Biological Forum – An International Journal 13(3a): 214-220(2021)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

# Status of Combine Harvested Paddy Straw Management and Economics of Pulse Sowing in Eastern India

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*(Received 02 July 2021, Accepted 09 September, 2021)*
*(Published by Research Trend, Website: www.researchtrend.net)*

**ABSTRACT: Combine Harvested (CH) paddy straw left behind in the field obstruct the movement of the machines and furrow openers causing irregular seed placement thereby affecting the growth of plants. Farmers opt for open field straw burning as an easy and economical way to manage straw without realising the implications on soil and the environment. A study comprising of 132 farmers was conducted through a three-stage purposive sampling method to assess different straw management and pulse sowing methods in two districts of Odisha and evaluate the cost economics involved in pulse sowing. The study revealed that the percentage of farmers adopting burnt-out straw (BOS), usable straw (US) and leftover straw (LOS) for Puri and Bhadrak districts are 67.14, 50.05 and 49.99% and 59.94, 51.93 and 55.93%, respectively. Among the four distinct conventional field preparation and pulse sowing methods practised in these regions, the two prominent methods were C + B + C (cultivator + broadcasting + cultivator) and C(2) + B + Cv (cultivator twice + broadcasting + covering) with 40.82, 47.50, 22.69 and 34.17% for Puri and Bhadrak, respectively. Very limited farmers (16.69%) in Puri district used R + S (rotavator + seed drill) technique while in Bhadrak none of the farmers used this technique and broadcasting was predominantly followed. Rotavator had the highest operating cost (Rs 2806 per ha) among the equipment used and the cultivator had the minimum (Rs 847 per ha). The two most economic methods of pulse sowing were C + B + C and C(2) + B + Cv with operating costs of Rs 1994 and 2476 per ha while, the R + S method was most expensive with Rs 4058 per ha. It was observed that open field straw burning and conventional methods of seedbed preparation are widely followed in the study areas. The necessity of an implement to manage the straw within the field after paddy harvesting and sow pulses under residual moisture conditions (reduced tillage) economically and efficiently is very high.**

**Keywords:** Residue burning, Straw management, Pulse sowing, Cost economics, Purposive sampling, Broadcasting.

## INTRODUCTION

India is an agrarian economy and the eastern part is no exception to that. Along with good quality soil and abundant sunshine, the place has plenty of groundwater for use and is considered to be the harbinger of the next green revolution. Odisha, located in the eastern coastal region of India has a tropical climate (high temperature and medium to high rainfall). It is suitable for the cultivation of paddy and pulses and has received the "Krishi Karman Award" numerous times for overall food grain production. In Odisha, paddy is cultivated in nearly 4 Mha of area (3.5 Mha *kharif* and 0.3 Mha rabi), with production touching 9.79 Mt (2.47 tonnes $ha^{-1}$) for the year 2016-17 (Anon., 2019). Pulses are grown mainly in the uplands during the *kharif* season and in rice fallow during the rabi season, mostly in coastal districts under available moisture conditions (Status of Agriculture in Odisha 2014-15). Mostly farmers in Odisha practice conventional methods of seedbed preparation (cultivator or rotavator operation) after burning straw or collecting it followed by broadcasting the seed. Despite proven benefits of zero tillage like saving time, money, resources (Erenstein *et al.,* 2008; Laxmi *et al.*, 2007; Singh *et al*., 2017 etc.) the use of conservation tillage and reduced tillage technology is very limited in Odisha. Pulses are grown in 20.8 lakh ha area with production and productivity of 10.6 lakh tonnes and 508 kg $ha^{-1}$ while green gram, black gram, and horse gram contribute 42%, 27% and 11% of the state's total pulse cropped area (OUAT Strategies, 2016).

Among the factors that contribute to states increased food grain production, farm mechanisation plays a crucial role. The farm power availability in the state has reached 1.647 kW $ha^{-1}$ by the end of 2016-17 (MAFW, 2018) and is growing every year. Among the various unit operations in farming, paddy harvesting has undergone a major shift from conventional practice (manual cutting using sickle) to the use of reapers to widespread use of combine harvesters. A Govt. of Odisha report shows around 3769 nos. (considering 6 years of useful life) of combines are operating in the state (Activity report 2018-19) while the actual numbers can be more taking into consideration the increased annual sale for each year and combines available on custom hiring from neighbouring states. Though combine harvesters have reduced the burden of farmers to a great extent but also has engendered issues related to residue management. Combine harvesters leave behind stubbles and drop back loose straw (after threshing) in alternate strips in the paddy field. This loose and standing straw obstruct the movement of machinery (seed drills, cultivators etc.) and create a problem. Paddy straw being rich in silica (up to 10%) and lignin (> 10%) content is not readily digestible to the livestock. The presence of high ash content (18-29 %) and low calorific value (14.08 to 15.09 MJ $kg^{-1}$) (Van Hung *et al*., 2020; Van Soest, 2006) lessens its economic worth, thus making its collection and utilisation an expensive manoeuvre. A short window period for the next crop worsens the problem and it becomes difficult to manage those straw and prepare the field considering unavailability of suitable machinery and higher input cost involved. This along with lack of awareness among the farmers leads to open field burning of paddy residues.

Odisha produces around 20.07 Mt of crop residues every year, with approximately 1.34 Mt burned each year (NPMCR, 2014). Though this practice is not as widely practised as in northern Indian states (Punjab, Haryana, Rajasthan etc.), it is spreading due to the increased use of combine harvesters and axial flow threshers among the farmers. Open-field burning of crop residue results in the emission of $SO_2$, $NO_x$, CO, dioxins, furans, volatile organic compounds (VOC), polycyclic aromatic hydrocarbons and particulate matters (Jain *et al.,* 2014; Jenkins *et al.,* 1996; Kim Oanh *et al.,* 2018). As per an estimate, one tonne of paddy straw burning accounts for a loss of 5.5 kg nitrogen, 2.3 kg phosphorous, 25 kg potassium and 1.2 kg sulphur besides organic carbon (Dobermann and Fairhurst, 2000). Also, it is estimated by researchers that, burning of one ton of paddy straw releases about 1460 kg $CO_2$, 60 kg CO, 199 kg ash, 3 kg particulate matter and 2 kg $SO_2$ (Gupta *et al.*, 2004). Besides global warming and multiple health hazards, straw burning also alters soil microbial activity, causes soil erosion and yield loss to a great extent (Kumar *et al.*, 2019; Page *et al.*, 2019).

Lots of studies have been conducted on causes and impacts of straw burning and different conservation tillage techniques to prevent straw burning across the country mostly for paddy-wheat cropping system. However, very limited studies have been reported on straw management and economics of pulse sowing methods for paddy-pulse cropping system. This study was undertaken to get an insight into various methods of combine harvested paddy straw management practised by farmers in two districts of Odisha during the years 2019-20. One more objective of the study was to ascertain distinct pulse sowing methods practised by the farmers in these areas and evaluate the cost economics involved in them.

## MATERIAL AND METHODS

**Plan of sample survey:** The selection of the study area was done by employing a three-stage judgmental/purposive sampling (non-probability sampling) method. Out of the thirty districts in Odisha, two districts (Bhadrak and Puri) were selected for survey purpose through the method of purposive sampling keeping in view the cropping pattern (paddy-green gram), use of combines for paddy harvesting, location and economics involved in the survey. The two districts selected come under two different agro-climatic zones (North Eastern coastal plain and East and South-Eastern coastal plain) of Odisha. Paddy is widely cultivated during *Kharif season* in these two coastal districts followed by black gram (BG) or green gram (GG) during Rabi. As such, the use of combine harvesters for paddy harvesting has become popular and common among farmers of these districts. From these two districts, it was decided to select two and three blocks from Bhadrak and Puri respectively maintaining a constant proportion of around 3.5:1. These five blocks were selected using the purposive sampling method. It was further decided to select one village from each block through purposive sampling considering the physical and financial limitations apart from the suggestions of the ground level field functionaries of Government Departments *i.e.*, Agricultural Engineers (Assistant Agricultural Engineers), Agricultural Officers (Assistant Agricultural Officers) and local NGOs. The complete three-stage purposive sampling is depicted in Fig. 1.

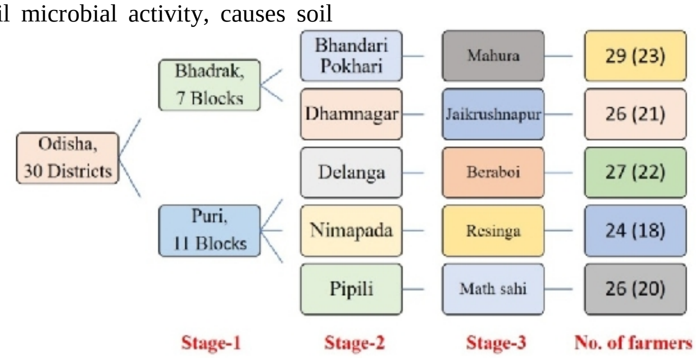


**Fig. 1.** Three stage purposive sampling method followed for the survey.

**Selection of respondents:** The survey was conducted with the help of a well-structured questionnaire (open-ended survey questions) prepared for this work. The study focused entirely on those farmers who harvested their paddy crop using combine harvesters either on an ownership or rental basis and also those who were growing pulses (Green gram and Black gram) following paddy cultivation. The answers were recorded by note-taking method for further analysis and study. A sample comprising 132 CH farmers was drawn from these five villages (sample constitutes approx. 35-40% of total CH farmers from the village) and interviewed. Out of these 132 CH farmers, 104 farmers (78.79%) cultivated Pulses (BG or GG) as the second crop for the rabi season. The survey results on paddy straw management, pulse sowing methods, and machines used for field preparation by the farmers were discussed further in the following sections.

**Straw Management and Pulse Sowing Methods:** The presence of loose and standing stubbles (after combine harvesting) choke/clog the furrow openers of the seed drills and cultivators and entangle the implements (rotary implements) and hinder their movement in the field. Loose straw creates poor traction of the ground wheel (seed drills) and frequent lifting of the machine is done to avoid it (Sidhu *et al.,* 2015). There are two major straw management methods like in-situ (managing straw within the field) and ex-situ (removal of straw from field) presently practiced (Mahal *et al.*, 2019; Modi *et al.,* 2020). Farmers can choose any method as per their suitability considering economic feasibility, availability of machinery, efficiency and window period for the next crop. The combine harvested farmers in these five villages followed different straw management practices like open field burning, collection and use and straw retention and the details are provided in the later section. The survey conducted to determine the methods followed by the farmers who took pulses as a subsequent crop after paddy highlights the general approach for field preparation and pulse sowing practices in those regions. The percentages of farmers choosing distinct methods were determined and discussed.

**Economics of pulse sowing:** The economics involved in field preparation and sowing contribute a significant part to the total cost of operation thereby deciding strategies to efficiently use the available capital and minimize the input cost which is highly essential to maximize the profit. Therefore, estimating the operating cost of a machine is crucial and it was determined following the guidelines given in IS 9164 (1979), (Mehta *et al.,* 2020; Singh and Mehta, 2015). The total operating cost of a farm operation involves fixed cost, variable cost and overhead charges. The cost of sowing pulses (Rs $h^{-1}$ and Rs $ha^{-1}$) was calculated from the cost of operation of individual equipment.

**Fixed Costs:** The fixed costs for a farm operation/machinery include depreciation, interest on capital, insurance and taxes and housing charges. The depreciation can be estimated by using various methods and here it was determined using the straight-line method (Mehta *et al.,* 2020).

$$D = \frac{P-S}{L}$$

Where, D = depreciation cost, Rs. Per year

P = Purchase price of the machine, Rs.

S = residual/salvage value of the machine, Rs.

L = useful life of the machine, years

The depreciation cost per hour could be calculated by dividing the yearly depreciation cost by number of hours the machine is expected to be utilized in a year. The residual value was taken 10% of the purchase price.

The annual interest on the capital invested was calculated by applying a 12% interest on the average investment by using the following formula (Mehta *et al.,* 2020):

$$A = \frac{P+S}{2} \times \frac{i}{100}$$

Where, A = annual interest charge, Rs. per year

P = purchase price of the machine, Rs.

S = residual/salvage value of the machine, Rs.

i = interest rate, %

The insurance and taxes were determined based on 2% of the average purchase price of the machine, (P+S)/2. The housing/shelter charge is calculated by taking 1.5% of the average purchase price of the machine.

**Variable costs**

The variable costs for the farm machinery include expenditure incurred in fuel, lubricating oil, repair and maintenance charges and wages and labour charges. The average fuel consumption of a tractor or engine is estimated using the following formulae (Mehta *et al.,* 2020):

For diesel engines, A = 0.15 × B

Where, A = average diesel consumption, l $h^{-1}$

B= rated power, kW

For petrol engines, C = 0.25 × B

Where, C = average petrol consumption, l $h^{-1}$

The cost of lubricating oil consumed during the operation may be taken as 2.5 to 3 percent of the fuel consumption on a volume basis and was taken as 3% of the fuel cost.

Repair and maintenance cost involves expenditure related to machine part failure and replacement, wear and tear, tyre and tube replacement, minor accidental repairs etc. General wear and tear of parts and lubrication are directly related to use and its restoration is assumed under variable costs. The cost of filters, replacement of oil and other lubricants are included under repair and maintenance cost. The accumulated repair and maintenance costs (TAR) at any point of a machine life can be determined using the following formula (Mehta *et al.,* 2020):

For four-wheeled and crawler tractors, TAR = 0.100 $X^{1.5}$

For PTO driven combine, seed drill, sprayer, TAR = 0.159 $X^{1.4}$

For plough, planter, harrow, ridger and cultivator, TAR = 0.301 $X^{1.3}$

Where,

TAR = total accumulated repair and maintenance cost as a percentage of the initial cost.

X = 100 times the ratio of accumulated hours of use to the wear-out life

Wages and labour charges include the wage of the operator and any other person/labour involved (assistant) during the working of the machine in the field. The average cost per hour may be computed by diving the total cost by the number of hours the operator has performed the task. The overhead charges for an operation are assumed as 20% of the sum of fixed and variable costs. The total cost per hour includes fixed cost, variable cost and overhead charges of the machine.

## RESULTS AND DISCUSSION

The information collected from the combine harvested paddy farmers (132 farmers) through the survey on the status of straw management in their paddy fields and techniques adopted for sowing of pulses (BG and GG) in rice-green gram cropping system in two selected districts (Bhadrak & Puri) of Odisha were analysed and categorised into different sections. The economics (cost of operation) involved in operating different machines was estimated and the total cost involved in different sowing methods was derived and discussed in this chapter.

**Combine Harvested Paddy Straw Management:** The results of the survey (Table 1) revealed various straw management practices adopted by farmers who have harvested paddy using combines. The methods of straw management can be broadly categorised into three sections as burnt-out straw (BOS), usable straw (US) and left-overstraw (LOS). The percentage of farmers opting for BOS, US and LOS in Puri district was 67.14, 49.96 and 49.99% whereas, for Bhadrak district it was 59.94, 51.93 and 55.93%, respectively. The average combine harvested paddy straw burning reported in the study area was 64.26% while US and LOS were 50.74 and 52.37%, respectively. The proportion of straw burning was comparatively higher than the other two (US and LOS) practices due to the short window period for sowing pulses and no involvement of cost in preparing the field (Similar findings were observed by Anuradha *et al*., (2021); Roy *et al.*, (2018). Many farmers could not have access to straw management machineries (mulchers, balers, straw reapers etc.) due to its higher operating cost and low economic value of collected straw. Straw was collected (US) manually and utilised for various purposes like fodder, household cooking, composting etc. It was also noticed that the practice of straw burning was increasing among the farmers.

**Pulse Sowing Methods in Combine Harvested Paddy Field:** The sowing of pulses in combine harvested paddy field is a cumbersome process and prior management of straw and field preparation is necessary. Conventional ways of seedbed preparation and sowing techniques adopted by the farmers in five villages of Odisha were are broadly classified into four categories and respective percentage were highlighted (Fig. 2 and Table 2).

| |
|---|
| Cultivator ⟶ Broadcasting ⟶ Cultivator (C + B + C) |
| Rotavator ⟶ Conventional seed drill or Zero-till drill (R + S) |
| Cultivator ⟶ Broadcasting ⟶ Rotavator (C + B + R) |
| Cultivator (2) ⟶ Broadcasting ⟶ Covering seeds (C + B + Cv) |

**Fig. 2.** Different pulse sowing methods followed in combine harvested fields.

**Table 1: Number of farmers following different straw management practices.**

| Name of village | No. of farmers | Straw management practices | | |
|---|---|---|---|---|
| | | BOS (%) | US (%) | LOS (%) |
| Matha Sahi, Pipili, Puri | 29 | 19 (65.52) | 15 (51.72) | 14 (48.28) |
| Beraboi, Delanga, Puri | 26 | 18 (69.23) | 13 (50.00) | 12 (46.15) |
| Resinga, Nimapada, Puri | 27 | 18 (66.67) | 13 (48.15) | 15 (55.56) |
| Jaikrushnapur, Dhamnagar, Bhadrak | 24 | 14 (58.33) | 12 (50.00) | 13 (54.17) |
| Mahura, Bhandari Pokhari, Bhadrak | 26 | 16 (61.54) | 14 (53.85) | 15 (57.69) |

**Table 2: Number of farmers following different pulse sowing methods.**

| Name of village | No. of farmers | Pulse sowing methods | | | |
|---|---|---|---|---|---|
| | | C + B + C (%) | R + S (%) | C + B + R (%) | C (2) + B + Cv (%) |
| Matha Sahi, Puri | 23 | 10 (43.48) | 4 (17.39) | 4 (17.39) | 5 (21.74) |
| Beraboi, Puri | 21 | 8 (38.09) | 4 (19.05) | 5 (23.81) | 4 (19.05) |
| Resinga, Puri | 22 | 9 (40.91) | 3 (13.64) | 4 (18.18) | 6 (27.27) |
| Jaikrushnapur, Bhadrak | 18 | 9 (50.00) | 0 | 3 (16.67) | 6 (33.33) |
| Mahura, Bhadrak | 20 | 9 (45.00) | 0 | 4 (20.00) | 7 (35.00) |

It was observed that the percentage of CH paddy farmers growing pulses were 80.0, 81.82, 79.16, 73.91 and 80.77 for Mahura, Jaikrushnapur, Beraboi, Resinga and Mathasahi villages, respectively. Seedbed preparation and sowing of pulses was performed by using combinations of different tractor-drawn implements like cultivator, rotavator and seed drill. Seed covering was done by attaching and dragging a wooden plank (width of 2.5 - 3 m) behind the tractor.

The tractor operator and labour costs (50 and 37.50 Rs. $h^{-1}$) were taken as per the prevailing rates in the locality. All the farmers followed these conventional methods of field preparation and sowing after either burning the left-over paddy straw or after collecting loose straw from the plots. The percentage of pulse growing farmers who followed residue burning after paddy harvest was 82.61, 85.71, 81.82, 77.78 and 80.0% for Mathasahi, Beraboi, Resinga, Jaikrushnapur and Mahura villages, respectively. Among all the methods, C + B + C was the most widely practised one with 40.82 and 47.50% of the farmers following this method in Puri and Bhadrak, respectively due to its cost-effectiveness. The second most popular method among the farmers was C(2) + B + Cv with 22.69 and 34.17% of farmers pursuing it in Puri and Bhadrak, respectively. For sowing pulses (green gram and black gram) most of the farmers followed the broadcasting method while limited farmers (16.69%) in Puri district used conventional and zero-till drills. The technique of conservation tillage and reduced tillage was not popular among the farmers in the study areas and the use of zero-till drills, strip-till drills and happy seeders are minimal. The complexity and higher energy input involved in field preparation and sowing of pulses could be prevented by adopting zero tillage and resource conservation technologies in pulse sowing resulting in timeliness and reducing economic burden without affecting yield.

**Economics of Pulse Sowing:** Various assumptions for calculating the cost of operation of the tractor-drawn implements are shown in Table 3. The total cost of operation of individual equipment was put in Table 4 and the total cost involved (Rs. $h^{-1}$ and Rs $ha^{-1}$) (Fig. 3) in sowing pulses using conventional methods followed by the farmers in these two districts of Odisha was calculated. The cost of operation of the rotavator was the highest (Rs. 2806 per ha) among the equipment used and the lowest (Rs. 847 per ha) for a cultivator. This huge difference was mainly due to the lower cost and higher field capacity of the cultivator compared to the rotavator. The cost involved in seed drill operation was Rs. 1252 per ha. Among the various pulse sowing methods, the use of rotavator and seed drill (R + S) involved 4058 rupees per ha and was the costliest method whereas, the C + B +C method was the most economic method costing only Rs. 1994 per ha. The cost for C + B + R and C(2) + B + Cv methods were Rs. 3834 and 2476, respectively. There is a good relationship between the economics involved in a sowing method and the percentage of farmers adopting that method.

**Table 3: Various Assumptions for Calculating Cost of Operation (IS: 9164-1979 and Mehta *et al.*, 2020).**

| Particulars | Tractor operated machineries (42 hp) | | | |
|---|---|---|---|---|
| | Tractor (42 hp) | Rotavator | Cultivator | Seed cum fertiliser drill |
| Initial Cost (Rs) | 5,50,000 | 1,00,000 | 20,000 | 65,000 |
| Useful life, years | 10 | 8 | 10 | 8 |
| Annual life, (h) | 1000 | 300 | 400 | 250 |
| Depreciation | Linear | Linear | Linear | Linear |
| Salvage value (% of initial cost) | 10 | 10 | 10 | 10 |
| Annual rate of interest, (%) | 12 | 12 | 12 | 12 |
| Annual repair and maintenance cost, TAR | 3.16 | 6.005 | 5.46 | 5.46 |
| Fuel consumption, (l $h^{-1}$) | | 4.8 | 4.5 | 4.2 |
| Fuel cost, (Rs $l^{-1}$) | 95 | | | |
| Speed of operation, km $h^{-1}$ | | 2.5 | 6.0 | 5.0 |
| Field efficiency, % | | 80 | 80 | 70 |
| Effective field capacity, (ha $h^{-1}$) | | 0.30 | 0.86 | 0.63 |
| Oil and lubrication cost (% of fuel cost) | 3 | | | |
| Taxes, insurance (% per annum) | 2.0 | 2.0 | 2.0 | 2.0 |
| Shelter (% per annum) | 1.5 | 1.5 | 1.5 | 1.5 |
| Labour (skilled) requirement | 1 | | | |
| Labour cost (Rs $h^{-1}$) | 50.0 | | | |
| Overhead charges (% of FC + VC) | 20 | | | |

**Table 4: Operating cost (Rs $h^{-1}$) of different equipment for sowing pulses.**

| Particulars | Tractor operated machineries (42 hp) | | | |
|---|---|---|---|---|
| | Tractor (42 hp) | Rotavator | Cultivator | Seed cum fertiliser drill |
| **Fixed cost** | | | | |
| Depreciation, (Rs $year^{-1}$) | 49,500 | 11,250 | 1800 | 7312.50 |
| Interest, (Rs $year^{-1}$) | 36,300 | 6600 | 1320 | 4290.00 |
| Taxes, insurance (per annum) | 6050 | 1100 | 220 | 715 |
| Shelter (per annum) | 4537.5 | 825 | 165 | 536.25 |
| Total fixed cost, (Rs $year^{-1}$) | 96,388 | 19,775 | 3,505 | 12,854 |
| Total fixed cost, (Rs $h^{-1}$) | 96.39 | 65.92 | 8.76 | 51.42 |
| **Variable cost** | | | | |
| Repair & maintenance cost, (Rs $h^{-1}$) | 9.56 | 10.01 | 1.65 | 7.81 |
| Fuel cost at, (Rs $h^{-1}$) | | 456 | 427.50 | 399 |
| Oil and lubrication cost, (Rs $h^{-1}$) | | 13.68 | 12.83 | 11.97 |
| Labour wage rate, (Rs $h^{-1}$) | 50.00 | | | |
| Total variable cost, (Rs $h^{-1}$) | 59.56 | 479.69 | 442 | 418..78 |
| Fixed cost + variable cost (Rs $h^{-1}$) | 155.95 | 545.61 | 450.76 | 470.20 |
| Overhead Charges (Rs $h^{-1}$) | 187.14 | 654.73 | 540.91 | 564.24 |
| Total cost of operation, (Rs $h^{-1}$) | | 841.87 | 728.05 | 751.38 |

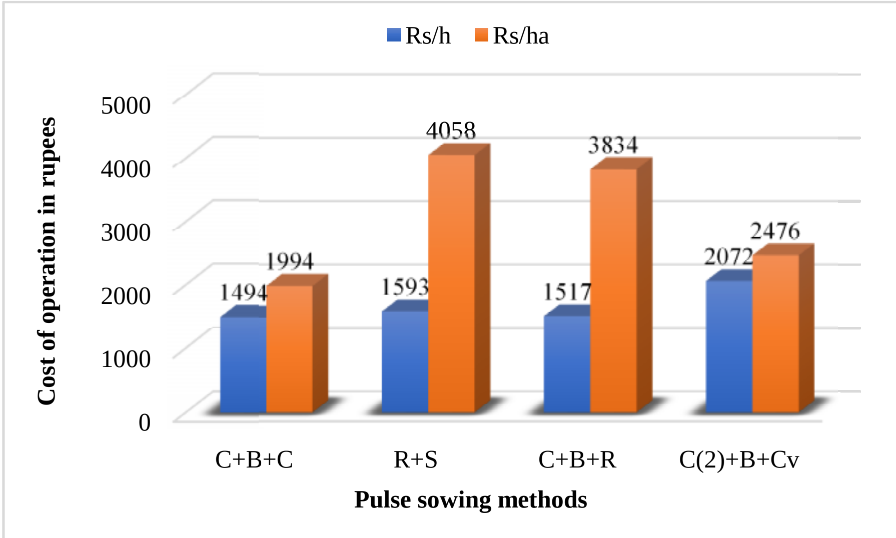


**Fig. 3.** Comparison of cost of operation (Rs $h^{-1}$ and Rs $ha^{-1}$) for different pulse sowing methods.

## CONCLUSIONS

The study was conducted employing a three-stage purposive sampling method to evaluate the status of CH paddy straw management and pulse sowing methods in Odisha with 132 respondents (farmers), and the following specific outcomes were obtained.

1. The farmers in the study area mostly practise the conventional method of straw management (burning, manual collection, and straw retention) with mean burning rates of 67.14 and 59.94% in the Puri and Bhadrak districts, respectively.

2. The practice of open field straw burning is emerging as a low-cost option to manage the combine harvested straw within the field to facilitate the operation of available machinery (rotavator, cultivator, and zero-till drill) in the field.

3. Among the practised conventional pulse sowing techniques, the most economical and popular methods of sowing were identified to be C + B + C and C (2) + B + Cv with an expenditure of Rs 1994.0 and 2476.0 per ha, respectively.

4. It was also observed that, use of conservation technology-based approaches, *viz*., mulchers, balers, zero till drills, strip-till drills, and happy seeders have experienced minimal application in the two study areas.

The shift from conventional methods of seed bed preparation to conservation tillage (residue retention, zero tillage) is essential to reduce the input costs and energy. This will help in reducing the states' rice fallow area, thereby increasing pulse yield and elevating the farmer's economic condition. The necessity of a suitable machinery to simultaneously chop and mulch the straw (both standing and loose) and sow pulses (zero-till condition) within the short window period (after paddy harvest) under residual moisture regime is high in this region.

**Acknowledgement.** The corresponding author is thankful to RKVY, the Government of India, for providing the research fund during his Ph.D. degree programme. The corresponding author expresses deep gratitude to the Science and Technology Department, Govt. of Odisha for providing fellowship and research assistance (BPRF) during his Ph.D. program.

**Conflict of Interest:** Nil.

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**How to cite this article:** Dash, B.S., Swain, S.K., Behera, D., Pattnaik, R.R. and Dash, A.K. (2021). Status of Combine Harvested Paddy Straw Management and Economics of Pulse Sowing in Eastern India. *Biological Forum – An International Journal*, *13*(3a): 214-220.