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Techno-economic feasibility of super seeder in combine harvested paddy field of Chhattisgarh

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Abstract
The rice-wheat cropping system is a globally widespread practice for cultivating cereal crops. In Chhattisgarh, most of the farmers belong to small land holding capacity. Weed infestation and non–decomposition of the straw were the topmost problems faced by them. In Chhattisgarh, where paddy cultivation is a primary agricultural activity, the introduction of super seeders has the potential to revolutionize traditional farming practices. Various farm machines were used in this experiment to focus on crop residue management within this rice-wheat cropping system., including the super seeder (T_1), happy seeder (T_2), mulcher + zero till drill (T_3), and field harvested by reaper + super seeder (T_4). Machine parameters like fuel consumption, speed of operation, field efficiency and field capacity; crop parameters like crop yield, wheat germination percentage; and residue parameter like length straw and weight of straw were considered for the feasibility study. Because two machines are used in the T3 treatment, fuel consumption is higher compared to the other treatments. The highest effective tillers per square metre, and 1000 grain weight were obtained in T_1 i.e. (372 tillers/ m^2), and (46.80 g) respectively. In terms of yield, the highest grain yield, at 5.62 tons per hectare, was achieved with reaper + super seeder, followed by $T_1>T_3>T_2$. Super seeder proved to be the most cost-effective straw management machine for post-rice harvest operations, with cost of operation rankings as follows: super seeder > T_3 > T_2 > T_4.

Keywords: Techno-economic, super seeder, paddy field

Introduction
The world's largest agricultural production system, the Rice (*Oryza sativa* L.) and the wheat (*Triticum aestivum*) cropping sequence (RWCS), covers approximately 12.3 M ha in India, 0.5 M ha in Nepal, 2.2 M ha in Pakistan and 0.8 M ha in Bangladesh and around 85% of this area falls in Indo-Gangetic plains (IGP) (Bhatt *et al*., 2016) [1]. Crop residues are plant parts that are left over after crops have been harvested with a combine harvester. Crop left overs are used as a source of energy in various nations in a variety of ways, including as animal feed, mushrooms, compost, Biofuel, bio-oil, gasification, bio-char production, and so on. In Chhattisgarh, crop residue produced about 11.25 million ton per years and burnt about 7.5 % is burnt per year (Srinivasarao *et al*., 2013) [5]. Burning of paddy straw results in air pollution with serious consequences on both human and animal health, and it increases the amount of emissions of greenhouse gases. Straw burning also results in loss of rich soil organic matter as well as nutrients in the straw itself. To solve the problem of burning of paddy straw and late sowing of wheat, many types of machinery are available in India. Mulcher, happy seeder, super seeder, lucky seeder helps to manage crop residue without burning in the field. Chhattisgarh, a region characterized by its small-scale farming operations, predominantly relies on paddy cultivation. The introduction of innovative agricultural technologies such as the super seeder has the potential to significantly impact crop management and overall farm productivity.

Materials and Methods
The experiment was carried out during the *kharif* season at Research Farm, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur (C.G).

Design of Experiment
Various farm machines were used for crop residue management in the rice wheat cropping system, including super seeder (T_1), happy seed drill (T_2), rotary mulcher + zero till seed cum fertilizer drill (T_3), harvested by reaper + super seeder (T_4). The experiment was laid-out in strip plot design with four treatments and five replications.

The machine parameters in the experiment are (operation speed, effective field capacity, and fuel consumption), the soil parameters are (moisture content, bulk density, porosity, and nutrient content of soil), the residue parameters are (length, weight of residue//straw before and after operation), and the plant parameters are (plant height, population of plant, length of ear head, grain weight, straw grain-ratio). A cost analysis was also performed.

Machine Parameter

Speed of operation

For determination of speed of operation, two wooden poles were fixed at 30.0 m distance. The tractor along with machine was operated between these poles. Operation time was noted with a stop watch.

$$\text{Operating Speed (m/s)} = \frac{L}{T}$$

Where,
L = Distance travelled (m).
T = Time taken (s).

Effective field capacity

The effective field capacity (EFC) of a farm machine is calculated by dividing the area covered by the hour of actual time.

$$\text{EFC} = \frac{A}{T}$$

Where,
EFC = Effective field capacity of the machine, ha/h.
A = Area covered, ha.
T = Time taken to cover area, h.

Field efficiency

From the actual and theoretical field capacity, the field efficiency was calculated.

$$\text{Field efficiency (\%)} = \frac{\text{EFC}}{\text{TFC}} \times 100$$

Where,

FE= Field efficiency.
AFC=Actual field capacity (ha/h); and
TFC=Theoretical field capacity (ha/h).

Fuel consumption

Fuel consumption (FC) was calculated using the top-up method. Before the operation, the fuel tank was fully charged. After an hour of work, it was back to full capacity. A measuring cylinder was used to determine the amount of fuel noted.

$$\text{FC}\left(\frac{\text{lit}}{\text{ha}}\right) = \frac{\text{Consumption of fuel}\left(\frac{\text{lit}}{\text{h}}\right)}{\text{covered area}\left(\frac{\text{ha}}{\text{h}}\right)}$$

Moisture content

In the experiment, irrigation was applied three times, and the moisture content of the soil was measured after each irrigation. Every week until the next irrigation, the soil moisture content is calculated. For soil moisture analysis, the oven drying method was used. Soil samples are collected in an oven set to 105 degree Celsius. After 24 hours, the weight of the dry soil sample was measured, and the moisture content of the soil was calculated using the following equation:

$$\text{Moisture content (db) \%} = \frac{\text{Wi} - \text{Wf}}{\text{Wi}}$$

Where,
wi = Initial weight of residue, g; and
wf = Dry weight of residue, g.

Crop parameters

Crop yield

Crop yield was measured in quintal per hectare, where the crop was randomly placed and harvested under all treatments. Using electric balance, the weight of grain was determined.

Wheat germination percentage

Wheat germination test was performed by counting out 50 seeds and placing them in a damp paper rowel. The paper towel was placed into a plastic bag to conserve moisture and stored in worm location out of direct sunlight. After 7 days, numbers of germinated seeds those have both intact root and shoot were counted.

$$\text{Germination \%} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds taken}}$$

Residue parameter

Length of residue/straw

The length of residue/straw was measured with a flexible measuring tape before and after the operation of the machine. The measurement was taken at ten points selected randomly of an area of 1 m^2.

Weight of residue

The straws were collected from a square meter area with the help of a square frame with sides 1 m. The weight of straw was done with the help of a digital balance having 1 g least count. The measured weight of straw is dry weight.

Cost analysis

Fixed cost and operation cast were used to calculate the operation cost. Lubricants, fuel, repair and maintenance, and wages are all part of the operational cost.

Result and Discussions

Machine parameter

Speed of operation

The observed speed of operation during experiment were 3.2 km/h, 1.8 km/h, 3.28 km/h and 2.7 km/h for treatment super seeder (T_1), happy seeder (T_2), rotary mulcher (T_3) and zero till seed drill (T_4) respectively.

Effective field capacity

The T_1 had the highest EFC (0.41 ha/h), followed by the T_2 (0.39 ha/h). The combination of two to three operations implemented in the same field resulted in the lowest EFC in the case of T_3 and T_4, as shown in Table 1.

Field efficiency

The rotary mulcher had the highest field efficiency (86.48 %), followed by the seed cum fertilizer drill (82.30 %), the happy seeder (75.94 %), and the Super Seeder (75.76 %).

Fuel consumption

The super seeder (T_1), out of the four selected implements, used the lowest amount of fuel (13.52 l ha^{-1}), followed by (T_4) i.e. the field harvested by reaper + super seeder (1.31 + 13.52

l ha^{-1}), the T_2 the happy seeder (15.30 l ha^{-1}), and the T_3 mulcher + seed cum fertilizer drill (15.15 + 4.48 l ha^{-1}).

Soil parameter
The minimum soil moisture loss was observed in the case of super seeder followed by reaper + super seeder (T_1 and T_4) compared to other treatments. The higher soil moisture loss was observed in the case of happy seeder and mulcher + zero till drill (T_2 and T_3).

Crop parameter
The average higher grain yield was observed in T_1 (5.56 t/ha) and the average higher straw yield was higher in T_2 (7.36 t/ha) as compared to other treatments. The 1000 weight was highest in T_1 (41.16 g). The highest wheat germination percentage was found in T_1 (88 %).

Residue parameter
The average height of paddy straw/stubble was found to be 36.1 cm before the application of various treatments, and the reduction in stubble height after the use of various residue management machine was significantly different at a 5% level. A significantly higher reduction was obtained with T_4, i.e. the field harvested with reaper and sown from super seeder (87.72%) and lower of 79.87 % with T_3, i.e. mulcher + seed cum fertiliser drill.

Cost analysis
In this experiment cost required in super seeder, happy seeder, rotary mulcher and zero till seed drill are 1481.28 Rs/ha, 1933 Rs/ha, 3499.37 28 Rs/ha and 1221.68 28 Rs/ha, respectively. T3 treatment has a lower cost requirement because no tillage work is done and labour work is minimal.

Table 1: Experiment Detail

S. No.	Particulars	Specification
1.	Number of Treatment	4
2.	Number of replications	5
3.	Net Plot size	62 m X 23 m
4.	Total no. of plot	20
5.	Distance between replications	0.5 m
6.	Distance between plots	0.5 m
7.	Last crop harvested	Paddy
8.	Soil type	Vertisol
9.	Sowing crop	Wheat
10.	Varity	Ambar
11.	Date of sowing	15.11.2022
12.	Date of harvesting	28.03.2023

Table 2: Average Machine parameter

Treatments	Speed of operation	Effective field capacity	Fuel consumption
T_1	3.2	0.39	13.52
T_2	1.8	0.41	15.30
T_3	3.28	0.36	19.63
T_4	2.7	0.35	14.82

Table 3: Comparison of yield attributing parameters for different treatments

Treatments	Effective tillers per m^{-2}	Plant height (cm)	Grains per panicle	1000 grain weight (g)	Panicle length (cm)
T_1	372±9.6	110.2±1.0	65.7±1.4	46.80±0.6	12.2±0.2
T_2	273±4.3	98.5±2.2	62.7±0.8	45.40±0.40	12.2±0.3
T_3	281±4.6	104.6±1.2	61.7±1.2	43.33±0.55	11.8±0.1
T_4	310±7.8	108.2±1.0	63.7±1.2	44.20±0.45	11.6±0.2

Fig 1: Seed cum fertilizer drill

Fig 2: Rotary mulcher

Fig 3: Happy seed drill

Fig 4: Super seeder

Conclusion
Super seeder showed the optimum level of crop residue management in combine harvested rice field followed by happy seeder, mulcher and seed cum fertilizer drill. The effect of straw decomposition rate was observed higher in field

harvested by reaper + super seeder. The addition of crop residue to the soil enhanced its physical, chemical, and biological characteristics. Overall, incorporation of crop residue appears to be better management option. The yield attributing characters and grain yield was obtained highest as 5.62 t ha^{-1} in case of reaper + super seeder followed by $T_1>T_3>T_2$. The super seeder turned to be cost effective straw management machine first after harvest of rice for sowing of wheat crop on the basis of cost of operation. However, after treatment follows the $T_3>T_2>T_4$.

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