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Weed composition and seed bank as affected by different tillage and crop establishment techniques in rice–wheat system

Amit Jha* and M.L. Kewat

Department of Agronomy, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh 482 004

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ABSTRACT

Field experiments were carried out at Krishi Nagar Research Farm, J.N. Krishi Vishwa Vidayalya, Jabalpur, (M.P.) during 2007-08 and 2008-09 to study weed composition and weed seed bank as influenced by tillage and crop establishment techniques in rice–wheat system. Sixteen treatments consisted with 4 tillage and planting management for both crop components under rice-wheat system were tested in strip plot design with 3 replications. Tillage and sowing methods were P_1- direct drilling in dry field, P_2- direct seeding of sprouted seeds through drum seeder in puddled field, P_3- manual transplanting and P_4- transplanting through self propelled transplanter (SPT) for rice cultivar '*Kranti*' and T_1- conventional tillage sowing, T_2- zero till sowing, T_3- strip till sowing and T_4- bed planting for wheat cultivar '*GW-273*'. The total weed density and weed biomass at 30 DAS and maturity stages were significantly greater under direct drilling in dry field (DSR-P_1) than other 3 sowing/planting methods of rice under puddled conditions (P_2-direct seeding of sprouted seeds through drum seeder in puddled field, P_3-manual transplanting and P_4-transplanting through self propelled transplanter). The DSR-P_1 had also higher weed seed counts on top layer of soil than other 3 tillage and sowing methods of rice. In wheat, intensity of grasses, sedges and other minor weeds was enhanced at maturity over their intensity at 30 DAS under conventional till sown wheat, while intensity of broad-leaved weeds (BLWs) declined at maturity over their intensity at 30 DAS. 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.

Key words: Crop establishment, Rice–wheat system, Seed bank, Tillage, Weed composition

Weeds have a greater genetic diversity than crops. Consequently, if a resource (light, water, nutrients or carbon dioxide) changes within the environment, it is more likely that weeds will show a greater growth and reproductive response. In central part (Madhya Pradesh and Chhattisgarh) of India, rice is grown in variable climatic condition. Tillage operation can have a major impact on the distribution of weed seeds in the soil on survival (Lutman *et al.* 2002). Tillage as a filter or constraints that influences weed species and weed seed distribution in the soil seed bank. The type of tillage implement and concomitant cultivation can significantly impact the weed seed distribution and composition in soil surface. Direct drilling and shallow tillage for example can increase the proportion of weed seed retained near the soil surface, compared to conventional system of sowing in rice–wheat system (Yenish *et al*. 1992). The above conditions have been the impetus for research concerned with the adoption of conservation tillage practices leading to the concept of a conventional tillage effect on weed intensity and seed bank. Keeping these points in views, the present investigation has been undertaken.

MATERIALS AND METHODS

Field experiments were carried out at Krishi Nagar Research Farm, Jawaharlal Nehru Krishi Vishwa Vidayalya, Jabalpur, (M.P.) during 2007-08 and 2008-09. The soil of the experimental field was sandy clay loam in texture and neutral in reaction (7.4) and low in organic C (0.68%) and analyzing medium in available N (250 kg/ha), P (12.5 kg/ha) and medium in available K (308 kg/ha) contents. Sixteen treatments consisted with 4 tillage and planting management for both crop components under rice-wheat system were tested in strip-plot design with 3 replications. Tillage and sowing methods were: P_1- Direct drilling in dry field, P_2- Direct seeding of sprouted seeds through drum seeder in puddled field, P_3- Manual transplanting and P_4- Transplanting through self-propelled transplanter (SPT) for rice cultivar '*Kranti*' and T_1- conventional tillage sowing, T_2 - zero till sowing, T_3- strip till sowing and T_4 - bed

***Corresponding author:** amitagcrewa@rediffmail.com

planting for wheat cultivar '*GW-273*'. Sowing of rice, *viz.* direct drilling in dry field before onset monsoon (P_1), sowing in nursery to get seedlings for transplanting (P_3 and P_4) and soaking of seeds to obtain sprouted seeds under (P_2) was done on the same day. The seed rate 100 kg/ha for direct seeding in dry field and 50 kg/ha for direct seeding of sprouted seeds through drum seeder in puddled field where as seeds as 30 kg/ha were used only for both manual transplanting and transplanting through self propelled transplanter. Tillage operations in direct seeding in dry field were once with cultivator, twice harrow followed by planking and for transplanting methods and direct seeding of sprouted seeds through drum seeder in puddle soil consisted of one cultivator, 2 puddling and 1 planking. Twenty one days old seedlings were used for manual transplanting and transplanting through SPT. The seedlings were raised on mat type nursery for transplanting through self-propelled transplater.

Butachlor 1.5 kg/ha was applied as pre-emergence for weed control in rice. This was supplemented with hand weeding twice at 20 and 40 days in direct seeding in dry field plots whereas one hand weeding was done at 40 days after in puddled condition field. All the direct-seeded plots received frequent irrigation to keep the soil wet. For transplanting under both methods and direct seeding of sprouted seeds through drum seeder in puddled soil, irrigation was applied for puddling, thereafter, uniform irrigation were applied to all the treatments. Sowing of wheat was done by different methods immediately after harvesting of preceding rice grown under different methods of tillage and sowing. After harvesting of rice, a pre-sowing irrigation was given to all plots to ensure optimum moisture for sowing of wheat. Sowing of wheat was done by conventional, zero till, strip till and bed planter. The conventional sowing in wheat involved 1 cultivator, 2 harrows and one planking. Under zero till, strip till and bed plating, sowing of wheat was done directly without land preparation. For weed control in wheat, isoproturon 1 kg + 2,4-D 0.5 kg/ha was sprayed after 35 days of sowing. A uniform dose (120 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha) of fertilizers was applied to both crops along with other agronomic practices. Soil samples of 0.5 kg by weight were taken with the help of core auger at 3 soil depths, *viz.* 0-5, 5-10 and 10-15 cm from each treatment plot before sowing of both crop components under a fixed rice-wheat system.

The existing seed bed conditions before sowing of each crop was taken into consideration to decide the time of sampling. Collected soil samples were well labelled with tags and allowed to sun-drying. After proper sun-drying, these samples were grounded into fine particles with help of mortar and pistal. Then, these samples spread on the Peteriplates separately in almost homogeneous and uniform layer. The Peteriplates were marked for each treatment separately with glass pencil. After this, regular watering was done upto 15 days with the help of water cane uniformly in all Peteriplates. The number of germinated weed seedlings was counted under each treatment at 15 days after regular watering. Finally, weed seed counts/kg soil was worked out for each treatment. The observations on weed density and dry weight (species wise and total) were recorded at 30 DAS/DAT and harvesting stages by using a quadrat of 0.25 m^2 size at 4 places in each plot and then species wise total weeds intensity and dry matter/m^2 were determined.

Weight of grains and straw yield per plot recorded under each treatment for both crops. Rice equivalent yield (REY) was determined for each treatment. For this purpose, grain yield of wheat was converted in to rice yield with the help of existing market value of both crops. After this, the wheat yields converted in to rice yields were added in the preceding rice yields of the same treatment.

RESULTS AND DISCUSSION

Weed dynamics and weed seed bank in rice

While considering the existence of weeds in cropped lands with rice, total 30 weed species consisting of 10 grasses, 6 sedges, 13 BLWs and 1 fern groups were observed in rice. The dominating weed species were identified as *Echinochloa colona* (L.) Link., *E. glabrescens* Murno ex Hook. f., *E. crusgalli* (L.) Beauv., *Eleusine indica* (L.) Gaertner., *Panicum repens* L., *Digitaria sanguinalis* L. (Scop.), *Dactyloctenium aegyptium* (L.) Willd., *Paspalum distichum* L., *Ischaemum rugosum* Salisb. and *Eragrastis japonica* among the grasses; *Cyperus iria* L., *C. difformis* L., *C. rotundus* L., *Fimbristylis miliaceae* (L.) Vahl., *Scirpus lateriflorus* Gmel. and *Eriocaulon quinquangulare* L. among the sedges; and *Caesulia axillaries* Roxb., *Eclipta alba* (L.) Hassk., *Ammania baccifera* L., *Cynotis axillaries* Schult.f., *Commelina communis* L *Alternanthera philoxeroides* (Mart.) Griseb., *Alternanthera sessilis* (L.) DC., *Monochoria vaginalis* (Burm f.) Kunth., *Lindernia crustacea* (L.) F. Muell., *Hydrolea zeylanica* Vahl., *Ludwigia octovalvis* (Jacq.) Raven., *Oldenlendia dichotoma* Hook f. and *Spilanthus calva* DC. among the broad-leaved weeds (BLWs). The presence of a fern-*Marsilia quadrifoliata* was also noted during advanced stage of rice only under the treatments associated with transplanted rice in wet lands. Besides these weeds, several other minor weeds also found in negligible density, hence their identification was not made individually.

The relative density of grasses, sedges, BLWs and other minor weeds was 46, 24, 25 and 5, 41, 15, 40 and 4, 35, 17, 45 and 3 and 35, 16, 44 and 5% under P_1- direct drilling in dry field, P_2-direct seeding of sprouted seeds through drum seeder in puddled field, P_3- manual transplanting and P_4- transplanting through self propelled transplanter tillage and sowing methods of rice, respectively at 30 DAS/DAT. But infestation of these groups of weeds changed as 37, 21, 30 and 12, 28, 24, 38 and 10, 27, 23, 38 and 10, 29, 23, 37 and 9% under P_1- direct drilling in dry field, P_2- direct seeding of sprouted seeds through drum seeder in puddled field, P_3- manual transplanting and P_4-transplanting through self propelled transplanter methods of rice establishment, respectively at maturity stage. The presence of fern *Marsilia quadrifoliata* having relative density of 2% was also noted under P_3- manual transplanting and P_4- transplanting rice establishment only at maturity stage.

It was obvious that the existence and spread of different weeds varied due to different tillage and sowing methods of rice at early growth as well as maturity stages under DSR- P_1 in dry fields. The intensity of *Echinochloa colona*, *E. crusgalli* and *Dactyloctenium aegyptium* reduced at maturity stage over their intensity at 30 DAS, while the intensity of *Eleusine indica*, *Panicum repens*, *Digitaria sanguinalis* and *Paspalum distichum* was higher at 30 DAS. The presence of *E. glabrescens*, *Ischaemum rugosum and Eragrstis japonica* was noted only at maturity stage under DSR. Among the sedges, the intensity of *Cyperus iria* was lesser at maturity stage over 30 DAS, while *C. rotundus* showed reverse trend only after 30 DAS under DSR- P_1. Simalrly, the severity of *Ammania baccifera* and *Oldenlendia dichotoma* was lesser at maturity as compared to other BLWs. Remaining minor weeds showed their presence during advanced growth stage after 30 DAS. It is remarkable that *Commelina communis*, *Monochoria vaginalis, Hydrolea zeylanica,* and *Marsilia quadrifoliata* were absent under DSR due to aerobic conditions in the field. Under direct-seeding of sprouted rice seeds in puddle fields- P_2, the intensity of grasses and sedge were less at 30 DAS than DSR-P_1 but intensity of BLWs showed their reversed trend at this stage because of wet land agro-ecosystem developed for growing rice under P_2. The weeds which found absent under DSR-P_1. as described above had shown their presence under P_2-direct seeding of sprouted seeds through drum seeder in puddled field due to puddled conditions developed for sowing of sprouted seeds.

The agro-ecosystem of rice plants under transplanted rice manually (P_3) or by SPT (P_4) was almost similar to that of under P_2. Therefore, the intensity of grassy weeds was lesser under transplanted rice (P_3 and P_4) rice than P_1 and it further reduced at maturity over their intensity recorded at 30 DAT. But infestation of other group of weeds was higher under transplanted rice at 30 DAT than under P_1 at maturity stage. The agro-ecosystem of rice plants under transplanted rice manually (P_3) or by SPT (P_4) was almost similar to that of under P_2. Therefore, the intensity of grassy weeds was lesser under transplanted rice (P_3 and P_4) rice than P_1 and it further reduced at maturity over their intensity recorded at 30 DAT. But infestation of other group of weeds was higher under transplanted rice at 30 DAT than under P_1 at maturity stage.

While studying the effect of weed seed counts/kg of soil at varying depths (0-5, 5-10 and 10-15 cm) before final seedbed preparation for sowing/planting of rice, it was observed that weed seeds were greater in number on top layer (0-5 cm) of soil, which orderly reduced in subsequent deeper layers (5-10 and 10-15 cm). The DSR-P_1 had higher weed seed counts on top layer of soil than other 3 tillage and sowing methods of rice, because of turning up of top layer to lower layer during puddling of lands. The zero till sown preceding wheat had greater seed count at each layer of soil than other 3 tillage and sowing methods of wheat (Table 1).

Consequence upon the above facts, total weed density/m^2 and total weed biomass/ha were significantly greater under DSR- P_1 than other 3 sowing/planting methods of rice under puddle conditions (P_2- direct seeding of sprouted seeds through drum seeder in puddled field, P_3- manual transplanting and P_4- transplanting through self propelled transplanter) at maturity stage (Table 2). Since the intensity of all weeds were maximum under DSR -P_1 among all sowing methods at 30 DAS and remained continuously higher at maturity, hence it could be said that DSR-P_1 needs more emphasis on control on weeds to realize the potential grain yields. It is also remarkable from the present investigation that long-term continuous cropping of direct seeded rice followed by zero-till sown wheat under rice might have given excellent opportunity to build up more severe weed infestation. Therefore, it would be good to change direct seeding of rice or zero till sowing of wheat into other tillage and sowing methods at an interval of 2 or 3 years to overcome this problem. Singh *et al.* (2008) and Gangwar *et al.* (2009) agreed with these findings from their studies under rice-wheat cropping system at other locations of India also.

Weed composition and weed seed bank in wheat

The existence and spread of different weed flora in wheat grown under different tillage and sowing methods at 30 DAS and maturity stages were 2,1 and 13/m^2 for grasses, sedgs and BLWs, respectively. Among the grassy weeds, *Phalaris minor* Retz. and *Avena fatua* L. were present. Only *C. rotundus* among the sedges and *Medicago* spp. *(M. denticulata* and *M. hispida* Willd), *Trifolium fragiferum* L., *Chenopodium album* L., *Melilotus* spp. (*Melilotus indica* (L.) All. and *Melilotus alba* Medikus.), *Rumex dentatus* L., *Fumaria parviflora* Lamk., *Spergula arvensis* L., *Anagallis arvensis, Vicia sativa* L. *Lathyrus aphaca* L. and *Portulaca oleracea* L. among the BLWs had also shown their presence.

It is remarkable that relative composition of weeds varied between early (30 DAS) and maturity stages of wheat under all tillage and sowing methods. The relative composition of grasses, sedges, BLWS and other minor weeds were 7, 7, 83 and 3%, respectively at 30 DAS under conventional till sown wheat, which changed as 10, 5, 79 and 5%, respectively at maturity stage. Thus, it is obvious that intensity of grasses, sedges and other minor weeds enhanced at maturity over their intensity at 30 DAS under conventional till sown wheat, while intensity of BLWs declined at maturity over their intensity at 30 DAS. Other tillage and sowing methods of wheat, *viz.* zero till sowing (T_2), strip till sowing (T_3) and bed planting (T_4) had similar trend of weed composition at both the growth stages as were with conventional till sowing (T_2). Although the composition of different weeds was similar in wheat grown under different tillage and sowing methods at both the growth stages, but total weed intensity/m^2

Table 1. Weed seed count/kg soil at varying depth as affected by different tillage and sowing methods in rice-wheat system before sowing of rice

Treatment	Depth of soil								
	0-5 cm			5-10 cm			10-15 cm		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
Sowing methods of rice									
P_1- Direct seeding	53.3	57	55.2	31.3	33.8	32.6	21.7	24.7	23.2
P_2- Seeding of sprouted seeds	36.7	40.6	38.7	42.2	45.7	44.0	29.3	30.9	30.1
P_3- Manual transplanting	35.4	39.4	37.4	40.5	41.6	41.1	28.3	26.9	27.6
P_4- Transplanting by SPT	34.0	37.3	35.6	40.4	41.5	41.0	27.6	27.2	27.4
LSD (P=0.05)	4.3	5.2	4.6	4.3	2.7	3.6	2.4	3.2	2.7
Sowing methods of wheat									
T_1 - Conventional till sowing	39.1	42.6	40.9	38.1	40.3	39.2	26.9	27.5	27.2
T_2 - Zero till sowing	40.5	43.9	42.3	38.9	40.4	39.7	26.5	27.9	27.2
T_3 - Strip till sowing	40.1	43.6	41.9	38.2	40.8	39.5	26.4	27.3	26.9
T_4 - Bed planting	39.0	43.9	41.5	39.3	41	40.2	27.7	27.0	27.4
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Mean weed density and weed dry weight as affected by different tillage and sowing methods in rice-wheat system in rice

Sowing method	Total weed density/m^2						Weed dry weight at maturity (kg/ha)		
	At 30 DAS/DAT			At maturity					
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
Rice									
P_1	126.0	140.0	133.0	209.0	238.0	223.5	555	598	570
P_2	95.0	105.0	100.0	196.0	211.0	203.5	508	525	517
P_3	89.0	98.0	93.5	184.0	205.0	195.0	453	498	475
P_4	85.0	92.0	88.5	179.0	188.0	183.5	449	489	469
LSD (P=0.05)	10.1	17.8	15.6	12.3	13.7	12.8	009	017	012
Wheat									
T_1	98.0	108.0	103.0	190.0	209.0	199.5	490	523	507
T_2	101.0	112.0	106.5	194.0	213.0	203.5	494	529	512
T_3	97.0	107.0	102.0	190.0	208.0	199.0	487	522	505
T_4	99.0	109.0	104.0	193.0	211.0	202.0	491	526	509
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Treatment details are given in Table 1.

was significantly higher with zero till sowing (T_2) than other 3 tillage and sowing methods. Among the tillage and sowing methods of wheat, strip till sown wheat had the lowest weed intensity/m^2. The higher weed seed counts/m^2 at top layer of soil were more extensively under zero till sowing of wheat (Table 3) resulted in to greater weed infestation than other sowing methods. The weed seed counts/kg of soil was almost similar before sowing of wheat with other 3 methods (conventional till sowing (T_1), strip till sowing (T_3) and bed planting (T_4). Numerically, strip till sowing of wheat– T_3 had the lowest weed seed counts/kg of soil on top layer of soil, which might be the reason for the lowest total weed intensity (Table 4). Consequent upon the above points, zero-till sowing (T_2) had maximum weed dry weight/ha at both growth stages of wheat, while strip till sowing (T_3) had the lowest weed dry weight/ha.

While going through the overall picture of weed dynamics in rice-wheat cropping system with varying tillage and sowing methods, it was evident that T_2 offered more severe weed infestation and it further aggravated when zero till sowing of wheat was associated with direct seeding of rice in dry field (P_1). Similar results have been reported by other workers also (Dhiman *et a.* 2003, Mishra *et al.* 2005, Brar *et al.* 2007 and Jha *et al.* 2008)

Table 3. Weed seed count/kg soil at varying depth as affected by different tillage and sowing methods in rice-wheat system before sowing of wheat

Sowing method	Depth of soil								
	0-5 cm			5-10 cm			10-15 cm		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
Rice									
P_1	32.7	33.3	33.0	19.0	18.3	18.6	11.1	12.0	11.6
P_2	31.2	32.1	31.7	18.0	18.2	18.1	10.4	11.2	10.8
P_3	30.7	32.5	31.6	17.8	18.5	18.1	10.3	11.0	10.7
P_4	31.4	31.9	31.7	17.7	18.7	18.2	9.9	10.9	10.4
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Wheat									
T_1	25.2	26.2	25.7	22.8	21.5	22.1	14.8	16.4	15.6
T_2	40.4	41.4	40.9	13.9	15.3	14.6	7.7	8.4	8.1
T_3	26.4	27.5	27.0	20.2	20.2	20.2	10.7	10.7	10.7
T_4	34.1	34.5	34.3	15.6	16.6	16.1	8.5	9.4	9.0
LSD (P=0.05)	5.4	6.4	5.8	4.2	4.5	4.1	3.6	3.4	3.6

Treatment details are given in Table 1.

Table 4. Mean weed density and weed dry weight as affected by different tillage and sowing methods in rice-wheat system in wheat

Sowing method	Total weed density/m^2						Total weed dry weight at maturity (kg/ha)		
	At 30 DAS/DAT			At maturity					
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
Rice									
P_1	101.0	112.0	106.5	69.0	72.0	70.5	388	386	387
P_2	99.0	109.0	104.0	68.0	71.0	69.5	382	382	382
P_3	98.0	111.0	104.5	68.0	68.0	68.0	368	382	375
P_4	98.0	110.0	104.0	67.0	69.0	68.0	364	378	371
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Wheat									
T_1	98.0	110.0	97.0	65.0	69.0	65.0	364	355	359
T_2	121.0	139.0	130.0	96.0	100.0	98.0	445	469	457
T_3	82.0	84.0	83.0	48.0	46.0	47.0	325	345	335
T_4	95.0	108.0	101.5	58.0	66.0	62.0	367	362	364
LSD (P=0.05)	6.8	10.5	3.9	6.4	5.3	6.4	011	009	006

Treatment details are given in Table 1.

System productivity

Grain yield of unhusked rice were affected significantly by various crop-establishment methods in rice (Table 5). The highest pooled yield (5.7 t/ha) was recorded with drum seeding (puddle bed), followed by direct seeding under dry field and mechanical transplanting- puddle conditions than manual transplanting in puddle conditions. The more grain yield under drum/direct seeding rice was mainly due to good weed management practices adopted under direct seeding rice in dry field (Gopal *et al.* 2010). The grain yield of wheat were influenced significantly due to different conservation establishment methods applied in preceding rice (Table 5). The grain yields were recorded to be significantly higher when wheat was grown after direct seeding of rice in dry field than after direct seeding of sprouted rice and both transplanted rice under puddle condition. This was mainly attributable to relatively greater compaction of soil under direct seeding of sprouted rice, manual and mechanical transplanted rice (puddled) and its carry over effect on succeeding wheat, which demonstrated the disadvantage of puddling on succeeding crops (Gangwar *et al.* 2009). Irrespective of the various methods in rice, sowing of wheat by strip till drill increased grain yield as well as straw yield significantly higher over other three methods. The possible reason for higher yields because of strip till sowing of wheat provided better germination of seeds and further establishment of seedlings because of good tilth at the time of sowing. Total productivity of rice-wheat system as a whole was determined in terms of rice equivalent yields (REYs) for all treatments.

Table 5. Total productivity of rice-wheat system as affected by different tillage and sowing management (mean of 2007 to 2008)

Sowing method	Rice		Wheat		Rice equivalent yield (t/ha)
	Grain yield (t/ha)	Straw yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)	
Rice					
P_1	5.32	7.22	4.26	6.28	11.25
P_2	5.70	7.58	4.10	6.18	11.46
P_3	5.11	6.94	4.02	6.20	10.96
P_4	5.21	7.03	4.08	6.12	11.05
LSD (P=0.05)	0.04	0.05	0.02	NS	
Wheat					
T_1	4.23	6.98	4.13	6.14	11.15
T_2	4.22	6.88	4.08	6.02	11.08
T_3	4.25	6.97	4.56	6.64	11.88
T_4	4.33	6.92	3.82	5.69	10.65
LSD (P=0.05)	NS	NS	0.07	0.04	

Direct seeding of sprouted rice gave the highest system productivity (11.26 t/ha/yr) and proved significantly better than other tow methods of establishment (Table 5). The next best treatment was direct seeding in dry field which gave (11.25 t/ha/yr). Strip till sowing produced significantly maximum REYs (11.88 tha/yr) among all sowing methods, while bed planting – T_4 led to record minimum REYs (10.65 t/ha/yr). The REYs were comparable with conventional till sowing -T_1 (11.20 t/ha/yr) and zero till sowing-T_2 (11.02 t/ha/yr). Similar findings have been reported by several workers from their studies in different rice– wheat growing areas of the country (Gill *et al.* 2006)

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