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Tillage and Crop Residue Management on Weed Dynamics and Productivity of Direct Seeded Rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during 2019 and 2020 to evaluate the effect of tillage and residue management on weed dynamics and productivity of direct seeded rice with four tillage systems; Conventional tillage in rice and wheat, Zero tillage in rice and wheat and two rotational tillage sequences that alternated between Conventional tillage and Zero tillage whereas four residue management practices; residue applied in both season, residue applied in kharif season only, residue applied in rabi season only and without residue in both season. The experiment was carried out at research farm of Birsa Agricultural University, Ranchi, Jharkhand. Results revealed that in direct seeded rice having highest grain yield (10%), straw yield (8%) and yield attributes (10-15%) as well as lesser weed density and weed dry matter found under Conventional tillage during both the seasons of experiment but performance of zero tillage was slightly better (3-4%) in second year as compared to all treatments. Whereas surface retention of residue @5 tonne/ha was significantly

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more effective in controlling different category of weeds, it decreased up to 60-75% weed population, resulting increment in grain yield up to 19% and 23% during first and second year, respectively, as compared to plot receiving no residue.

Keywords: Conventional tillage; direct-seeded rice; residue; rice-wheat system; weed control; zero tillage.

1. INTRODUCTION

Rice (*Oryza sativa* L.) Is the most important cereal crop in Asia, being the primary source of food for more than 50 percent of the world population. Globally, rice is cultivated on 160 million hectares, with an annual production of 740.9 million tonnes [1]. More than 90 percent of the world's rice is being consumed and produced by the Asian continent (143 million hectare area with a production of 612 million tonnes) [1]. During last 50 years, world rice area has increased by 1.37 times from 115.50 to 160 million hectare but production has increased three times from 216 to 741 million tonnes and productivity has increased 2.5 times from 1.87 t/ha to 4.30 t/ha. India possesses largest area under rice (45 million hectare) occupying second position after China and producing nearly one fourth of Asia's production [2]. In India rice is grown on an area of 43.78 million hectares with production of 118.43 million tonnes with an average productivity of 2705 kg/ha. In Jharkhand, it occupies an area of 193.53 (000 ha), with production of 384.66 (000 tonnes), and productivity of 1988 kg/ha [3]. In India, rice-wheat cropping system is the most important system and its occupying 10.3 million hectare area in Indo-Gangetic plains [4]. This region is essential for the food security of India contributing more than 45 and 75% of total rice and wheat, production, respectively [5]. The higher productivity of rice-wheat cropping system is exhausting the natural resources (land, water and energy) rapidly. The sustainability and productivity of rice-wheat cropping system is under damage due to resource degradation on one hand and poor efficiency of conventional practices on other hand.

Conventional cultivation of rice and wheat crops are negatively affecting the soil health. Puddling in rice makes hard pan under sub surface which reduces the yield and root development of succeeding wheat crop. It is revealed that repeated tillage practices directly affect on overall soil quality and also delays sowing of next crops which causes yield decrease about 35-60 kg/ha/day [6]. Resource conserving technologies that include zero tillage, direct seeding of rice, improved water usage, farm residue management, avoiding straw burning, high nutrient use efficiency and diversification of resource intensive crops may help in achieving sustainable productivity [7]. Zero tillage, under such conditions can play a critical role in saving resource, time and money, without losing on crop productivity besides sustaining natural resources [8]. Conventional tillage owing to 4-6 number of tillage operations consumes a large proportion of total operational cost and energy. Soil structure and soil quality may also get negatively affected with conventional tillage. This system can be changed over to zero tillage without any reduction in grain yield. Zero tillage aids in improvement of water retention capacity and nutrient-use efficiencies, increased crop productivity and carbon sequestration, amelioration of soil properties and mitigate emission of green house gases [9].

Crop residue management may be considered an important component of sustainable agriculture, while in recent years it is also looked upon for improving nutrient status and organic matter of the soil and most importantly for omitting the negative effects caused by residue burning [10]. Mulching with minimum or zero tillage, or removing straw for some constructive alternate use, is among the main options available for residue management. As an alternate to burning especially in North West India, the rice residue may be incorporated into the soil about 10-20 days before sowing of next crop [11]. The surface retention of crop residue is considered an option when we consider that incorporation of crop residue may require multiple tillage operations or sophisticated machinery, which may increase the cost of cultivation. However, many a times, while trying to directly drill wheat seed with the help of happy seeder or seed drill into non-tilled combine harvested rice fields, problems may occur due to accumulation of loose straw in the seed drill furrow opener. This causes poor grip of seed metering drive wheel which influence the uniformity in depth of seed placement. Many farmers therefore practice partial burning owing to cost savings with reduced fuel quantity and labour [12].

2. MATERIALS AND METHODS

2.1 Site and Soil

A field experiment was carried out in 2019-20 & 2020-21 at agronomical research farm of Birsa Agricultural University, Ranchi situated at 23°17´ North latitude and longitude of 85°19´East with an altitude of 625 m above the mean sea level. The climate of the area is sub-tropical, with an average annual rainfall of 1430 mm (75–80% of which is received during June-September), minimum temperature ranges from 3-5 ˚C in January, and maximum temperature ranges from 35-38 ˚C in May. Mean monthly temperature, sunshine duration, wind velocity and monthly rainfall during given seasons of rice are given in Table 1. The soil at the study site was sandy loam in texture (Typic chromusterts) in the 0-15 cm surface layer. Before the beginning of the experiment, physical and chemical properties of the soil were determined. The values of some physical and chemical properties of the soil are given in Table 2.

2.2 Treatments Detail

The experiment was initiated in June 2019 with rice crop after the harvest of wheat. The experiment was laid out in split plot design with three replications. Main plot treatments comprised of four tillage sequences *viz.*, conventional tillage (CT) in rice and wheat (CT–CT), zero tillage (ZT) in rice and wheat (ZT–ZT), and two rotational tillage sequences that alternated between CT and ZT (CT–ZT and ZT–CT) and sub-plot treatments were four residue management *viz.,* no residue (No Res.) In rice and wheat (NR-NR), residue (Res.) In rice and wheat (R-R), residue used in rice (R-NR) only and residue used in wheat (NR-R) only. Residue of the preceding crop was used @5 tonne per ha. Each sub-plot measured 8.5 m × 5 m. Crops were either dry-seeded without tillage (ZT) or conventionally planted after the soil was tilled to a depth of 15 cm (CT). CT consisted of tillage twice with a field cultivator, and tilled once with rotavator to prepare a fine seedbed before planting the crops. CT and ZT dry seeded rice was sown using tractor mounted seed-cum-fertilizer drill. In both CT and ZT, seeds were placed at 4–5 cm depth in dry soil. Glyphosate at 1.0 kg a.i. ha^{-1} in 500 litres ha^{-1} of water was applied two week before crop seeding in all the plots to kill the existing vegetation.

2.3 Crop Management

Direct seeding of rice cultivar '*Sahbhagidhan*' (semi-dwarf with 115 days duration) was done in the third week of June with 80 kg ha^{-1} seed. All the plots received 80 kg N as urea and di-ammonium phosphate (DAP), 40 kg P_2O_5 as DAP, and 20 kg K_2O as muriate of potash per hectare. Full dose of phosphorus and potash and $1/3^{rd}$ of nitrogen were placed 2-3 cm below the seed as basal dose using ferti-seed drill (conventional/zero) at the seeding. Remaining $2/3^{rd}$ nitrogen were applied in two equal splits at mid tillering (30 DAS) and panicle initiation stage (55 DAS). Two irrigations were given during reproductive stage due to withdrawal of monsoon. Rice was harvested manually with sickle at a height of 10–15 cm from ground level in the last week of October and threshed by thresher.

2.4 Observations

Weed count, for estimating weed density at 30, 60 and 90 days after sowing (DAS) in rice, was recorded with the help of a quadrate (0.5 m × 0.5 m) placed randomly at two spots in each plot. To record weed dry weight at 30, 60 and 90 DAS, weeds were cut at ground level, washed with tap water, sun dried, hot-air oven-dried at 70 ˚C for 48 hours, and then weighed. For yield attributes, Yield attributing parameters, *i.e*. Total number of panicles, number of grains per panicle and 1000-grain weight (at 14% moisture content) were recorded using 1 m^2 quadrate from two places in each plot at harvest. Grain yield was taken from net plot area of each plot and expressed in kg/ha at 14% moisture.

2.5 Statistical Analysis

All the data on weed density and weed dry matter values, yield and yield parameters of rice, were analyzed for analysis of variance (ANOVA). Weed density and weed dry weight data were transformed to square root $\sqrt{(x+0.5)}$ before analysis to reduce heterogeneity of variance. Back transformed data are presented in tables. Treatments were compared by computing the ''F-test''. The significant differences between treatments were compared by critical difference at 5% level of probability.

Table 1. Weather data during rice crop

Month	Max Temp(˚C)		Min Temp.(˚C)		Sunshine Duration (hrs.)		Wind velocity (km/hr)		Rainfall (mm)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
June	38.5	33.2	24.4	22.9	231.7	132.1	3.3	2.64	98.7	283.7
July	32.3	32.2	23.4	23.2	132.9	128.2	3.0	2.81	239.4	394.0
August	30.3	32.4	23.2	23.2	81.4	133.1	3.1	2.95	337.7	406.6
September	30.5	32.2	22.6	23.0	126.2	205.2	3.0	2.87	291.9	158.2
October	28.0	30.4	19.8	20.6	186.6	229.7	2.6	2.29	261.2	14.2

Table 2. Soil physical and chemical properties at 0-15 cm soil depth before beginning of the experiment (2019)

Parameters	Values	Procedure	Parameters	Values	Procedure
Texture class	Sandy loam soil	International pipette Method (Piper, 1966)	Bulk density	1.52	Core sampler method (Blake and Hartge, 1986)
pH (1:2.5)	5.6	Ph meter with glass electrode Method (Jackson, 1973)	Available nitrogen (kg/ha)	243.65	Alkaline potassium Permanganate method (Subbiah and Asija, 1956)
E.C. (1:2.5) (ds/m)	0.04	Conductivity bridge method (Jackson, 1973)	Available phosphorus (P kg/ha)	14.25	Bray's P-1 method (Jackson, 1973)
OC (%)	0.54	1 N $K_2Cr_2O_7$ solution method (Walkley and Black, 1934)	Available potassium (kg/ha)	125.8	Ammonium acetate extraction Method (Jackson, 1973)

USDA texture classification, OC-Organic carbon.

3. RESULTS AND DISCUSSION

3.1 Weed Compositions

In rice, the experimental field was infested with all three categories of weed species throughout the crop growth in direct-seeded rice during 2019 and 2020. The total number of species was 16, out of which *Echinocloa colona*, *Sitaria glauca*, *Digitaria sanguinalis* Scop, *Cynodon dactylon*, *Elusine indica* and *Dactyloctaneum aegiptium* among grasses, *Commelina benghalensis*, *Ageratum conyzoides*, *Euphorbia hirta*, *Alternanthera sessilis* L, *Phyllanthus niruri* and *Amaranthus viridis* among broad-leaved weeds and *Cyperus rotundus*, *Cyperus iria*, *Cyperus difformis* and *Fimbristylis miliacea* among sedges were prominent.

3.2 Effect of Tillage and Residue on Weed Density

Highest numbers of weed species recorded from broad leaved weed then grasses and sedges respectively at all crop growth stages, whereas weed population decreased with increasing number of tillers. Weed population were recorded at 30 and 60 DAS. Conventional tilled rice after conventional tilled wheat (CT-CT) had lowest number of grasses at 30 DAS (8.25 and 7.92 no./m^2 during 2019 and 2020 respectively) and at 60 DAS (4.15 and 4.11 no./m^2 during 2019 and 2020 respectively) interestingly highest grassy weed population observed in zero tilled rice grown after zero tilled wheat (ZT-ZT) (11.18, 9.54 no./m^2 at 30 DAS and 5.52, 4.81 no./m^2 at 60 DAS during 2019 and 2020 respectively). Similarly, less number of broad leaved weeds (9.46, 9.15 no./m^2 at 30 DAS and 4.75, 3.87 no./m^2 at 60 DAS) and sedges (5.70, 5.53 no./m^2 at 30 DAS and 3.51, 3.21 no./m^2 at 60 DAS) recorded from (CT-CT) during both the year of experimentation (Table 3).

Residue management practices were highly effective on weed density than tillage. Minimum number of weed population observed in plots having residue at both season (R-R) and maximum in plots having no residue (NR-NR). R-R had lesser number of grassy weeds (7.29, 5.12 no./m^2 at 30 DAS and 3.66, 2.85 no./m^2 at 60 DAS in 2019 and 2020 respectively), broad leaved weeds (8.80, 7.19 no./m^2 at 30 DAS and 4.26, 2.74 no./m^2 at 60 DAS in 2019 and 2020 respectively) and sedges (4.89, 2.97 no./m^2 at 30 DAS and 3.05, 2.07 no./m^2 at 60 DAS in 2019 and 2020 respectively) and it was at par with residue applied in *kharif* season only (R-NR) during both season of experiment at all the crop growth stages (Table 3). Crop residue retention with conventional tillage might be suppressed as well as delayed weed emergence and germination. It might be a sustainable and effective approach for weed management in crop rotations, reducing the need for herbicides application. Similar results were found by Nath et al. [13].

3.3 Effect of Tillage and Residue on Weed Dry Matter

CT-CT had minimum weed dry matter accumulation of grasses (2.98, 2.54 g/m^2 at 30 DAS and 2.53, 2.14 g/m^2 at 60 DAS during 2019 and 2020 respectively), broad leaved weeds (2.75, 2.57 g/m^2 at 30 DAS 2.15, 2.04 g/m^2 at 60 DAS during 2019 and 2020 respectively) and sedges (1.87, 1.83 g/m^2 at 30 DAS 1.72, 1.59 g/m^2 at 60 DAS during 2019 and 2020, respectively) and it was at par with CT-ZT, whereas maximum weed dry matter accumulation recorded under ZT-ZT at 30 and 60 DAS during both year (Table 4).

Application of residue @ 5 tonne per hectare from preceding crop was positively effective on weed density as well as weed dry matter accumulation. Maximum weed dry matter of grassy weed (4.30, 3.96 g/m^2 at 30 DAS; 3.63, 3.55 g/m^2 at 60 DAS during 2019 and 2020 respectively), broad leaved weeds (3.46, 3.42 g/m^2 at 30 DAS; 2.86, 3.06 g/m^2 at 60 DAS during 2019 and 2020 respectively) and sedges (2.45, 2.43 g/m^2 at 30 DAS; 2.32, 2.09 g/m^2 at 60 DAS during 2019 and 2020 respectively) were recorded under NR-NR, while minimum dry matter of grassy (2.61, 1.60 g/m^2 at 30 DAS; 2.27, 1.65 g/m^2 at 60 DAS during 2019 and 2020 respectively), broad leaved weed (2.55, 2.12 g/m^2 at 30 DAS; 2.27, 1.80 g/m^2 at 60 DAS during 2019 and 2020 respectively) and sedges (1.76, 1.53 g/m^2 at 30 DAS; 1.66, 1.39 g/m^2 at 60 DAS during 2019 and 2020 respectively) were recorded, under R-R (Table 4). The dissimilarity of the total weed biomass and its proportion may be attributed to the tillage and crop residue management, resulting in the difference in temperature, moisture, light and property of soil between treatments, thereby affecting emergence of weed population and biomass. The significantly higher dry matter of weeds under zero tillage without residue in both the season might be due to the lower soil water content and less upper layer soil disturbance. These findings suggest that the seasonal weed population disturbed with tillage operation and residue act as mulch resulting hampering of weed seed germination at early stage [14].

3.4 Effect of Tillage and Residue on Yield Attributes and Yield

Conventionally tilled rice followed by (*fb*) conventionally tilled wheat (CT-CT) produced 21% higher productive tillers; 14% higher filled grain; resulting 11% higher grain (4151 kg/ha) and 8% higher straw yield (6488 kg/ha) compared to zero tilled rice *fb* zero tilled wheat (ZT-ZT) (3745 kg grain and 6033 kg straw/ha). Similarly, in second year of experiment CT-CT produced higher productive tillers/m^2, longer panicle and grains/panicle 17%, 15%, 13% respectively; resulting 10% higher grain (4274 kg/ha) and 8% higher straw (6510 kg/ha) yield than ZT-ZT. Zero tillage produced more grain yield (3 %) from first year to second year than conventional tillage (Fig. 1). The increase in yield and yield attributes of rice was due to reduced grassy, broad leaved and sedges weeds. Tillage operations improve impaired soil physical, chemical and biological properties as well as soil water retention (Das et al. 2018).

Among the residue management, residue used in both season (R-R) produced 27% higher productive tillers, as well as 16% higher filled grain/panicle resulting 19% higher grain (4289 kg/ha) and 14% higher straw yield (6614 kg/ha) than no residue in both season (NR-NR) treatment. The present study found residue retention treatments had higher grain yields than that of no residue, signifying that mulching with preceding crop residue promotes crop yield. This might be attributed to the residues and their decomposition improving the soil structure through enhancing the soil properties and soil aggregate stability, while limiting soil crusting and soil water evaporation [15]. The improved soil property increased its infiltration and availability of water to the crop [16], which enhance yield attributes as well as yield. Mulching with crop residues directly impacts on the weed emergence and dry matter, so that the crop-weed competition could be mitigated and finally the crop yield may increase [17].

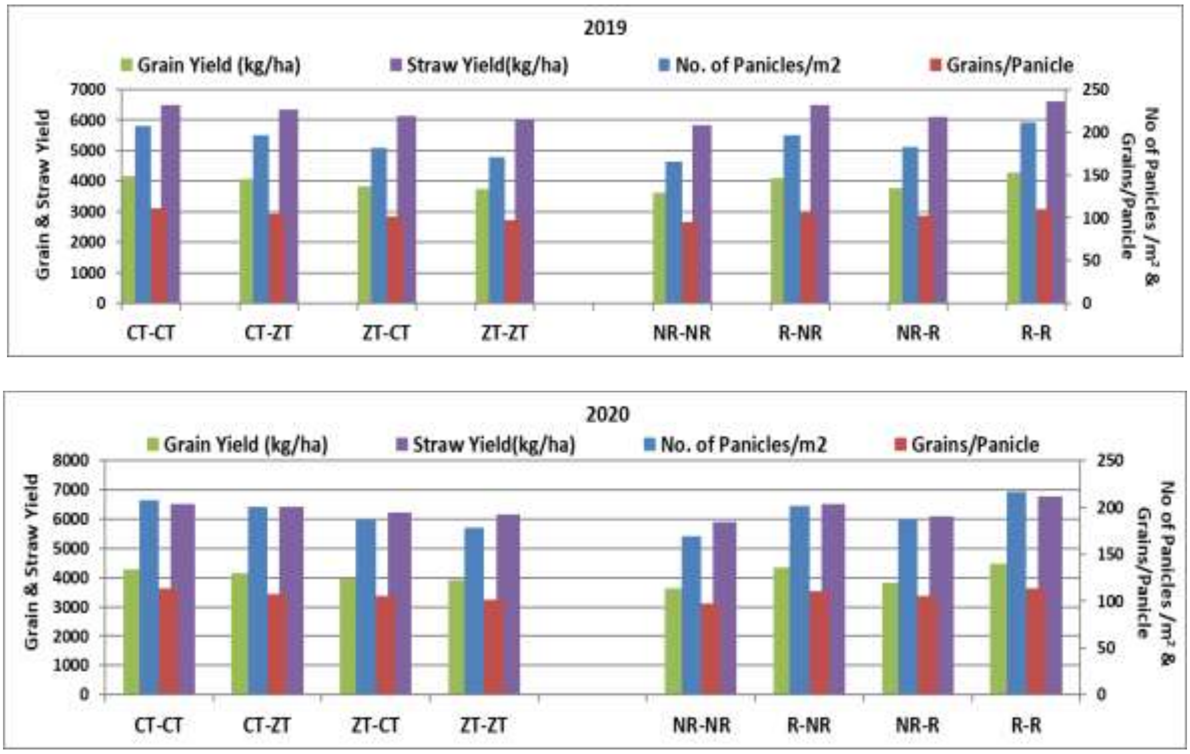

Fig 1. Effect of tillage and residue management on yield and yield attributes of rice.

Table 3. Effect of tillage and residue management on weed density in rice

Treatments		**Weed Density (nos./m^2)**											
Tillage		**Grassy**				**Broad leaves**				**Sedges**			
		30 DAS		**60 DAS**		**30 DAS**		**60 DAS**		**30 DAS**		**60 DAS**	
Kharif	*Rabi*	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
CT	CT	8.25 (73.75)	7.92 (70.1)	4.15 (18.2)	4.11 (17.6)	9.46 (91.9)	9.15 (86.8)	4.75 (23.0)	3.87 (15.9)	5.70 (36.3)	5.53 (35.3)	3.51 (13.2)	3.21 (11.0)
CT	ZT	8.75 (81.2)	8.33 (77.3)	4.58 (21.9)	4.35 (19.9)	9.95 (101.1)	9.59 (95.2)	5.00 (25.5)	4.21 (18.6)	6.22 (43.2)	6.00 (40.9)	3.82 (15.7)	3.37 (11.8)
ZT	CT	10.26 (109.5)	9.35 (92.0)	5.11 (26.7)	4.48 (21.3)	10.83 (119.6)	9.99 (102.9)	5.61 (32.0)	4.30 (19.5)	7.43 (58.2)	6.46 (46.6)	4.51 (20.9)	3.81 (15.3)
ZT	ZT	11.18 (128.3)	9.54 (97.4)	5.52 (31.1)	4.81 (24.1)	11.81 (141.2)	10.27 (108.6)	6.15 (38.3)	4.53 (21.6)	8.32 (70.8)	6.87 (52.1)	4.94 (24.4)	3.94 (16.4)
SEm±		0.24	0.23	0.14	0.09	0.22	0.19	0.15	0.10	0.15	0.14	0.10	0.07
LSD (P=0.05)		0.84	0.81	0.49	0.31	0.75	0.65	0.51	0.36	0.52	0.48	0.34	0.24
Residue Management													
NR	NR	12.10 (146.7)	11.99 (143.7)	6.03 (36.1)	5.94 (34.9)	12.22 (149.7)	12.18 (148.4)	6.37 (40.5)	5.79 (33.2)	8.96 (80.4)	8.90 (78.8)	5.32 (28.0)	4.84 (23.1)
R	NR	7.72 (61.3)	6.78 (49.8)	3.88 (15.1)	3.87 (14.6)	9.14 (84.4)	8.05 (66.1)	4.78 (22.9)	3.66 (13.2)	5.24 (29.0)	4.39 (19.7)	3.34 (11.4)	3.18 (9.9)
NR	R	11.34 (130.1)	10.25 (105.3)	5.79 (33.4)	5.10 (25.7)	11.89 (141.8)	10.57 (111.3)	6.11 (37.2)	4.73 (22.1)	8.58 (73.9)	7.61 (57.8)	5.07 (25.4)	4.25 (17.7)
R	R	7.29 (54.6)	5.12 (26.9)	3.66 (13.3)	2.85 (7.8)	8.80 (77.9)	7.19 (51.7)	4.26 (18.1)	2.74 (7.0)	4.89 (25.3)	2.97 (8.5)	3.05 (9.5)	2.07 (3.8)
SEm±		0.18	0.57	0.12	0.36	0.16	0.27	0.19	0.32	0.14	0.47	0.11	0.38
LSD (P=0.05)		0.52	1.76	0.36	1.12	0.48	0.89	0.61	0.97	0.40	1.46	0.35	1.13
Interaction (T × R)													
SEm±		0.36	0.31	0.25	0.22	0.33	0.33	0.28	0.25	0.27	0.25	0.17	0.15
LSD (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CT-Conventional tillage; ZT-Zero tillage; NR-No residue; R-Residue; DAS-Days after sowing; NS-Non significant

Table 4. Effect of tillage and residue management on weed dry matter accumulation in rice

Treatments		**Weed Dry Matter (g/m^2)**											
Tillage		**Grassy**				**Broad leaves**				**Sedges**			
		30 DAS		**60 DAS**		**30 DAS**		**60 DAS**		**30 DAS**		**60 DAS**	
Kharif	***Rabi***	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
CT	CT	2.98	2.54	2.53	2.14	2.75	2.57	2.15	2.04	1.87	1.73	1.72	1.59
		(9.1)	(6.8)	(6.4)	(4.7)	(7.3)	(6.3)	(4.2)	(3.9)	(3.2)	(2.6)	(2.5)	(2.1)
CT	ZT	3.19	2.79	2.69	2.23	2.84	2.69	2.22	2.11	2.00	1.85	1.85	1.61
		(10.5)	(8.2)	(7.1)	(5.0)	(7.8)	(7.0)	(4.5)	(4.2)	(3.7)	(3.0)	(3.2)	(2.2)
ZT	CT	3.62	2.91	3.14	2.77	3.10	2.81	2.85	2.37	2.25	2.01	2.01	1.79
		(13.2)	(9.0)	(9.8)	(7.7)	(9.3)	(7.6)	(7.7)	(5.4)	(4.7)	(3.7)	(3.6)	(2.8)
ZT	ZT	3.96	3.11	3.31	3.10	3.30	3.10	3.01	2.68	2.33	2.19	2.27	2.18
		(15.7)	(10.1)	(10.8)	(9.7)	(10.6)	(9.5)	(8.7)	(7.0)	(5.0)	(4.5)	(4.2)	(4.4)
SEm±		0.08	0.08	0.07	0.07	0.06	0.06	0.07	0.05	0.06	0.05	0.05	0.05
LSD (P=0.05)		0.26	0.27	0.23	0.25	0.22	0.20	0.23	0.17	0.22	0.18	0.17	0.16
Residue Management													
NR	NR	4.30	3.96	3.63	3.55	3.46	3.42	2.86	3.06	2.45	2.43	2.32	2.09
		(18.1)	(15.3)	(12.8)	(12.3)	(11.6)	(11.3)	(7.9)	(9.0)	(5.6)	(5.5)	(5.0)	(3.9)
R	NR	2.76	2.35	2.38	2.15	2.65	2.55	2.39	1.96	1.81	1.62	1.79	1.70
		(7.4)	(5.1)	(5.3)	(4.4)	(6.7)	(6.6)	(5.4)	(3.4)	(2.9)	(2.9)	(2.8)	(2.5)
NR	R	4.08	3.45	3.39	2.89	3.34	2.98	2.70	2.38	2.44	2.00	2.07	1.98
		(16.3)	(11.5)	(11.1)	(8.0)	(10.7)	(8.5)	(7.0)	(5.3)	(5.1)	(3.5)	(3.8)	(3.5)
R	R	2.61	1.60	2.27	1.65	2.55	2.12	2.27	1.80	1.76	1.53	1.66	1.39
		(6.6)	(2.1)	(4.8)	(2.4)	(6.0)	(4.0)	(4.8)	(2.9)	(2.7)	(1.9)	(2.4)	(1.5)
SEm±		0.09	0.25	0.06	0.19	0.06	0.16	0.05	0.07	0.05	0.06	0.05	0.11
LSD (P=0.05)		0.26	0.75	0.18	0.59	0.19	0.47	0.16	0.21	0.16	0.18	0.13	0.35
Interaction (T × R)													
SEm±		0.18	0.17	0.12	0.13	0.13	0.12	0.11	0.15	0.11	0.12	0.09	0.10
LSD (P=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

CT-Conventional tillage; ZT-Zero tillage; NR-No residue; R-Residue; DAS-Days after sowing; NS-Non significant

4. CONCLUSION

The current study well evaluated the effect of Tillage and crop residue management on weed dynamics and productivity of direct seeded rice. The result showed that surface retention of residue @5 tonne/ha was significantly superior in controlling different categories of weeds, reducing up to 60-75% weed population and increasing grain yield by 19% and 23% during the first and second years, respectively, when compared to plot receiving no residue. The surface retention of crop residue is considered an option when we consider that incorporation of crop residue may require various tillage operations or sophisticated machinery.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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