasture legumes and winter crops on barnyard grass emergence and growth.*
A second set of seeds of barnyard grass were prepared where 100 barnyard grass seeds were mixed with 5g of sieved soil and broadcast on the soil surface of pots at 21 DAS of the three pasture legumes, winter crops (canola and barley), and control. During harvest the shoots (leaves, stems, and inflorescence) were cut, oven dried at 40°C until weight are constant, and the biomass was recorded. The barnyard grass emergence was monitored and recorded as total emergence at the end of the trial. Barnyard grass biomass was also recorded, as per the method described above. The pots were arranged in a two factorial randomized complete block design (RCBD) and the field plots were arranged in a split plot RCBD, both with four replications.

*Analysis*
All data were analysed using ANOVA to evaluate differences between treatments and the means were separated using the least significant differences (LSD).

**Results**
The seed mortality of barnyard grass was not influenced by any of the pasture legumes and winter crops in either glasshouse or field studies (Figure 1 and 2). However, barnyard grass seed mortality rates (13-20%) were observed to be higher in pots/plots without any crop and where barnyard grass seeds were placed on the surface in both trials. Results also showed that the % viable (dormant and non-dormant) barnyard grass seeds after retrieval remained high, ranging from 88-98%. This suggests that after one season of pasture legumes or winter crops a high proportion of barnyard grass seeds is likely to add to the soil seedbank or germinate in the following summer crop.

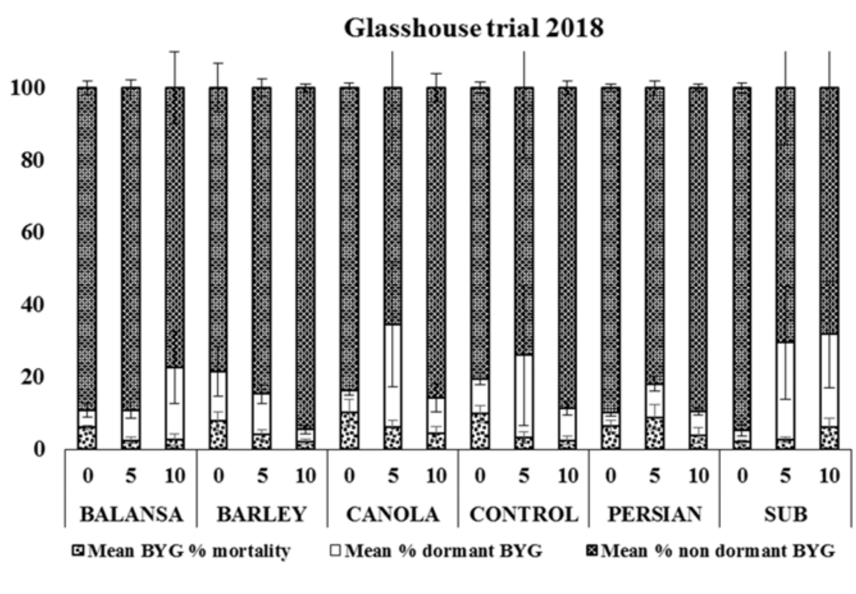

**Figure 1. Effect of pasture legumes and selected winter crops and depth of burial treatments (0, 5 and 10 cm)on the % seed mortality and viability (dormant and non-dormant) of barnyard grass seeds. (Glasshouse trial)**

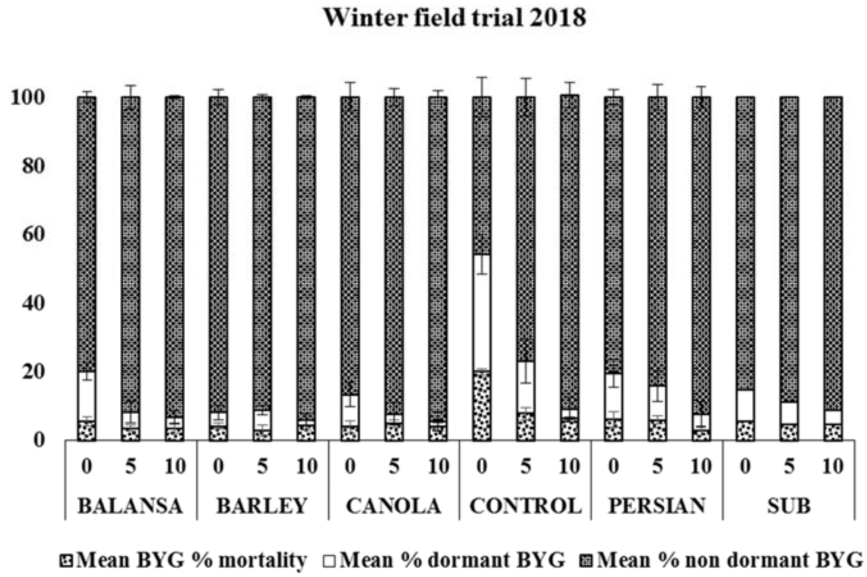


**Figure 2. Effect of pasture legumes and selected winter crops and depth of burial treatments (0, 5 and 10 cm) on the % seed mortality and viability (dormant and non-dormant) of barnyard grass seeds. (Field trial)**

Barnyard grass emergence and growth were influenced by the pasture legumes and winter crops (Table 1). During the winter cropping season lower barnyard grass emergence was observed with pots sown with balansa (2 $m^{-2}$), subterranean (7 $m^{-2}$), and Persian clovers (20 $m^{-2}$) compared with control (97 $m^{-2}$), canola (78 $m^{-2}$), and barley (70 $m^{-2}$). Barnyard grass biomass was also lower in pots sown with pasture legumes: balansa (0 g $m^{-2}$), subterranean (0.10 g $m^{-2}$), and Persian (0.40 g $m^{-2}$) clovers, and winter crops canola (0.40 g $m^{-2}$) and barley (0.50 g $m^{-2}$) compared with control (34.20 g $m^{-2}$). Results showed a 97-98% reduction in emergence and a 99-100% reduction in growth of barnyard grass in pots sown with pasture legumes compared with control pots. Reduced emergence and growth of barnyard grass observed may be due to competition for light, space, nutrients, and water, inhibitory chemical compounds exuded by the plants, or some combination.

**Table 1. Effect of pasture legumes/winter crops on emergence and growth of barnyard grass.**

| Crop treatment | BYG count (n $m^{-2}$) | BYG biomass (g $m^{-2}$) |
|---|---|---|
| Control (no crop) | 97 | 34.20 |
| Canola (cv AV Garnet) | 78 | 0.40 |
| Barley (cv Hindmarsh) | 70 | 0.50 |
| Subterranean (cv Antas) | 7 | 0.10 |
| Balansa (cv Border) | 2 | 0.00 |
| Persian (cv Shaftal) | 20 | 0.40 |
| *LSD* (P=0.05) | *43.72* | *20.57* |

## Conclusion

The results of the study suggest that pasture legumes in rotation can be integrated as a tool to impede barnyard grass in water saving methods in rice. The pasture legumes reduced the densities and growth of barnyard grass during the winter cropping season.


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