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Weed seed bank studies after harvest of transplanted rice

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Abstract
A field experiment was conducted during *Kharif*, 2013 and 2014, Collage of Agriculture, Rajendranagar and Hyderabad in Telangana state. Fourteen weed management practices were evaluated in a randomized complete block design, replicated thrice. Higher weed seed count (Number/kg soil) and dry weight (g/kg soil**)** at 0-10cm soil depth was recorded in T_{14} (weedy check) however it was on par with single application of herbicides penoxsulam, pyrazosulfuron ethyl, bispyribac sodium, pretilachlor and cyhalofop p butyl treatments. Major contribution towards weed seed bank was 36% grasses, 54% sedges and 35% broadleaves.

Keywords: weeds, Seed bank, transplanted rice

Introduction
Rice crop suffers from various biotic and abiotic production constraints. The transplanted rice plays a vital role in terms of rice production of the country. The direct and most important effect of weeds is the reduction in crop yields resulting from competition for water nutrients and sunlight, but also quality of grains is impaired besides causing some nuisance at the time of harvest (Rao *et al*. 2007) [9]. Greater yield losses can occur at times when weed competition coincides with the critical period of growth of rice. Yadav *et al*. (2008) [13] reported 30 to 60 days after transplanting as critical period of crop weed competition. Reduction in grain yield due to unchecked weed infestation in transplanted rice varies between 29% and 83% (Bhuvaneswari *et al*. 2009) [2]. Herbicide technology provided an alternative control method. However, the widespread use of herbicides may led to herbicide resistance in weeds. With a growing concern about sustainability of agricultural production systems, increasing the understanding of weed seed bank dynamics will improve efficiency of management. Weed seed bank refers to the weed seeds in the soil that is able to germinate under convenient conditions (Robert, 1981) [9]. Monitoring the changes in weed seed bank for extended period enables us to have an insight into efficiency of the applied measures of weed control and to predict weed occurrence in the following period (Ambrosio *et al*. 2004) [1]. Weed seed bank represents constant source of weeds, which enables their continuous occurrence in the field (Boutsalis and Powles, 1998) [3]. It is variable in space and time and largely depends on application of cultural practices, crop rotation and herbicide choice (Rosa *et al*. 2011) [11]. An important part of crop weed ecology is the weed seed bank as it is the most important source of annual weeds in cropping systems and therefore represents a significant point in the weed life cycle for control. The weed seed bank serves as a physical history of the successes and failures of cropping systems and management in a field. These relationships make understanding the weed seed bank even more important for increasing the efficiency of weed management. Keep in view the present investigation was carried out.

Materials and Methods
The soil of the experimental site was sandy clay loam in texture, neutral in reaction, low in available nitrogen, high in available phosphorus and available potassium. The experiment was laid out in randomized block design with fourteen weed management practices T1: pretilachlor 625 g a.i/ha asPE at 3 DAT, T2: pyrazosulfuron-ethyl 20 g a.i/ha3 DAT, T3: pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT, T4: pyrazosulfuron-ethyl 20 g a.i/ha at 3 DAT followed manual weeding at 25 DAT, T5: penoxsulam 22.5 g a.i/ha as early PoE at 12 DAT, T6: cyhalofop-p-butyl 100 g a.i/ha as early PoE 12 DAT, T7: bispyribac sodium 25 g a.i/ha as PoE 25 DAT, T8: azimsulfuron 35 g a.i/ha as PoE at 25 DAT, T9: bispyribac sodium 25 g a.i/ha+ ethoxysulfuron 18.75 g a.i /ha as PoE at 25 DAT, T10: bispyribac sodium 20 g a.i/ha+ metsulfuron methyl + chlorimuron ethyl 4 g a.i /ha asPoE at 25 DAT, T11: pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* ethoxysulfuron 18.75 g a.i/ha as

PoE at 25 DAT, T12: pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i/ha as PoE at 25 DAT, T13: hand weeding twice at 25 and 45 DAT and T14: weedy check.

Weed seed bank studies carried out, for this tray method technique was used. After harvesting of crop soil was sampled 1 kg using a 15 cm diameter metal core from 0-10 cm soil depth from each plot. Bulk soil samples were partially air dried and then clods were broken by hands. The collected soil samples were well labelled. Samples were spread on 30 x 20 x 5 cm plastic tray separately in almost homogeneous and uniform layer. The plastic tray was marked for each treatment separately. After this, regular watering was done up to one season. The numbers of germinated weed seedlings were counted under each treatment up to 90 days. Finally, total weed seed counts of soil was worked out for each treatment and presented as number of weeds/kg soil. Then weeds were removed, washed under tap water and dried in hot air oven at 60-65^{0}C till the constant weight was obtained. The oven dry weight of plant samples was presented as g/kg soil.

Results and Discussion

Effect of weed management practices of rice on weed seed bank (Number/kg soil) at 0-10 cm soil depth

Data pertaining to weed seed count was recorded over a period of three months were statistically analysed and presented Table 1 and 2 expressed in number/kg of soil.

Grass weed density

During both the years of study the lower grass weed seed count registered with T_{13} (hand weeding twice at 25 and 45 DAT) which was on par with T_4 (pyrazosulfuron ethyl 20 g a.i./ha as PE at 3 DAT *fb* manual weeding at 25 DAT), T_{12} (pretilachlor 750 g a.i./ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i./ha as PoE at 25 DAT), T_{10} (bispyribac sodium 20 g a.i./ha+ metsulfuron-methyl + chlorimuron-ethyl 4 g a.i./ha as PoE at 25 DAT), T_{11} (pretilachlor 750 g a.i./ha as PE at 3 DAT followed by ethoxysulfuron 18.75 g a.i./ha as PoE at 25 DAT), T_8 (azimsulfuron 35 g a.i./ha as PoE at 25 DAT), and T_9 (bispyribac sodium 25 g a.i. /ha+ ethoxysulfuron 18.75 g a.i./ha as PoE at 25 DAT). The higher grass weed seed count was recorded in T_{14} (weedy check) however it was on par with T_3 pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT, T_1 pretilachlor 625 g a.i/ha as PE at 3 DAT, T_2 pyrazosulfuron-ethyl 20 g a.i/ha 3 DAT, T_5 penoxsulam 22.5 g a.i/ha as early PoE at 12 DAT, T_7 bispyribac sodium 25 g a.i/ha as PoE 25 DAT and T_6 cyhalofop-p-butyl 100 g a.i/ha as early PoE 12 DAT treatments. Transplanted rice with conventional tillage resulted in perceptibly lesser weed seeds count. These results were in accordance with the findings of Legere and Sampson (1999) [5] who have observed higher weed biomass with more than 60 per cent of weed seedlings emerged from the surface soil layers in non-inversion chisel ploughing and no tillage systems.

Sedge weed density

The lower sedge weed seed count registered with T_{13} (hand weeding twice at 25 and 45 DAT) which was on par with T_4 (pyrazosulfuron-ethyl 20 g a.i./ha as PE at 3 DAT *fb* manual weeding at 25 DAT), T_8 (azimsulfuron 35 g a.i./ha as PoE at 25 DAT), T_{12} (pretilachlor 750 g a.i./ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i./ha as PoE at 25 DAT) and T_9 (bispyribac sodium 25 g a.i./ha+ ethoxysulfuron 18.75 g a.i./ha as PoE at 25 DAT). T_{10} (bispyribac sodium 20 g a.i./ha+ metsulfuron-methyl + chlorimuron-ethyl 4 g a.i./ha as PoE at 25 DAT) recorded significantly comparable sedge weed seed count with T_{11} (pretilachlor 750 g a.i./ha as PE at 3 DAT followed by ethoxysulfuron 18.75 g a.i./ha as PoE at 25 DAT) and at par with T_3 pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT, T_1 pretilachlor 625 g a.i/ha asPE at 3 DAT, T_2 pyrazosulfuron-ethyl 20 g a.i/ha 3 DAT, T_5 penoxsulam 22.5 g a.i/ha as early PoE at 12 DAT, T_7 bispyribac sodium 25 g a.i/ha as PoE 25 DAT and T_6 cyhalofop-p-butyl 100 g a.i/ha as early PoE 12 DAT treatments. Significantly higher sedge weed seed count was recorded in T_{14} (weedy check) during 2013 and 2014. Shyam *et al*. (2014) [12] reported that the total number of seeds was recorded maximum in 0 to 5 cm and minimum in 10 to 15 cm soil depth under all the tillage methods.

Broad leaf weeds density

The lower broad leaf weed seed count registered with T_{13} (hand weeding twice at 25 and 45 DAT) which was comparable with T_4 (pyrazosulfuron-ethyl 20 g a.i./ha as PE at 3 DAT *fb* manual weeding at 25 DAT). In turn *fb* treatments pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i/ha as PoE at 25 DAT, T_8 azimsulfuron 35 g a.i/ha as PoE at 25 DAT, T_3 pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT, T_2 pyrazosulfuron-ethyl 20 g a.i/ha3 DAT, T_5 penoxsulam 22.5 g a.i/ha as early PoE at 12 DAT, T_7 bispyribac sodium 25 g a.i/ha as PoE 25 DAT, T_9 bispyribac sodium 25 g a.i/ha+ ethoxysulfuron 18.75 g a.i /ha as PoE at 25 DAT, T_{10} bispyribac sodium 20 g a.i/ha + metsulfuron methyl + chlorimuron ethyl 4 g a.i /ha as PoE at 25 DAT and T_{11} pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* ethoxysulfuron 18.75 g a.i/ha as PoE at 25 DAT which recorded comparable broad leaf weed seed count among themselves. The higher broad leaf weed seed count was recorded in T_{14} (weedy check) and which was on par with T_1 and T_6 during both the years of study. Ramsdale (2006) [8] found that under no-till and conventional system, soil seed banks consisted of about 87 per cent broadleaf and 13 per cent grasses species, whereas under the mulch-till system soil seed bank consisted of 68 per cent broadleaf and 32 per cent grasses species in spring wheat-soybean cropping systems. Weed seed bank in the soil are exposed to various influences and changes and the result of its studies provide immediate, but not general.

Table 1: Effect of weed management practices of rice on weed seed bank (No./kg soil).

S.No.	Treatments	Grasses		Sedges	
		2013	2014	2013	2014
T_1	pretilachlor 625 g a.i/ha as PE at 3 DAT	4.74(21.69)	5.15(25.67)	4.55(19.74)	5.15(26.00)
T_2	pyrazosulfuron-ethyl 20 g a.i/ha 3 DAT	4.80(21.48)	5.10(25.06)	4.57(20.02)	5.13(25.33)
T_3	pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT	4.90(21.92)	5.06(24.67)	4.49(18.28)	4.81(22.17)
T_4	pyrazosulfuron-ethyl 20 g a.i/ha at 3 DAT *fb* manual weeding at 25 DAT	4.08(15.62)	3.95(14.67)	3.90(14.26)	4.36(18.00)
T_5	penoxsulam 22.5 g a.i/ha as early PoE at 12 DAT	4.79(20.90)	5.08(24.81)	4.87(22.72)	5.13(25.33)

T_{6}	cyhalofop-p-butyl 100 g a.i/ha as early PoE 12 DAT	4.99(24.15)	5.21(26.28)	4.64(20.62)	5.19(26.17)
T_{7}	bispyribac sodium 25 g a.i/ha as PoE 25 DAT	4.75(21.60)	5.22(26.28)	4.25(17.08)	4.92(23.17)
T_{8}	azimsulfuron 35 g a.i/ha as PoE at 25 DAT	4.26(17.24)	4.29(17.22)	3.53(11.51)	4.21(17.33)
T_{9}	bispyribac sodium 25 g a.i/ha+ ethoxysulfuron 18.75 g a.i /ha as PoE at 25 DAT	4.27(17.44)	4.30(19.89)	3.18(9.11)	4.28(17.33)
T_{10}	bispyribac sodium 20 g a.i/ha + metsulfuron methyl + chlorimuron ethyl 4 g a.i /ha asPoE at 25 DAT	4.24(17.22)	3.95(14.67)	4.92(23.47)	4.62(20.35)
T_{11}	pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* ethoxysulfuron 18.75 g a.i/ha as PoE at 25 DAT	4.28(17.51)	4.19(16.61)	4.69(21.00)	4.54(19.67)
T_{12}	pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i/ha as PoE at 25 DAT	4.16(16.27)	4.11(15.89)	3.74(13.03)	4.19(16.67)
T_{13}	hand weeding twice at 25 and 45 DAT	4.03(15.38)	3.79(13.44)	3.55(11.64)	3.87(14.00)
T_{14}	weedy check	5.02(24.19)	5.26(26.89)	6.35(39.34)	6.18(37.33)
	LSD (p=0.05)	0.29	0.95	0.82	0.71

Note: Figures in parenthesis are original values

Table 2: Effect of weed management practices of rice on weed seed bank (No./kg soil)

S.No.	Treatments	Grasses		Sedges	
		2013	2014	2013	2014
T_{1}	pretilachlor 625 g a.i/ha as PE at 3 DAT	4.74(21.69)	5.15(25.67)	4.55(19.74)	5.15(26.00)
T_{2}	pyrazosulfuron-ethyl 20 g a.i/ha 3 DAT	4.80(21.48)	5.10(25.06)	4.57(20.02)	5.13(25.33)
T_{3}	pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT	4.90(21.92)	5.06(24.67)	4.49(18.28)	4.81(22.17)
T_{4}	pyrazosulfuron-ethyl 20 g a.i/ha at 3 DAT *fb* manual weeding at 25 DAT	4.08(15.62)	3.95(14.67)	3.90(14.26)	4.36(18.00)
T_{5}	penoxsulam 22.5 g a.i/ha as early PoE at 12 DAT	4.79(20.90)	5.08(24.81)	4.87(22.72)	5.13(25.33)
T_{6}	cyhalofop-p-butyl 100 g a.i/ha as early PoE 12 DAT	4.99(24.15)	5.21(26.28)	4.64(20.62)	5.19(26.17)
T_{7}	bispyribac sodium 25 g a.i/ha as PoE 25 DAT	4.75(21.60)	5.22(26.28)	4.25(17.08)	4.92(23.17)
T_{8}	azimsulfuron 35 g a.i/ha as PoE at 25 DAT	4.26(17.24)	4.29(17.22)	3.53(11.51)	4.21(17.33)
T_{9}	bispyribac sodium 25 g a.i/ha+ ethoxysulfuron 18.75 g a.i /ha as PoE at 25 DAT	4.27(17.44)	4.30(19.89)	3.18(9.11)	4.28(17.33)
T_{10}	bispyribac sodium 20 g a.i/ha + metsulfuron methyl + chlorimuron ethyl 4 g a.i /ha asPoE at 25 DAT	4.24(17.22)	3.95(14.67)	4.92(23.47)	4.62(20.35)
T_{11}	pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* ethoxysulfuron 18.75 g a.i/ha as PoE at 25 DAT	4.28(17.51)	4.19(16.61)	4.69(21.00)	4.54(19.67)
T_{12}	pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i/ha as PoE at 25 DAT	4.16(16.27)	4.11(15.89)	3.74(13.03)	4.19(16.67)
T_{13}	hand weeding twice at 25 and 45 DAT	4.03(15.38)	3.79(13.44)	3.55(11.64)	3.87(14.00)
T_{14}	weedy check	5.02(24.19)	5.26(26.89)	6.35(39.34)	6.18(37.33)
	LSD (p=0.05)	0.29	0.95	0.82	0.71

Note: Figures in parenthesis are original values

Insight into the situation in the field. The results of this study showed that spatial distribution monitoring allows prediction of weed behavior and thus can be a valuable tool for management decisions and increases our understanding of the dynamics of weed densities. So the seed bank maps can be used as information database of seedling germination.

Total weed density

During both the years of study the lower total weed seed count registered with T_{13} (hand weeding twice at 25 and 45 DAT) which was on par with T_{4} (pyrazosulfuron ethyl 20 g a.i./ha as PE at 3 DAT *fb* manual weeding at 25 DAT). Followed by T_{12} pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i/ha as PoE at 25 DAT, T_{11} pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* ethoxysulfuron 18.75 g a.i/ha as PoE at 25 DAT, T_{8} azimsulfuron 35 g a.i/ha as PoE at 25 DAT, T_{7} bispyribac sodium 25 g a.i/ha as PoE 25 DAT and T_{9} bispyribac sodium 25 g a.i/ha + ethoxysulfuron 18.75 g a.i /ha as PoE at 25 DAT during 2013, T_{12} pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i/ha as PoE at 25 DAT, T_{11} pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* ethoxysulfuron 18.75 g a.i/ha as PoE at 25 DAT, T_{8} azimsulfuron 35 g a.i/ha as PoE at 25 DAT, T_{7} bispyribac sodium 25 g a.i/ha as PoE 25 DAT and T_{10} bispyribac sodium 20 g a.i/ha+ metsulfuron methyl + chlorimuron ethyl 4 g a.i /ha as PoE at 25 DAT during 2014. In turn *fb* T_{6} cyhalofop-p-butyl 100 g a.i/ha as early PoE 12 DAT, T_{1} pretilachlor 625 g a.i/ha as PE at 3 DAT, T_{5} penoxsulam 22.5 g a.i/ha as early PoE at 12 DAT, T_{2} pyrazosulfuron-ethyl 20 g a.i/ha3 DAT, T_{3} pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT and T_{10} bispyribac sodium 20 g a.i/ha+ metsulfuron methyl + chlorimuron ethyl 4 g a.i /ha asPoE at 25 DAT during 2013, T_{7} bispyribac sodium 25 g a.i/ha as PoE 25 DAT, T_{2} pyrazosulfuron-ethyl 20 g a.i/ha3 DAT, T_{3} pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT and T_{5} penoxsulam 22.5 g a.i/ha as early PoE at 12 DAT during 2014. Significantly higher total weed seed count recorded with T_{14} (weedy check) during both the years of study however it was comparable with T_{1} pretilachlor 625 g a.i/ha as PE at 3 DAT and T_{6} cyhalofop-p-butyl 100 g a.i/ha as early PoE 12 DAT during 2014. These results are in conformity with Rahaman *et al.* (2003) [7], who reported herbicides reduce weed densities and hence reduce the number of weed seeds that are produced and enter the seed bank. Jha and Kewat (2013) [4] revealed.

Table 3: Effect of weed management practices of rice on weed seed population dry weight (g/kg soil).

	Treatments	2013	2014
T_{1}	Pretilachlor 625 g a.i/ha asPE at 3 DAT	3.78(13.7)	3.79(13.37)
T_{2}	pyrazosulfuron-ethyl 20 g a.i/ha3 DAT	2.82(7)	3.65(12.35)
T_{3}	pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT	3.08(8.6)	3.56(11.69)
T_{4}	pyrazosulfuron-ethyl 20 g a.i/ha at 3 DAT followed manual weeding at 25 DAT	2.60(5.9)	3.03(8.20)

T_5	penoxsulam 22.5 g a.i/ha as early PoE at 12 DAT	2.83(7.4)	3.58(11.92)
T_6	cyhalofop-p-butyl 100 g a.i/ha as early PoE 12 DAT	4.23(17.0)	4.53(20.40)
T_7	bispyribac sodium 25 g a.i/ha as PoE 25 DAT	3.04(8.90)	3.69(12.62)
T_8	azimsulfuron 35 g a.i/ha as PoE at 25 DAT	2.63(6.10)	3.56(12.04)
T_9	bispyribac sodium 25 g a.i/ha+ ethoxysulfuron 18.75 g a.i /ha as PoE at 25 DAT	2.93(7.6)	3.47(11.20)
T_{10}	bispyribac sodium 20 g a.i/ha+ metsulfuron methyl + chlorimuron ethyl 4 g a.i /ha asPoE at 25 DAT	2.70(6.4)	3.64(12.40)
T_{11}	pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* ethoxysulfuron 18.75 g a.i/ha as PoE at 25 DAT	2.44(5.01)	3.47(11.02)
T_{12}	pretilachlor 750 g a.i/ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i/ha as PoE at 25 DAT	2.98(8.2)	3.36(10.28)
T_{13}	hand weeding twice at 25 and 45 DAT	2.25(4.1)	2.95(7.74)
T_{14}	weedy check	5.75(32.1)	6.11(36.50)
	LSD (p=0.05)	0.87	0.75

Note: Figures in parenthesis are original values

that the higher weed seed count (40.9/m^2) at top layer of soil was obtained extensively under zero-till sowing of wheat than conventional till sowing, strip till sowing and bed planting. According to Purshotam *et al*. (2010) [6] major contribution towards weed seed bank was of *Paspalum scrobiculatum* (21.23%) followed by *Echinochloa colonum* (13.17%) and *Echinochloa crusgalli* (10.14%), but under weedy conditions major contribution was of *Echinochloa colonum* (23.4%) followed by *Echinochloa crusgalli* (21.1%) and *Paspalium scrobiculatum* (16.9%). Viability of *Echinochloa spp*. is reported to be less than 10% after two and half year of burial in soil.

Effect of weed management practices of rice on weed seed population dry weight (g/kg soil) at 0-10cm soil depth

Data pertaining to weed seed population dry weight was recorded over a period of three months at 0-10cm depth and statistically analysed and presented in Table 3. During both the years of study the higher weed dry weight was recorded in T14 (weedy check), in turn followed T1 (pretilachlor 625 g a.i./ha as pre emergence at 3 DAT) and T6 (cyhalofop-p-butyl 100 g a.i./ha as early PoE 12 DAT) treatments.

The lower weed dry weight registered with T13 (hand weeding twice at 25 and 45 DAT) which was on par with remaining other treatments, *viz.*T4 (pyrazosulfuron –ethyl 20 g a.i./ha as PE at 3 DAT *fb* manual weeding at 25 DAT), T12 (pretilachlor 750 g a.i./ha as PE at 3 DAT *fb* metsulfuron-methyl + chlorimuron-ethyl 4 g a.i./ha as PoE at 25 DAT), T_{10} (bispyribac sodium 20 g a.i./ha + metsulfuron-methyl + chlorimuron-ethyl 4 g a.i./ha as PoE at 25 DAT), T_{11} (pretilachlor 750 g a.i./ha as PE at 3 DAT *fb* ethoxysulfuron 18.75 g a.i./ha as PoE at 25 DAT), T_8 (azimsulfuron 35 g a.i./ha as PoE at 25 DAT), and T_9 (bispyribac sodium 25 g a.i./ha + ethoxysulfuron 18.75 g a.i./ha as PoE at 25 DAT), T_3 (pretilachlor 6% + bensulfuron methyl 0.6% 10 kg granules/ha as PE at 3 DAT), T_2 (pyrazosulfuron ethyl 20 g a.i./ha 3 DAT), T_5 (penoxsulam 22.5 g a.i./ha as PoE at 12 DAT) and T_7 (bispyribac sodium 25 g a.i./ha as PoE at 25 DAT).

Rahman *et al*. (2000) [7] revealed that weed seedling emergence and seed bank depletion are greater from seeds near the soil surface than from those more deeply buried. Cultivation with power harrow or rotary hoe did not significantly change the weed seed distribution, suggesting that despite mixing the soil in different patterns, neither implement redistributed the seeds uniformly through the tillage depth. Ploughing was the only implement that clearly shifted the seeds to deeper profile. In ploughed plots there was a more even distribution of seeds in the top three profiles and the deepest layer of 15 – 20 cm had significantly more seeds than the other three treatments.

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