Success story under RKVY Project Implemented at UAS, Raichur

SUCCESS STORY-XII

Techno-economics of Baling Biomass: A Mechanised Way of Managing Rice Straw for Valuable Feedstock

1. Title - Techno-economics of Baling Biomass: A Mechanised Way of Managing Rice Straw for Valuable Feedstock

2. Category- Agriculture Mechanization

3. Challenge

The practice of burning in-field crop residues including rice, wheat, sugar cane, etc., right after their harvest are being increasing in Indian farms. High cost associated with traditional method of in-field management of paddy straw and non availability of farm labours during peak harvesting season are the major cause of burning paddy straw in the field. Burning of crop residues in the field causes several adverse effects to soil and environment. Straw balers can be used to pick-up the straw from the harvested paddy field and densify in to bales. The optimization of operating parameters of baler as well as total production cost of paddy straw has not been systematically studied. To overcome the problems associated with the open field burning of crop residues and to meet the requirements of crop residues for livestock feed, fuel and industrial uses, an investigation on techno-economic analysis of baling rice straw was conducted to assess the total production cost of bales in the overall supply chain system in India with the following objectives.

1. To develop appropriate technology and farm machinery for converting crop wastes into biomass based sustainable animal/energy feedstock.
2. To evaluate the field performance of baling of crop residues at different operating and crop conditions.
3. To estimate the cost, time and energy appraisals of the machine baling.
4. To demonstrate the in-field technologies to convert crop residues into animal feedstock for popularization / adoption among farmers.

4. Initiative

Field trials were conducted for the performance of tractor operated square baler with rake wheel and without rake wheel under harvested paddy field. Treatments selected were three forward speeds and three moisture content of rice straw. The bale output, density of

bale, fuel consumption during baling, and straw pick up efficiency with rake wheel and without rake wheel were analysed in harvested rice straw field. The mechanized straw harvesting results revealed the performance of square baler interms of effective field capacity, field efficiency, bale output, output of twine tied bales, output of un-tied bales, average fuel consumption, straw pickup efficiency, percent untied bales, and density of bales.

Fig. 1. Field operation of tractor operated baler

Fig. 2. Field operation of tractor operated rake

5. Key Results

The research revealed that, the maximum bale output found at a forward speed of baler of 2.5 km h^{-1} with low moisture content of paddy straw (Fig. 3 and Fig. 4). Generally at low moisture content of straw, the bale output was high due to higher straw pickup efficiency and easy flow-ability of dried straw into the baler. Both forward speed of baler and moisture content of straw had significant effect on bale output for baling without and with raking. In case of baling with raking, energy required per tonne of baling is almost half than that of the baling without raking (Fig. 5 and Fig. 6). Even though additional quantity of fuel is required for raking in case of baling with raking but energy per tonne of bale will be almost half when compared to baling without raking. This is mainly due to more than twice the number of bales produced in raking than that of without raking. Straw output is almost 2.5 times more in with raking condition than that of without raking. Due to 8.5 folds densification of baled straw compared to un-baled straw, almost same folds of cost could be saved for loading and unloading and transportation of straw (Fig. 7 and Fig. 8). Increase in moisture content of straw will generally increase its percentage densification with respect to loose straw. This could be due to higher moisture exhibit the higher mass of straw per unit volume of bale.

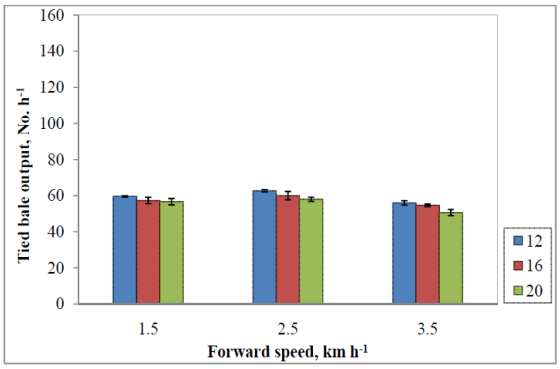

Fig. 3. Effect of forward speed of baler on bale output for with raking

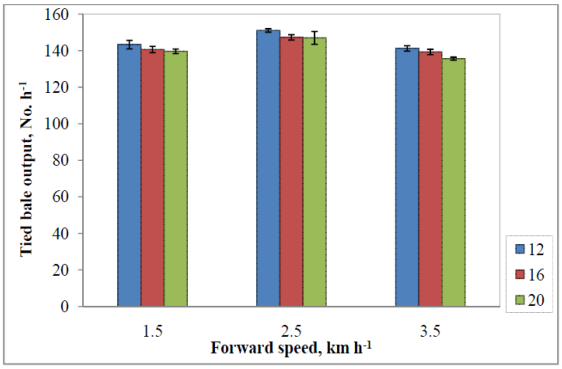

Fig. 4. Effect of forward speed of baler on bale output for without raking

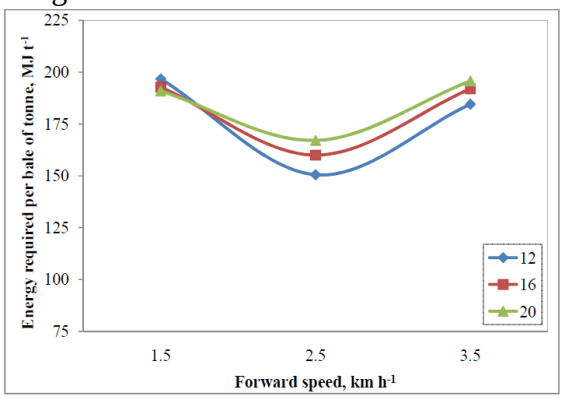

Fig. 5. Effect of forward speed of baler on energy per tonne of bale for without raking

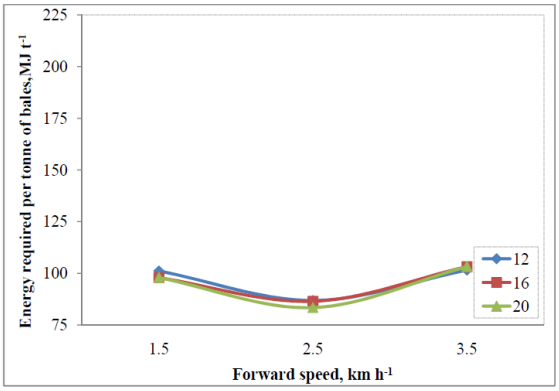

Fig. 6. Effect of forward speed of baler on energy per tonne of bale for with raking

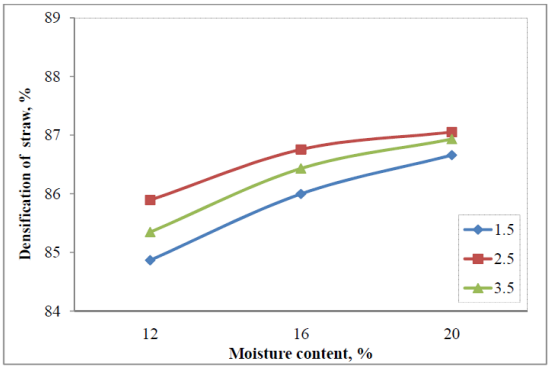

Fig. 7. Effect of moisture content of straw on densification of straw for without raking

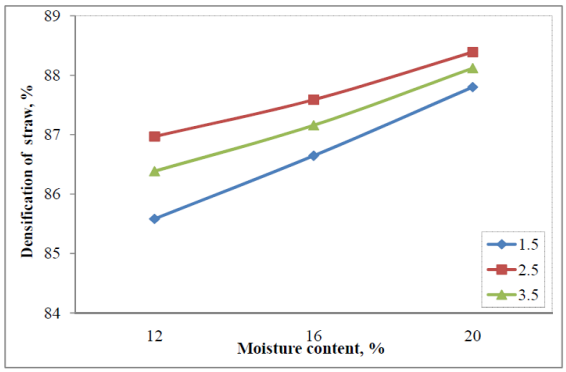

Fig. 8. Effect of moisture content of straw on densification of straw for with raking

The required total energy, time and cost (includes straw collection, transport, and loading and unloading) were 1861.81 MJ t^{-1}, 5.39 h t^{-1}, and 3218.87 Rs t^{-1} respectively for baling without raking. Whereas the same for baling with raking were 100.78 MJ t^{-1}, 2.34 h t^{-1}, and 2606.45 Rs t^{-1} respectively. Percent saving in total time for baling were 293.14 % for without raking and 805.56% for with raking. Percent saving in total cost for baling were

135.32 % for without raking and 225.99 % for with raking respectively (Fig. 9 and Fig. 10). These clearly indicates that, even though the total energy consumption is more for baling without and with raking when compared to traditional method but the total time and total cost are less for the same. Compared between without and with raking, percent reduction in cost of baling, collection, transport, and loading and unloading are 35.56 %, 19.52 %, 1.16 %, and 39.64 % respectively for with raking than without raking (Fig. 11 and Fig. 12). Hence cost per unit energy required for a tonne of straw management is more for traditional method. The techno-economics of using tractor operated square baler revealed that there will be saving in cost, time, and energy in paddy straw collection, handling, and transportation compared to traditional method of manual straw management.

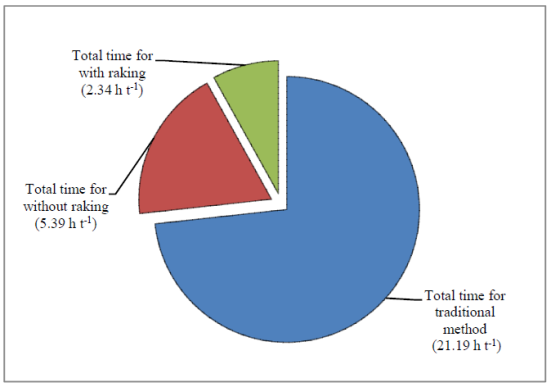

Fig. 9. Relative total time consumption

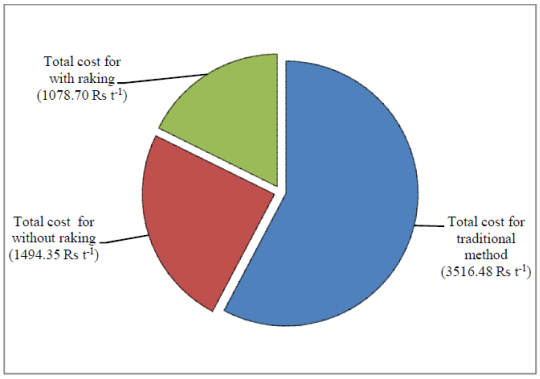

Fig. 10. Relative total cost consumption

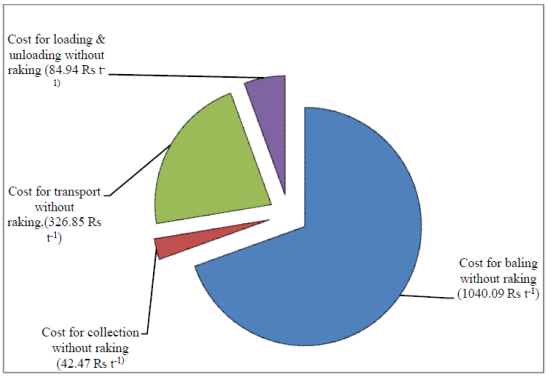

Fig. 11. Total cost of operation without raking

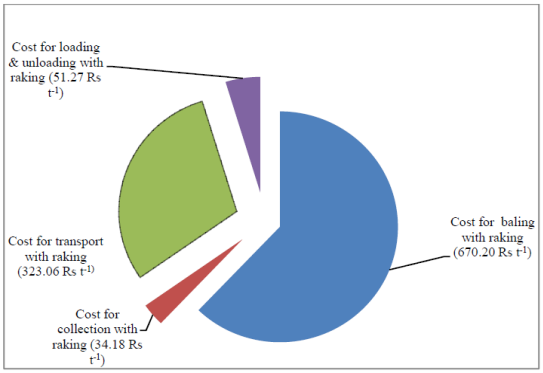

Fig. 12. Total cost of operation with raking

6. Impact

Straw baling in the combine harvested paddy field is considered as technically and economically viable option for sustainable management of straw for animal feed, biofuel and other industrial uses. Crop residue baling is considered as technically and economically viable option for sustainable management of crop residues for animal feed, biofuel and other industrial uses.

Conducted field demonstrations and trainings of straw baling using tractor operated square baler for farmers at Gillesugur, ARS Gangavati, CAE Raichur, UAS-R Krishimela, Desai camp, Gangavati Krishimela, ARS Dhadesugur, KVK Gangavati, and Sirwar. The demonstration of tractor operated straw baler was also conducted in paddy fields at ARS-Gangavati, ARS-Dhadesugur, ARS-Sirguppa, and KVK-Gangavati research farms producing around 630 tonnes of straw bales covering 1050 acres. The demonstrations were carried out at various forward speeds and moisture content of paddy straw. Many paddy growers in around the region visited the site and get exposed the technology of mechanized baling of paddy straw. Many paddy farmers expressed that straw baling technology is very useful for mechanized collection of straw and can be done in less time and also straw bales are more convenient and economical for handing, transportation and storage of straw. From large scale multi-location demonstrations more than around 1,40,000 farmers and stakeholders had the opportunity to understand and got benefitted from this technology.

1. Lessons Learned

Techno-economics of rice straw baling and its demonstration proved that such technology can greatly help in converting crop wastes/ residues into sustainable biomass based energy/ animal feedstock. This could not only increase the efficient utilization and value addition of rural biomass wastes but also help to solve immediate need of animal feed requirement as well as future biomass energy feedstock supply. These operations at the farm level can also generate rural employment opportunities and income generation to farming community. Custom hiring of the tractor operated baler and rake machines has greater potential to encourage on-farm employment and rural income.

Fig. 12. Field demonstration and trainings of the straw baling using tractor operated baler

2. Supporting Quotes

"Use of baler is very useful technology to the farming community especially to the rice growers. Without any drudgery and labour rice straw can easily be collected from the field. Which other- wise, most of the farmers simply burn the paddy straw" – Shankar Reddy, Rice grower, Tungabhadra village, Raichur

"Rice growing farmers generally burn their straw right after harvest, because manual collection, handling, transportation, and stacking is very uneconomical, labourious, and time consuming. Using tractor operated baler, one can easily do these operations with less operating costs" – Shekar, Rice farmer, Desai Camp, Sindhanur.

"I am very impressed to see and convince the use of baler machine using existing tractor power source. This technology definitely boosts the availability of rice straw as fodder to livestock, during scarcity period at a lesser cost" – Shivappa, Farmer, Ballatagi village, Dhadesugur.

"Baling is the great way of collecting and compressing in to small straw bales in the field itself. Otherwise manual method of collection, handling, transporting, and storing of loose straw will not only economical but also leads to wastage" Irappa, Farmer, Dharwad.

"After realizing the great importance of the baling rice straw and other such crop residues, I feel that in order to make use of such technology by the farming community, the Government should take appropriate steps to include such baler machines under subsidy and also available to the farmers through its custom hiring centres" – Mohan R. Gowda, Small Agri. Entrepreneur, Mysore.

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5. Contact person for this story (name, position, email address)

Dr. Devanand Maski, M.E., Ph.D., PDF (USA), MIE, MISAE
Assistant Professor
Farm Machinery and Power Engineering Department
College of Agricultural Engineering
University of Agricultural Sciences-Raichur
Raichur – 584102, Karnataka (India)
Phone (O): +91-8532-220079 Ext. 225
Fax (O): +91-8532-220079
Mobile (India): 8277284868
E-mail: devm04@gmail.com or dmaski@gmail.com