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Long Term Rice-Rape Seed Cropping Effects on Weed Seed Bank Size and Composition

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ABSTRACT

To study the long term rice-rape cropping effect on weed seed bank size and composition, soil samples were collected from a long term (2004–2012) experiment under the cultivation techniques of conventional tillage transplanting (CTTP), no-tillage transplanting (NTTP), conventional tillage direct seeding (CTDS), and no-tillage direct seeding (NTDS) at a various soil depths of 0-5 cm, 5-10 cm, 10-15 cm, and 15-20 cm during 2011- 2012. Results indicate that, the highest weed seed accumulation of most species was in the 0-5 cm soil depth. More than 60% (% to total weed seeds) seeds were germinated at 20 days after placement of tray (DAP). The seed bank size of *Echinochloa crus-galli*(L) under direct seeded was 53% higher than transplanted in both years irrespective of tillage system. It decreased 67% under CT and 87% under NT from 0-5 to 5-10 cm soil depth in 2011. The ranked of weed species were grass > broad leaf > sedge based on their number per unit area in both years. The rank of *Echinochloa crus-galli*(L) was CTDS > NTTDS > NTTP > CTTP among the treatments at 0-5 cm soil depth in both years. *Monochoria vaginalis* (Burm.f) Kunth, *Fimbristylis miliacea* and *C. iria* L were fewer in number. The pressure of germination of weed seeds was more at 20 DAP at 0-5 cm soil depth. Total number (up to 60 DAP) of *Echinochloa crus-galli* was higher in CTDS at 0-5 cm soil depth in both the years and drastically reduced under no tillage than under conventional tillage towards deeper horizon of soil.

Key words: Rice-rape cropping, weed seed bank

INTRODUCTION

Weed seed bank in the soil is mainly influenced by tillage system, weed management options and crop rotation. Secondary weed could be converted to become a primary weed by changing the tillage system. Direct seeded rice occupied many areas of the world and needs less aggressive tillage and a greater use of herbicides. This cultivation practice increases annual weed problems and a shift in the spectrum of annual weeds. Shrestha *et al.*, (2002) reported that, conventionally tilled land faces greater weed pressure than in no-tillage systems. Tillage system plays an important role to influence the depth distribution, abundance and species composition of seeds in the soil. Weed seeds that accumulate close to soil surface in no-till and are more or less uniformly distributed with depth by moldboard plowing in combination with disking (Ball, 1992; Yenish *et al.*, 1992). These differences in seed burial depth affect weed community composition and emerge at or near the soil surface tend to increase in reduced tillage systems (Buhler, 1995). Perennial weeds may increase after several years of reduced tillage (Barberi *et al.*, 1998; Cardina *et al.*, 1991; Triplett and Lytle, 1972; Wicks *et al.*, 1994).Weed seed bank size and composition in soil influences to a much greater by tillage systems than crop rotation (Barberi and Cascio, 2001). Higher number of annual dicot weed seed has been reported in 5-15

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cm deep in conventional tillage than in minimum tillage or reduced tillage (Vanasse and Leroux, 2000). Some information is available about weed seed bank size and composition caused by tillage system. Therefore, this study has been taken to evaluate the long term rice-rape cropping effect on weed seed bank size and composition.

MATERIALS AND METHODS

The experiment was conducted in a long term rice-rape cropping pattern research farm of Hunan Agricultural University, Hunan, China during 2004-2012 (May to September). Data were taken from 2011-2012. The experiment was laid out in a RCB (Randomized complete block) design with four replications. Factor A was tillage system; conventional tillage (CT) and no-tillage (NT), factor B was crop establishment method; transplanting (TP) and direct seeding (DS). So, crop cultivation techniques were conventional tillage and transplanting (CTTP), conventional tillage and direct seeding (CTDS), no-tillage and transplanting (NTTP) and no-tillage and direct seeding (NTDS). Animal-drawn plowing was done in conventional tillage followed by harrowing and non- selective herbicide and flooding was used in no-tillage. Twenty-five-day-old seedlings were manually transplanted at a spacing of 20 x 20 cm with one seedling per hill on 8th June in case of transplanting. Pre-germinated seeds were manually broadcasted on the soil surface at a seeding rate of 22.5 kg per ha on 24th May in case of direct seeding.

Weather condition during study period: During 2011, the highest and the lowest temperatures gradually increased from 20 - 40 days after placement (DAP) of pot and then slightly decreased at 60 DAP. During 2012, the highest temperature slightly decreased but the lowest temperature slightly increased from 20 - 60 DAP (Fig.1). Average sunshine hour (h) gradually decreased from 20 - 60 DAP in 2011. During 2012, sunshine hour sharply decreased from 20 - 40 DAP and then slightly decreased up to 60 DAP. Average rainfall sharply decreased from 20 - 40 DAP and then slightly decreased at 60 DAP during 2011. But rainfall sharply increased from 20 - 40 DAP and then sharply decreased at 60 DAP during 2012 (Fig. 2).

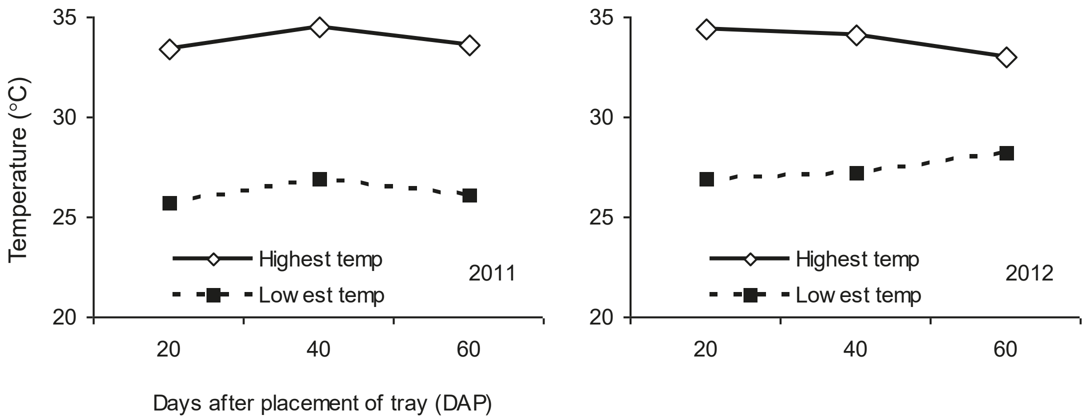


Fig. 1. Highest and lowest temperature during weed seed bank study, Hunan, China.

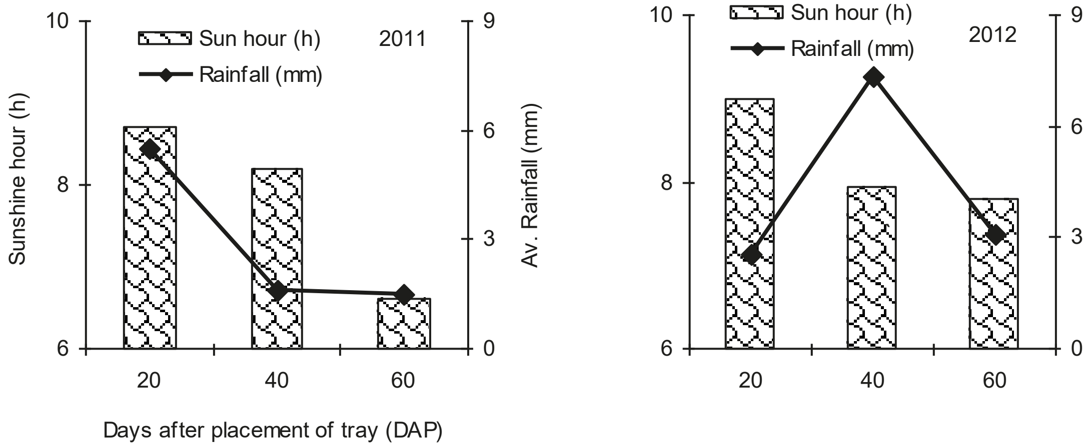
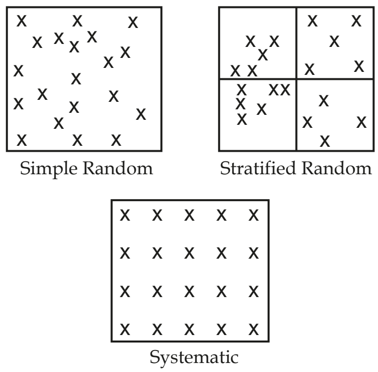


Fig. 2. Sunshine hour and rainfall during weed seed bank study, Hunan, China

Time and method of soil sampling: After harvesting of rape but before rice planting, soil samples were taken from each of the 0-5 cm, 5-10 cm, 10-15 cm and 10-20 cm soil layers of each plot. The systematic sampling plan was used in this study because it has been widely accepted, straightforward and potentially increases the accuracy of the study.



Working procedure of weed seed bank study During 2011 and 2012, soil cores were taken from 21 spots of each plot. Then bulk samples were stored for three weeks in a dark place at room temperature (Jagat *et al.*, 2007) and then transferred to plastic trays. The soil cores from each plot and each depth was combined, crumbled and laid on the tray ($5 \times 19 \times 24$ cm^3). The soil was kept moist by watering if and when necessary. To identify the number and species of weed, trays were placed under open environment at 20 June in both the years. Germinated weed seedlings were pulled out, identified and counted at 20, 40 and 60 days after placement of tray (DAP). Total number of weed (group wise) was calculated from 20-60 DAP respectively. The identified weeds were categorized into different groups' like grass, sedge, broadleaf etc.

Data analysis All data were analyzed by statistical software, Statistix9. Means of cultivation methods were compared to LSD with 0.05 probability level.

RESULTS

Total weed seed size and compositions at different soil depth and treatment: A total of five weed species were identified during 2011 and six species were during 2012 (Table 1). Out of them, the ranked of weed species were grass > broad leaf > sedge based on their number per unit area in both years. *M. vaginalis, F. miliacea* and *C. iria* were fewer in number. A total seed of *E. crus-galli* was higher during 2011 than 2012. Total number of *E. crus-galli* was significantly higher under DS than TP either in CT or NT system at 0-5 cm soil depth in both years and reduced drastically under NT towards deeper horizon of soil than under CT (Fig. 3a). Total number of *L. octovalvis* was similar in CTTP, NTTP and CTDS at 0-5 cm soil depth during 2011 but was higher in CTDS followed by NTTP during 2012. It was significantly higher in CTTP but NTTP, NTDS and CTDS were similar in number at 5- 10 cm depth during 2011and CT had significantly higher number of L. *octovalvis* than NT either in TP or DS during 2012. Same trend was observed at 10-15 cm soil depth (Fig. 3b). In case of C. *difformis*, total number was higher in CT than NT at all soil depth in both years (Fig. 3c).

Table 1. Weed species found in weed seed bank study, Changsha, Hunan, China, 2011-2012.

Latin name	Bayer code	Common name
2011		
Cyperusdifformis L	CYPD1	Sedge, small flower umbrella
Echinochloacrus-galli(L) Beauv	ECHCG	Barnyard grass
Fimbristylismiliacea (L) Vahl	FIMMI	Globe, fringe rush
Ludwigiaoctovalvis (jacq.) Raven	LUDOC	Primrose-willow, long fruited
Monochoria vaginalis (Burm.f) Kunth	MOOVA	Monochoria
2012		
Cyperusdifformis L	CYPD1	Sedge, small flower umbrella
*Cyperusiria*L	CYPIR	Flat sedge, rice
Echinochloacrus-galli(L) Beauv	ECHCG	Barnyard grass
Fimbristylismiliacea (L) Vahl	FIMMI	Globe, fringe rush
Ludwigiaoctovalvis (jacq.) Raven	LUDOC	Primrose-willow, long fruited
Monochoria vaginalis (Burm.f) Kunth	MOOVA	Monochoria

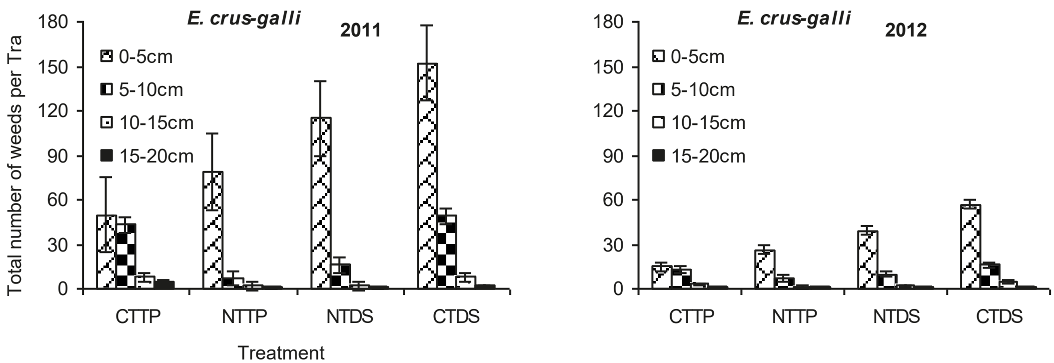


Fig. 3a. Effect of treatments and soil depth on total number of predominant weeds up to 60 DAP. Bar represents SE

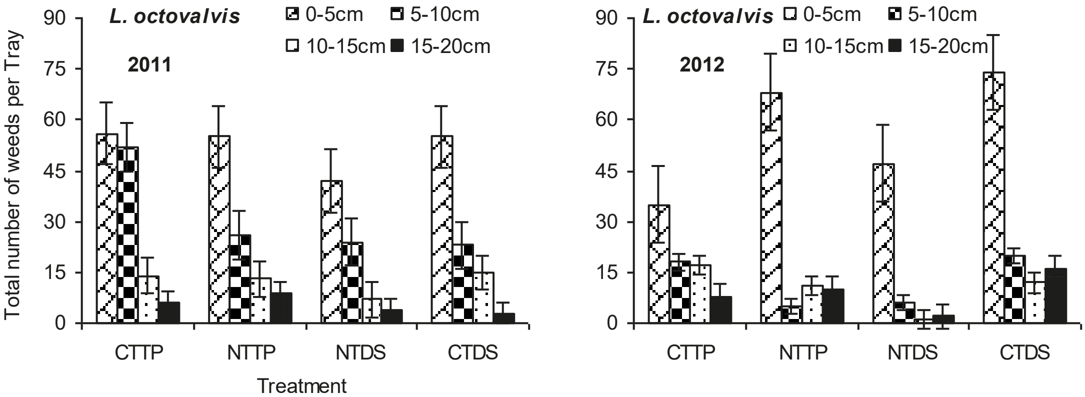


Fig. 3b. Effect of treatments and soil depth on total number of predominant weeds up to 60 DAP. Bar represents SE

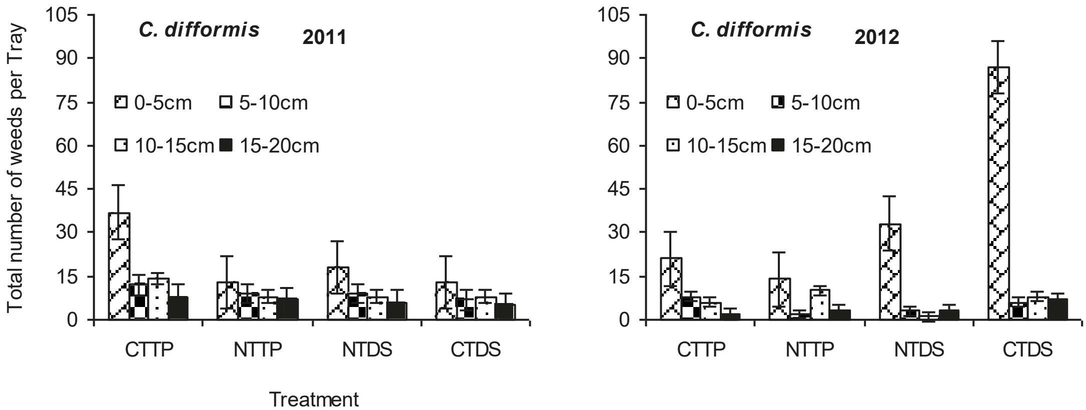


Fig. 3c. Effect of treatments and soil depth on total number of predominant weeds up to 60 DAP. Bar represents SE

Effect of soil depth and treatment on weed seed bank size and composition at different DAP

A few weeds were found at 60 DAP as well as at 15-20 cm soil depth at all treatments in both years. So, weeds on 20 and 40 DAP were reported and weeds at 15-20 cm soil depth were excluded from the presentation but were considered when calculated total number of weeds which discussed earlier.

At first counting (20 DAP) The rank of *E. crus-galli* was CTDS > NTTDS > NTTP > CTTP among the treatments at 0-5 cm soil depth in both years. *E. crus-galli* was comparatively higher during 2011 than 2012. DS plots had significantly higher number of seeds than TP plots irrespective of tillage system. In direct seeding (DS), CTDS had higher number of seeds than NTDS but they were statistically similar and in TP, higher number of seeds was found in NTTP than CTTP in both years. Tillage system had positive impact on *E. crus-galli* and towards deeper horizon of soil *E. crus-galli* reduced drastically under NT than under CT (Table 2a). Number of L. *octovalvia* was higher in 2012 than 2011 at 0-5 cm soil depth. There was no significant difference among the treatments at all soil depth during 2011. In TP, L. octovalvis was slightly higher under NT at 0-5 cm soil depth than under CT but in DS, was higher under CT than under NT in both years. Towards deeper horizon of soil, L. octovalvis decreased gradually under CT but decreased sharply under NT during 2012 (Table 2b). Number of *C. difformis* was higher in 2012 than 2011 at 0-5 cm soil depth. There was no significant difference among the treatments at all soil depth in both years except 15-20 cm during 2012. Both in TP and DS, *C. difformis* was higher under CT at 0-5 cm soil depth than under NT in both years. Towards the deeper soil depth, *C. difformis* decreased gradually under CT than NT (Table 2c).

Table 2a. Effect of treatments and soil depth on predominant weed seed size at 20 DAP

Treatment	*E. crus-galli*					
	0-5 cm		5-10 cm		10-15 cm	
	2011	2012	2011	2012	2011	2012
CTTP	38 c	10 b	31 a	8	7	2 a
NTTP	62 bc	19 ab	6 b	6	1	0 b
NTDS	95 ab	29 ab	14 b	8	2	0 b
CTDS	117 a	42 a	34 a	11	7	4 a
Analysis of variance						
Establishment method (A)	*	NS	NS	NS	NS	NS
Tillage (B)	NS	NS	*	NS	*	*
A X B	*	*	*	NS	NS	*
SE at 0.05	20.91	12.6	3.73	2.09	2.91	0.78

* = significant at $P = 0.05$, NS = not significant at $P = 0.05$.

Table 2b. Effect of treatments and soil depth on predominant weed seed size at 20 DAP

Treatment	*L. octovalvis*					
	0-5 cm		5-10 cm		10-15 cm	
	2011	2012	2011	2012	2011	2012
CTTP	13	28	17	11	7	8 a
NTTP	16	39	9	2	5	5 ab
NTDS	13	20	11	4	5	0.33 c
CTDS	19	38	13	6	14	3 bc
Analysis of variance						
Establishment method (A)	NS	NS	NS	NS	NS	*
Tillage (B)	NS	NS	NS	NS	NS	NS
A X B	NS	NS	NS	NS	NS	*
SE at 0.05	8.82	9.71	3.36	3.78	4.56	1.81

* = significant at $P = 0.05$, NS = not significant at $P = 0.05$.

Table 2c. Effect of treatments and soil depth on predominant weed seed size at 20 DAP.

Treatment	*C. difformis*					
	0-5 cm		5-10 cm		10-15 cm	
	2011	2012	2011	2012	2011	2012
CTTP	15	18	7	6	10	3
NTTP	7	9	7	1	6	6
NTDS	5	18	7	3	7	1
CTDS	8	66	5	4	8	5
Analysis of variance						
Establishment method (A)	NS	NS	NS	NS	NS	NS
Tillage (B)	NS	NS	NS	NS	NS	NS
A X B	NS	NS	NS	NS	NS	NS
SE at 0.05	5.37	31.56	4.01	2.31	2.74	3.70

* = significant at P = 0.05, NS = not significant at P = 0.05.

At 2nd counting (40 DAP) Similar trend like 20 DAP was observed in case of *E. crus-galli (*Table 3a). But in case of *L. octovalvia*, it was higher in 2011 than 2012 at 0-5 cm soil depth. There was significant difference among the treatments at all soil depth in both years. In TP, *L. octovalvis* was slightly higher under NT at 0-5 cm soil depth than CT but in DS, was significantly higher under CT than NT during 2011. With increasing of soil depth *L. octovalvis* decreased gradually under CT but decreased sharply under NT in both years (Table 3b). Number of *C. difformis* was higher in 2011 than 2012 at 0-5 cm soil depth. There was significant difference among the treatments at all soil depths during 2011. In CT, *C. difformis* was higher in TP than DS at 0-5 cm soil depth during 2011 but reversed during 2012. In NT, it was higher in DS in both years. Towards the deeper soil depth *C. difformis* decreased gradually both under CT and NT except 10-15 cm soil depth (Table 3c).

Table 3a. Effect of treatments and soil depth on predominant weed seed size at 40 DAP.

Treatment	*E. crus-galli*					
	0-5 cm		5-10 cm		10-15 cm	
	2011	2012	2011	2012	2011	2012
CTTP	10 b	4 c	9 a	5	1	1 a
NTTP	14 b	6 bc	1 b	1	1	0 b
NTDS	17 b	9 ab	1 b	2	0.33	0 b
CTDS	35 a	12 a	15 a	5	1	1 a
Analysis of variance						
Establishment method (A)	*	*	NS	NS	NS	NS
Tillage (B)	NS	NS	*	NS	NS	*
A X B	*	*	*	NS	NS	*
SE at 0.05	6.30	2.04	2.19	2.25	0.90	0.24

* = significant at P = 0.05, NS = not significant at P = 0.05.

Table 3b. Effect of treatments and soil depth on predominant weed seed size at 40 DAP

Treatment	*L. octovalvis*					
	0-5 cm		5-10 cm		10-15 cm	
	2011	2012	2011	2012	2011	2012
CTTP	24 ab	5 b	16 a	6 ab	3	8 a
NTTP	29 ab	20 ab	8 ab	1 b	4	4 ab
NTDS	22 b	20 ab	2 b	2 b	0	1 b
CTDS	36 a	25 a	10 ab	11 a	1	9 a
Analysis of variance						
Establishment method (A)	NS	NS	NS	NS	NS	NS
Tillage (B)	NS	NS	*	*	NS	*
A X B	*	*	*	*	NS	*
SE at 0.05	5.03	7.25	3.72	2.44	2.16	2.71

* = significant at $P = 0.05$, NS = not significant at $P = 0.05$.

Table 3c. Effect of treatments and soil depth on predominant weed seed size at 40 DAP

Treatment	*C. difformis*					
	0-5 cm		5-10 cm		10-15 cm	
	2011	2012	2011	2012	2011	2012
CTTP	16 a	2	5 a	1	3 a	2 a
NTTP	4 b	4	1 b	1	2 ab	3 a
NTDS	10 ab	10	2 ab	0.33	1 bc	0 b
CTDS	5 b	13	2 ab	1	0 c	2 a
Analysis of variance						
Establishment method (A)	NS	*	NS	NS	*	*
Tillage (B)	NS	NS	NS	NS	NS	NS
A X B	*	NS	*	NS	*	*
SE at 0.05	3.81	4.76	1.27	0.77	0.77	0.68

* = significant at $P = 0.05$, NS = not significant at $P = 0.05$.

DISCUSSION

Total grass weed seeds decreased over time but the pressure was more in the first 0-5-cm depth at 20 DAP. The seed bank size of *E. crus-galli* under DS was 53% higher than TP in both years. It decreased 67% under CT and 87% under NT from 0-5 to 5-10 cm soil depth during 2011. Similar trend was found in 2012. Weed seeds of sedges and broadleaf also showed a similar trend but the percent increase was not as high as in grass. About 61% weed seeds (% to total number of weed seeds) were concentrated at 0-5 cm soil depth, 25% at 5-10 cm, 10% at 10-15 cm and 4% at 15-20 cm soil depth during 2011 but were 67% at 0-5 cm soil depth, 16% at 5-10 cm, 10% at 10-15 cm and 7% at 15-20 cm soil depth during 2012. Seeds of *E. crus-galli, L. octovalvis* and *C. difformis* were 58%, 30% and 12% respectively at 0-5 cm soil depth during 2011 and were 27%, 42% and 31% during 2012. Seeds of *E. crus-galli, L. octovalvis* and

C. difformis were 41%, 45% and 14% respectively at 5-10 cm soil depth during 2011 and were 41%, 42% and 17% during 2012. More than 60% seeds were germinated at 20 DAP, 29% at 40 DAP and 10% at 60 DAP during 2011 but were 63%, 28% and 9% during 2012.

The vertical distribution of total weed seeds in the seed bank showed a declining trend in density as the depth increased from 5- 20 cm to all other treatments. *E. crus-galli* was higher in CTDS at 0-5 cm soil owing to continuous direct seeding for long time and drastically reduced under NT than CT towards deeper horizon of soil owing to tillage system. But in case of broad leaf weed, there was no distinct trend followed like grass weeds. Weed density was greater in conventionally tilled land than in no-tillage systems (Shrestha *et al.*, 2002). Weed seeds accumulate near the soil surface in NT and are more or less uniformly distributed with depth by mould board plough in combination with disking (Ball, 1992; Yenish *et al.*, 1992).

CONCLUSION

The weed seed accumulation of most species was highest in the 0-5 cm soil depth. The ranked of weed species were grass > broad leaf > sedge based on their number per unit area in both years. The rank of *E. crus-galli* was CTDS > NTTDS > NTTP > CTTP among the treatments at 0-5 cm soil depth in both years. The pressure of germination of weed seeds was more at 20 DAP at 0-5 cm soil depth. Total number (up to 60 DAP) of *E. crus-galli* was higher in CTDS at 0-5 cm soil depth in both years and was drastically reduced under NT than under CT towards deeper horizon of soil. But there was no distinct trend like followed grass weeds in case of broad leaf weed seed size and composition.

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