Tillage system effects on seedling recruitment pattern and persistence of *Lolium rigidum* Gaudin (annual ryegrass) seed-bank

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Abstract

In the growing season of 2003, a field study was undertaken to investigate the effects of tillage systems on the vertical distribution, recruitment pattern and persistence of *Lolium rigidum* Gaudin (annual ryegrass) seed-bank. The tillage systems comprised low soil disturbance discs (Day-Break and K-Hart), intermediate narrow openers (16 mm Harrington knife point) and high disturbance Ribbon seeder (178 mm wide point). Assessment of vertical distribution of weed seeds after the sowing operation showed that in the case of the disc systems most (76%) of *L. rigidum* seed remained on the soil surface. In contrast, the surface seed-bank was considerably lower in the Harrington knife point (42%) and the Ribbon seeder (11%) systems. In the Ribbon seeder, about 80% of the seeds were found in the 1-5 cm soil layer, which is optimal seed placement for rapid germination. This difference between the tillage systems in the vertical distribution of seeds may have been responsible for the slower and lower final recruitment of *L. rigidum* seeds in the two disc systems. The persistence of *L. rigidum* seed however, was extremely high but unaffected by the tillage system. Irrespective of the tillage system, about 50% of *L. rigidum* seed carried-over from one growing season to the next, which is much greater than previously reported. The soil at this study site was non-wetting in nature and this may have been responsible for the unusually high persistence of the seed-bank of this species. Further research is needed to investigate the effects of non-wetting soils on the ecology and management of weed species.

Media summary

Tillage systems affected the recruitment of weed seedlings from the seed-bank. Presence of unusually persistent *L. rigidum* seed-bank on non-wetting soils has important implications for weed management.

Key Words

Seed-bank, tillage, *Lolium rigidum*

Introduction

The use of no-till is increasing rapidly in the farming systems of southern Australia and weed management is going to be an important issue in the long-term viability of the system. The effect of tillage systems on seedling recruitment depends on many factors including the level of soil disturbance and its interaction with the weed species present. The level of soil disturbance from pre-sowing tillage and the sowing operation itself affects the vertical distribution of weed-seeds in the soil (Yenish et al. 1996). However, the impact of changes in the vertical seed distribution on weed seedling recruitment is unclear. There is some evidence for lower weed seedling recruitment under reduced tillage systems such as no-till, but often the responses are species specific (e.g. Buhler and Daniel 1988, Mohler and Galford 1997).

The fate of weed-seeds that fail to germinate under no-till is also unclear. Do the weed seeds that fail to germinate under no-till or zero-till systems decay before the start of the next growing season, or do they become part of a more persistent seed-bank? In order to improve weed management in changing tillage systems it is important to understand the ecology of the weed seed-bank under different tillage systems. This study was conducted to assess the impact of different no-till seeding equipment on the emergence of *L. rigidum* from the seed-bank and the persistence of the residual seed-bank.

Material and Methods

Site description and data analysis

The field study was conducted near Minlaton on the southern Yorke Peninsula of South Australia. The soil of the experimental field was sandy loam in texture and was known to have some non-wetting properties. Wheat (*Triticum aestivum*, cv. Krichauff) was sown on 15th June, 2003.The experiment was arranged as a split-plot design with tillage systems as the main-plots and herbicide treatments as the sub-plots. The tillage systems comprised Day-Break and K-Hart (low soil disturbance discs), Harrington knife point (intermediate soil disturbance 16 mm narrow point) and Ribbon seeder (high disturbance 178 mm wide point). The data on herbicide efficacy are not presented in this paper. Each treatment was replicated four times. Analysis of variance was conducted on all data using GENSTAT 5.

Vertical seed distribution

To quantify vertical seed distribution, 2 g (about 945 seeds) of *L. rigidum* seeds coated with a fluorescent pigment (Blaze Orange?) were uniformly broadcast in each plot over an area of 0.5 m? just before sowing. Soil cores (7 cm diameter) from different depths (0-1, 1-5 and 5-10 cm) were taken immediately after the sowing operation. Seeds that fluoresced under ultraviolet light in the laboratory darkroom were counted in each layer of the soil.

Recruitment pattern

Two permanent quadrats (0.5 m x 0.5 m) were placed in each control plot (not treated with any herbicide) to determine the recruitment pattern under different tillage systems. *L. rigidum* seedlings emerging within these quadrats were counted at 18, 31 and 45 days after wheat was sown.

Persistence of L. rigidum seed-bank

To estimate the initial seed-bank of *L. rigidum*, 20 soil cores (7 cm in diameter) were taken immediately after wheat was sown. In each plot, cores were taken diagonally (10 cores per diagonal) and to a depth of 10 cm. The soil samples were washed through metal sieves (0.5 mm diameter) and then dried at 40?C prior to counting the number of *L. rigidum* seeds in each sample. To estimate the residual seed bank, 20 cores were taken in the spring (September – prior to new seed-set) from the plots sampled earlier at sowing. This seed bank was also estimated by the method described above.

Results and Discussion

Low disturbance disc systems retained more than 75% *L. rigidum* seeds on the soil surface, while the high soil disturbance Ribbon seeder buried more than 75% of the seeds to a depth of 1-5 cm (Fig. 1). The Ribbon seeder left only 11% seeds on the surface while the knife point system was intermediate with 41% seeds remaining on the soil surface. Only a small proportion of the total seed-bank was found in the 5-10 cm soil layer for all the tillage systems investigated. Similarly Yenish et al. (1996) found that in the no-till system more than 90% of glass beads, representing seeds, remained in the top 2 cm of the soil profile while the mouldboard ploughing buried 50 to 60% of seeds to a depth of 11 to 16 cm.

In our study, plots sown with the two disc systems (Day-Break and K-Hart) had significantly lower recruitment of *L. rigidum* than the other tillage systems (Fig. 2). The narrow point seeder (Harrington knife point), which gives intermediate soil disturbance, had greater germination (914 plants/m?) than discs (693 plants/m?) but lower than the Ribbon seeder (1186 plants/m?). At the date of the last seedling census (45 days after sowing), *L. rigidum* density in the Ribbon seeder sown plots was nearly 500 plants/m? greater than in plots sown with the Day-Break system. Lower seedling establishment under the disc systems could be due to more rapid desiccation of seeds on soil surface. Predation of seeds by insects is also likely to be greater in seeds present on the soil surface.

The initial seed-bank of *L. rigidum* at the experimental site was estimated to be more than 4000 seeds/m^2. Although there were significant differences between the tillage systems in the recruitment of this weed (Fig. 2), these differences were not reflected in the size of the residual seed-bank present at the end of the growing season (Fig. 3). The carry-over of old seeds (residual seeds) from one year to the next was found to be around 50%, which indicates long-term dormancy in the seeds of this species. In contrast, earlier studies on *L. rigidum* indicated seed persistence levels well below 10% (e.g. McGowan 1970). However, in a later study in Western Australia, Peltzer and Matson (2002) reported 20-30% persistence of *L. rigidum* seed-bank. It appears that the dominant influence on seed persistence at this site was the non-wetting nature of the soil. Consequently, smaller differences due to tillage systems may have become difficult to detect. Not all of the seeds that appeared visually intact in the anthesis sampling may have retained viability. Therefore, follow-up studies are being undertaken to determine the viability of the residual seed-bank.

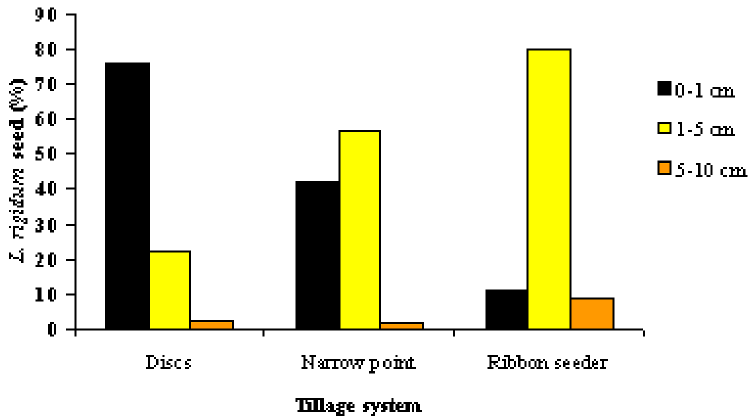

Figure 1. Tillage system effects on the vertical distribution of *L. rigidum* seed

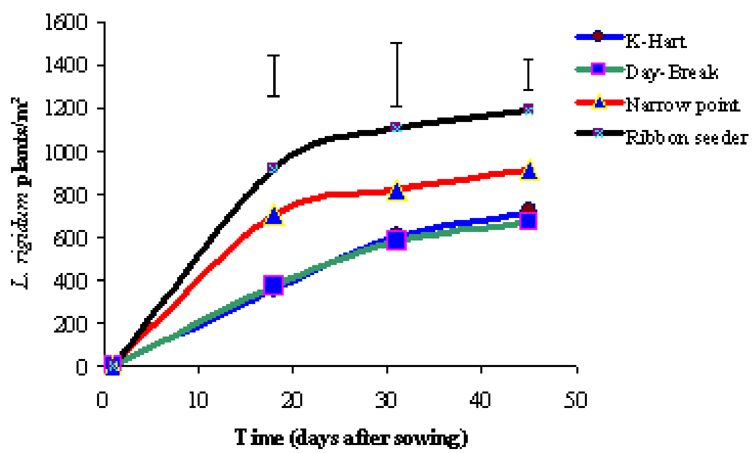

Figure 2. Tillage system effects on the recruitment pattern of *L. rigidum*; vertical bars represent LSD (P=0.05)

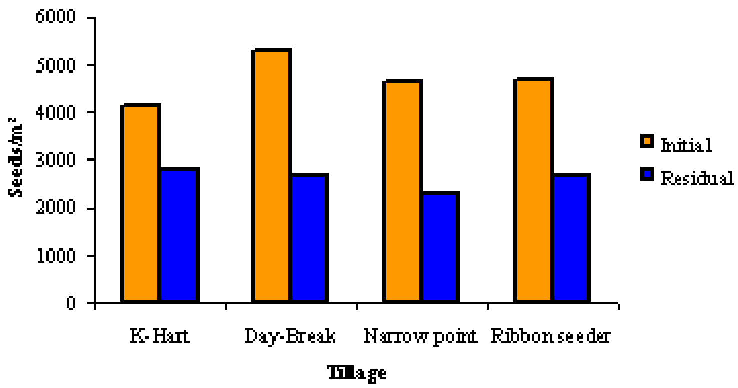

Figure 3. Tillage system effects on the persistence of *L. rigidum* seed (P > 0.05; non-significant)

Conclusion

The distribution of surface seeds of *L. rigidum* through the soil profile was correlated with the level of soil disturbance. Low disturbance seeding equipment left more seed on the surface; however, none of the seeding equipment buried much seed below 5 cm. Seeding machines with disc openers left most of the seeds on the soil surface which may have caused slower and reduced establishment of *L. rigidum* from the seed-bank. Seeding equipment had no influence on the residual *L. rigidum* seed-bank in this study, suggesting a need for further research on *L. rigidum* population dynamics in non-wetting soils. This persistent seed-bank may have important ramifications for weed control in no-till seeding systems.

Acknowlegements

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