EFFECT OF STRIPPER FORWARD SPEED ON HEADER LOSSES AND HARVESTER EFFICIENCY OF A SELF PROPELLED GRAIN HARVESTER

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Abstract

The introduction of modern high- yielding rice 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 or feed into the machine. Every attempt to reduce post harvest losses must inevitably begin with minimizing losses during harvesting. A developed 30cm width prototype stripping harvester was evaluated to further establish stripper harvesting technology in Nigeria by determining the effect of forward speed on header losses and harvester efficiency. At optimum settings of the critical operating parameters (machine rotor height and forward speed), when rotor height was set at 270 mm, the forward speed was 3 km/h where minimum shattering loss was 4.3%, stubble loss was 4.5%, lodging loss was 2.1% and harvester efficiency was 81%. Also when rotor height was set at 220mm, the shatter loss was 7.0%, stubble loss was 4.8%, lodging loss was 2.7% and harvester efficiency was 77%. Hence machine settings at 270 mm rotor height, 3 km/h forward speed is hereby recommended.

Keywords: Header Losses, Stripper, Forward Speed, and Grain Harvester.

Introduction

The crop harvesting equipment available to small scale farmers mostly in the developing countries have not received adequate improvement over the years. Knives, sickles and scythes continue to be the traditional tools used for harvesting crops (Stout and Cheze, 1999). In the past, some reapers with low power rating were developed, but because of their low field capacity, high cost and other operational problems, they were usually not considered suitable alternatives to the manual methods (Carruthers, 1985).

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.

Rice harvesting requires cutting of the matured heads, threshing, cleaning and bagging. With mechanical means, it is not as tedious as when done manually. Apart from the intensive labour involved, losses are encountered at various stages of harvesting and processing which are usually higher with manual than mechanical method of harvesting, (Ajiboye, 2007). Losses and waste will need to be curbed even more than in the past at harvesting and post harvesting stages. Few men and more cost effective methods and machines will be required to reduce the adverse effect high inflation has on labour and machinery costs (Ferreira et al., 2001).

Introduction of modern high- yielding rice 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 or feed into the machine (Tado and Quick, 2003). Every attempt to reduce post harvest losses must inevitably start with minimizing losses during harvesting. 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.

There was a need to develop a harvester which should be simple without involving any complex production technology. At Silsoe Research Institute in United Kingdom, stripping harvester was developed in late 1980s. Philippine Rice Research Institute in early 1990s improved on this for their country side peasant farmers (Tado and Quick, 2003). This stripping harvester was developed as an alternative to manual harvesting for small scale rice farmers. The stripping comb- like resilient elements were mounted horizontally on an upward rotating drum which engages crop stalks as machine advances forward.

In machinery development, there is need to optimize the critical operating parameters of the stripping harvester (Tado, 2002). Tado and Quick (2003) observed that stripper rotor performance was highly influenced by parameters of forward speed and rotor height. Johnson (2000) carried out a research and designed improved form of crop feeding rate into the rotor of an axial flow combine harvester for effecting a threshing and separating action on the crop materials passing through between the rotor and the concave assembly. This study is to determine the effect of stripper forward speed which varies the machine's crop feeding rate on header losses and harvester efficiency of a self propelled prototype stripper harvester prototype (Adisa, 2009).

Methodology

Agrophysical characteristics of cereal crops to be harvested are essential parameter which was considered in developing a 30 cm width self propelled prototype stripping harvester which was tested on a faro 44 rice variety field in Zaria, Nigeria in 2008 and the study work got completed in 2009s . This was done to further establish this new stripper harvesting technology in Nigeria by studying the effect of machine forward speed on header losses like shattering, lodging and stubble and harvester efficiency at different machine settings of the critical operating parameter like rotor height. At different machine forward speeds and rotor heights, the crop material feeding rate of the machine differs which affected performance of the machine. The effect of forward speed in combination of rotor height and rotor speed on the field performance of the rice harvester with minimum header loss were determined to know the best combination.

A randomized complete block design (RCB) was adopted to carry out the study of the effect of machine forward speed and rotor height on header losses and harvester efficiency. The harvester was operated at five forward speeds 3 km/h, 4 km/h, 5 km/h, 6km/h and 7 km/h in combination with two rotor heights 270mm and 220mm at a set rotor speed. The rotor heights 270 mm and 220 mm were the two available settings of the lowest tip of the stripper and the ground level. A three factorial experiment, where a parameter was varied while others were fixed at a time was conducted. At each run, the grains that shattered on the ground inside a square quadrant of 0.1 m^2 were collected, grains left behind on the standing crops (stubble) were collected and the grains left on the lodged crops were also collected and they were weighed. Before the harvesting started, crop harvesting of 1m^2 area was done manually covering several locations on each of the block and the average were found to determine crop yield per hectare. Total grains stripped per each plot were collected and was weighed. The following formulas were used to calculate the header losses, shattering loss, stubble loss, lodging loss and harvester efficiency.

The following are the parameters computed in this study:

(i) Shattering losses, S_l (loss caused by the header due to vibration and it impact on the crop during harvesting, kg)

(ii) Lodging losses, Lg (grains left behind on lodged plants, kg)

(iii) Stubble losses, St (grains left on stubbles by the header, Kg)

Each of the losses was expressed as percentage of the total yield (TY) in each plot using equations 1, 2,3,4 and5.

$TY = C_t + S_l + L_g + S_t$ (kg) ....(1)

C_t = mass of total grain and MOG harvested (kg)

$$S_l = \frac{\text{mass of shattered grains}}{TY} \times 100(\%) \qquad (2)$$

$$L_g = \frac{\text{mass of grains left on lodged crops}}{TY} \times 100(\%) \qquad (3)$$

$$S_t = \frac{\text{mass of grains left on stubble (standing crop)}}{TY} \times 100(\%) \qquad (4)$$

The harvester efficiency was calculated by expressing the mass of grain harvested (stripped) and conveyed through the box to the total yield as shown below:

$$\eta = \frac{C_{tg}}{TY} x100(\%) \qquad (5)$$ (Kalsirisilp and Singh, 2001)

Where: C_{tg} = total grain stripped and collected, kg

Where: MOG is materials other than grain.

Results and Discussion

Figure 1 shows the effect of harvester forward speed on shattering loss at two levels of rotor heights. At rotor height 270 mm, the graph is a linear one that rises from 4.5% to 7.0% as the harvester speed increased from 3km/h to 7 km/h. Also at 220 mm rotor height, the graph follow a polynomial trend as the shattering loss increased from 3 km/h and later began to drop at 6 km/h. The shattering loss 6.8% at rotor heights 220 mm and 270 mm was the same at machine forward speed 6.9km/h.This is an indication that as the crop feed rate was increased at higher forward machine speed, the crop was disturbed more, hence the harvester shattered the grains more which may require that the intake entrance be increased at high speed of the harvester.

Figure 2 shows the effect of machine forward speed on stubble loss at two levels of rotor height. At rotor height 27 0mm, the stubble loss graph was a linear and it slightly rose as the forward speed increased. When the machine was set at 220 mm rotor height, the graph was of a polynomial trend which increased though not too sharp increase as the forward speed increased. At harvester forward speed 3.4 km/h, the stubble loss 4.6% was the same at 220 mm and 270 mm. Increased crop feed rate of the harvester does not have much significant effect in leaving grains behind on the standing crops.

Figure 3 shows the effect of harvester forward speed on the lodging loss at two levels of rotor height. The graph is a linear one at 270 mm rotor height setting and the lodging loss rose from 2.0% to 3.5% when the machine forward speed increased from 3 km/h to 7 km/h. The behavour of the graph when rotor height was set at 220 mm was only slightly different from when it was set at 270 mm. Lodging loss rose from 2.5% to 3.0% when machine forward speed increased from 3 km/h to 7 km/h. More grains were left on the lodged crops as the forward speed of the machine increased or crop feed rate increased. This because it has lesser time to pick up grains from lodged crops.

Figure 4 shows the effect of harvester forward speed on harvester efficiency at two levels of rotor height. At 220 mm and 270 mm rotor height settings, the graph trends were similar where both took up at 78% and 82% efficiencies at 3 km/h and dropped to 76% and 78% respectively before they both rose up again and became same value, 80% at 7 km/h. At high crop feeding rate, harvester efficiency dropped because more stripped grains were lost mainly by shattering and lodging as forward speed increased as indicated in Figures 1 and 3. At optimum settings of the critical operating parameters where the losses were least the rotor height 270mm, the forward speed was 3 km/h, shatter loss was 4.3%, stubble loss was 4.5%, lodging loss was 2.1% and harvester efficiency was 81%. At 220 mm rotor height setting, forward speed was 4km/h, shatter loss was 7.0%, stubble loss was 4.8%, lodging loss was 2.7% and harvester efficiency was 77% where minimum header losses both occurred.

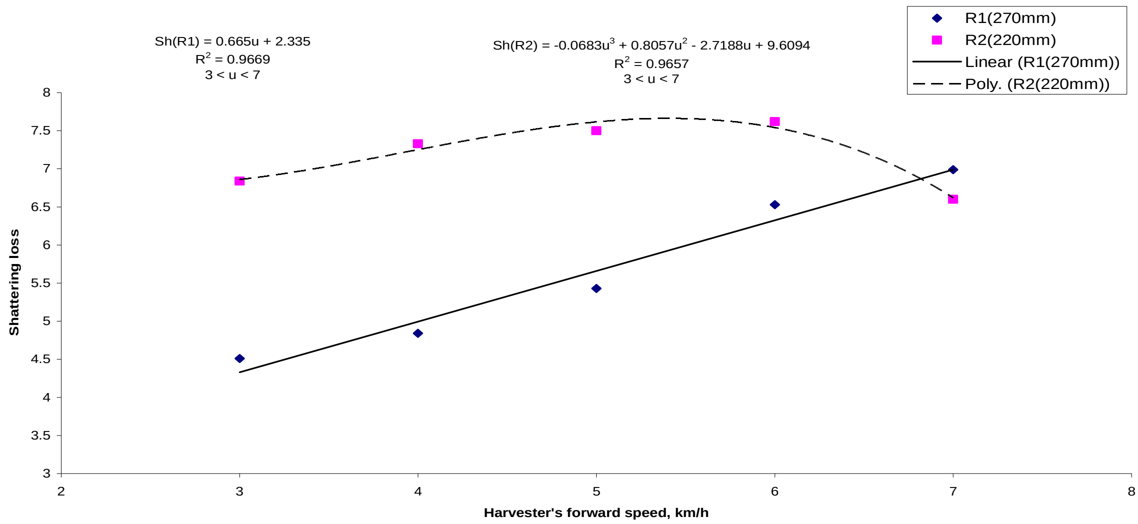

Figure 5.1a: Effect of harvester's forward speed on shattering loss at two levels of rotor height.

Figure 1:

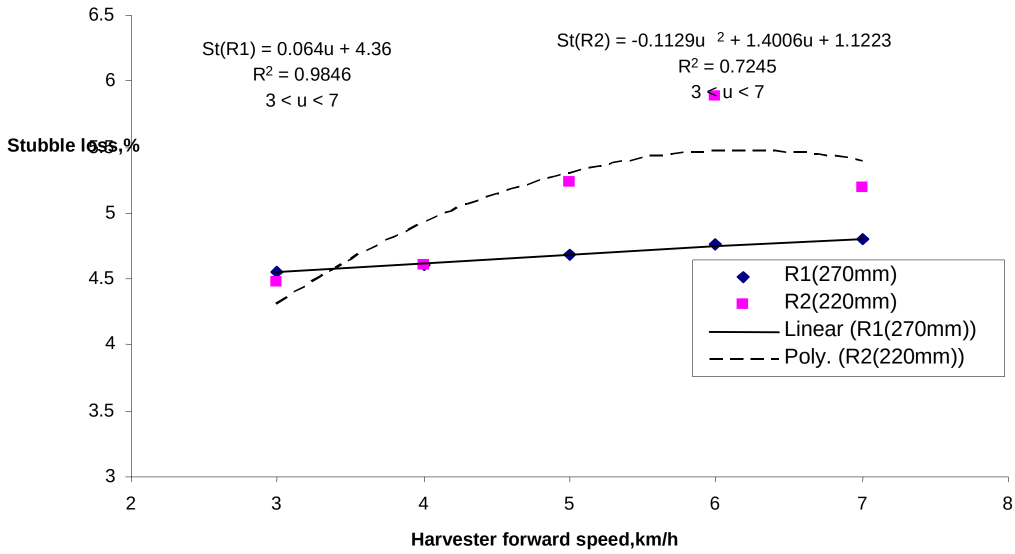

Figure 2: Effect of harvester's forward speed on stubble loss at two levels of rotor height.

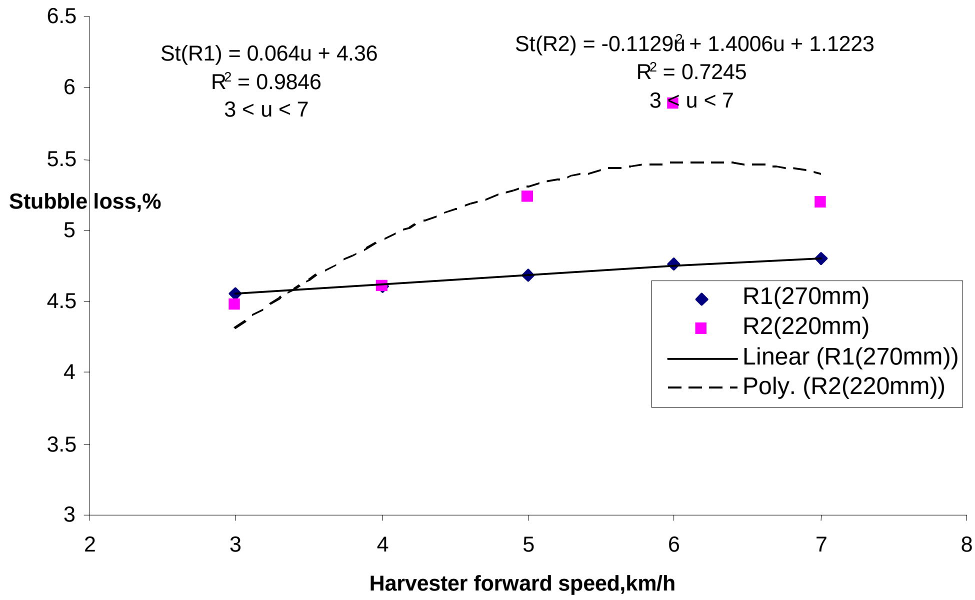

Figure 3: Effect of harvester's forward speed on stubble loss at two levels of rotor height.

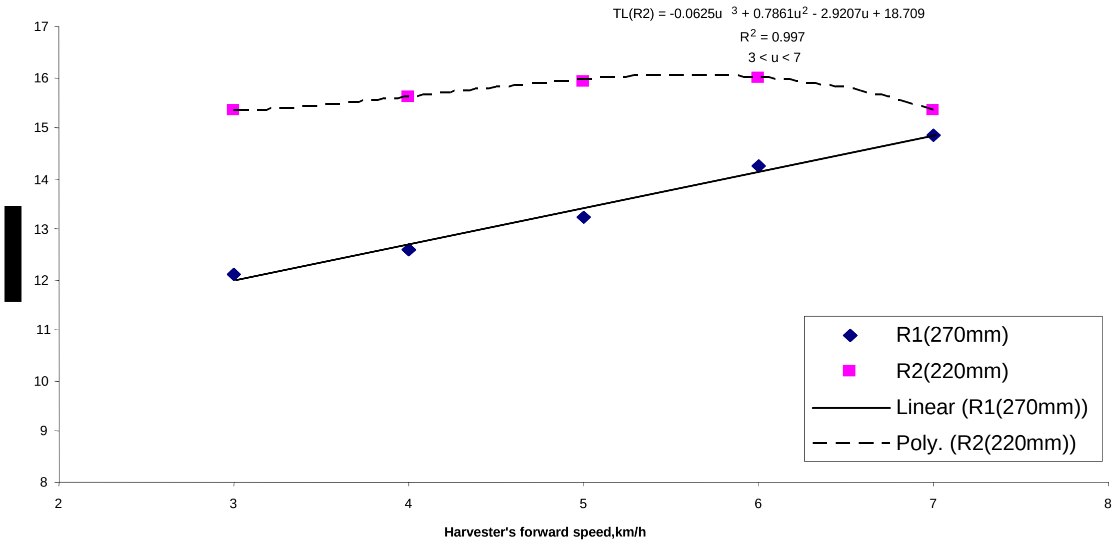

Figure 4: Effect of harvester's forward speed on total loss at two levels of rotor height.

Conclusion

A 30cm width prototype stripper harvester was evaluated to determine forward speed effect on header losses and harvester efficiency. This effect was of forward speed when crop is fed at variable rate into the machine on the stripper header losses like shattering, stubble, lodging and harvester efficiency. The shattering loss increased at both rotor heights 220 mm and 270 mm as the forward speed increased. Stubble loss increased slightly at 270 mm rotor height while it increased a bit more at 220 mm rotor height. Lodging loss increased rapidly at two rotor heights 220 mm and 270 mm as the machine forward speed increased. The harvester efficiency decreased to minimum points 74% and 78% at 220 mm and 270 mm rotor heights at 6km/h machine forward speed respectively.

At optimum settings of the critical operating parameters, the forward speed was 3 km/h resulting into minimum shatter loss of 4.3%, stubble loss was 4.5%, lodging loss was 2.1% and harvester efficiency was 81% at 270 mm rotor height. When the rotor height was set at 220 mm, the forward speed was 4 km/h resulting into minimum shatter loss of 7.0%, stubble loss was 4.8%, lodging loss was 2.7% and harvester efficiency was 77%.

References

Adisa, A. F. (2009). *Development and performance evaluation of a pedestrian controlled rice stripper.* Unpublished Ph.D Thesis, Ahmadu Bello University, Zaria, Nigeria.

Ajiboye, V. A. (2007). *Development and performance evaluation of a motorized single axle cowpea harvester.* Unpublished Ph.D Thesis, Ahmadu Bello University, Zaria, Nigeria.

Carruthers, I. (1985). *Tools for agriculture,* I. T. Publications in Association with GTZ/Gate, U.K.

Ferreira, D. B., Ferreira O. O., Alonco A. D. S. & Bley H. (2001). Grain loss monitoring during all harvest season (Gathering and Processing Losses), in the irrigated rice crop, and its result in reducing losses due to immediate adjustment in the combines. *America Society of Agricultural and Biological Engineers (ASAE). ASAE Publication 011075 Michigan, U. S. A.*

Johnson, M. (2000). *Feeding crop to the rotor of an axial flow combine harvester*. IP Research Tools, Data and Communities, U. S.A.

Kepner, R. A., Bainer R. & Barger, E. L. (2005). *Principles of farm machinery*. CBS Publishers & Distributors, third edition, New Delhi, India.

Kalsirisilp, R. & Singh, G. (2001). Adoption of a stripper Header for Thai-made rice combine harvester. *J. Agric. Eng. Res. 80(2), pp163 – 172.*

Riethmuller, G. (2001). *Harvest loss estimation, agriculture Western Australia,* farm Note 04196, Australia.

Stout, B. A. & Cheze, B. (1999). *CIGR handbook of agricultural engineering volume III*. Published by the America Society of Agricultural Engineers, U. S. A.

Tado, C. J. M. (2002). *Influences on the performance of the stripper rotor in rice. VDI-MEG 384. Published Dissertation.* University of Hohenheim, Stuttgart, Federal Republic of Germany, 143pp.

Tado, C. J. M. & Quick, G. R. (2003). *Development of pedestrian controlled stripper harvesters for Southeast Asian rice fields.* Proceedings of the International Conference on Crop Harvesting and Processing, ASAE Publication Number 701p1103e, Kentucky U. S. A.