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Estimating Field Loss of a Developed Rice Stripper Harvester in Nigeria

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ABSTRACT

Every attempt to reduce post harvest losses must inevitably start with minimizing losses during harvesting. Grain stripping harvester is a technology which is being developed and so far is becoming effective for rice and wheat harvesting. Grain losses in stripping harvester occur at the gathering/stripping operation which are shattering, stubble and lodging losses. The harvest loss estimation of rice harvesting with a self propelled grain stripper developed in Nigeria was carried out. The best machine settings of critical operating parameters were determined to obtain total minimum harvest loss estimation which was 13.5% of the total yield while the manual harvesting loss was 20.3% under the same condition. The machine setting at this combination was 270.0mm rotor height, 670.0rpm peripheral rotor speed and 3.0km/h forward speed which gave shattering loss as 5.5%, stubble loss was 4.9% and lodging loss was 3.1% of the total yield. Planting pure seed variety will reduce stripper header losses at harvest because it will result in uniform crop height at maturity.

Keywords: *Estimating, Field loss, stripper, Rice*

1. INTRODUCTION

Grain loss at harvest reduces the profitability of crops which happens in a number of places during harvest and must be assessed for a newly developed machine for corrective action to be taken (Riethmuller, 2001). Combine harvesters are designed to harvest small grains like, rice, wheat, soybean and corn with other cereal crops. The machines are also used for wide variety of small-area or special seed crops. There are direct combining (harvesting) which require cutting and harvesting in one operation which is currently most common, Kepner et al (2005). Grain stripping harvester is a new technology which is being developed and so far is becoming effective for rice and wheat harvesting, Tado and Quick (2003).

Ever-increasing Asia and World population at large coupled with the degradation and reduction of the prime rice lands is now placing tremendous pressures on the rice farmers to increase production. This can be achieved through the utilization of modern rice production technologies and reduction of post harvest losses (Tado, 2000).

Every attempt to reduce post harvest losses must inevitably start with minimizing losses during harvesting. Introduction of modern high-yielding varieties which are more susceptible to shattering loss than traditional varieties has increased the problem of harvesting because of the greater amount of crop that has to be handled with increase in crop density, Tado and Quick (2003).

Whenever serious grain losses occur at harvest, it reduces the profitability of crops. The grain can be lost at a number of places during harvest like pre-harvest loss due to natural shedding, at the front due to front header type or set up, and also from the threshing system of the machine due to concave drum and sieve settings, Riethmuller (2001). Seed losses occur in the four basic operations performed by conventional combine harvester in recovering the seed which are cutting, threshing, seed and chaff separating and cleaning units, Kepner et al (2005). Grain losses in stripper harvesting occur at the gathering/stripping operation which are shattering (grains spilled on the ground), stubble (grains left on the standing stalks) and lodging (grain left on the lodged stalks) losses. These losses can be reduced by resetting the machine and changing the harvesting technique. The losses should be assessed so that corrective measure can be taken to minimize the loss which is the main purpose of this study for rice harvesting with a self propelled prototype stripping harvester developed in Nigeria, Adisa (2009).

2. METHODOLOGY

2.1 Field Experiment

A pre-field or preliminary field experiment was carried out to study the performance of the machine at various settings of the functional component machine parts to identify which of the part require modification. All the necessary adjustments and modifications were done before the commencement of the field data taking. The preliminary field experiment on the rice field could not be carried out elaborately until there was ripe rice field before the real field data was taken. Field experiments were carried out on an upland rice field (Faro 44 variety) along Basawa road, Samaru, Zaria, Nigeria by the middle of September, 2008. Sample of the harvested rice seed

grains were taken to nearby National Seed Service Centre at Samaru for seed variety identification.

Randomized Complete Block Design (RCB) was adopted to carry out the study grain loss estimation at various stripper rotor heights, rotor speeds and forward speeds and MOG (matters other than grain)/grain ratios. This was adopted as 2 x 5 x 5 factorial treatment combination of two levels of rotor height which were 270mm and 220mm five levels of forward speed which were 3km/h, 4km/h, 5km/h, 6km/h and 7km/h and five levels of rotor speeds which were 400rpm, 500rpm, 600rpm, 700rpm and 800rpm.

The variables that were measured throughout each run for header losses are grain lost in the shatter, stubble and lodge. Shatter header loss was measured by weighing the grain that was collected in the quadrant placed on the ground of known area ($0.1m^2$), made of square iron rod. This was placed in the crop ahead of the harvester, and the value was extrapolated to give the loss in kilograms per hectare. Pre-harvest loss was eliminated in this way. Also the amount of grain left on the standing stalks unstripped by the rotor header was collected weighed (stubble loss). While those left behind on the lodged stalks was collected and weighed (lodged loss) for each plot of 0.3m width by 10m length size. Rice field size of 20m by 50m was divided into three blocks which was subdivided further into these plots size where the experiment was carried out in three replications. Along side with the stripper harvesting, manual harvesting with sickle was carried out, threshed, cleaned manually and weighed while all the operations were timed.

2.2 Laboratory Field Experiment Measurement

Four field men were involved in carrying out the field experiments. It included harvester operator that guides harvester through each run, the time keeper took note and recorded the time taken for each run and measured amount of fuel consumed per run from a calibrated cylinder.

Another man picked the unstripped grains left on the stubble (standing crop), grain left on lodged crop, and grains that spilled or shattered on the ground within the $0.1m^2$ quadrant. A technician assisted the team to change the pulleys and belts to obtain right machine and rotor speeds and rotor height variations. The speed combinations were checked to confirm the accuracy of the forward speed, rotor speed, augers' speed and rotor height before each set of run commences. The instruments made used for the laboratory and field experiment data measurements were lutron digital photo/contact tachometer of 0.5 to 100,000rpm range and accuracy ± 0.05% was used to measure speeds. The weighing were done in the laboratory with the Mettler Model 2010 electronic scale of up to 0.1g accuracy. An analogue stop watch which gave time readings of 0.01seconds was used to measure time. Measuring tape of 50m length calibrated in mm was used to measure length and distance.

3. RESULTS

Table 1is the field performance indices measured while Table 2 is the field performance indices computed. Figure 1 is effect of stripper rotor speed on total loss at two levels of rotor height, Figure 2 is effect of harvester's forward speed on total loss at two levels of rotor height, Figure 3 is contribution of the various sources of loss to the total loss in a 2x5x5 factorial experiment and Figure 4 is contribution of the various sources of loss in a 2x5x5 factorial experiment.

Table 1: Field performance indices (measured)

Measured indices	Mean values
Mean crop yield	1,300kg/ha
Pre harvest loss	40kg/ha
Crop moisture content at harvest	21% - 15.6%
Height of the crops	55cm – 90cm
Weight of grains left unstripped on the stubble	18.8g/plot
Weight of grains left unstripped on lodged crops	11.4g/plot
Weight of materials other than grains (MOG) stripped	16.8g/plot
Weight of total grains and MOG stripped	288.1g/plot
Weight of grains found in quadrat (shattered loss)	22.9g/plot
Maximum wind velocity at time of harvest	2.34m/s
Time taken to reap a plot	14.3s/plot
Weight of grains threshed during harvest	255.2g/plot

Table 2: Field performance indices (computed)

Computed indices	Mean values
Shattering loss	6.9%
Cracked grain loss	0.0%
Lodging loss	3.4%
Stubble loss	5.7%
Crop purity	89.7%
Total grain loss	15.9%
Fuel consumption rate	8.4ml/plot
Effective harvester field capacity	0.044ha/h
Harvester field efficiency	56.68%
Harvester efficiency	78%

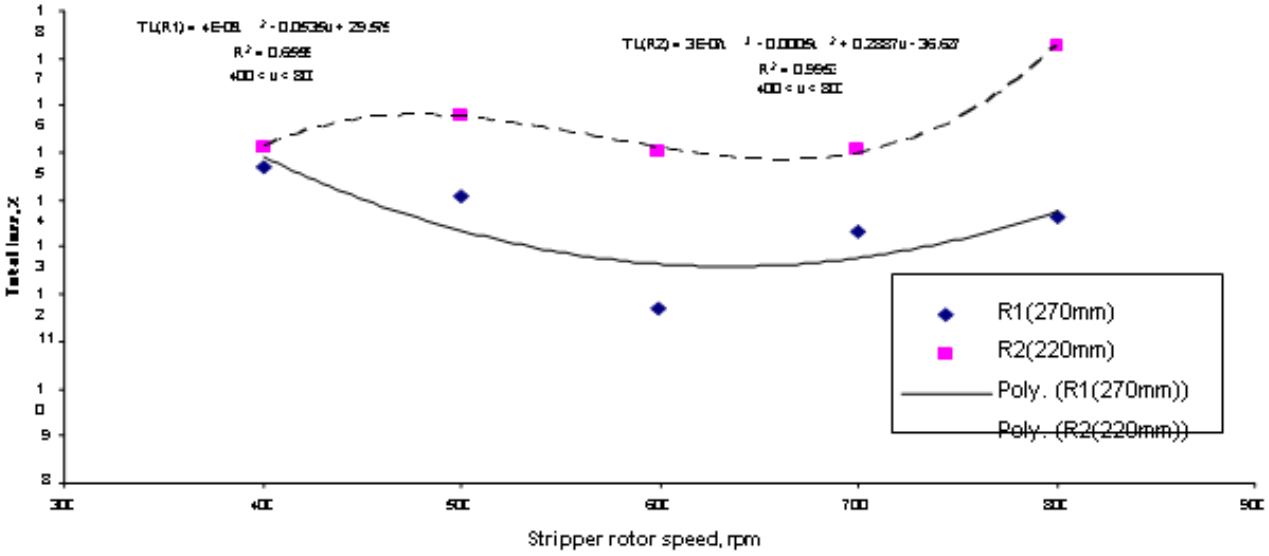

Figure 1: Effect of stripper rotor speed on total loss at two levels of rotor height.

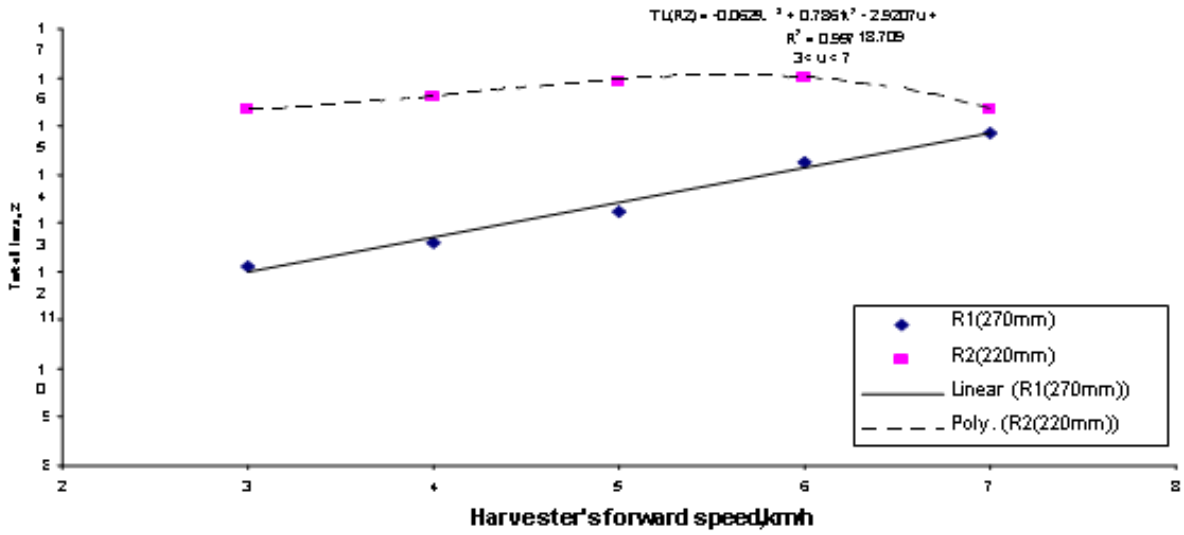

Figure 2: Effect of harvester's forward speed on total loss at two levels of rotor height.

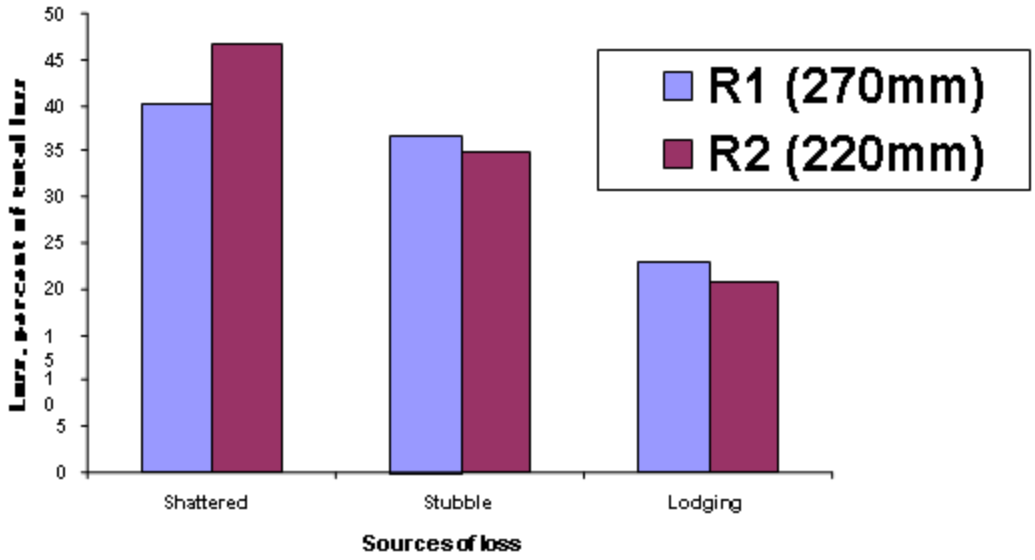

Figure 3: Contribution of the various sources of loss to the total loss in a 2x5x5 factorial experiment.

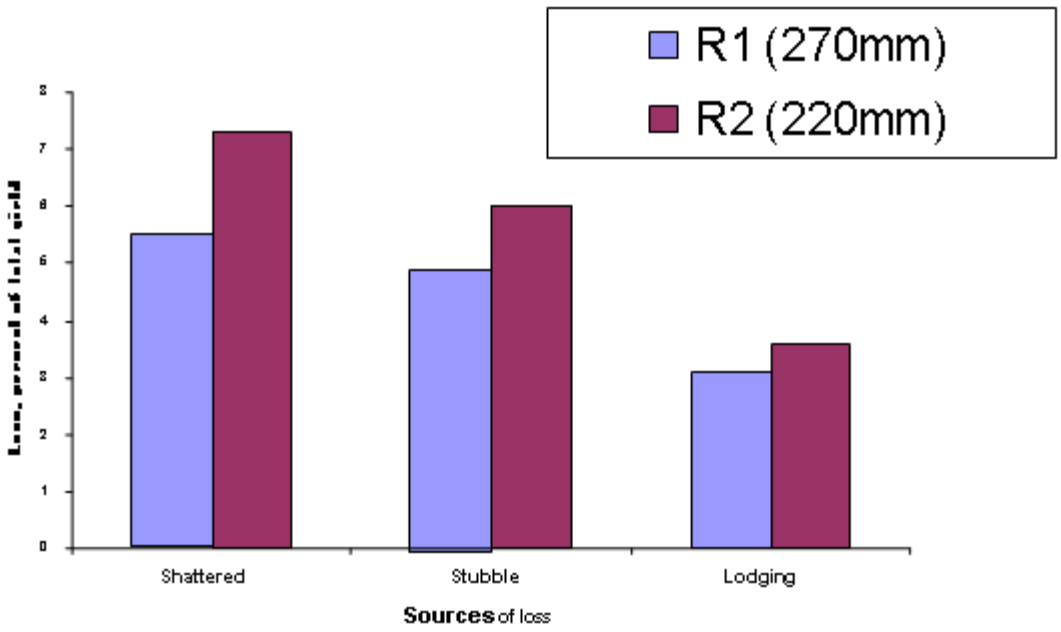

Figure 4: Contribution of the various sources of loss in a 2x5x5 factorial experiment

4. DISCUSSIONS

4.1 Results of the Field Experiment

The field performance indices measured from Table 1 shows the mean

Crop's yield was 1,300kg/ha, the pre-harvest loss was found to be 40kg/ha. The shattered loss was 22.9g/plot, stubble loss was 18.8g/plot while lodging loss was 11.4g/plot which was the least because there was no serious lodging of the rice crop. Stripping operation was effective where mean total grains stripped with MOG was 288.1g/plot out of which 255.2g/plot of grains was threshed leaving very small unthreshed.

Field performance indices computed from Table 2 shows the mean values of the shattering loss to be 6.9% which was the highest, followed by stubble loss 5.7% lodging loss 3.4% and cracked grain loss was 0.0% out of the total loss of 15.9%. Cracked grain was absent because the inner hood of the stripper with which the fleeing stripped grains

collided was lined with rubber carpet to reduce grain rebouncing (rechochetting). The crop moisture content during the seven day experimental test varied from 21.0% to 15.6% on wet basis. Soil moisture content was 11.0% on the average while the crop height varied from 55.0cm to 90.0cm because it was discovered that the seed grains planted were not pure when taken to the National Seed Service Centre at Samaru. The manual harvesting total loss was 20.3% of the total yield which was done in 120.0 seconds while the same plot size was harvested within 14,3 seconds and the total loss was 13.5% of the total yield.

4.2 Effect of Harvesters Settings on Total Loss

Figure 1 shows the trend with which the total loss increased with the rotor speed. The minimum total loss occurred at 270.0mm of rotor height setting which was 556.0rpm and 669.0rpm before it both increased again. Figure 2 shows how the total loss increases both linearly and polynomially as the harvester's forward speed increased. This was as a result of combined effects of machine's behaviour under varied material feeding rate of stripping unit and rotor height in relation to crop height. The minimum total loss mean occurred at stripper rotor speed 700.0rpm which was 13.5% of total yield at 220.0mm rotor height settings. It occurred at harvester's forward speed 7.0km/h and lowest total loss mean been 14.3% of the total yield at rotor height setting 270.0mm.

The histograms or bar chart in figures 3 and 4 shows the contributions of the various sources of loss. Figure 3 shows that the shattering loss contributed the highest of 40.2% to the total loss at a rotor height 270.0mm while the shattered loss also had the highest contribution of 46.6% of the total loss for rotor height 220.0mm. Figure 4 shows the histogram of the contributions of the various sources of loss computed as a percentage of total yields. The shattered loss was more pronounced, contributing about 5.5% of the total yield at rotor height 270.0mm and 7.3% at rotor height 220.0mm. This was closely followed by stubble loss, contributing 5.0% and 6.0% of total yield at rotor height 270.0mm and 220.0mm respectively. The loss due to lodging was 3.1% and 3.6% of total yield at rotor heights 270.0mm and 220.0mm respectively.

4.3 Harvester Settings for Minimum Loss

The minimum total loss was obtained at rotor height 270.0mm and estimated values of stripper rotor speed was 669.0rpm and 3.0km/h harvester forward speed. At rotor height 220.0mm the estimated values of stripper rotor speed 556.0rpm and 4.2km/h harvester forward speed. Hence operating the harvester at these settings 270.0mm, 670.0rpm and 3km/h combination brought the shattering loss to the barest minimum of 5.5%, stubble loss was 4.9% and lodging was 3.1% of the total yield. Operating the harvester at 220.0mm, 560.0rpm and 4.2km/h gave shattering loss as 7.3%, stubble loss was 6.0% and lodging loss was 3.6% of the total yield. Kalsirislip and Singh (2001) tested a similar rice stripping machine developed in Thailand and got the shattering loss to be 5.3%, stubble loss was 4.0% and lodging loss was 5.6% of the total yield. Klinner et al (1987) got over all losses which ranged between minimum of 4.3% and as high as 10.7% of the total yield on his stripping machine that was tested in England on some cereal crops.

5. CONCLUSION

Harvest loss estimation of rice harvesting with a grain stripping harvester develop in Nigeria gave overall 13.5% loss of the total yield at best settings. At 270.0mm rotor height, 670.0rpm rotor speed and 3.0km/h forward speed combination setting minimum shattering loss was 5.5%, stubble was 4.9% and lodging loss was 3.1 of the total yield. At 220.0mm rotor height, 560.0rpm rotor speed, and 4.2km/h forward speed combination settings, minimum shattering loss was 7.3%, stubble loss was 6.0% and lodging loss was 3.6 of the yield. These losses were found to be too high and will require further improvement work to be done to reduce the losses to the barest acceptable level. Also planting pure seed will reduce losses at harvest because it will result in more uniform crop height at maturity.

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