

Crop Residue Management by Different Farm Machinery

Sourabh Kumar Dewangan^{1,*}, R.K. Naik², Geeta Patel³, Harshaj Singh Tuteja⁴

Abstract

Crop residue management is a constraining issue in the rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system, which is commonly used in the Indian Subcontinent and China and covers around 22.5×106 ha. India's major agricultural system, rice-wheat, is facing sustainability issues due to soil degradation and climate change. The issue is critical since there is a short turnaround period between rice harvest and wheat seeding. Crop residue management has procedures such as residue removal, residue burning, and residue inclusion. Residue assimilation should be favoured over residue burning, which causes the loss of vital plant nutrients and poses an environmental and health risk. Crop residue management innovations can promote sustainable productivity by reducing straw burning, fertilizer and water inputs and risks from climate change. Crop residue was managed using a heterogeneity of agricultural machines, including the zero till happy seeder (T_1), the mulcher + zero till drill (T_2), the zero till drill (T_3), and the conventional system (T_4). Among soil nutrient parameters reduction is found in pH of soil, electrical conductivity, nitrogen, potassium, manganese, sulfur and zinc content parameters of the soil as compared to untreated plot. From the all-treatments highest pH reduction was found 8.82% on T_1 treatment. Highest organic carbon content (12.64%) was measured in T_4 . Lowest reduction of nitrogen (4.63 %) was found in T_2 treatment. Phosphorus and iron of the soil was increased in all treatments but it was reduced 0.50% and 47.75% in T_4 treatment, respectively. Due to incorporation of residual matter in the soil improve soil properties.

Keywords: Zero till-happy seeder, Mulcher, Zero till-drill, Organic carbon, Phosphorus, Nitrogen

INTRODUCTION

13.5-million-hectare Indo-Gangetic Plains' rice-wheat system is essential to the region's food security. Climate change and decreased soil productivity have caused productivity of rice and wheat to stall and drop recently, seriously endangering the sustainability of the rice-wheat cropping system

(Ladha *et al.*, 2009). The entire geographical area of Chhattisgarh is around 137.91 lakh hectares, of which 46.76 lakh ha are arable land, according to Sharma *et al.* (2014). Caused by favorable soil and weather circumstances the two main crops farmed in Chhattisgarh that are wheat and paddy, Paddy is important crop in Chhattisgarh, also known as India's "rice bowl". Another significant crop in Chhattisgarh is wheat, which has a productivity of roughly 1174 kg/ha and a cropping pattern of 103.7 ha. In 2011, rice production in Chhattisgarh was 6159.0 tons and productivity were 1751 kg/ha. (Sharma *et al.*, 2014).

Crop residues are plant components that remain on the field after crops have been harvested with a

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combine harvester. Crop wastes are used as a source of energy in many nations in a variety of ways, including livestock feed, mushroom growing, composting, bio-fuel, bio-oil production, gasification, and bio-char manufacturing. India produces approximately 501.60 million tons of crop wastes each year, of which approximately 92.81 million tons are burned (Pathak *et al.*, 2010).

Singh *et al.* (2004) investigated the impact of crop residue disintegration on productivity and soil nutrient content in the rice-wheat cropping system. The residue mass loss was 25% on the tenth day, 35% on the twentieth day, and 51% on the fortieth day of decomposition prior to wheat planting. Throughout the season, residual nitrogen emissions ranged from 6 to 9 kg/ha. Nitrogen provided during residue integration had little effect on wheat yields, but it affected the efficiency of recovery nitrogen. Crop yield decreased due to nitrogen stabilization, which occurred as a result of crop residue incorporation. The long-term use of rice residue has increased the storage of carbon in soil.

MATERIAL AND METHOD

The Chhattisgarh region is separated into three agro climatic zones: the Northern hills, the Chhattisgarh Plains, and the Bastar plateau. Chhattisgarh's geological structure is generally divided into four areas known locally as Marahan, Tikara, Bhata, and Gabhar. Soils are classified into three kinds based on their texture: *Bhata*, *Matasi*, *Dorsa*, and *Kanhar*.

Experimental site

The experiment was carried out during the season of *Rabi* at 21023'54" North latitude and 81069'56" East longitude, with an altitude of 268.99 meters above mean sea level Research Farm of IGKV, Raipur (C.G.). In this experiment used rice crop residue where crop is harvested by combine harvester and HG-365 variety of wheat sown in the field and seed drill, seed drill and conventional sowing method were used sowing operation.

Design of Experiment

Various farm machines such as zero till happy seeder (T_1), mulcher + zero till drill (T_2), zero till drill (T_3) and conventional system, were used for management of crop residue. In these experiment soil parameters included such as Moisture content of the soil, Bulk density of soil, Soil nutrient analysis.

Table 1. Experiment detail

S.N.	Material	Detail
1	Design of plot	Randomized block design
2	Number of Treatment	4
3	Number of replications	5
4	Net Plot size	62 m X 22.5 m
5	Total no. of plot	20
6	Distance between replications	0.5 m
7	Distance between plots	0.5 m
8	Last crop harvested	Paddy
9	Soil type	Vertisol
10	Date of sowing	15.11.2018
11	Date of harvesting	27.03.2019

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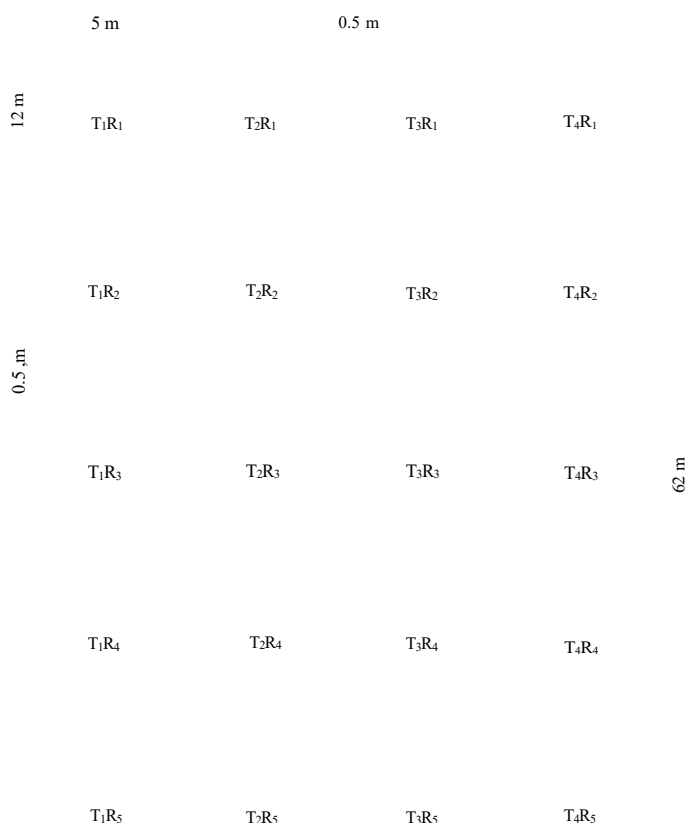


Figure 1. Layout of experimental field.

Table 2. Specification of Mulcher.

S.N.	Parameter	Specification
1.	Machine	Rotary mulcher
2.	Three point linkage	
	a. Upper hitch attachment (mm)	
	• Diameter of hitch pin hole	26.2
	• Width between inner faces of yoke, Min	70
	• Width between outer faces of yoke, Max	90.4
	b. Lower hitch points	
	• Diameter of hitch pin	26.5

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S.N.	Parameter	Specification
	<ul style="list-style-type: none"> Linch pin hole distance min, Lower hitch points span 	112 845
	c. Other dimension	
	Diameter of linch pin	
	<ul style="list-style-type: none"> for upper hitch pin, Min for lower hitch pin, Min Mast height 	17 17 810
3.	Mast	
	<ul style="list-style-type: none"> Type Size of sheet, mm Shape 	M. S. Flat 670 x 230 x 10 Pyramid shape
4.	Drive shaft/propeller shaft	
	Type	Telescopic shaft with universal joints
	<ul style="list-style-type: none"> No. of pieces No. of splines Length, mm Weight, kg 	Two 6 at PTO side & 6 at gear box 940 (minimum) 1010 (maximum) 20.30
5.	No. of splines	6 at both ends
6.	No. & types of bearing	One sealed ball bearing
7.	Bolt	Top cover provided
8.	Rotary shaft	
	Material	M. S. rod (covered by M. S. pipe)
	Type of rotor axle	Tubular section with M. S. plate bracket
	<ul style="list-style-type: none"> No. of flanges Method of mounting blades on flange Types of blade Total no. of blades 	24 Each blade is mounted with the help of one nut and bolt Inverted gamma 72
9.	Transmission	
	<ul style="list-style-type: none"> Gear ratio Diameter of drive Pulley, mm Type of pulley Number of pulleys 	6:9 225 C- section, V-belt 2

Table 3. Specification of Happy seed drill

S.N.	Parameter	Specification
1.	Horse power requirement	45-55 hp tractor with double clutch
2.	Capacity, ha/h	0.25-0.35
3.	Weight of machine	500-550 kg
4.	Working width of machine	1.78m
5.	Row to row distance	225mm
6.	No. of rows	11
7.	Type of furrow openers	Inverted 'T' type
8.	Rotor drum diameter	750 mm
9.	Rotor diameter	140mm
10.	Windrow area	0.200x0.450 = 0.09 m ²

S.N.	Parameter	Specification
11.	Rotor rpm	1360 rpm at 540 rpm of tractor PTO
12.	Types of flail blades	Reversible straight gamma type
13.	Flails length from rotor surface	240 mm
14.	Blade length	165 mm
15.	Bottom width of blade	85 mm
16.	Top width of blade	50 mm
17.	Blade overlap with furrow openers	60mm
18.	Horizontal clearance between edges of blades	75mm
19.	No. of depth wheel of ground wheel	Two no. with adjustable depth
20.	Minimum diameter of ground wheel	550 mm
21.	No. of lugs on periphery of GW	15 (with sharp and long edges)

Residue Parameter

At the research farm found length, weight and moisture content of residue and compared to before sowing residue parameter. A flexible measuring tape was used to measure the length of the residue/straw both before and after the machine was operated. The measurement was made at ten randomly chosen locations across a 1 m² area. For calculation of weight of residue, a digital balance with a least count of one gram was used to weigh the straw. With the use of a square frame with one-meter-sides, the straws were gathered from a square-meter area. Straw weight is measured as dry weight.

Moisture content of paddy crop residue

At the research farm, residue from the combined harvested paddy field was gathered in November 2018. After harvesting, stems and chaff were collected and dried for 24 hours at 60°C. (Sonwani, 2018). Any plant material that lay flat on the soil's surface and went through the combine when harvesting grains was referred to as chaff. The sample was then weighed once more using a weighing machine, and the moisture content of the residue was determined using the formula below:

$$mc (db) = \frac{M_i - M_d}{M_i}$$

Where,

mc = Moisture content, %;

M_i = Initial weight of residue, g; and

M_d = Dry weight of residue, g.

Moisture Content of the Soil

In this experiment, irrigation was applied three times, and the soil's moisture content was assessed following each application. The soil's moisture content is determined once a week tills the following irrigation. Soil moisture was analyzed using the oven drying method. Random soil samples were taken from the experimental plots, and wet soil samples were also collected and weighted using a weighing balance. A soil sample is then obtained and baked at 105⁰ degrees Celsius (Sonwani, 2018). The weight of a dry soil sample was measured after a day, and the soil's moisture content was calculated using the formula below:

$$mc, \% (dry basis) = \frac{w_2 - w_3}{w_3 - w_1} \times 100$$

Where,

mc = Moisture content;

w₁ = weight of container;

w₂ = weight of container and wet soil; and

w₃ = weight of container and oven dry soil.

Bulk Density of Soil

Using a core cutter and a hammer, the bulk density of the soil was determined. Samples of soil measuring 10 cm in diameter and 17 cm in length were taken from each plot, dried for 24 hours at 105°C, and then weighed (Sonwani, 2018).



Figure 2. Happy seed drill during operation.



Figure 3. Rotary mulcher during operation.

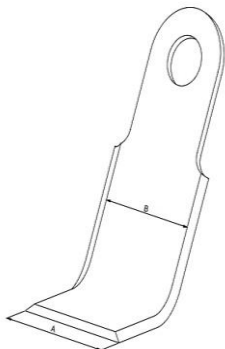


Figure 4. Hatched 'L' type blade of rotary mulcher



Figure 5. Zero till seed cum fertilizer drill during operation

RESULT AND DISCUSSION

Effect on Length of Residue

To measure the straw's length, a meter tape with a minimum count of 1 mm was used. Every treatment, as indicated in Table 4, was documented both prior to and following the wheat cropping procedure. Treatment-2 show higher percentage of reduction in length of rice residue.

Table 4. Length of residue

Treatment	Before operation (cm)	After operation (cm)	Per cent of reduction in length
T1: Happy Seed Drill	85.6	21.8	74.53
T2: Mulcher + ZTSD	83.5	11.3	86.47
T3: ZTSF	83.7	83.7	0.00
T4: Cultivator (2) + Broadcasting	84.3	84.3	0.00

Effect on Weight of Residue

The weight is a crucial factor to consider when analyzing every treatment. For each treatment, the weight of wheat straw was measured both before and after the procedure, as indicated in Table 5. Due to happy seeder and mulcher rice residue cut through its length and drop its weight while in treatment 3 & 4 had no any rice residue.

Table 5. Weight of residue.

Treatment	Before operation (g)	After operation (g)
T1: Happy Seed Drill	444.9	215.9
T2: Mulcher + ZTSF	149.2	138.2
T3: ZTSF	-	-
T4: Cultivator (2) + Broadcasting	-	-

Effect on Moisture Content of Crop Residue

Straw in the T1 and T2 treatments has a moisture content of 15.95% and 16.19%, respectively. Ishii and Furuichi (2014) state that paddy straw has a moisture content ranging from 13% to 20%.

Effect of Incorporation of Rice Residue on Soil Moisture

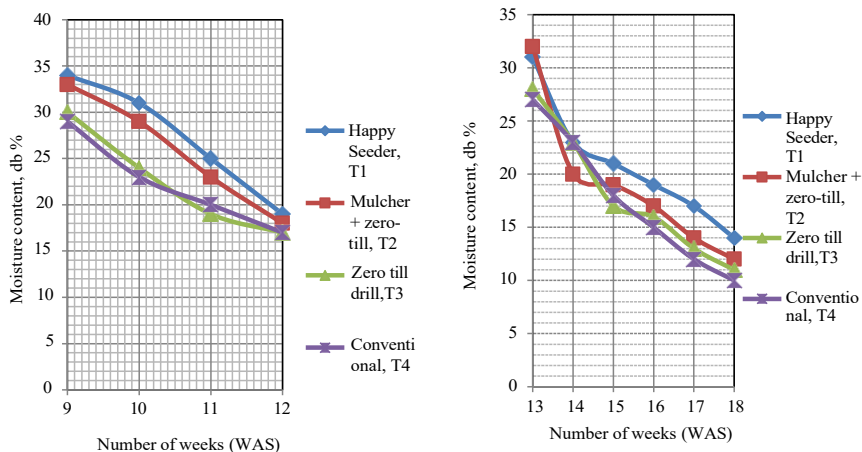
Weekly average soil moisture contents for the various treatments are displayed in Figure 6. Following the initial irrigation, it was observed that the soil's moisture content was the same in all treatments. Before the second irrigation, the moisture content was found to be higher in the T₁ treatment and lower in the T₄ treatment. An analogous observation was made regarding the soil's moisture content for additional irrigation. The average soil moisture content at treatment T₁, T₂, T₃, and T₄ after eighteen weeks was observed to be 14, 12, 11, and 10%, respectively.

According to the testing, there was very little moisture loss in the happy seed drill scenario because no field was completed, which prevented any soil tilling. Conversely, with treatment T₄, the data collected indicates that the total loss of soil moisture happens at different replications. Better soil tilth to a deeper depth is the cause of the increased soil moisture loss that is seen.

Moisture content, db %

Moisture content, db %

Moisture content of soil of various treatment after 1st irrigation. Moisture content of soil of various treatment after 2nd irrigation.



Moisture content of soil of various treatment after 3rd irrigation. Moisture content of soil of various treatment after 4th irrigation.

Figure 6. Moisture content of soil on weekly basis.

Effect of Incorporation of Rice Residue on Soil Bulk Density

Bulk density of the soil is almost equal to 1.44 g/cc prior to any operation being carried out. The average bulk density of the soil was observed to be 1.17 g/cc and 1.10 g/cc in treatment happy seed drill (T₁) and zero till drill (T₃), respectively. No-tillage operations were carried out for seed bed preparation in T₁ and T₃ treatments. In the case of T₁, or happy seed drill, where the no-tillage operation was carried out for seedbed preparation, the average bulk density of the soil was observed to be 1.17 g/cc. It is discovered that the T₂ treatment, which uses a zero-till drill and rotary mulcher separately, has a bulk density of 1.25 g/cc of soil. The T₄ treatment's bulk density is 1.20 g/cc. The opinions of Chauhan (2016) and Prasad (1995) were likewise comparable.

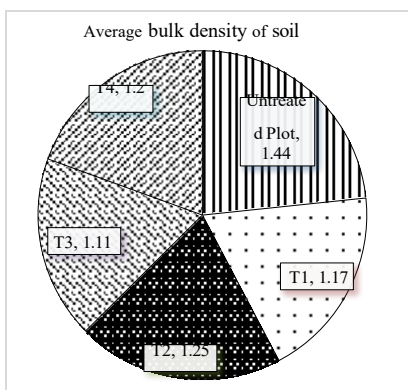


Figure 7. Average Bulk density of soil

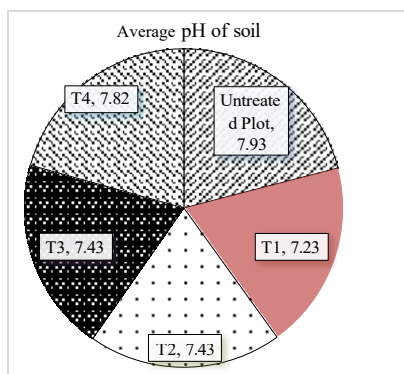


Figure 8. Average pH of soil

pH of soil

Before seeding, the average pH of the soil was 7.93. Following the application of various treatments, the pH of the soil was found to have decreased to 8.82 percent for the happy seed drill (T₁), 6.30 percent

for the rotary mulcher + zero till drill (T₂), 6.30 percent for the zero till seed cum fertilizer drill (T₃), and 1.40% for the conventional system (T₄).

Electrical Conductivity of Soil

During the test, we discovered that the average electrical conductivity of the soil was 0.27 S/m before planting, and that it was 0.21, 0.21, 0.22, and 0.27 S/m for treatments T₁, T₂, T₃, and T₄, respectively, after the operation.

Effect of Crop Residue Management on Soil Nutrient

Compared to an untreated plot, there is a decrease in the soil's nitrogen (N), phosphorus (P), potassium (K), manganese (Mn), sulfur (S), and zinc (Zn) etc. content characteristics. When compared to the nitrogen content of the soil before operation, the reduced nitrogen content of the soil after the operation of various treatments was found to be 16.44% for the happy seed drill (T₁), 4.85% for the rotary mulcher + zero till drill (T₂), 18.52% for the zero till seed cum fertilizer drill (T₃), and 13.88% for the conventional system (T₄). Before sowing, the average soil phosphorus content was found to be 20 kg/ha. Following the application of various treatments, the phosphorus content of the soil was found to be higher for the happy seed drill (T₁), rotary mulcher + zero till drill (T₂), and zero till seed cum fertilizer bore (T₃) than for the soil phosphorus content prior to the application of the treatments. Before sowing, the average potassium content of the soil was 475.4 kg/ha, according to the test results. After the various treatments were applied, the average potassium content of the soil was found to have decreased to 9.54% for happy seed drill (T₁), 7.8% for rotary mulcher + zero till drill (T₂), 21.24% for zero till seed cum fertilizer drill (T₃), and 17.83% for conventional system (T₄). Other parameter of soil is given in the table below. Average zinc content in T₁, T₂, T₃ and T₄ found 1.34, 1.11, 1.42 and 1.06 respectively which was decreased as compared to before sowing plot, where in conventional treatment showed higher decrease rate of zinc.

Table 6. Chemical Properties of Soil and Their Value Ranges for Agricultural Suitability

Chemical properties	Value range		
pH	Strongly acidic < 4.5 Moderate acidity 4.5-5.5 Neutral 6.5-7.7	Slightly acid 5.5-6.6 Moderate alkaline 8.5-9.5 Strongly alkaline >9.5	Slightly alkaline 7.7-8.5
EC (dSm ⁻¹)	No deleterious effect on crop <1 Critical for germination 1-2 Critical for salt sensitive crop 2-3 Injurious to most crop >3.0		
OC %	Low < 05 Medium 12.5-25 High > 0.75	Available P (kg/ha ⁻¹)	Low <12.5 Medium 0.5-0.75 High >25
N (kg/ha ⁻¹)	Very low <200 Low 200-250 Medium 250-500 High >500	Available K (kg/ha ⁻¹)	Low <133 Medium 133-280 High > 280
Zn (ppm)	Deficiency <0.60	Available Fe (ppm)	Deficiency <4.5
Cu (ppm)	Deficiency <0.2	Available Mn (ppm)	Deficiency <3.5

Table 7. Average of the soil's nutrient content after various treatments.

Average	pH	EC (dSm ⁻¹)	OC (%)	N (kg/ha ⁻¹)	P (kg/ha ⁻¹)	K (kg/ha ⁻¹)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
Before sowing	7.93	0.27	0.51	180	20	475.4	3.54	13.87	3.06	1.58
Happy seed drill	7.23	0.21	0.54	171.66	20.3	430.0	4.11	12.23	2.77	1.10
Mulcher + zero till drill	7.4	0.21	0.54	171.66	21.5	438.0	4.11	12.23	3.10	1.42
Zero till drill	7.43	0.22	0.52	146.66	20.9	374.4	4.11	11.23	3.1	1.42
Conventional system	7.82	0.25	0.57	155.0	19.1	390.6	3.54	13.8	3.06	1.58

CONCLUSION

Straw length as measured by the residue parameter, when comparing the happy seeder machine to a rotary mulcher, the straw cut length was greater. Both processes' moisture contents are practically stuff. All the treatments, T₁ had the highest soil moisture content, whereas T₄ had the lowest. For further irrigation, comparable moisture content findings were also noted. Following eighteen weeks, the average soil moisture content at treatment T₁, T₂, T₃, and T₄ was 14, 12, 11, and 10%, respectively. Compared to an untreated plot, there is a decrease in the soil's pH, electrical conductivity, nitrogen, potassium, manganese, sulfur, and zinc content characteristics. The T₁ treatment showed the largest pH decrease (8.82%) out of all the treatments. Compared to the organic carbon content of the soil prior to operation, the following treatments' operating results showed higher organic carbon content: 7.40 % for happy seed drill (T₁), 7.40% for rotary mulcher + zero till drill (T₂), and 3.85% for zero till seed cum fertilizer drill (T₃). The average carbon content of the soil in the conventional system (T₄) was determined to be 0.50%. T₃ treatment had the largest reduced nitrogen concentration (18.52%) of soil. The T₂ treatment had the highest amount of soil phosphorus content (7.5%) of all the treatments. The T₃ treatment had the largest reduction in soil potassium level (21.24%) among the treatments. Long time practice of crop residue incorporation increased soil nutrients. Due to incorporation of crop residue moisture loss in the soil was decreased and improve soil properties.

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