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RESEARCH ARTICLE

PERFORMANCE EVALUATION OF WHEAT STRAW CHOPPER BLOWER

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ABSTRACT

The combine harvesters compete only with the crops, leaving large stubbles and machine-thrown straw on the ground. Removing wheat residues from the field can be very costly and laborious, farmers generally burn this left-over straw for cultivation operation of subsequent crop. Wheat straw chopper is an agricultural resource conservation environment friendly technology to collect stubbles from combine-harvested wheat fields. Currently, this technology is being used but, not evaluated in fields intensively. Therefore, the main the purpose of this study was to assess the wheat straw chopper output at Rana Agric after combine-harvested wheat, Jatoi estate, Punjab and the economies of this machine. Four different wheat varieties Sehar-2006, Lasani, Faisalabad-2008 and Punjab-2011 were in the test fields. Wheat straw chopper was operated with 75 hp tractor at two selected forward speeds 1.5 and 3.5km h^{-1}. Results showed that the average effective field range of the chopper was 0.3 to 0.7 ha h^{-1} and 65 percent field efficiency. For the chaff the approximate volume recovered was 2234 kg ha^{-1}. The running cost for the Chopper setup was $41.24 ha^{-1}. The total value of the chaff and grain recovered was $216 ha-1 (@$0.1 kg-1) and $17.13 ha^{-1} (@$0.25 kg-1) respectively. The net savings for the wheat straw chopper were 192$$ha^{-1}$. Wheat straw chopper has proven to be an effective technology which is gaining popularity in combined harvested wheat fields to save chaff and increase farmers ' income.

KEYWORDS

Straw Management, Wheat Straw Chopper, Field Testing, Economic analysis

1. INTRODUCTION

Crop residues, especially wheat, are an essential alternative feed which should be used to the fullest extent possible in all developing member countries. They may also become major raw stuff for wood-based biofuels, manufacturing, paper and panels (Devendra, 2007). Combined harvesting is better than manual harvesting since it saves about 10-15 per cent in one process apart from labor losses and harvests and thresholds. The harvesters combine crops and pick only wheat, leaving large field stubbles, trampled on, and machine-drown (Erenstein 2010). Farmers typically burn this left-over straw to clear their fields for most subsequent crop cultivation operations, but it can be very expensive and laborious to harvest crops and gather residues from the fields. Criticism of air pollution reduced microbial activity, degradation of organic matter, depletion of crop-friendly bacteria and lack of soil nutrients for wheat straw burning is widespread (Chen et al., 2005).

Successful residue management system commences with crop harvesting safe and productive cropping method calls for an integrated straw management approach. The use of off-field wheat straw has brought changes in the handling of grains. Another alternative for waste management will be the addition of chemical compounds to the soil surface. Efficient residue management system starts by harvesting the crops. A safe and productive cropping method calls for an integrated straw management approach. It has modified the way straw is handled with off-field used wheat straw (Mangaraj and Kulkarni, 2011).

Wheat straw chopper blower is both a trailed field and a platform for conveyance operations. It harvests all the stubbles and removes the combine discarded grass from the field. The straw is cut into bhoosa, and a trolley hooked bellowed. It is driven on a tractor with more than 50 hp. Chopper wheat straw blower capable of harvesting uncut straw and collecting combined straw from the harvested field (Gill et al., 2012). On farmer 's fields, the wheat straw chopper has been tested to assess its suitability for adoption under local conditions. Because of the chopper's field performance, the machine can convert wheat stubbles on an acre into straws by consuming just about 6 litres of diesel in an hour (Zafar et al., 2002).

For reasons such as turning wheat straw into wheat straw for animal feed, and removing straw burning and emissions from the environment, the combination of harvester and wheat straw chopper collector has proved a more successful wheat harvesting and threshing technology. In rice-wheat and cotton-wheat cropping systems in Punjab, many locally built wheats straw choppers are now in use (Rehman et al., 2011). Although the wheat straw chopper has been implemented in Pakistan for several years, the field manufacturing of this technology has not yet been thoroughly evaluated and published to future reference in any scientific paper. The goal of this study was to assess Rana Agric wheat straw chopper production in combined harvested wheat fields. Farm Jatoi, Punjab and the economics that are to be decided at that point.

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2. MATERIAL AND METHODS

2.1 Experiment Sites and Test Fields

Two test sites were selected Rana Agric. Farm and neighborhoods farmers field Jatoi, Punjab where wheat crops were harvested with combine harvesters. Four tests were conducted for evaluating the performance of the machine and the total area harvested with wheat straw chopper at four test fields was 27 ha (9, 7, 5, 6 ha, respectively). All test fields were rectangular in shape. Appropriate field patterns (circuitous pattern with rounded corners) were selected to keep the nonproductive time minimum.

2.2 Wheat Straw Chopper Blower

In this study during field operation a trailed type wheat straw chopper powered by a PTO tractor was selected. The wheat straw chopper carries out four major operations: (1) loose straw pickup; (2) anchored straw harvest; (3) straw threshing, and (4) chaff blowing. PTO power supplied via V-belts, Pick-up wire string and pulleys, cutting handle, threshing disc, blowing ventilators, oscillating sieves, and feeding (Mahmood et al., 2016).

Table 1: Specifications of various components of wheat straw chopper blower

Machine component	Parameter	Specifications
Tractor required	Horsepower (hp)	65 or higher
Conventional straw chopper	Length (mm)	4115
	Width (mm)	2686
	Height (mm)	2400
	Weight (kg)	1450
Threshing drum	Cutter bar	Cutter type
	Width of cut (mm)	2330
	No. of knives on cutter bar	26
	No. of ledger plates	26
	Fan	Suction cum blower
	Threshing drum diameter (mm)	500
	Concave opening (mm)	12
Reel	Number of Horizontal loops	4
	Number of springs per round bar	**10**
	Number of fingers per round bar	20
	Length per round bar (mm)	2260
Throat	Length of the throat (mm)	1260
Straw Feeder	Number Of the bars in tetragon	4
	Number Pressing glues per bar	**88**
	Length of the chopping drum (mm)	1380
Chopping Drum	Diameter from the Cutting Drum (mm)	482.6
	Length of the chopping drum (mm)	1500
	No. of knives of chopping drum	217

2.3 Field Trails

The trails for the wheat harvesting were conducted in season 2020. The Fiat-385 (75 hp) was used with the help of a wire-mesh canopy trolley Drive straw chopper for collecting the chaffs. Operated with 2 field speeds on the straw chopper: 3.5 km/h with 2nd low gear tractor and 1.5 km/h with 1st low gear tractor. Similar tractor forward speed was recommended (Mahmood et al., 2016). At higher field velocities the straw load was unmanageable.

2.4 Data Collection

Even prior to operation, the crop parameters were determined including straw moisture content, wheat stubble height, number of tillers per m^2, wheat straw diameter, row spacing and variety of wheat crops. For Straw wheat grafting the most significant parameter was the moisture content. The straw was harvested at about 18 percent or less of the straw moisture to ensure proper threshing (Pioneer, 2013). By twisting and breaking the straw with hands, the moisture content was measured qualitatively by judgement method.

Average tractor forward speed was measured by distance time method for 50 m long field strip. Theoretical and effective field capacities are the machine performance in ideal and actual field conditions, respectively. For this, theoretical cutting width was taken from the manufacturer's specifications while the effective cutting width was measured in the field repeated thrice in the field to get average effective cutting width. The following equations were used for measuring theoretical and effective field capacity. Field effectiveness is defined as the ratio of effective field capability to the theoretical field capability (Celik 2006; Sağlam et al., 2010).

$$TFC = \frac{S \times W}{10} \quad (1)$$

$$EFC = \frac{A}{TP+TL} \quad (2)$$

$$\eta = \frac{EFC}{TFC} \times 100 \quad (3)$$

Where; TFC = theoretical field capacity (ha h^{-1}), EFC = effective field capacity (ha h^{-1}), S = tractor forward speed (Kmh^{-1}), W = Theoretical working width (m), A = Total area actually covered by the machine (ha), TP, TL = Productive and non-productive time of the machine (h) and η = field efficiency.

Using a full tank method, the fuel consumption was measured in each field trail. During the test the man-hours needed to operate the chopper were calculated, and the chaff trolley was unloaded. Complete operating costs for the wheat straw chopper include integrating ownership costs (fixed costs) with operating costs (variable costs) (Field and Solie, 2007). Fixed costs include depreciation, average investment interest, insurance, tax and shelter; variable costs include gasoline, oil, repair and maintenance, consumables and the required operation of the computer. The wheat straw chopper operating costs were determined in accordance with the procedure (RNAM, 1995). The quantity of the chaff and grain recovered were recorded in kg ha^{-1} based on trails data.

3. RESULTS AND DISCUSSION

3.1 Crop Parameters

The crop parameters showed the machine performance, and the total recovery of the chaff from the test fields. The moisture content of the straw was given as very important in Table 2. The performance of wheat straw chopper with a high humidity content was reduced. Harvesting the higher moisture content straw frequently obstructed the threshing machine and caused machine breakdown. Increased fuel consumption, and machine efficiency significantly reduced. In the mornings the tractor used his maximum power to thresh the moist straw. The content of moisture observed across all field trails ranged from 13-16% of all test fields.

Table 2: Evaluation of crop related parameters

Parameter	Field-1	Field-2	Field-3	Field-4
Variety	Sahar-2006	Faisalabad-2008	Lasani	Punjab-2011
Moisture content (%)	15.1±0.02	14.7±0.05	14.4±0.01	13.6±0.03
Row spacing (mm)	18.2	18.7	19	18.2
Wheat stubbles height (mm)	342	355	361	325
No. of tillers	4.3	4.7	3.8	4.1
Straw diameter (mm)	4.2	4.1	4.2	4.3

3.2 Machine Performance Parameters

Computer forward speed directly impacted chopper wheat straw output (Table 3). The unit performed with success in 1.5 km/h (first low gear) and 3.5 km/h (second low gear). Low speeds were used in heavy straw loads, even in sandy soil where extra slippage caused the tractor to have less traction power. This means that not only should the chopper be used at one field speed, but the speed should be adjusted according to the straw load between the above two field speeds. Always operate the transverse chopper onto the straw windrows that the combine ejects. If chopper is used along the rows, heavy combine-thrown straw is likely to reduce machine performance and breakage or clogging of the machines. Forward speed to feed large heaps of combined expelled straw should be controlled, or reduced consequently.

This wheat straw chopper had a theoretical cutting distance of 2.33 m before beginning field tests and had been tested according to manufacturer specifications. In all tests the successful cutting width was 2.0 m. For the unit the effective cut width was an average of 2.10 m (Table 3). The disparity between theoretical and practical cutting width has been attributed to duplication of the cutting stripes in the successive runs. The test fields were stone-free and thus the cut height was held from 30-40 mm above ground level to the lowest possible level. For both field studies, the theoretical field capacity was 0.7 ha h^{-1} at a field speed of 3.5 km h^{-1} and 0.3 ha h^{-1} at field speed of 1.5 km h^{-1} while the real field capacity was 0.62 ha h^{-1}. The chopper 's effective field capability varied from 0.20 ha to 0.43 hectares h^{-1}. At 1.5 km h^{-1} the effective field potential was less and higher at field speeds of 3.5 km h^{-1}.

It was directly related to operating velocity and unproductive field time. The field efficiency of Chopper in various field tests ranged from 58.6 per cent to 73.3 per cent. The machine's average efficiency was 65 per cent in all tests (Table 3). Machine field efficiency from previous versions has been increased with a supreme field efficiency of 60 % (Zafar et al., 2002). That's why the wheat straw chopper's use in combining harvested wheat fields is now gaining momentum within the agricultural community. The fuel consumption depends primarily on tractor operating conditions, crop load and straw moisture content. The tractor develops more power at heavy crop loads, and thus consumes more fuel, the higher straw moisture content, higher fuel consumption. The tractor 's average fuel consumption at a field speed of 1.5 km h^{-1} was around 13.7 l ha^{-1}, while the average fuel consumption was around 15.4 l ha^{-1} at 3.5 km h^{-1}. In all field tests the mean fuel consumption was calculated to be 14.58 l ha^{-1}.

Table 3: Evaluation of machine performance after field trails

Trail	Trail area (ha)	Forward speed (Kmh^{-1})	Effective cutting width (m)	Cutting height (mm)	TFC (ha h^{-1})	EFC (ha h^{-1})	Field efficiency (%)	Fuel consumption (l h^{-1})
1	9	3.5	2.0	32	0.7	0.41	58.6	14.1
2	7	3.5	2.0	40	0.7	0.43	61.4	16.7
3	5	1.5	2.0	36	0.3	0.22	73.3	14.6
4	6	1.5	2.0	33	0.3	0.2	66.7	12.9
Avg.	6.75	2.5	2.0	35.25	0.5	0.32	65	14.58

3.3 Operational Cost of Straw Chopper

For driving tractor, chopper and trolley, and unloading the chaff trolley at a chaff collection point, one driver and 2 labor men were required. One of them also carried chaff-filled trolley from the field to the place that collected the chaff. It took 3 man-hours to harvest one hectare to operate the tractor and the machines. Unloading and transporting chaff trolleys to a hectare chaff took five man-hours. To harvest one hectare of loose and anchored wheat straw, the total labor input required was 8 man-hours. An economic analysis of the wheat straw chopper has been shown in Figure 1 for all tests carried out. The average cost was calculated as \$41.24 ha^{-1} for the tractor- and trolley-operated wheat straw chopper. Tractor and trolley can also be used for other purposes during the year, but in the wheat harvest season, the wheat straw chopper was used only for about a month. The chopper used for the wheat straw ranged from 10 h to 300 h per annum. All the machines' fixed and variable costs were calculated on the basis of their annual usage.

For all of the tests, the average gain and chaff recovery was 68.5 and 2159 kg ha^{-1}, using a wheat straw chopper, respectively. This chaff recovery result is consistent with (Zafar et al., 2002). This amount can vary depending on the variety of wheat crops, as already mentioned. The reasons are threshing to make it a bit fine straw, straw spread around the field, lots of field patches are left uncut and wheat straw close to boundaries, uncut remains which are also the reason for low chaff recovery. Also, a certain amount of straw is lost from the trolley mesh canopy due to the high blower pressure. The straw chopper assumed all of these losses to be roughly 15 per cent of the total recovered chaff. The price of the chaff produced by the wheat straw chopper was 0.1\$kg-1 according to local market price. The total price of the chaff has varied from \$209-218 kg-1. The net savings for the farmer was 205 \$ha^{-1}. The chaff is retrieved for cattle feeding with the use of wheat straw chopper, soil organic matter is saved from burning and waste is minimized for the atmosphere.

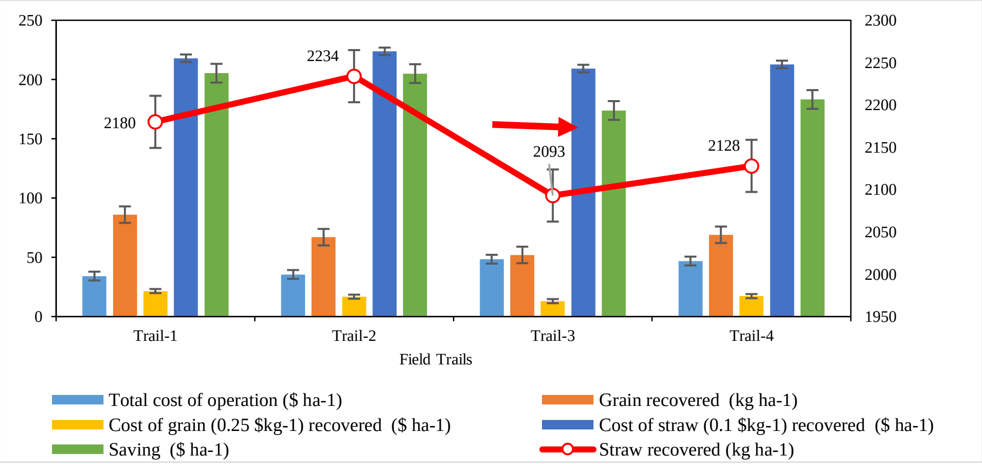

Figure 1: Economic analysis of recovered grain and straw (USD were taken equal to 150 PKR)

4. CONCLUSION

The management of the wheat residues in the field is costly and laborious. Wheat straw chopper is an environment friendly resource conservation technology for agriculture that collects stubbles from combined harvested wheat fields. Consequently, This study aimed at intensively testing the efficiency of Rana Agric's wheat straw chopper after combining harvested wheat. Farm Jatoi, Punjab and the economics of that system to be decided. Results showed that the average field efficiency was 65%. The maximum recovered amount of chaff was 2234 kg ha^{-1}, and the total recovered value of chaff and grain was respectively 216 \$ha^{-1} and 17.13 \$ha^{-1}. The net savings for the wheat straw chopper were 192\$ha^{-1}. Wheat straw chopper has proven to be a profitable technology which is gaining momentum in combined harvested wheat fields to save chaff and increase the benefit of the farmer.

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Conflict of Interest

The authors showed no conflict of Interest at any point for this manuscript

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Author Contributions

Rana Shahzad Noor contributed in Conceptualization of research study, Design & Development of the experiment, Data collection, Formal Analysis, Investigation, Methodology, Visualization, writing an original draft, reviewed, supervised and Write-up editing. Fiaz Hussain, Abu Saad and Muhammad Umair contributed in Data collection, Formal Analysis, Investigation, Methodology, Visualization and Writing an original draft. Muhammad Umar Farooq and Abu Saad contributed in Data collection and data formal analysis.

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