

Testing of small scale threshing machines in rural Karnataka

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Summary

This report aims to capture the key findings following testing of small-scale rice threshing machines with local farmers in rural Karnataka. By reducing the labour intensity of the threshing process, these machines can help to alleviate pressure on rice farmers caused by a labour shortage in the region.

Based on discussions with farmers, a number of key factors which determine the suitability of small-scale threshers have been developed. Of particular importance are overall threshing rate, portability, cost and performance across different rice varieties. One feed-in threshing machine and two hold-on threshing machines were tested at four different farms. Quantitative measurements of both machine and hand threshing rate were conducted, and a cost analysis was completed.

The results of this investigation indicate that a hold-on thresher has good potential to be used by small farms in this region. This machine has a high overall output rate as four people may thresh simultaneously, is about twice as fast as hand threshing, works well across many rice varieties, and is competitively priced.

Background

In southern Karnataka, small-scale farmers cultivate rice in small paddy fields and the growing & harvesting process is very labour intensive. Due to a labour shortage in the area, some farmers are switching to low maintenance cash crops such as rubber.



Figure 1 – Rice harvesting at small scale farms is a labour intensive process

Few machines have been designed specifically for small farmers, and even when products are available, often farmers lack knowledge of or access to this machinery. Therefore small machines have yet to be adopted extensively in many regions. Local conditions such as crop variety or the farming method used will also affect machine performance.

By working with local farmers, Selco Labs has been testing various small-scale agricultural machines including a paddy transplanter, rice threshers, and dehusking machines. Field testing offers farmers the opportunity to try the machinery while Selco engineers check machine performance.

Selco has obtained three different threshing machines, this investigation aimed to test the threshers in order to:

- Identify what criteria are important for small scale threshing machines
- Measure machine performance and sensitivity to local operating conditions (e.g. paddy variety)
- Collect feedback from farmers on the machines

Thresher Specification

During farm testing and discussions with farmers, a number of key factors were identified which are important to consider when evaluating the suitability of a small-scale threshing machine.

Threshing Rate - The primary aim of threshing machines is to reduce the labour required for the threshing process. Farmers indicated that the overall threshing rate is more important than the rate per person, as paddy must be threshed as soon after harvesting as possible. Once threshing rate is accurately determined, this may be used for an economic analysis of the threshing method.

Threshing Losses - IRRI defines threshing losses as *scattering loss*, *threshing loss* and *grain breakage* (IRRI, 2009). While these losses may be significant for industrial scale machines, it was found that detailed measurement of these factors was not practical or particularly informative when testing small-scale machines. The farmers themselves are a good judge of threshing quality and therefore can be asked to evaluate the output and threshing loss instead of using quantitative measurements.

Versatility - Hand threshing is relatively insensitive to a range of variables such as the paddy variety, length or moisture content. These variables may affect the performance of threshing machines, and therefore machines should be tested under a range of operating conditions and paddy should be characterised as far as is practically possible.

Output quality - Output quality is determined by the amount of chaff/straw and dummy grains mixed with the paddy. Generally it was found that farmers do not mind additional dummy grains being mixed with the paddy, as these will absorb moisture during paddy storage and will not significantly increase winnowing time. However machines which winnow out the straw will reduce the time required to collect the paddy post threshing.

Portability - Portability is a key factor for access to farms which may not have direct road access, and to enable farmers to share or lend out a machine.

Power Source - Electric motors are cheaper to run than diesel motors, and many farmers have subsidised electricity rates and single phase supplies. Due to power cuts and off the grid farms, it is useful if the machine has a back-up power source, such as pedalling. To save the cost of buying a new motor, consider testing existing motors available on a farm, for example a tiller.

Ease of use - Factors such as if women can use the machine, the ease of collecting the paddy (scattering) and the effect of the machine on the rest of the threshing process should be considered. For example, feed in threshers required sudis to be untied prior to threshing and output a pile of mixed straw. Some farmers may wish to maintain the sudis bunches as this is how straw is sold.

Safety - Exposed rotating parts are common on threshing machines, and users should be warned to tie back loose clothing and take relevant precautions.

Cost - Both the purchase and running cost of the machines should be considered, as well as the cost of additional components such as motors. Farmers will often inquire if there is a government subsidy when considering purchasing machinery.

Other factors to consider are the availability of spare parts and ease of machine maintenance. The quality and finish of the machine has also been identified as important if farmers. Farmers may not be willing to invest in a machine which is built from, and looks like, a collection of recycled materials.

Threshing Methods

Small-scale mechanical threshing methods may be grouped into two categories; hold on threshers and feed in threshers. Both types of thresher were tested, alongside hand threshing.

Hand Threshing

Traditionally, a group of farmers and labourers will beat bundles of straw called “sudis” over a wooden board, causing the paddy to fall off the panicles. This is a slow and laborious process, which scatters the grain over a large area. A tarpaulin is normally used to collect the scattered grain.



Figure 2 - Hand threshing

Hold-on thresher

Hold on threshers consist of an open rotating drum with teeth which will comb the sudis, stripping the paddy from the straw shoots. The drum may use peg teeth or wire hoops to comb. The operator grips the base of the sudi and holds the straw against the drum to be threshed.



Figure 3 – Model 1 machine



Figure 4 – Selco Foundation machine

Two hold on threshers were tested; an open drum machine with wire hoops which was bought from West Bengal, and an enclosed, peg-tooth machine designed by the Selco foundation and built locally. Each machine was powered by a 1/2hp electric motor, and the Model 1 machine may also be powered by pedalling. Drums are about 3ft long.

Feed-in thresher

The crop is fed into a feed-in thresher, and the straw circulates between a rasped drum and the casing, causing the paddy to fall through a grate into a collection chute. Feed-in threshers may be tangential flow, or axial flow. This design is typically used in industrial threshing machines.

A tangential flow, feed-in thresher (Model 2) was tested by Selco. The thresher requires a 4hp motor, however the thresher was tested using a v-belt connection to a tilling machine in order to save the cost of a 4ph motor. This thresher also incorporates a winnowing fan.



Figure 5 – Model 2 machine

Farm Testing

The three machines were tested during several farm visits with the aim of quantitatively assessing the threshing performance, and gathering feedback from farmers. It was found that counting sudis threshed was an efficient and unintrusive method to measure threshing rate. By measuring the average paddy/sudi the overall output rate of the machine in kg/hr could then be calculated.

Rate Measurement Method

1. Characterise a sample of sudis by measuring the overall length, the length from tip to lowest panicle and recording the variety, harvest date and estimated wetness.
2. After familiarising farm workers with the machine, measure threshing rate of workers by passively timing and counting sudis as the operators thresh.
3. Thresh around 20 sudis and weight the output in order to calculate the average paddy per sudi. If possible, winnow a sample of threshed paddy to determine the dummy grain content.



Figure 6 – Hand and machine threshing rate measurements

There are a number of inherent variables associated with testing these machines at different farms and on different crops. Some of these are:

- Crop yield, sudi size and moisture content will vary depending on rice variety, growing conditions and the harvest season.
- Farm workers take about 1 hour to learn to use the machine and thresh at a steady rate. Different workers thresh at different rates, and workers will thresh faster if there is a possibility of rain and the threshing area is uncovered.
- The time taken to pick-up each unthreshed sudi from the stack is 5 – 15% of the total threshing time. This will change depending on the layout at each farm and as the sudi pile depletes.
- The output rate (kg/hr) will vary significantly depending on the yield of the paddy.

While it is useful to have a quantitative assessment of threshing rate for comparison and cost analysis purposes, the measured rates are by no means absolute. Threshing rates were measured under different conditions in order to provide a performance range.

Threshing Rates

Threshing rates were measured over a number of tests at different farms. Five varieties of rice were tested, as detailed in Appendix C. The paddy yield per sudi ranged from 155g to 450g, length varied from 60cm to 100cm, while the spread of panicles from the tip of the sudi ranged from 35cm to 64cm. All the crops were relatively green, as testing was conducted during the wet harvest season.

Back-to-back comparison of all the machines across all paddy varieties was not possible, however general trends were observed. The thresher model was slightly faster when panicles were distributed over shorter length of paddy and with smaller diameter sudis. Another thresher tended to jam with less stiff straw stalks, and therefore the feed rate was limited with certain varieties of rice.

As discussed earlier, the overall threshing rate for each machine is more important than the rate per person. The maximum achievable rates in sudis/hr and kg/hr (based on 250g paddy/sudi) are presented in Table 1. For comparison purposes, the rate of four people threshing by hand has been included.

The Model 1 machine has the highest overall threshing rate, and is approximately twice as fast as four people threshing by hand. While the Model 2 machine has the highest individual threshing rate, the overall output is significantly lower as only one person may thresh at a time.

For more information on specific performance and tests, please contact us.

Thresher Comparison

Aside threshing rate, it is useful to directly compare other aspects of threshing performance, as presented in Table 2.

Criteria		Hand	Selco Foundation Model	Model 1	Model 2
Machine Specification	Cost (excl. motor)	N/A	Bespoke (unknown)	₹6500	₹22 500
	Weight (kg)	N/A	60kg	50kg	40kg
	Size (cm)	N/A	150x145x60	125x90x75	150x80x100
	Power requirement	N/A	½ hp motor	½ hp motor or pedalling	4 hp motor
	Operating speed (RPM)	N/A	300	200 - 300	1500 - 2100
	No. of Operators	No limit	2	4	1
Threshing Rate	Rate per person (sudi/hr)	110 - 140	150	160 - 270	220 - 340
	Overall rate (sudi/hr)	No limit	300	640 - 1080	220 - 340
	Overall output* (kg/hr)	No limit	75	160 - 270	55 - 85
Threshing Performance	Versatility	High - insensitive to	Low - doesn't thresh panicles	Medium - lower rate	Low - jams with lip or long sudis

		sudi properties	>40cm from tip	with thick sudis	
	Output quality	Medium - some straw and dummy grains	Low - lots of straw & dummy grains	Medium - straw & dummy grains	High - few dummy grains and straw
	Paddy breakage	Low	Low	Low	Low
Ease of Use	Scattering	High	Low	High	Low
	Portability	N/A	Low	Low	Medium
	Accessibility	N/A	Low	High	Low
	Safety	High	Low – pulls sudis into drum	Low - exposed rotating drum	Medium – enclosed rotating drum

**Based on 250g of paddy/sudi*

Discussion of Performance

Selco Foundation Model- The Selco thresher has the lowest overall threshing rate and the rate per person was only marginally faster than hand threshing. Threshing efficiency was limited as long sudis did not fit in the machine, paddy collected inside the machine which was difficult to access, and a lot of straw was mixed with the paddy and occasionally clogged the output chute. The machine tended to catch and pull sudis into the drum, alarming the user. The small drum diameter size meant that only a limited area of sudi was threshed at a time.

Model 1 - This machine was about twice as fast as hand threshing per person, and has the highest overall output rate. Threshing rate was above 200 sudi/hr under most conditions and was less sensitive to sudi properties than the Chinese machine. Pedal powered threshing was slightly slower than motor powered threshing. The machine is heavy, and requires four people to handle and scatters paddy to a similar extent as hand threshing. Slightly more straw is mixed with the output than with hand threshing, and when four people threshed a fifth person is needed to sweep the straw away from the output. Thick sudis had to be splayed broadly to ensure the centre panicles were threshed.

Model 2 - This machine had the highest threshing rate per person however only one person may operate the machine at a time. Therefore the overall threshing rate is lower than hand threshing. The machine tends to jam if the feed in rate it too high, especially with limp straw. The maximum achieved output rate was 85kg/hr. Despite sweeping various operational parameters, this rate was significantly lower than the specified 450kg/hr, therefore it is suggested that this rate may be for other grain varieties. Portability is good, as two people can transport the machine. Sudis must be untied prior to threshing which reduces the rate.

Cost Analysis

A cost analysis was conducted to calculate the payback period of the machines based on threshing 10,000 sudis per season.

It was calculated that the Model 1 machine would save around ₹2000/season while the Model 2 machine powered by a tiller would save ₹1000/season. However, threshing 10,000 sudis on the Chinese machine would take over 30 hours, as opposed to 10 hours by eight people hand threshing or four people using the Model 1 machine.

Payback period for the Model 1 machine was estimated to be 2.5 years, while the Model 2 was over 10 years.

Diesel costs were a significant proportion of the Model 2 machine running cost. To reduce costs an electric motor could be used. As three phase power supplies are not common on farms, it may be useful to test the Chinese machine using a 1hp, single phase electric motor.

See Appendix C for details of cost analysis.

Conclusions

This investigation has evaluated the performance of three small-scale threshing machines both quantitatively and qualitatively based on criteria developed from farmer feedback.

The results of the testing indicate that an open drum, hold-on thresher similar to the Model 1 has the most potential to be used by small-scale farmers in this region. This machine has a high overall threshing rate, reduces labour requirement by 50% and has an estimated payback period of 2.5 years. Additionally, the machine has a low power requirement and may be manually pedalled if required. Farmers who have used this machine are already showing interest in purchasing.

While the feed-in thresher had a high output rate per person, the performance was significantly lower than the 450kg/hr quoted, and threshing rate was dependant on the plant properties, particularly stalk stiffness. Ultimately, because only one person can operate the machine, the overall threshing rate of around 300sudi/hr means threshing will take too long to complete. Coupled with the high purchase and operating costs and high power requirement this means the machine is uncompetitive.

Next Steps

Following on from this testing, a number of things can be done to progress the small-scale threshing machine project:

- Arrange threshing demonstrations of the Model 1 machine at local farms to raise awareness and gather feedback
- Test thresher performance during the dry season harvest
- Look into improving the performance of the Model 1 machine (handles for portability, socket/switch, some sort of winnowing/fan combination)
- Investigate the potential market for a threshing machine with farmers in the region

Lessons applicable to other small-scale agri-machine testing

These points may be applicable to testing of other types of small-scale agricultural machinery:

- Understand the sensitivity of the machine to local variables and aim to quantify machine performance against manufacturer claims.
- Consider how the machine will affect other stages of farming process (e.g. untying sudis for the feed in thresher)
- It is useful to quantitatively measure key performance criteria for direct evaluation between machines and for cost analysis purposes.
- Consider the practicalities of data measurement when planning tests (e.g farmer time and labour availability)
- Not all measurements used for industrial scale machinery are relevant to small scale machinery. Often asking a farmer's opinion can be more useful than extensive measurements.

References

IRRI, (2009). *Loss Assessments*. Retrieved 13.10.13 from <http://www.knowledgebank.irri.org/rkb/measurements-in-harvesting/harvesting-loss-assessment.html>

Appendixes

Appendix A – General Data

Hand threshing rate	110-140 sudi/hr
Approx. paddy/sudi	200-300g
Cost of farm labour	₹50/hr or about ₹250/day
1kWhr electricity	₹2-4

Appendix B – Rice varieties tested

Gulwadi Sanna – about 155g paddy/sudi, 95cm long, lowest panicles around 64cm from top of sudi, harvested that morning and quite green

Mussori – a “high yield” variety, about 450g paddy/sudi, 100cm long, lowest panicles around 40cm from top of sudi, harvested that morning and quite green

Shakthi – about 275g paddy/sudi, 60cm long, lowest panicles 35cm from top of sudi, harvested that morning, Parmeshwar said the stalks are “stiff”

Kolake-dodra – about 230g paddy/sudi, 110cm long, lowest panicles 65cm from top of sudi, harvested that morning

Mallige – about 275g paddy/sudi, 72cm long, lowest panicles 40cm from top of sudi, harvested that morning and quite dry

Appendix C – Cost Analysis

Assuming threshing 10,000 sudis and farm labour costs ₹50/hour. Assuming mid-range threshing rates. Chinese machine powered by an 8hp tiller and Premier Magnetos machine powered by a 1/2hp electric motor.

Threshing Method	Machine Cost (RS)	Number of Workers	Labour Cost/hr Threshing	Running Cost (₹/hr)	Rate/person (sudi/hr)	Overall rate (sudi/hr)
Model 1	10000	4	200	2	240	960
Model 2	22500	1	20	75	300	300
Hand	0	8	400	0	120	960

Method	Hours Threshing	Labour Cost (₹)	Operating Cost (₹)	Total Cost (₹)	Saving/season (₹)	Payback Period (seasons)	Payback Years
Model 1	10	2083	21	2104	2063	4.85	2.42
Model 2	33	667	2500	3167	1000	22.50	11.25
Hand	10	4167	0	4167		N/A	