RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 11 | Issue 1 | April, 2018 | 54-59
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/11.1/54-59**

To study of effective speeds for harvesting of wheat straw by straw combine

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Received : 10.01.2018; **Revised :** 08.02.2018; **Accepted :** 17.02.2018

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■ **ABSTRACT :** This research study was conducted in order to determine and the performance and economic benefits of straw combine for harvesting of straw of wheat crop in combine harvested field. Straw combine are widely used for harvesting of wheat straw for small and large farm owners. Straw combine are used for straw recovered in the combine harvesting field and also recovered grains present in stubble straw of wheat crop. Today's National Green Tribunal (NGT) banned the burning of stubble straw in the field so farmers can't burn stubble straw in field. Harvesting of stubble straw is earnable and low cost process by straw combine. Three replications were taken and values of dependent variables were computed to indicate the performance and economic benefits of straw combine for harvesting of wheat straw were carried out for recovery of wheat straw w.r.t straw recovery, grain recovery, labour requirement and cost economics. The observation were taken at three speeds of 2.50 kmph, 2.00 kmph and 1.50 kmph for straw combine at the different moisture content of 8.2 per cent, 8.6 per cent and 9.2 per cent, respectively. The analysis of data and results obtained from the evaluation of straw combine for harvesting of wheat show that the straw recovery were 89.85 per cent, 87.35 per cent and 85.74 per cent at the moisture content of 8.2, per cent 8.6 per cent and 9.2 per cent and the grain recovery were 10.13 per cent, 9.80 per cent and 9.38 per cent at the moisture content of 8.2 per cent, 8.6 per cent and 9.2 per cent, respectively. Overall results obtained from the study of straw combine for harvesting of wheat straw was time of operation, straw recovery, grain recovery, man-h/day.

■ **KEY WORDS :** Field capacity, Field efficiency, Straw recovery, Grain recovery, Overlap percentage, Fuel consumption

■ **HOW TO CITE THIS PAPER :** Upadhyay, Ankit Kr., Singh, Vivekanand and Moses, Sheen C. (2018). To study of effective speeds for harvesting of wheat straw by straw combine. *Internat. J. Agric. Engg.*, **11**(1) : 54-59, **DOI: 10.15740/HAS/IJAE/11.1/54-59.**

Wheat is India's prime most staple crop, placed second only to rice. It is mostly consumed in the north and north-west parts of the country. Being rich in protein, vitamins and carbohydrates, it provides a balanced food to millions of people each day. In current scenario, India with a production of 87 million tonnes is the second largest producer of wheat in the world after china. Even the productivity increased at a good pace and was computed to be around 2872 kg/ hectare in the latest report by the Indian department of agriculture (agricultural statistics at a glance 2015-16). Indian agriculture accomplished an all-time record production of 95.9 million tonnes of wheat, a 6.4 per cent increase from a year 2016-17 of about 735 million grown on over 240 million hectares globally.

India is a vast country, covering about 329 million

hectare geographical area of the total geographical area. About 166 million hectare is cultivated land and net area sown is about 142 million hectare. In U.P. about 70 per cent of total geographical area is under cultivation andwheat is grown on 29.5 million hectare area of the country. A random survey was conducted in various districts of Allahabad during the harvesting season of year 2016. It was found that on an average 40.8 per cent of the area under wheat crop was combine harvested. Straw combine was used over only 30 per cent of the combine harvested area (Manpur, 2016). A flash survey was conducted by the author at Kissan Mela, Shiats (2016), in which views of about 100 farmers, regarding the straw quality produced by straw combine in comparison to haramba thresher, were collected. 78 per cent of the farmers stated that the straw harvested by straw combine is of inferior quality than the straw produced by haramba thresher due to high dust content.

In the past traditional methods (manual or animal drawn reapers) were used for harvesting of wheat straw, however, with the increasing trend of mechanization, combine harvester are being used to harvest the wheat crop. The combine harvester collect grains and throw wheat straw on the rear side of the combine in the field. Most of this wheat straw is normally burnt in the field while rest is used to feed the animals. Burning of wheat straw results losses of 80 per cent nitrogen (N), 25 per cent phosphorus (P), 21 per cent potassium (K) and 4 per cent to 60 per cent sulphur (S).

Combine harvesters as mechanical harvesting have gained popularity over the years due to shortage of labour during harvesting, uncertain weather conditions and less turnaround time between harvesting and planting of next crop. But combine harvesters leave the wheat straw in field as such. It reduces the availability of straw to livestock, which is already in short supply by more than 40 per cent. Now-a-days, straw combine are used by farmers of Allahabad to collect the wheat straw after harvesting the wheat with combine harvesters.

Straw combine:

Straw reaper or combine is a tractor power take off (PTO) driven threshing machine. It cuts, threshes, cleans and collects the straw in a single operation. The wheat stalks left after combine harvester are cut by an oscillating blades while revolving reel pushes them back toward and auger. Straw combine system designed to provide superior separating performance double blower system operating in the rear of the machine rushes the straw to the trolley and at same time also separates the dust particles fully belt operated machine coming with adjustable cutting height.

Manual harvesting:

Harvesting is one of the major field operations for food grain crops and consumes as much as 20-30 per cent of manual labour requirement. Harvesting is actually a small part of the whole process of taking wheat from the field to a usable final product include the post-harvest steps of threshing and winnowing. Manual harvesting of field crops is considered a labour intensive operation and takes from cutting to bundle making about 185- 320 man-h/ha.

■ METHODOLOGY

Independent variables:

Speed of operation:

The speed of operation was taken as an independent variable to see its effect of various performance parameters like height of cut, grain losses, field capacity and fuel consumption etc. of the straw combine. The speed of operation was 2.50kmph, 2.00kmph and 1.50kmph.

Moisture contents of straw:

The grain and straw moisture content as obtained from each plot are shown in Table 1. For wheat crop, the moisture content of straw was 8.2 per cent, 8.6 per cent and 9.2 per cent.

Dependent variables:

Effective or actual field capacity:

The effective or actual field capacity of a farm machine or implement is defined as the actual area covered by the machine or implement per hour when the machine or implement is actual working in the field which is given as follows:

$$\text{Effective or actural field capacity} = \frac{\text{Area covered (ha)}}{\text{Time taken (h)}}$$

Field efficiency:

The field efficiency is defined as the ratio of effective or actual field capacity to the theoretical field capacity. It takes into account the time losses

encountered in the field due to various reasons. The field efficiency was calculated as below :

$$\text{Field efficiency (\%)} = \frac{\text{Effective or actual field capacity}}{\text{Theoretical field capacity}} \text{x100}$$

Straw recovery:

It refers to the recovery of straw from the leftover wheat straw in field by combine harvester. To determine straw recovery 3 or 4 plots of 1m^2 were marked in the field. (This excludes the area containing loose straw) and harvested the straw by straw combine and calculated the average weight. In order to include the loose straw mark 3 or 4 plots of 5 m run of the straw combine. Collected the loose straw and find the average weight per meter run of the machine. Multiply this by the total run of the machine in the given area to determine the total loose straw. In order to calculate the loose straw area per divide the total loose straw by the given area. Add straw recovered (excluding loose straw) and the loose straw/m to determine the total straw available before harvesting.

$$\text{Straw recovery (\%)} = \frac{\text{Straw recovery (g/m}^2\text{)}}{\text{Weight of straw (stubble + loose) (m}^2\text{)}} \text{x100}$$

Grain recovery :

It refers to the recovery of grain from the leftover wheat straw in field by combine harvester. To determine grain recovery 3 or 4 plots of 1 were marked in the field and collected the unthreshed grain (threshed grain lying onto ground not included) and earheads present in straw and weighed it. After operation of straw combine again collected the grains and earheads at 3 places were marking 1 area. Calculated the percentage of grain recovered of straw combine.

$$\text{Grain recovery (\%)} = \frac{\text{Grain recovery (g)}}{\text{Grain (unthreshed) before harvesting the straw (g)}} \text{x100}$$

Overlap percentage :

Run the straw combine for at least 3 consecutive runs at the straw field. Measured the width of 3 consecutive runs and calculated the average width of the straw combine and theoretical width of the straw combine. The difference between theoretical width and average effective width calculated the overlap percentage of straw combine.

$$\text{Overlap (\%)} = \frac{\text{Theoretical width (m) - Average effective width (m)}}{\text{Theoretical width (m)}} \text{x100}$$

■ RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Crop characteristics of wheat:

The straw of wheat crop on which experiment was conducted was Manpur and all the data were taken. The crop characteristics in that wheat field from where the study was conducted are presented in Table 1.

Effective/ actual field capacity:

It is evident from the Fig. 1 that maximum effective field capacity of 0.52 ha/h, 0.50 ha/h and 0.48 ha/h was obtained from the different moisture content 8.2 per cent, 8.6 per cent, 92 per cent at forward speed 2.50kmph.

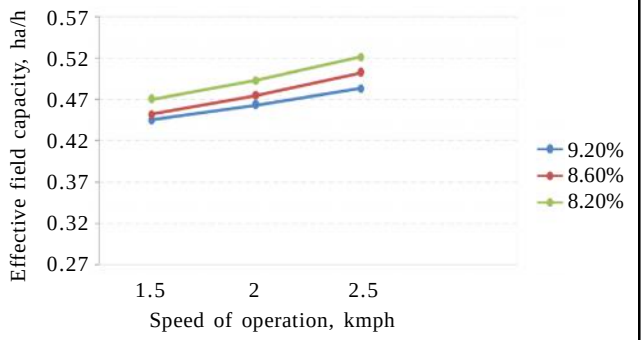

Fig. 1 : Effective/ actual field capacity

Table 1 : Crop characteristics of wheat

Observation	Crop variety	Area of plot (m^2)	Crop density (p/m^2)	Height of plants (cm)	Straw grain ratio	Moisture content (%)	
						Grain	Straw
A	PBW-43	3782	320	27	120:1	10.00	8.2
B	PBW-43	3938	310	28	125:1	10.05	8.6
C	PBW-43	4095	297	26	115:1	10.10	9.2
Average			309	27		10.05	8.67

While the minimum effective field capacity of 0.47 ha/h, 0.45 ha/h and 0.44 ha/h was obtained from same moisture content at 1.50kmph. The effective field capacity increased with the forward speed of travelling.

Field efficiency:

It is evident from the Fig. 2 that maximum field efficiency of 98.22 per cent, 95.76 per cent and 94.15 per cent was obtained from the different moisture content 8.2 per cent, 8.6 per cent, 9.2 per cent at forward speed 2.50kmph. While the minimum field efficiency of 91.06 per cent, 89.93 per cent and 89.14 per cent was obtained from same moisture content at 1.50kmph. The field efficiency increased with the forward speed of travelling.

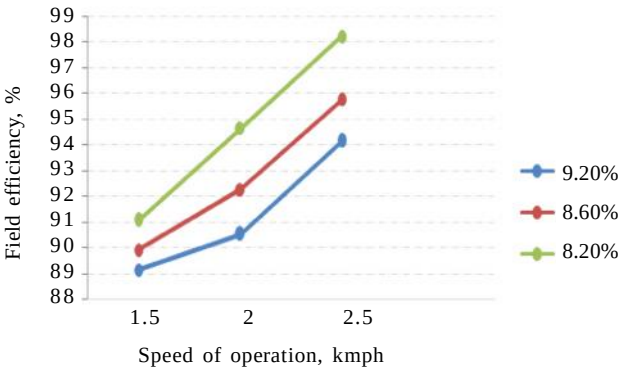

Fig. 2 : Field efficiency

Straw recovery percentage:

The straw recoveries at different operating speeds of harvester are shown in the Fig. 3. Straw recoveries are varied between to 89.85 per cent to 85.74 per cent. The minimum grain recover was recorded at minimum operating speed of 1.50 kmph and 2.00 kmph. However, the maximum grain recovery was recorded at highest operating speed of 2.50kmph. The straw recovery increased with the forward speed of travelling.

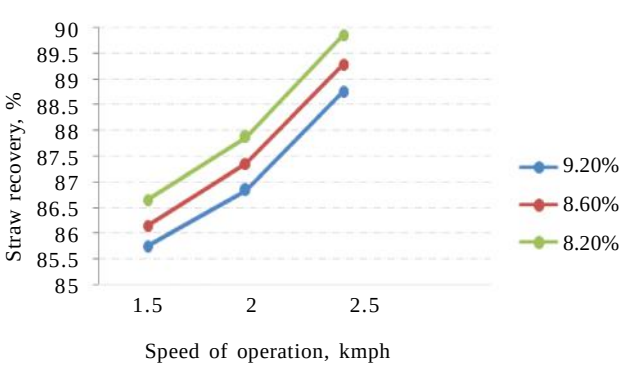

Fig. 3 : Straw recovery percentage

Grain recovery percentage:

The grain recovery at different operating speeds of harvester is shown in the Fig. 4. Grain recovery varied between to 10.13 per cent to 9.38 per cent. The minimum grain recover was recorded at minimum operating speed of 1.50 kmph and 2.00kmph. However, the maximum grain recovery was recorded at highest operating speed of 2.50kmph. The grain recovery increased with the forward speed of travelling.

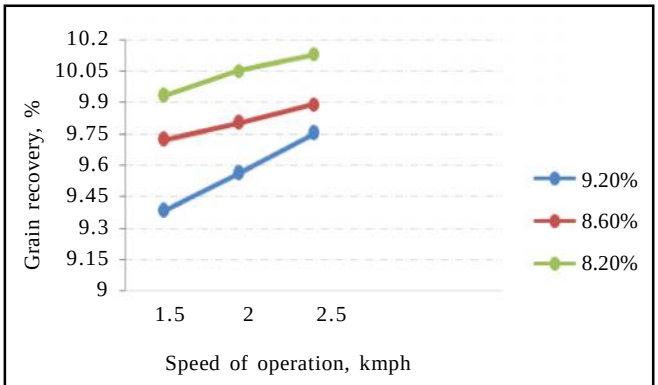

Fig. 4 : Grain recovery percentage

Overlap percentage:

The overlap at different operating speeds of straw combine is shown in the Fig. 5 Overlaps per cent varied between to 4.76 per cent to 3.76 per cent. The minimum overlap was recorded at minimum operating speed of 1.50 kmph and 2.00 kmph. However, the maximum overlap percentage was recorded at highest operating

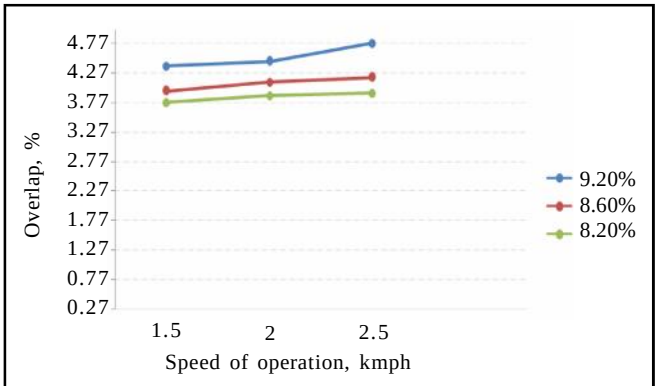

Fig. 5 : Overlap percentage

speed of 2.50kmph. The overlap percentage increased with the forward speed of travelling.

Fuel consumption:

The fuel consumption at different operating speeds of straw combine is presented in the Fig.6 Fuel consumption varied from 4.00 l/h to 5.15 l/h. The minimum fuel consumption was recorded at operating speed of 2.50 kmph and 2.00kmph. However, the maximum fuel consumption was recorded highest at operating speed of 1.50kmph. The fuel consumption decreased with the forward speed of travelling. Similar work related to the present investigation was also carried out by Bhardwaj and Mahal (2014); Dange *et al.* (2013); Dhimate *et al.* (2015) and Ghaly *et al*. (2013).

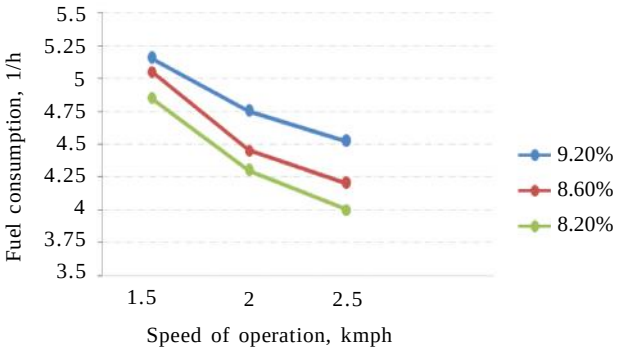

Fig. 6 : Fuel consumption

Conclusion:

Harvesting of wheat straw by straw combine:

Three replications were taken and values of dependent variables were computed to indicate the performance evaluation of harvesting method through straw combine were carried out for harvesting of wheat straw w.r.t. effective field capacity, field efficiency, fuel consumption, straw recovery percentage and grain recovery percentage. The observations were taken at three speeds of 2.50kmph, 2.00kmph and 1.50kmph at the three replications for crop moisture content of 8.2 per cent, 8.6 per cent and 9.2 per cent, respectively. The overall performance of straw combine was quite satisfactory.

Effect of variables on performance:

– The straw recovery percentage of straw combine between the speed of 2.50 kmph and 1.50kmph were found to be 89.85 per cent and 85.74 per cent at different crop moisture content.

– The grain recovery percentage of straw combine between the speed of 2.50 kmph and 1.50kmph was found to be 10.13 per cent and 9.38 per cent at different crop moisture content.

– The overlap percentage of straw combine between the speed of 2.50 kmph and 1.50kmph was found to be 4.115 per cent and 3.885 per cent at different crop moisture content.

– The field capacity of straw combine between the speeds of 2.50 kmph and 1.50 kmph was found to be 0.52 and 0.45 ha/h. at different crop moisture content.

– The field efficiency of the straw combine between the speeds of 2.50 kmph and 1.50 kmph was found to be 98.22 per cent and 89.14 per cent at different crop moisture content.

– The fuel consumption of straw combine between the speed of 2.50 kmph and 1.50 kmph was found to be 4.00 l/h and 5.15 l/h at different crop moisture content.

The operating speed for straw combine could be varied from 2.50 kmph, 2.00 kmph and 1.50 kmph and crop moisture content varied from 8.2 per cent, 8.6 per cent and 9.2 per cent. However, the best performance of straw combine was found at speed of 2.50 and crop moisture content of 8.2 per cent.

Overall result of performance evaluation of straw combine is better in terms of straw recovery, grain recovery, time of operation and straw combine is better in terms of cost of operation than manual harvesting for wheat straw.

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