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Comparative assessment of different tillage cum crop establishment practices and crop residue management for wheat crop under combine harvested rice field in Chhattisgarh

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Abstract
Rice (*Oryza sativa* L.) and wheat (*Tricticumaestivum*) cropping system is the most extensively cultivated cereal crop in India and other countries. The major problem with this cropping system is that the management of straw and stubbles in the field after the rice harvesting. In the present study different farm machines were used to assess the impact of crop residue management on crop productivity. Farm machines such as happy seeder, mulcher + zero till seed cum fertilizer drill (ZTSFD), zero till seed cum fertilizer drill (ZTSFD), rotavator + seed fertilizer drill (SFD), cultivator + seed fertilizer drill (SFD) were used to compare the performance of each treatment for residue management and impact on crop productivity. Machine parameters such as speed of operation, effective field capacity and fuel consumption were found highest 4.2 km/h, 0.42 ha/h and 5.25 l/h in rotavator +SFD. Lowest fuel consumption was observed in ZTSFD. The residue parameters i.e. percent reduction in length of straw was observed higher in mulcher + ZTSFD and incorporation of straw was observed in rotavator +SFD as compared to other machines. Soil parameters such as moisture content evaporation and bulk density found highest in cultivator + SFD. The crop parameter straw grain ratio was found no significant difference between the treatments. The highest crop yield was observed to be 23.70 q/ha with happy seeder and the lowest was observed 22.60 q/ha in cultivator +SFD treatment. The total cost of operation for treatment T_1, T_2, T_3, T_4 and T_5 were calculated as 2121.46 3215.91, 1178.39, 3087.13 and 1926.92 ₹/ha, respectively. From all the treatments the lowest operational cost was found in ZTSFD because there is no requirement for tillage practice.

Keywords: residue management, happy seeder, zero till drill, mulcher, rotavator, crop yield, tillage

Introduction
Wheat (*Triticumaestivum*) after Rice (*Oryza sativa* L.) cropping system in India is mostly adopted cropping system practiced by the Indian farmers on estimated area of about 10.5 million hectares (Singh *et al*., 2004) [11]. This cropping system is prevalent in Indo-Gangetic plains (IGP) and is predominant in Chhattisgarh, Uttar Pradesh, Punjab, Haryana, Bihar, West Bengal, Madhya Pradesh etc. Rice and wheat both is major staple food crop across all over the world. According to Pradhan *et al*. (2018) [9] in Chhattisgarh, rice is cultivated on an average area of 3.77 million ha with productivity ranging between 1.2 to 1.6 t/ha and total production of 8.58 Mt mostly rain fed. Crop residues are substances which were left in an agricultural field after crop has been harvested such as stalks and stubbles of paddy crop. Among different crops, cereals crops produces maximum amount of crop residue consisting around 70% of total crop residue produced in India, while rice crop alone contributes about 34% to crop residue with an estimated production of 500 Mt annually in India. (Anon, 2014) [1]. Crop residue burning is the common practice for residue management in the field adopted mostly by the farmers. Burning of crop residue not only causes environmental pollution but also causes health hazard problems. Burning of rice straw contributed 0.05% of India’s overall green house gas emission (Gadde *et al.*, 2009) [4]. In addition, the tillage intensive practice for crop residue management increases the cost of operation as well as adversely affects the soil fertility over time. Incorporation of residue was more effective method for crop residue management (Mandal *et al.*, 2004) [7]. Crop residue management was involved in agriculture conservation practice by incorporation of crop residue into soil to avoid straw burning. The incorporation of straw and stubbles of previous crop also increases the soil nutrient. The unpuddled transplanting of rice, direct-seeded rice, zero-tillage direct-seeded rice and

successive wheat-crop establishment under zero-tillage often recommended for conserving the natural resources and improving the sustainability of RWCS (Das *et al.*, 2013) [2] The mulching can increase water use efficiency, profitability and increase yield and decreases the growth of weeds. (Singh and Sidhu, 2014) [12]. Sowing of seeds by seed drill gives better yield as compared with the broadcasting method. (Murumkar *et al.*, 2015) [8]. In the present study efforts have been made to compare the performance of the different tillage cum crop establishment practices and to assess the comparative performance on the crop productivity in rice-wheat cropping system.

Material and Methods

The present experiment was conducted in Rabi season at Research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) in 2019-2020 for paddy crop residue management on combine harvested paddy field and to assess the crop productivity of wheat crop for the different farm machines. In the experiment various farm machine was used for crop residue management in rice wheat cropping system. It is laid-out in randomized block design with five treatments and four replications. The performance of different farm machine was compared with the four different parameters i.e. machine parameter, residue parameter, soil parameter and crop parameter as discussed below:

Machine Parameters

Performance of different machines was compared based upon the speed of operation, effective field capacity and fuel consumption for the different field operation. The details of the procedure followed to determine the above machine parameters were discussed below:

Speed of operation, m/s

The speed of operation of different machines was measured using standard procedure. Two poles were fixed in the field which was 30m apart from each other. The tractor along with machines was allowed to run between these poles and the time required to cover this distance were recorded with the help of stop watch. The speed of operation was calculated by using following equation.

$$\text{Speed of operation}, \left(\frac{\text{m}}{\text{s}}\right) = \frac{\text{L}}{\text{T}}$$

Where,
L = Distance travelled, m
T = Time taken, s

Effective field capacity, ha/h

Effective field capacity is actual area covered by machine expressed in ha/h. The effective field capacity was calculated by following equation

$$\text{EFC} = \frac{\text{A}}{\text{T}_\text{p} + \text{T}_\text{l}}$$

Where,
EFC = Effective field capacity of machine, ha/h;
A = Actual area covered by machine, ha;
T_p= Productive time, h
T_l= Non productive time, h

Fuel consumption, lit/h

Fuel consumption (FC) was determined by top up method in litre per hour. In this method an additional measuring cylinder was used to measure the amount of fuel required for operation. The fuel tank was first filled at full level before operation and after one hour of operation the additional fuel requirement to full the tank was measured.

Residue Parameter

Crop residue parameter was measured before and after the operation of machine. Following parameters like length of residue, weight of residue, moisture content was measured by the suitable instruments.

Length of Residue/ Straw

Length of the residue/paddy straw was measured using flexible measuring tape before and after the operation. The paddy straw was collected from 10 random places in the field of 1 m^2 area using square frame.

Weight of Residue

Weight of residue was determined by using an electronic weighing balance before and after the operation. The samples were collected from 10 random places in the field of 1 m^2 area using square frame.

Moisture content of paddy straw

Crop residue was collected from paddy harvested field in November 2019. Chaff and stems were gathered from the post harvested field and dried at 70 ^{0}C for 4 days. Weighing balance machine was used to weigh the sample and moisture content of the residue on dry basis was measured by following relationship:

$$\text{MC }(db) = \frac{\text{W}_i - W_d}{W_d}$$

Where,
MC (db) = moisture content on dry basis,%
W_i = Initial weight of residue, g: and
W_d = Dry weight of residue, g

Soil Parameter

Soil parameter like, moisture content of soil, bulk density of soil was measured before and after the sowing from the each plot.

Moisture content of the soil

Moisture content of soil was measured using oven dry method. The soil samples were collected from the field after every week until the next irrigation for 18 weeks. The wet soil samples collected from the field were weighed using electronic weighing balance. The soil sample was kept in oven at 105 ^{0}C for 24 h. After 24 h the soil sample was again weighed to determine the dry weight of the soil. The moisture content of the soil was then determined by using following formula:

$$\text{MC }(db) = \frac{\text{W}_\text{w} - \text{W}_\text{d}}{\text{W}_\text{d}}$$

Where,
MC (db)= Moisture content of soil on dry basis
W_w = weight of wet soil, g

W_d = weight of dry soil, g

Bulk density of soil

Bulk density of the soil is defined as mass of soil divided by volume of the soil. Bulk density of soil was measured using core cutter sampler having 10 cm diameter and 17.5 cm in length. The core cutter was penetrated into the soil with the help of hammer. Undisturbed soil sample collected from the field was kept in oven at 105 ^{0}C for 24 hours and then weighted using electronic balance. Bulk density was then calculated by dividing the dry mass of soil to volume of the soil sample.

Crop Parameter

Crop parameters such as straw grain ratio, 1000 grain weight and crop yield were observed during experiment and recorded. The methodology followed to determine the above parameters were as follows:

1000 Grain weight

After threshing of crop 1000 grains were selected manually and weighed by using electronic weighing balance from each plot.

Straw-grain ratio

Straw grain ratio (SGR) is defined as the ratio of weight of straw to the weight of the grain. The randomly selected crop bundles were threshed in the field and the weight of grain and weight of straw was measured separately. Then the straw grain ratio was determined by dividing of weight of straw and weight of total grain.

$$\text{Straw} - \text{grain ratio} = \frac{W_s}{W_g}$$

Where,
W_s = weight of straw, gm
W_g = weight of grain, gm

Crop yield

Crop yield was determined to evaluate the productivity of the wheat crop under different treatments. The crop was harvested and threshed after the crop was matured from each plot in the field. Then the weight of grains was measured using electronic weighing balance.

Cost Analysis

The economic use of different machines was carried out by using straight line method considering standard assumption for different parameter to find out the cost of operation of different farm machines.

Result and Discussion

The results of the performance of different farm machines treatment has been discussed in the following section. The five treatments i.e. T_1 (happy seeder), T_2 (mulcher + ZTSFD), T_3 (ZTSFD), T_4 (rotavator + SFD) and T_5 (cultivator + SFD) were operated in the field (Fig 1) and the results on different machine parameters, residue parameters, soil parameters and crop parameters were discussed below:

(a) Mulcher

(b) Happy seeder

(c) Rotavator

(d) Zero till seed fertilizer drill

Fig 1: Different treatments during the field operation

Machine parameter

The performance of different treatments was compared for the different machine parameters and the results were presented in Table 1. It was observed that the highest and lowest speed operation was 4. 2 km/h and 2.5 km/h for the treatment T_4 and T_1, respectively. The effective field capacity was observed to be highest for treatment T_3. Higher field capacity during treatment T_3 may be due to fact that there was single pass of operation during this treatment compared to other treatments. The fuel consumption for the different treatments were measured and it was found highest for treatment T_4 and lowest was observed for treatment T_3. The results found for the different machine parameter were in agreement with the result found by Dewangan *et al.,* 2020 [3]; Kosariya *et al.,* 2019 [6] for chickpea.

Table 1: Results on the different machine parameter for the different treatments

Treatments	Operational speed (km/h)	Effective field capacity (ha/h)	Fuel consumption (l/h)
T_1: Happy seeder	2.50	0.32	4.30
T_2: Mulcher + ZTSFD	3.12 + 3.5	0.35 + 0.38	4.2 + 2.50
T_3: ZTSFD	2.70	0.28	2.43
T_4: Rotavator + SFD	4.2 + 2.9	0.42 + 0.36	5.25 + 2.6
T_5: Cultivator + SFD	4.1 + 2.6	0.38 + 0.38	4.1 + 2.9

Residue parameters

The results on the residue parameters have been presented in Table 2. Incorporation of residue in the soil was compared for different treatments by measuring the length of straw and weight of straw before and after the operation. The result showed that treatment T_2 performed better in chopping the crop residue and treatment T_4 performed in incorporation of crop residue in soil as compared to other treatment. It was observed that the management of crop residue in the field was achieved satisfactorily in treatment T_2, T_4 and T_1 as compared to treatment T_3 and T_5 because the paddy straw get stuck in the tines of ZTSFD and cultivator. Similar results were also found by Dewangan *et al.,* 2020 [3], Sonwani *et al.,* 2019 [13].

Table 2: Results on the different residue parameter for the different treatments

Treatments	Length of residue			Weight of residue		
	Before operation (cm)	After operation (cm)	Percent of reduction in length	Before Operation (cm)	After Operation (cm)	Percent incorporation of crop residue
T_1: Happy seeder	85.3	21.5	74.7	517.2	350.3	32.26
T_2: Mulcher + ZTSD	83.2	11.2	86.5	520.4	312.2	40.00
T_3: ZTSD	83.5	83.5	0	515.5	417.4	19.3
T_4: Rotavator + SFD	86.2	43.5	49.5	512.3	220.6	56.93
T_5: Cultivator + SFD	84.1	84.1	0	514.2	420.2	18.28
SE(m)±	3.325	2.016		6.427	5.465	
CD at 5%	NS	6.678		NS	18.100	
CV	6.819	7.163		6.777	6.813	

Soil Parameter

It was observed that there was linear decrement of moisture occurred during the irrigation intervals. However, it was found that the loss of moisture was minimal in case of happy seed drill may be due to fact that no tilling operation was done. While the loss of moisture was high during the treatment T_5: cultivator + SCFD due to better soil tilt to a deeper depth. Similarly, the bulk density of the soil was observed to be high in case of treatment T_5 and lowest was observed in treatment T_3. Similar results were also reported by Sonwani *et al*., 2019 [13].

Crop Parameter

The crop parameters such that straw grain ratio, crop yield, 1000 grain weight and cost of operation were observed and recorded during the experiment. The results on the crop parameters were showed in the table 3. It was observed that there is no significant difference in between all treatments in straw grain ratio of crop. The highest crop yield was observed 23.70 q/ha in case of treatment T_1 (Happy seeder) which is significantly higher than other treatments. Overall it was found that the treatment T_1 performed better in terms of crop productivity as compared to other treatments. The 1000 grain weight was also observed significantly higher for treatment T1 as compared to other treatments. Similar results were also found by Prasad *et al.*, 1999 [10], Tanveer *et al.*, 2003.

Table 3: Results on the different crop parameter for the different treatments

Treatments	Straw grain ratio	Crop yield, q/ha	1000 Grain weight, gm
T_1: Happy seeder	1.31	23.70	46.24
T_2: Mulcher + ZTSFD	1.30	23.10	44.71
T_3: ZTSFD	1.30	23.20	41.98
T_4: Rotavator + SFD	1.32	22.80	42.12
T_5: Cultivator + SFD	1.35	22.60	39.88
SE(m)±	0.058	0.161	1.719
CD at 5%	NS	0.534	5.694
CV	7.677	6.769	6.832

Cost of operation
The total cost of operation for treatment T_1, T_2, T_3, T_4 and T_5 were calculated 2121.46 3215.91, 1178.39, 3087.13 and 1926.92 ₹/ha, respectively. From all the treatments the lowest operational cost was found in treatment T_3 because there is no requirement for tillage practice.

Conclusion
The comparative assessment of all the five different tillage cum crop establishment farms machine was determined. The result showed that highest crop yield was observed in case of happy seeder while the lowest cost of operation was observed in zero till seed cum fertilizer drill due to direct sowing of seed in field without tillage operation.

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