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[F] PhD Extended Abstract Form *(Please select the Calibri 10 typeface)*

FULL PhD THESIS TITLE … Development and evaluation of a seeding attachment of combine harvester for sowing wheat while paddy (rice) harvesting.

by

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Extended Abstract

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Chapter 1: Introduction

Asia produces 640 Mt rice from 143 Mha land, constituting more than 90% of the world's rice production, which generates 800 Mt rice residue in the fields. Indias contribution is 25% of total rice straw produced with an annual rice straw production of 200 Mt. Intensive rice-wheat cropping system and increasing mechanization perticularly harvesters are considered as main reasion 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.

In northern India, rice is harvested using combine harvesters, which leave a trail of loose residues and straw that interferes with the land preparation and sowing/planting of the next crop. The fully decomposition of the residue may take 45 to 60 days which may delay the wheat sowing. Delay in wheat sowing directly associated in yield loss as well as more irrigation water consumption. This loose rice residue and straw are considered to be a poor feed for the animals due to high silica content. Moreover, collecting rice straw from field is very laborious and not economical practice for the farmers. There isn't always enough time to remove the rice straw and prepare seedbed for sowing of wheat. To eliminate these rice residues quickly, farmers often resort to burning them in open fields. 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.

The burning of the residue can be avoided by managing it by incorporation of residue into the soil, use as crop mulch or any other ex-situ application. Residue incorporation or direct sowing of wheat in residue field requires highly energy inetnsive machinery to achieve desired results. Currently, farmer's practice includes rice harvesting with a combine harvester, than straw management options (stubble shaver, straw chopper, straw reaper, mulcher) followed by land preparation machinery (rotavator, cultivator, planker); after that, seeding equipment (*i.e.* seed cum fertilizer drill) is used for sowing of wheat. Therefore, there is only a short window period of 10-15 days to manage this residue and sow wheat. In another practice, farmer used partial burning of rice residue and/or removing loose straw and direct drilling of wheat into rice stubble field with a happy seeder, zero till drill, or super seeder. Therefore, the existing technologies for direct seeding of wheat into rice straw are highly energy intensive and time consuming.

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 with the following objectives:

1. Development and evaluation of different furrow openers for sowing of wheat in rice residue condition.
2. Development of an attachment of combine harvester for seeding wheat while harvesting rice.

3. Evaluation of developed attachment for combine harvester for sowing wheat on best parameters obtained in objective (1).

Chapter 2: Review of literature

Combine harvesting, intensive cropping systems, and the absence of buyers for rice residue were significant factors driving the practice of burning. Despite the detrimental environmental impacts, farmers resorted to burning rice straw due to its economic advantages. However, this burning resulted in the loss of up to 80% of the available nitrogen content in the crop residue. Ex-situ straw management techniques faced drawbacks, such as the time-consuming and labor-intensive task of collecting and transporting straw from the field, causing delays in field preparation. In contrast, the practice of zero tillage emerges as a sustainable agricultural technique offering numerous benefits, including reduced costs (22-23%), lower fuel consumption (31.5%), decreased water usage (25%), and fewer weed-related (18-32%) issues. Additionally, it contributes to an increase in carbon content (14-29%) in the soil.

Farmer's practice includes rice harvesting with a combine harvester, than straw management options (stubble shaver, straw chopper, straw reaper, mulcher) followed by land preparation machinery (rotavator, cultivator, planker); after that, seeding equipment (i.e. seed cum fertilizer drill) is used for sowing of wheat. In another practice, farmers used partial burning of rice residue and/or removing loose straw and direct drilling of wheat into rice stubble field with a happy seeder, zero till drill, or super seeder. Direct energy sources comprise human energy and fuel energy, whereas the indirect source comprises energy from machines (combine harvester, tractor, and seeders). The output energy is the sum of energy from grains and the energy from wheat straw.To further enhance agricultural efficiency, the combine harvester can be employed for direct seeding of wheat, especially in rice fields. This not only streamlines rice residue management efforts but also minimizes the associated costs and energy required for wheat seeding.

Chapter 3: Materials and Methods

There are several types of furrow openers are found to be usefull for working in different soil conditions. Therefore, to obtain the best suited furrow opener for developing seeding attachment three different furrow opener (i.e. concave disc, double disc and punch hole) were evaluated into the rice stubble fields. From the performance evaluation of furrow opener, the concave disc was selected. 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 arrengment. 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 (Fig 1).

Figure 1 CAD model and field evaluation of developed seeding attachment

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.

Chapter 4: Results and Discussion

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 enegy indicies 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.

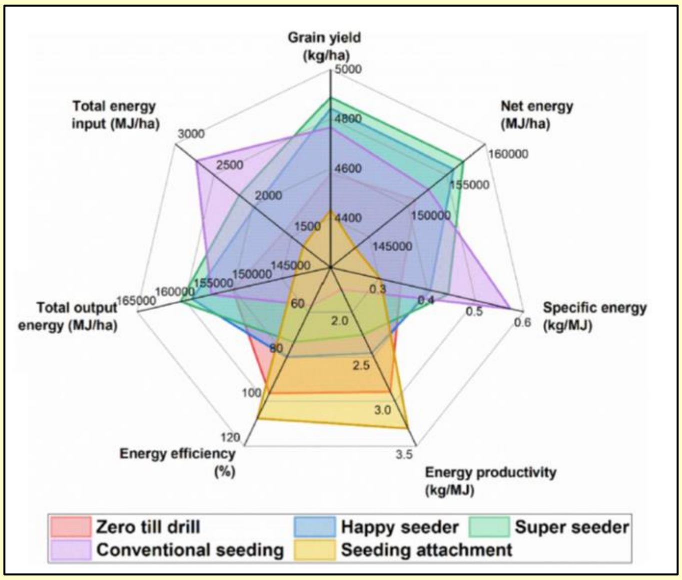

Figure 2. Energy indicies for wheat crop establishment using different techniques

Final remarks concerning benchmarks and strength points of the the Pellizzi Prize 2024

The issue of rice residue burning in India, driven by the challenges of residue management after combine harvesting. The use of seeding attchmnet with combine harvester for the direct seeding of wheat, especially in the rice field can reduces 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.