



## 1 Introduction

Intensive rice-wheat cropping system and increasing mechanization particularly harvesters are considered as main reason behind such a massive straw generation. At present, combine harvesters are found throughout the country due to labour shortages, high wages during the harvesting season, and weather uncertainty. In 2019, India had 40,000 combine harvesters, with an increase of 5,000 units per year. This constitutes roughly 1% of the total farm power availability, estimated at 2.49 kW/ha. Due to lack of alternative residue management practices, 70-80 % of the residue is burnt in the open fields, causing greenhouse gas emissions and air pollution, which is detrimental to humans, animals, and the environment. After industrial and vehicular emissions, straw burning is the third most significant source of air pollution in many parts of the world. The northern states of India, such as Punjab, Haryana, and New Delhi are severely afflicted with this problem.

**If rice harvesting and wheat sowing operation are performed simultaneously by combine harvester, the transplantation of rice can be delayed in the farmers field that may lead to water saving also. The concept of attaching a seeding unit behind the combine harvester may be explored to minimize the effort and time for wheat sowing.** The developed attachment will be very useful for long duration and super fine varieties of rice. This attachment may reduce the energy in tillage operation for wheat sowing as well as utilize the rice straw as mulch. Moreover, it will provide solution to avoid rice straw burning and offer net profits to the farmers. Hence, keeping all these problems and effective solutions in view, this study was carried out for development of a seeding attachment for combine harvesters.

## 2 Materials and Methods

The seeding attachment consisted of two gangs of concave disc at an angle of 23° from the direction of travel with the spacing of 225 mm. The seeding attachment comprises of a triangular main frame covering overall seeding width of 3100 mm. A fluted roller metering mechanism was used to meter the seed and fertilizer with the help of a chain and sprocket-driven ground wheel arrangement. Two hydraulic cylinders were installed with the frame of the combine harvester for smoothly lifting and down the seeding attachment while operating. The seeding attachment was supported with two lower link arrangements provided at the rear axle of the combine harvester. A 60 hp tractor mounted combine harvester was used to evaluate the performance of sowing of wheat while harvesting of rice crop at three different combinations of forward speeds and stubble heights.



The desired stubble height was achieved by shifting the bolt position in the header of the combine harvester. The different operating speed was maintained with the transmission gear in the tractor. University recommended wheat (variety-Unnat 550, seed rate-112 kg/ha) and fertilizer Di-ammonium phosphate (DAP, 161.2 kg/ha) was used for sowing in the rice stubble field. The experiment plots were randomly selected in a completely randomized block design (RCBD). A total of 27 treatments were laid down with three different combinations of forward speeds (1.5, 2.1 and 2.8 km/h) and stubble heights (38, 45 and 52 cm) having three replications for each treatment. Statistical Analysis System Package (SAS on demand software) was used for the analysis of variance (ANOVA). The least significant difference (LSD 0.05) test was used when the F-test indicated statistical significance at the  $p = 0.05$  probability level.

## 3 Results

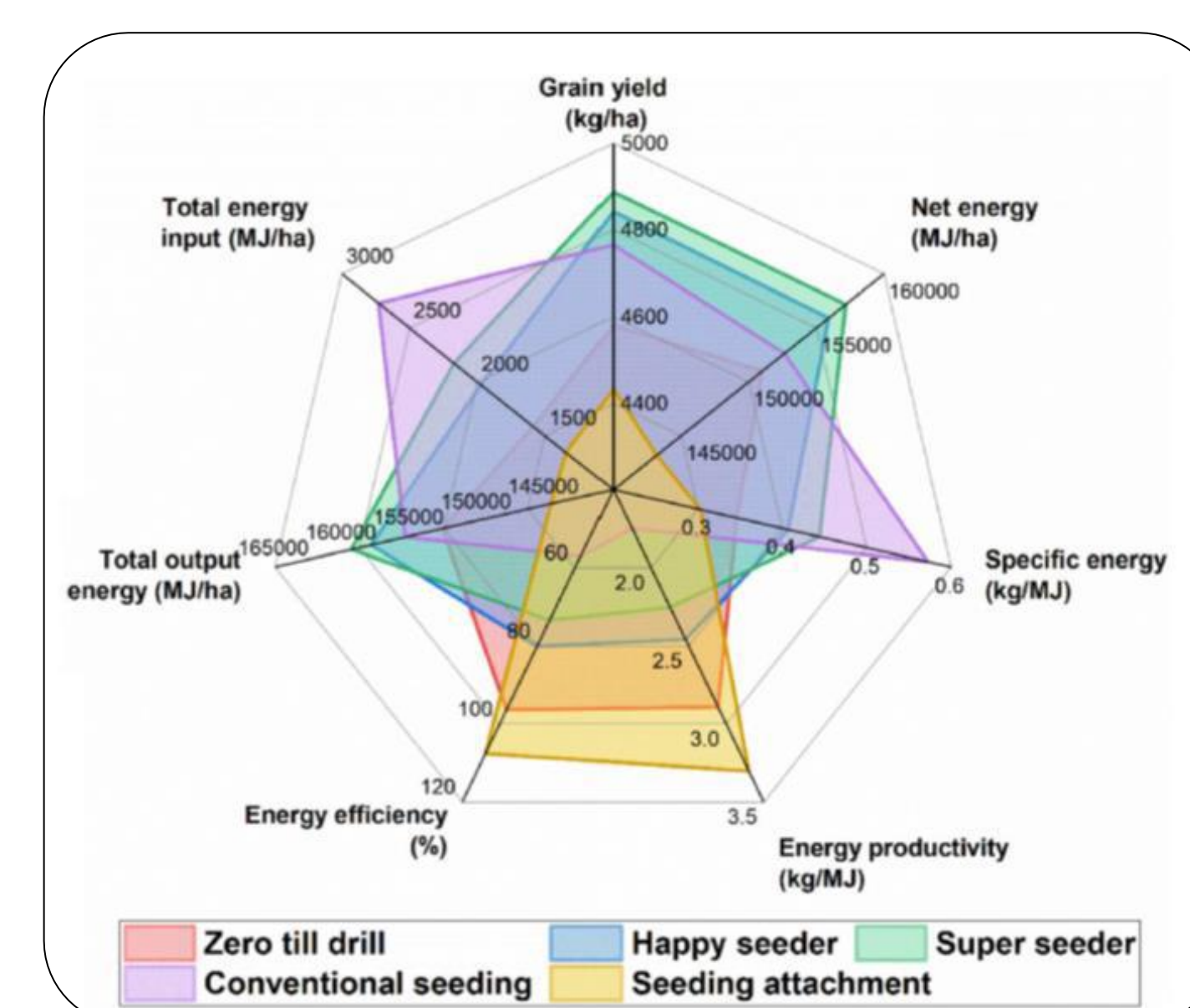
The agronomy parameters for wheat crop establishment such as plant emergence and effective tillers were found at par as compared to other prevalent methods, whereas the average field capacity, fuel consumption, and grain yield of the developed attachment were found 0.43 ha/h, 9.2 l/h, and 4430.7 kg/ha, respectively.

Rice harvesting using a conventional combine harvester followed by straw management operation and then preparing land for the sowing of wheat consumes the highest energy (2728.28 MJ/ha) is required in the harrow operation followed by the planker and seed cum fertilizer drill because of the 2 passes of the harrow and one pass of the planker and seed drill. Alternatively, direct seeding with zero till drill, happy seeder, or super seeder consumes 1584.39, 1970.75, and 2170.42 MJ/ha, respectively.

The total energy used for wheat crop establishment using the developed seeding attachment was 1343.2 MJ/ha and which is 36.65 % less than energy demand from other methods (2113.46 MJ/ha). Figure 2 showing the comparison for energy indices for wheat crop establishment using different techniques. This was mainly due to combining both energy-intensive operations (harvesting and sowing); therefore, there was no need to put extra effort into rice residue management before wheat sowing. Moreover, the tractor passes are reduced in the field which helps to reduce the fuel requirement for both operations.

## 4 Conclusion

The issue of rice residue burning in India, driven by the challenges of residue management after combine harvesting. The use of seeding attachment with combine harvester for the direct seeding of wheat, especially in the rice field can reduce the effort for rice residue management. With the developed seeding attachment, wheat crop establishment consumes only 63.35% of average energy, with 88.57% energy productivity compared to other predominant methods. The developed seeding attachment may allow farmers to delay the rice transplanting which may conserve the significant amount of ground water used in hot summer. The developed seeding attachment not only mitigates delays in wheat sowing by bridging the straw management window but also delivers substantial energy savings, environmental benefits, and enhances the utility of combine harvesters, affirming its pivotal role in improving agricultural efficiency while curbing residue burning and environmental impact.



## n Final Remark(s)

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