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Performance Evaluation of Tractor driven Round Baler in Residue Management

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ABSTRACT: The increasing use of combine harvesters in Nepal has led to a surge in straw burning, causing environmental pollution, soil degradation, and other adverse effects. To address this issue, a 4-wheel tractor-driven round baler was tested and evaluated in Nepal.

Field testing was conducted to gather information on straw, machine, and bale parameters, as well as baling costs. The machine's field capacity, efficiency, straw recovery, fuel consumption, and baling time were determined. The baling process, including drying and bale formation, was also assessed.

Results: The round baler demonstrated a field capacity of 0.75 ha/h, 95% efficiency, 92% straw recovery, 5 liters/hr fuel consumption, and 1.3 hrs/ha baling time. The bales, with 20% moisture content, measured 0.64 m in diameter, weighed 16 kg, and had a cost of NRs 4600/ha. The machine exhibited an average baling capacity of 30-35 bales/hr for rice straw and 35-40 bales/hr for wheat straw, with better efficiency in baling wheat straw.

The tested round baler showed promising results in addressing the residue burning issue, promoting the "earn, do not burn" concept. It offered a viable solution for efficiently baling rice and wheat straw, thereby contributing to environmental sustainability and economic viability in the agricultural sector

KEYWORDS: Tractor, Baler, Efficiency, Economic analysis

1. INTRODUCTION

The Terai area of Nepal is often regarded as the nation's food basket (Regmi AP, Ladha JK, Pathak H, Pashuquin HE, Bueno C, Dawe D, et al.,2002: Chaudhary & Mishra, 2021a&b). The plain area of Nepal, known as the Terai region, is a thin strip that runs from the country's east to west and connects the southern border with India to the foothills of the Churia range. 22 of Nepal's 77 districts, which are spread over the country's southern plain, are referred to as Terai districts. Though just making up 23% of the country, Nepal's Terai districts are the country's primary producer of 57% of the country's grains (MoALD, 2020).

This shows the significance of agricultural productivity and performance that need to be improvised with respect to changing conditions through standardised mechanism

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(Verma, K., Shrivastava, A., & Gautam, A. K.,2019). The use of mechanized harvesting yields significant benefits, as revealed by Jha et al.'s (2022) findings. Specifically, the self-propelled reaper and tractor-mounted reaper reduced harvesting costs by 64.00% and 85.71%, respectively, while the combine harvester alone reduced overall production costs by 33.14%.

Depending on the straw market price, the payback perio d (Investment/Benefit) for the 600 hectares of yearly are a coverage ranged from 4.3 to 1.8 years (Verma et al., 2019). In a study by Singh, S., & Dixit, A. (2007) paddy straw ranged in weight from 20–27 kg, while wheat straw weighed 7–12 kg. Paddy straw had a density of 130–200 kilograms/m^3, whereas wheat straw had a density of 39–61 kg/m^3. The baler consumed between 5.0 and 5.5 litres of fuel per hour. For paddy crops, the baler's field capacity was 0.36 ha/h. With MC 19–21% and speed of 3 km/h, the actual field capacity, field efficiency, straw recovery, and time needed for baling were determined to be, respectively, 0.721 ha/h, 93.47%, 94.42%, and 1.26 h/ha (Verma et al., 2019). When the traditional field baler reached its maximum forward speed of 3.41 km/h, its average field capacity, field efficiency, and fuel consumption were 1.09 ha/h, 70.97%, and 3.255 l/h, respectively (Kumar, U., & Thakur, T. C. 2006).

A straw baler machine is a piece of agricultural equipment designed to compress and bundle straw or hay into compact and manageable bales (round or rectangular). Farmers and agricultural workers commonly use these machines to facilitate the handling, storage, and transportation of straw for various purposes, such as livestock feed, bedding, and other agricultural applications (mushroom cultivation, manufacturing of paper/ cardboard, electricity generation). For harvesting wheat and rice, farmers in the Terai region are increasingly using combine harvesters. There are 700 combine harvesters in Nepal (Shrestha et al., 2021). Farmers in the regions of Parsa and Bara now own more than 300 sets of combines, both tractor-mounted and self-propelled. When combines are used in the field, they can leave patches of rice or wheat straw behind. Many farmers burn straw in the field rather than gathering it for livestock feed owing to a manpower shortage, which exacerbates residue burning problems.

The level of mechanization especially in terai region of Nepal is increasing day by day in various agricultural operations mainly in tillage, harvesting and threshing due to labour scarcity problem. The harvesting of rice and wheat in Bara, Parsa, Rautahat, Rupandehi, Chitwan etc. is now done using combine harvesters and harvesting by combines is growing exponentially. But, due to labour shortage, the farmers are unable to withdraw straw of rice and wheat from the field harvested and left by the combine harvester. As a result, the farmers are burning their crop residue in the field similar to as done in Punjab, Haryana, Uttar Pradesh of India causing reduction of soil moisture content which is not favourable for resource conservation practices and also causing environmental pollution which is not good for health. The burning of crop residue is growing day by day and there is deterioration of soil characteristics i.e., activity of microorganism in the soil which enhances soil nutrients. On the other hand, there is scarcity of fodder for cattle due to burning and hence affecting the dairy farming also. There is reduction in adoption area of Resource Conservation Technologies last year due to burning of crop residues. Thus, there is no proper management of crop residues in the farmers' field these days and hence, the testing and evaluation of round baler machine will definitely address these sorts of residue burning problems.

2. STUDY LOCATION

The testing and evaluation of the machine was performed in actual field condition at Directorate of Agricultural Research, Madesh Pardesh, Parwanipur, Bara. The station is located at 115 meters above sea level and 27° 02' 00" N latitude and 84°53' 00" E longitude. It is 11 km north from the country's commercial city Birgunj, 1.5 km east from National high way. The climate of Parwanipur is hot and humid in summer season and cool in winter. The maximum average temperature ranges from 22.7 to 34.52°C and minimum temperature ranges from 8.54 to 25.9 °C. The average annual rainfall of Parwanipur is 1550 mm.

3. METHODOLOGY

The Indian made 4-wheel tractor driven round baler was procured by the station in the fiscal year 2018/19. The performance evaluation of the machine was tested/ evaluated in actual field condition in on-station (at Directorate of Agricultural Research, Madesh Pradesh, Parwanipur, Bara) in about 2.0 ha. The laboratory and actual field tests were performed for two fiscal years in on-station viz. 2018/19 & 2019/20. The machine performance parameters, straw parameters and bale parameters were taken. The laboratory test includes hitching of machine with 45 hp tractor with power and transmission points (P-and T- connections) whereas actual field tests initial moisture content of straw, speed of the operation, effective working width, wheel slip, theoretical/ actual field capacity, field efficiency, fuel consumption, baling capacity and economic analysis.

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4. COMPONENT OF PLANTER

It consists of two units, i.e., baling and binding units along with two ground wheels for transportation and sensor unit. The technical specifications of the machine are given below:

Table 1: Technical specifications of 4-Wheel Tractor Driven Round Baler Machine

S.N.	Particulars/Parameters	Required specifications
1	Brand	Shaktiman
2	Dimension (L*W*H), mm	2350*1780*1515
3	Ground clearance, mm	337
4	Power, hp	>=45
5	PTO speed(rpm)	540
6	Hitching system	Drawbar hitch
7	Tires ● Axle Tyre size ● Pick-up Tyre size	● 5.2-14,6 ply ● 4-8,6 ply
8	Bale size(dia*width) (mm*mm)	600*635
9	Baler chamber ● Type ● No of roller ● Roller dia*length(mm*mm) ● Bale chamber dia* width(mm*mm)	● chain driven pressure rollers rotating on sealed bearing at ends ● 19 ● 93*622 ● 595*633
10	Working capacity(bales/hr.)	40-50
11	Baler weight(kg)	700 kg
12	Pick-up type	fully floating, cylindrical drum with spring tines
13	No. of tines	40
14	Binding (twine System) Activation	manual
15	Twine recommended	sisal or polypropylene

5. WORKING PRINCIPLE OF BALER

The machine is hitched with 45 hp tractor with power and transmission points (P-and T- connections) and the whole operation of baling is done by power take off unit and hydraulic pressures. This machine has two units, i.e., baling, and binding unit. During operation, the straw is fed inside and compressed by the aluminum rollers. When required bale size is formed, the sound is made by the siren fitted in the machine. Then, the operator makes binding unit on, and the bale is binded by the jute/ plastic thread along the circumference. The Baler machine door is opened by the operator and bale is thrown outside of the machine.

Figure 1: Field testing of baler at On-station

6. RESEARCH DESIGN

The round Baler machine was used for collecting straw in Rice and wheat fields in about 2.0 ha each and performance parameters were recorded and analyzed using Microsoft Excel 2016. The straw was collected in one day, three days and four days after the combine harvested wheat and rice and the different parameters such as Bale weight, baling time and recovery percentage was recorded.

Two-hectare of land was harvested by combine harvester in both Paddy and Wheat at Directorate of Agricultural Research, Madesh Pradesh, Parwanipur, Bara . The straw was collected and baled by a round Baler machine attached to 45Hp tractor in one day after harvesting, three days after harvesting and four days after harvesting and necessary data related to performance were recorded in scientific way.

7. RESULTS AND DISCUSSIONS

The round baler machine has been introduced and evaluated in the country first time and results are very encouraging in aspects of residue burning issues of the country.

Average time required to make Bales.

On conducting five replicated trials in collecting straw for both rice and wheat and averaging the time taken to make a bale including binding time, it was found that time taken to bale rice straw was slightly higher than wheat straw harvest. It was found to be 1.5 to 1.8 minutes in the case of wheat and 1.6 to 2 minutes in the case of rice. The fuel consumption was 5 liter per hour. The number of bales made per hour are dependent on straw density, stiffness of straw, moisture content of straw and speed of operation.

Baling capacity

After conducting the baling trial five times in the research area, the average binding capacity of the machine was around 30-35 bales/hours in case of rice straw and 35-40

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bales/hr in case of wheat straw, which shows that in both cases the number of bales made per hour are almost like one another with bale sizes of about 64cm both in length and diameter if the full capacity of the baling space is used.

Bale mass variation

The bale weight was measured one day, three days and four days after the binding and significant reduction in mass was found. The weight was 24kg on the day of bailing, reduced by 8 kg two days after binding and further 3 kg weight reduction was found after one day and then almost constant then after. This indicated that the straw holds sufficiently high amount of moisture during bailing and it was about 20 %. It was found difficulty in operation of this machine during foggy period of winter season.

The best holding time is 2-3 days for rice straw and 1 day for wheat straw for both bailing efficiency enhancement and for long term storage point of view.

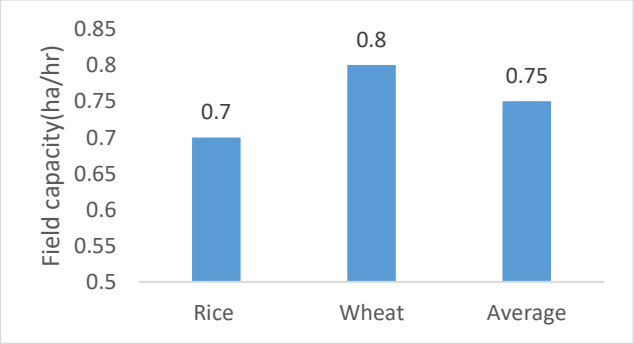

Figure 2: Variation of field capacity

Field capacity was found to be varying from 0.70 ha/h and 0.80 ha/h in case of rice and wheat average value being 0.75ha/hr. The field capacity was found to be less in the case of rice because of field moisture condition. In the case of wheat straw collection, the baler can be operated faster that enhances field capacity. This machine works well when the straw is well dried. Thus, it showed higher capacity and better efficiency of wheat straw baling than the rice straw.

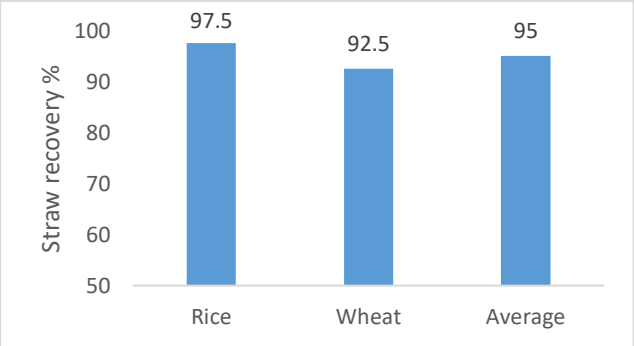

Figure 3: Variation of straw recovery

The straw recovery was calculated using the weight of bundles of the straw made by baler and the left-over straw collected by manually. The straw recovery was slightly higher in case of rice average recovery being 95%. The variation might be because of the straw moisture, and distribution of the straw in the field.

Economics analysis of Round Baler Machine

The given information presents the results of an economic analysis for a tractor-drawn round straw baler for paddy. The analysis includes the cost of the round baler machine, labor costs, tractor hiring charges, and other expenses. The net return after baling 1 hectare of land was NRs. 10,800, and the benefit-cost ratio was found to be 1.35.

Here's a summary of the results:

- The cost of the round baler machine was NRs. 75,000.
- The life of the round baler machine was 10 years.
- The annual use hour was 540 hours.
- The salvage value of the round baler machine was 10% of the purchase price.
- The hiring charge of a 45 hp tractor was NRs. 1,000 per hour.
- The fixed cost was NRs. 271.18 per hour.
- The variable cost was NRs. 6.94 per hour.
- The total operating cost (fixed cost + variable cost) was Rs. 278.12 per hour.
- The total operating cost along with the tractor was NRs. 2,360.77 per hour (NRs. 1,000 + 278.12).
- The total cost of baling was NRs. 4,564.73 per hectare, which approximately equals NRs. 4,600 per hectare.

The economic analysis shows that the tractor-drawn round straw baler for paddy is viable, with a benefit-cost ratio of 1.35. This means that for every NRs. invested in the baler, NRs. 1.35 are returned, making the investment profitable. However, it's essential to consider that wages, hiring charges of the tractor, and the cost of machines may vary, which could affect the results.

In a note, the tractor-drawn round straw baler for paddy appears to be an economically viable option, providing a reasonable return on investment. However, it's crucial to consider the potential variations in wages, tractor hiring charges, and machine costs when making a final decision.

8. CONCLUSION AND RECOMMENDATION

The round baler can be used successfully to collect the straw in both rice and wheat harvested fields. One day after harvesting the wheat and 2-3 days after harvesting rice, is most efficient for straw recovery and long-term

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storability of the straw. The technology seemed to be fruitful to overcome the residue burning issues of the country. The analysis includes the cost of the round baler machine, labor costs, tractor hiring charges, and other expenses. The net return after baling 1 hectare of land was NRs. 10,800, and the benefit-cost ratio was found to be 1.35. the tractor-drawn round straw baler for paddy appears to be an economically viable option, providing a reasonable return on investment. However, it's crucial to consider the potential variations in wages, tractor hiring charges, and machine costs when making a final decision.

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