

Influence of tillage on patterns of weed seedling emergence in rice

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Summary Differences in weed seedling emergence patterns due to agronomic management practices, such as tillage, have implications for weed competition and weed management strategies. The effect of different tillage systems, including conventional (CONT), minimum (MINT) and zero tillage (ZT), on the emergence pattern of different weed species was evaluated in a field experiment. Seedling emergence of *Digitaria ciliaris* (Retz.) Koel., *Echinochloa colona* (L.) Link, *Eleusine indica* (L.) Gaertn., *Ageratum conyzoides* L., *Eclipta prostrata* (L.) L. and *Portulaca oleracea* L. was greater under ZT compared with the other two tillage systems. MINT had greater emergence of *E. colona*, *E. indica* and *A. conyzoides* compared to CONT, while the emergence of *D. ciliaris*, *E. prostrata* and *P. oleracea* was similar between these two systems. The results will facilitate improved decision making with respect to the timing of weed control and contribute to the development of integrated weed management practices for dry seeded, rainfed rice.

Keywords Zero till, conservation tillage, seed bank.

INTRODUCTION

Reduced tillage or conservation tillage is being widely promoted in Asia to reduce soil erosion, improve soil physical and chemical properties, conserve soil moisture and save fuel costs. Changes in tillage practices may also be a major influence on the relative abundance of weed species in the field (Froud-Williams *et al.* 1981). Tillage can affect the vertical distribution of seeds in the soil (Chauhan *et al.* 2006a) and this differential distribution of seeds in the soil profile may change weed population dynamics (Buhler 1991). Where the response of weed seedling emergence to tillage is species specific, change in the tillage system has the potential to cause major change in the composition of weed flora in the field (Froud-Williams *et al.* 1981). There is little research data available however in relation to the weed species occurring in rice. The trend toward reduced tillage is likely to continue and therefore research is needed to understand the effects of tillage on shifts in weed flora. The aim of the research was to determine the influence of different tillage systems on the seedling emergence pattern of major weed species in rainfed rice.

MATERIALS AND METHODS

The effect of tillage systems on seedling emergence pattern of *Digitaria ciliaris*, *Echinochloa colona*, *Eleusine indica*, *Ageratum conyzoides*, *Eclipta prostrata* and *Portulaca oleracea* was studied during the wet season of 2007 on the farm of International Rice Research Institute, Los Baños, Philippines. The tillage systems comprised conventional (CONT), minimum (MINT) and zero till (ZT). Seed (500 m⁻²) of each of these species were spread in fixed quadrats (size 1 m × 1 m) in mid April 2007. Control plots where seeds were not spread were included in the experimental layout.

Two pre-sowing cultivations to a depth of 8 cm were given to the CONT plots, while the MINT plots were cultivated once to a depth of 5 cm before crop sowing. In the ZT plots, soil disturbance was limited to the sowing operation only. Rice variety 'RC 9' was sown in all tillage systems with a combine drill fitted with double-disc soil openers. The rice was sown in rows 25 cm apart on May 31, 2007. Weed seedling emergence was measured at 0, 7, 14, 21, 28, 35, 42, 49, 56, 63 and 70 days (d) after rice sowing and expressed as a percentage of the seed bank at sowing.

The experiment was arranged in a split-plot design with tillage systems as the main-plots and weed species as the sub-plots. There were four replicates of each treatment. Seedling emergence values for each species under different tillage systems were fitted to a functional three-parameter sigmoid model $\{E = E_{max}/[1 + \exp(x - T_{50}/E_{rate})]\}$; where E is the total seedling emergence (%) at time x , E_{max} is the maximum seedling emergence (%), T_{50} is the time (d) to reach 50% of the maximum seedling emergence, and E_{rate} indicates the slope} with the use of SigmaPlot 10.0.

RESULTS AND DISCUSSION

Control plots indicated that there was no background seed bank of these species in the study area. Seedling emergence of all the tested species was greater under ZT as compared to the MINT and CONT sown plots (Figure 1 and Table 1). The maximum seedling emergence of these weed species ranged from 15.4 to 22.4% under ZT, 2.0 to 11.6% under MINT, and 0.8 to 6.4% under CONT. MINT had greater emergence of *E. colona* (12% vs. 6%), *E. indica* (9% vs. 4%) and

A. conyzoides (7% vs. 2%) compared to CONT, while the emergence of *D. ciliaris* (3 to 5%), *E. prostrata* (1 to 2%) and *P. oleracea* (3 to 5%) was similar between these two systems. The time taken for 50% seedling emergence (T_{50}) and the rate of emergence (E_{rate}) of different species was variable among the tillage systems. For example, T_{50} for *E. prostrata* was 7.3 and 28.8 d under ZT and CONT, respectively, while these values for *E. indica* was 13.8 and 8.8 d.

Results of past research investigating weed populations in crops have been variable. *Vulpia bromoides*

(L.) S.F.Gray density, for example, was increased but *Lolium rigidum* Gaudin density was decreased in no-till compared to MINT (Chauhan *et al.* 2006b). In our study, density of all the tested species was greater under ZT. Light stimulates germination in all these species, except *E. indica* in which seed germinate equally in light and dark (Chauhan and Johnson unpublished data). Light can penetrate only in the surface layer of soil (Egley 1986), but seed under MINT and CONT are buried deep. Moreover, seed buried too deep may have insufficient reserves to support hypocotyl

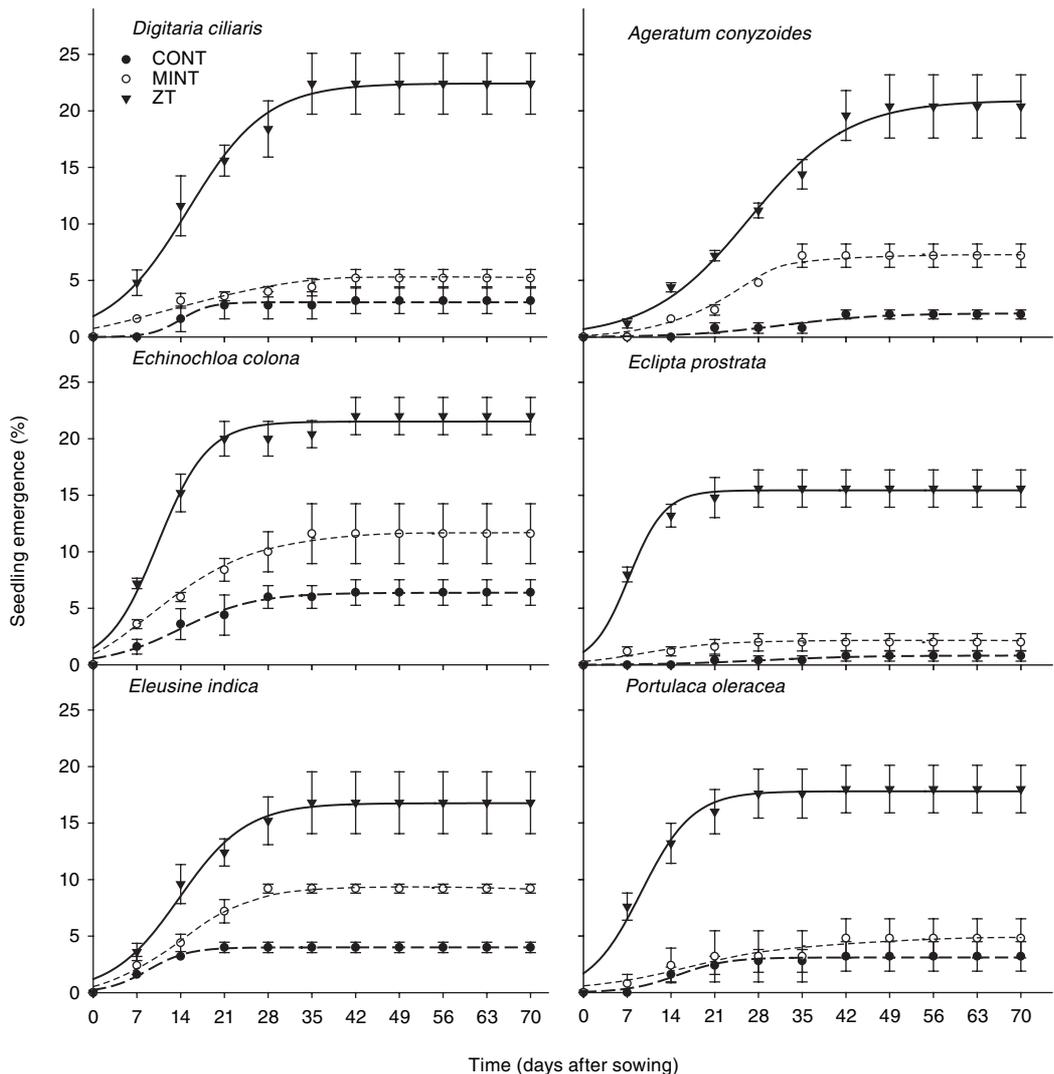


Figure 1. Seedling emergence pattern of different weed species as influenced by conventional tillage (CONT), minimum tillage (MINT) and zero till (ZT). Vertical bars represent \pm SE values and lines represent a three-parameter sigmoid model fitted to the data.

Table 1. Parameter estimates (E_{max} – maximum seedling emergence (%), T_{50} – time to reach 50% of the maximum seedling emergence (d) and E_{rate} – slope) of a three-parameter sigmoid model fitted to the seedling emergence data of different weed species in zero till (ZT), minimum tillage (MINT) and conventional tillage (CONT).

Species	Parameter estimates											
	ZT				MINT				CONT			
	E_{max}	T_{50}	E_{rate}	r^2	E_{max}	T_{50}	E_{rate}	r^2	E_{max}	T_{50}	E_{rate}	r^2
Grassy species												
<i>D. ciliaris</i>	22.4	15.1	6.3	0.99	5.1	13.8	7.7	0.95	3.1	14.0	2.4	0.98
<i>E. colona</i>	21.5	10.4	4.0	0.99	11.6	14.1	6.4	0.99	6.4	14.0	5.9	0.98
<i>E. indica</i>	16.8	13.8	5.4	0.99	9.3	14.1	5.1	0.99	4.0	8.8	3.2	0.99
Broad-leaved species												
<i>A. conyzoides</i>	20.9	26.5	7.9	0.99	7.3	23.8	5.1	0.99	2.1	31.9	7.6	0.93
<i>E. prostrata</i>	15.4	7.3	2.9	0.99	2.0	9.5	6.1	0.92	0.8	28.8	8.0	0.93
<i>P. oleracea</i>	17.8	9.3	4.1	0.99	4.8	18.7	9.6	0.93	3.1	15.1	3.9	0.98

elongation. ZT may therefore favour seedling emergence of weeds with a small seed size and those that require light for germination. The results suggest that adoption of ZT techniques may encourage the emergence and prominence of these weed species in rice crop. These weed species have recently been reported to occur in 17 to 24 countries in direct dry-seeded rice (Rao *et al.* 2007).

The T_{50} for some species, for example *E. prostrata*, was lower under ZT, which may have implications for weed management in the field. It could mean that seedlings emerging earlier are likely to be more vigorous and competitive and may produce higher number of seed than seedlings emerging later in the crop. It could also mean however that these seedlings may have greater exposure and be killed more effectively by early post-emergence herbicide application.

The information gained from this study may be useful for developing predictive models and deciding optimal timing for the control of weeds in a crop. Regardless of the tillage system and weed species, maximum seedling emergence was 22%. Such a result raises some important questions: What is the long-term fate of seed that remain in the seed bank as a consequence of low seedling emergence, do they decay before the start of the next growing season or do they become part of a more persistent seed bank? There is a need for further research to address this knowledge gap in our understanding of the ecology of these weed species.

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