Agricultural Mechanization

Modification and evaluation of SG-2000 multi- crop thresher

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Abstract
Thresher is a machine that helps to separate grains from the harvested crop and provide clean grain without much loss and damage. During threshing grain loss in terms of broken grain, unthreshed grain blown grain, spilled grain etc, should be minimal. Therefore, this study is aimed to modify SG-2000 multi-crop thresher with cleaning mechanism. The thresher was evaluated for its performance in terms of threshing efficiency, cleaning efficiency, visible damage and sieve overflow. Results of the study indicated that the thresher work best with drum speed (900, 1000, 600, 400 rpm), feed rate (8, 10, 14, 15 kg/min) at which the thresher capacity was measured to be (130, 126, 194, 636, 665 kg/hr) for wheat, barely, teff, sorghum and maize respectively. The cleaning efficiency is not sufficient, so there must be supplementary manual blowing.

Introduction
Indigenous threshing technology practised by farmers in Ethiopia is mainly done by the use of animal treading and beating by stick on level ground, which is time and labour consuming and involve drudgery. After harvesting, the crop is transported to the threshing site where it is left stacked till the threshing season, which is usually November, December and January. The threshing floor is usually made by smearing the ground with cow dung and left to dry for some time otherwise the ground after being levelled will be watered and trampled by foot according to the type of crop, which is going to be threshed. During threshing, the loose crop is laid on the floor and several oxen tread on it. The oxen go round on the threshing floor over the crop for some time and they are taken out to turn the unthreshed crop from the bottom up and down to spread it laying the heads up for efficient treading. The threshed crop is subjected to winnowing by natural wind flow.
Threshing with animals need both skill and energy to keep the animal moving around the threshing floor. The threshing season normally lasts 2-3 months, but with the increased in production and shortage of labour power threshing may not be completed with this time. The delay on completion of the threshing operation within safe time will expose the crop to unfavourable weather and will result in quality deterioration, insect and rodent attack. Therefore, this method of threshing method gives low quality grain and high percentage of loss.
Past thresher development experience in Ethiopia indicate that the Chilalo Agricultural development unit (CADU) tested different threshers. Test result of the animal drawn trade multi-type thresher revealed that the thresher was found inefficient because of its low peripheral velocity (17.5m/s) and the difficulty of keeping a uniform speed. It is difficult to move the thresher from place to place since it is stationary model. Lastly

CADU designed a wooden type cleaning thresher. Later on it was found that the change in dimension of wooden part made interchangeability difficult and was costly.
The Arusi Rural Development project (ARDP) developed 8 hp diesel engine driven and non-cleaning type wheat barely thresher. Except its seed breakage problem this thresher was found to be good. The Institute of Agricultural Research (IAR) took over it and improved the concave assembly and reduces the breakage to 21 % for wheat and 4.5% for barely. This machine is suitable only for wheat and barely where its limited annual use hours make it expensive (Firew.K, Muluken.T Awotahegn.T, 1994).
The existing method does not encourage high output and often result in low quality products. However, there is a growing need of providing the farmer with an appropriate thresher. In the past years, some stakeholders and research centres tried to develop mechanical threshers to minimize these shortcomings. Among different attempts, Sasakawa Global 2000 has recently developed multi crop thresher with its model name SG-2000 multi crop thresher.

Materials and Methods

SG-2000 multi-crop thresher

SG-2000 multi-crop thresher was primarily designed for threshing pulse crops without winnowing the chaff from the grain (Figure 1). The thresher is driven by 5 hp diesel engine and operates on the principle of axial flow movement of material. Threshing is done by the impact of a cylindrical drum equipped with a number of spikes mounted on its periphery and concave. The upper cover has inclined louvers, which move the threshing material axially between the threshing drum and the cover.

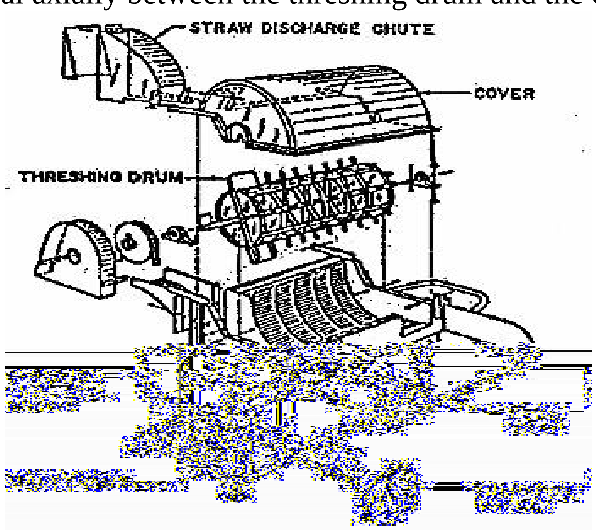

Figure 1: SG-2000 multi-crop thresher

The material is loaded on the feeding table and feed into the opening between the cylinder and lower concave. The crop is brushed in to fine straw, which results in good animal feed. The majority of the grain is threshed during the initial impact, but further threshing is performed while the material moves axially to the straw outlet. Finally the straw is discharged through the outlet by the straw paddle. The maximum threshing capacity of the machine is 3.9q/h. It requires 14 man hours to clean 100kg of grain from the chaff and straw.

During testing of the thresher, the following demerits and merits were observed respectively.

Demerits

- The engine is exposed to fire hazardous due to overheating.
- Frequent clogging of engine air cleaner is observed due to chaff and straw.
- Inconvenient construction of concave hole for different crops, hence unthreshed ear and straw pass through it.
- Construction of grain and straw outlet in one side (direction) caused mix-up of grain mixture and straw.
- Feeding is uncomfortable since the thresher height is short.
- Extra length of feeding table at the right side with the edge of the inlet hole caused breakage of ears.
- Without cleaning mechanism, it is tedious, time and labours consuming to separate grain from chuff.

Merits

- The thresher is simple for production, transportation, operation and easy for maintenance and repair.
- The cost of this thresher is cheap compared to other types of threshers.
- Farmers can operate the machine within a short period of training (Test report 1992 E.C. Combolcha).

Taking the above demerits in to consideration, the following modifications were done during manufacturing.

- ❖ Suitable guard is installed to protect the engine for fire hazard.
- ❖ While constructing the concave, the space between the round bars is made to be 5mm, this decreases unthrushed ear and straw passing through the concave opening.
- ❖ Clean grain is discharged to the side of the thresher using discharge auger, while the straw and chaff blows out of the thresher.
- ❖ Height of the feeding table is increased by 15 cm to make comfortable for the operator during feeding.
- ❖ Length of the feeding table is made to fit equally to inlet hole edge at the right side.

The total power required for driving the thresher is 7.1 KW. Therefore, the total power required for main component and transmission loss is calculated to be 8 KW. Based on this ADN-43 diesel engine is recommended (Bosoi.E.S, O.V.Verniaev, 1991).
A centrifugal blower consists of four fan blades mounted on a shaft supported by ball bearing and housing which is used to deliver the specified volume of air to separate light particle mounted underneath the concave. The air inlet of the centrifugal blower casing is located at 90 degrees to the outlet (Figure 2). Air enters the centre of the rotating blower impeller parallel to the impeller shaft and turned through 90 degrees by

the impeller before being discharged. Too much draught blows the grain out of the block; while too little fails to keep the screen clear (Figure 3).

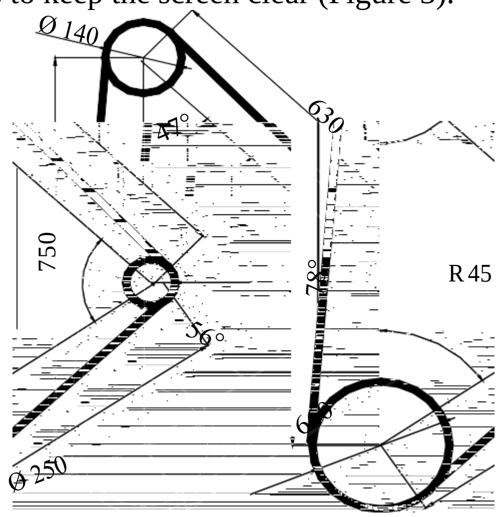

Figure 2: Power transmission

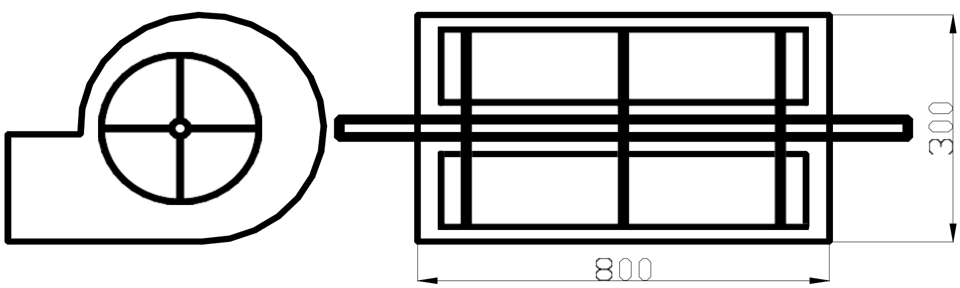

Figure 3: Blower assembly

The sieve helps for further cleaning of the grain by allowing heavier straw to overflow. When solid particles are dropped over a screen, the particles smaller than the size of the screen-opening pass through it, and large particles greater than the size of the screen opening retained over the screen (Figure 4).

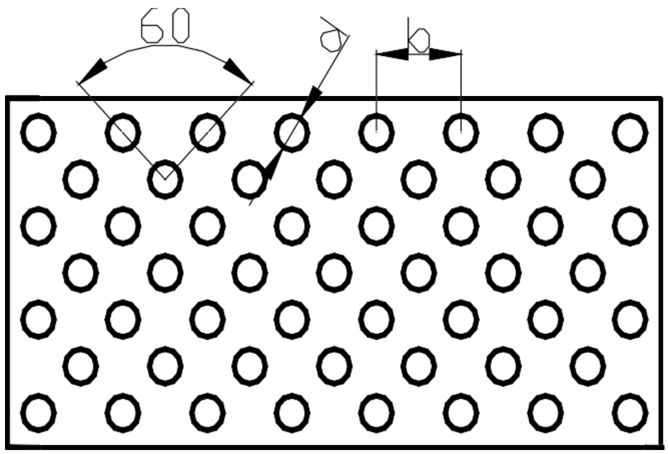

Figure 4: Screen design

An eccentric unit agitates the screen suspended on the side plate because of vibrating motion allowing materials to be agitated and separated during transit over the screen. The vibration of the screen helps in providing passage to particles through the opening of the screen and it restricts clogging of the screen by particles that become trapped in the opening (Shahy K.M and Singh K.K, 2003). Grain pan and discharge auger is located under the screen which is used to collect the grain and discharge it to the side of the thresher. The modified SG-2000 thresher is indicated on Figure 5.

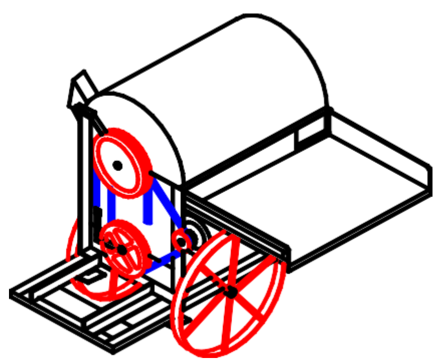

Figure 5: Modified SG-2000 thresher

Testing method

A combination of feed rate (F) at three level and cylinder speed (S) at three levels were selected according to the type of crop to be threshed. Each test was repeated three times by sampling nine sets of data. Four types of crops viz. wheat, barely, teff, sorghum, and maize were selected for the experiment. The bundle were feed in to threshing unites and threshed materials was collected at the outlet which was cleaned and weighed.

The portion of the material that contain unthreshed grain was separated from straw and weighed after hand threshing and cleaning in order to determine the threshing efficiency in terms of percentage of the total grain recovered. Determination of optimal input capacity and selection of the feed rate to improve the efficiency are within the specified limits. This was achieved by drawing a curve for efficiencies versus feed rates. Instruments used for the tests include tachometer, sensitive balance, spring balance and oven dry.

Results and Discussion

Test result on wheat

During testing of multi-crop thresher on wheat, three levels of feed rate (10, 9, 8 kg/min) and three level of speed (800, 900, 1000 rpm) were taken for the study. The best combination is selected by drawing three graphs, but the graph for threshing efficiency is omitted because the difference between the treatments is insignificant. The test result shows that cleaning efficiency increases as the feed rate and speed increases up to a certain limit and then finally it decrease. The visible grain damage increases as speed increases and feed rate decreases, and sieve overflow also increases, as speed and feed rate increases because the material handled by the sieve is more than the sieve capacity (Table 1 and Figures 6, 7 and 8).

Table 1: Performance of thresher on threshing of Wheat

No	Treatment	Blown(%)	Cleaningefficiency(%)	Visibledamege(%)	Normal grain(%)	Sieveloss(%)
1	F1,S1,T1	0.24	91.5	0.1	99.9	18.2
2	F1,S2,T2	0.32	91.9	0.21	99.6	22.8
3	F1,S3,T3	0.23	92	0.16	99.8	24
4	F2,S1,T4	0.46	93.5	0.13	99.8	19.7
5	F2,S2,T5	0.52	85.6	0.26	99.7	12
6	F2,S3,T6	0.63	85.7	0.42	99.5	14.9
7	F3,S1,T7	0.72	85.6	0.16	99.6	9.2
8	F3,S2,T8	0.74	83.3	0.35	99.64	8
9	F3,S3,T9	0.69	85	0.42	99.6	11.8

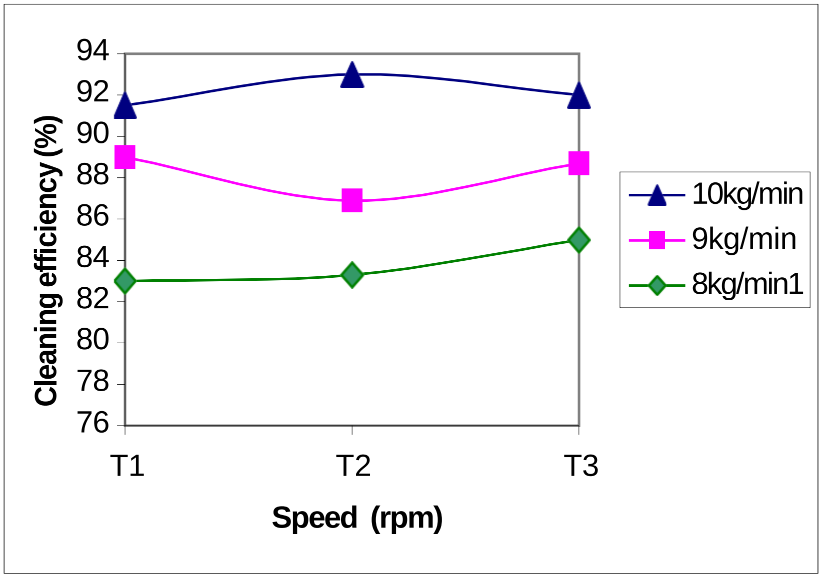

Figure 6: Effect of speed and feed rate on cleaning efficiency of wheat

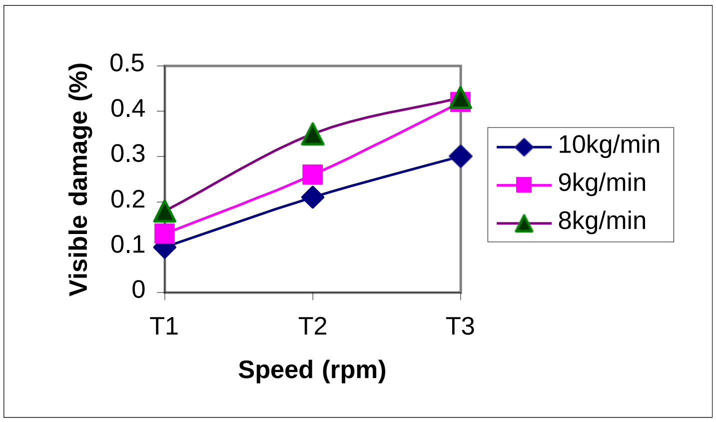

Figure 7: Effect of speed and feed rate on visible damage of wheat

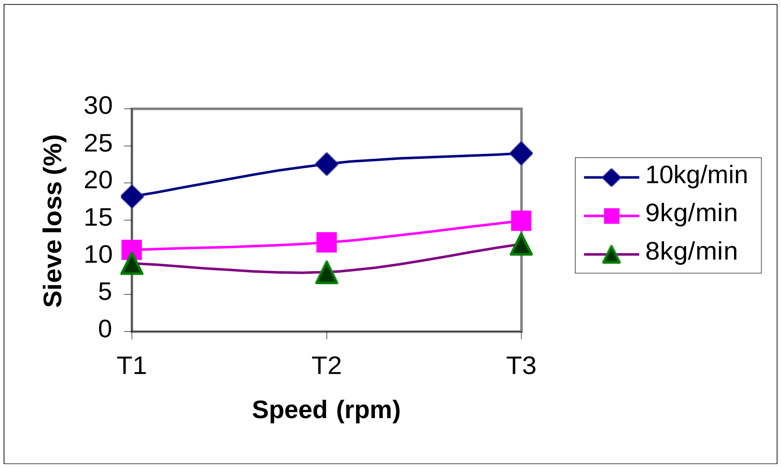

Figure 8: Effect of speed and feed rate on sieve loss of wheat

Test result on barely

During testing of multi-crop thresher on barely, three levels of feed rate (10, 9, 8 kg/min) and three level of speed (800, 900, 1000 rpm) were taken for the study. The best combination is selected by drawing three graphs, but the graph for visible grain damage is omitted because the difference between the treatments is insignificant. The test result shows that threshing efficiency increases as the speed and feed rate increases. This is because at a higher speed the energy imparted to the ear head and grain increases causing higher threshing efficiency. Cleaning efficiency increases as feed rate and drum speed increase up to certain limit and decrease again, and the sieve overflow increase as the speed and feed rate increase (Table 2 and Figures 9, 10 and 11).

Table 2. Performance of thresher on threshing of barely.

No	Treat ment	Threshing efficiency (%)	Cleaning efficiency(%)	Sieve overflow(%)
1	F1,S1,T1	99.4	81	2.5
2	F1,S2,T2	98.6	85.8	6.5
3	F1,S3,T3	98.5	82.5	9.1
4	F2,S1,T4	98.6	75	1.6
5	F2,S2,T5	99.3	77.5	4.6
6	F2,S3,T6	99.5	80.9	7.6
7	F3,S1,T7	98.6	74.5	1.6
8	F3,S2,T8	99.2	80.5	3.2
9	F3,S3,T9	98.3	75.6	13

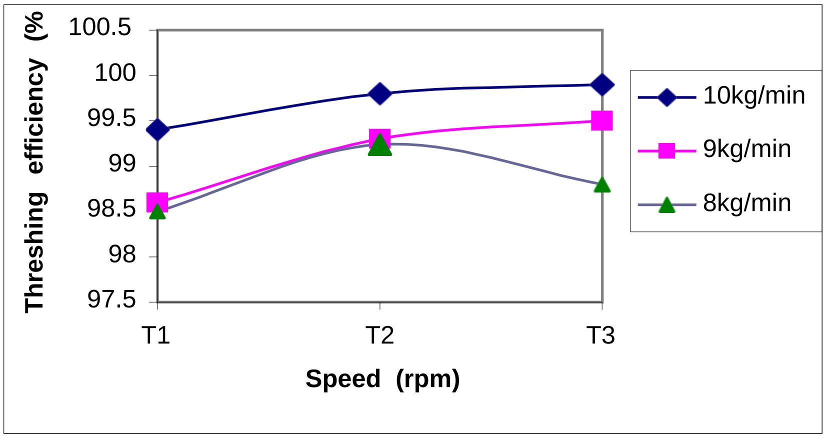

Figure 9: Effect of speed and feed rate on threshing efficiency of barley

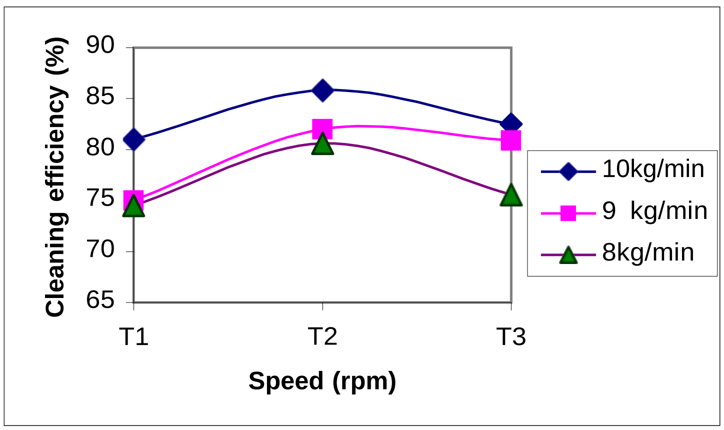

Figure 10: Effect of speed and feed rate on cleaning efficiency of barley

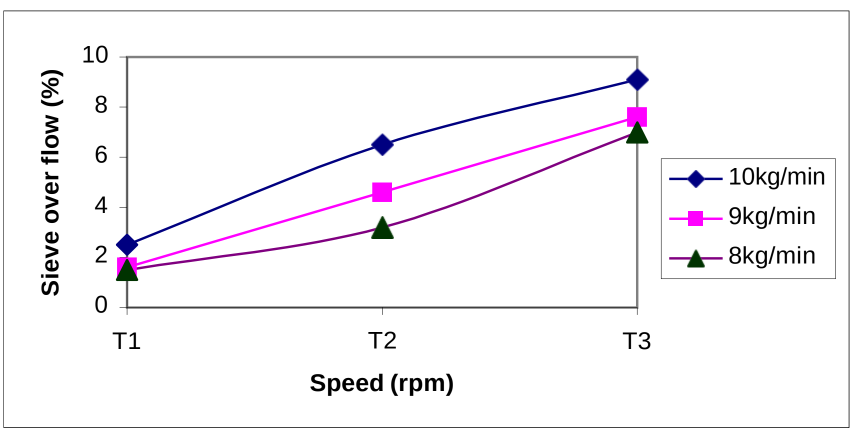

Figure 11: Effect of speed and feed rate on sieve overflow of barley

Test result on teff

During testing of multi-crop thresher on *Teff*, three levels of feed rate (8, 10, 12 kg/min) and three level of speed (800, 900, 1000 rpm) were taken for the study. The best combination is selected by drawing two graphs, but threshing efficiency and visible grain damage are omitted, because the difference between treatments is insignificant. Cleaning efficiency increases as the speed increases and feed rate decreases. Also sieve over flow increases as speed and feed rate increases, because the sieve begin bulged. Since cleaning efficiency is not sufficient, manual blowing by natural wind is essential (Table 3 and Figures 12 and 13).

Table 3: Performance of thresher on threshing of *Teff*

No	Treatment1	cleaning efficiency %	Sieve loss
1	F1,S1, (T1)	85	34
2	F1,S2,(T2)	89.9	23.6
3	F1,S3, (T3)	91.5	51.9
4	F2,S1, (T4)	87.7	55
5	F2,S2, (T5)	92.4	41
6	F2,S3,(T6)	95	39.9
7	F3,S1, (T7)	91.9	62
8	F3,S2, (T8)	92	57
9	F3,S3, (T9)	94.6	63

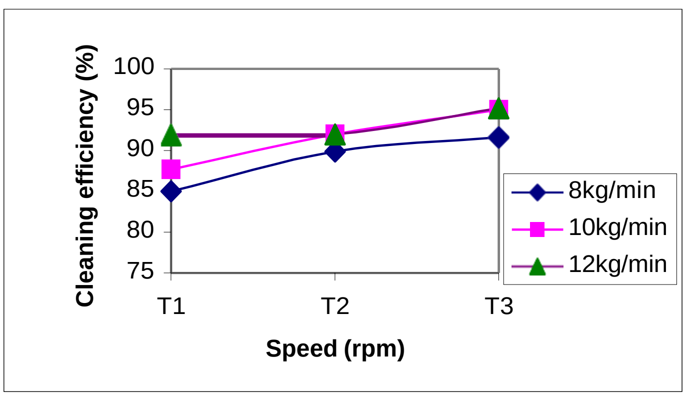

Figure 12: Effect of speed and feed rate on cleaning efficiency of *Teff*

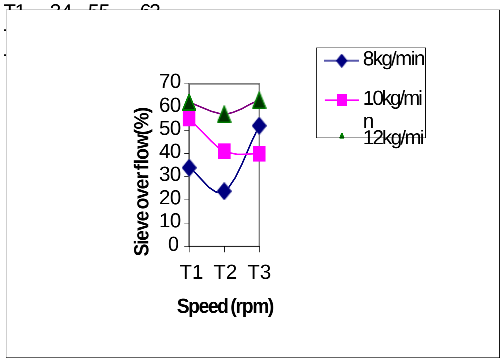

Figure 13: Effect of speed and feed rate on sieve overflow of *Teff*

Test result on sorghum

During testing of multi-crop thresher on sorghum, three levels of feed rate (10, 12 and 14 kg/min) and three level of speed (600, 700 and 800 rpm) were taken for the study. The best combination is selected by drawing four graphs. The test result shows that threshing efficiency increases with increase cylinder speed for all feed rate, where cleaning efficiency increases as feed rate decreases and speed increases. Visible grain damage increases as the speed increases and feed rate decreases where as sieve overflow increases as speed and feed rate increases (Table 4 and Figures 14, 15, 16 and 17).

Table 4: Performance of thresher on threshing of sorghum

No	Treatment	Threshing efficiency(%	Cleaning efficiency(%	Visible damage(%)	Sieve loss(%)	Blown(%)
1	F1,S1,T1	97	97	0.4	12	2
2	F1,S2,T2	98	97.8	0.84	20.9	1.7
3	F1,S3,T3	98	96.6	2.42	20.9	2.1
4	F2,S1,T4	97.7	98.8	0.43	11.8	2.4
5	F2,S2,T5	98.9	98.9	0.71	16	2.3
6	F2,S3,T6	99	98.8	1.97	15.67	2.2
7	F3,S1,T7	98	94	0	14.2	0.4
8	F3,S2,T8	99	97.9	0.26	15	1.6

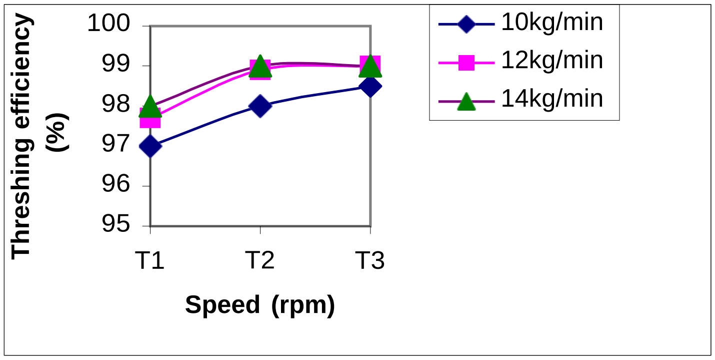

Figure 14: Effect of speed and feed rate on threshing efficiency of sorghum

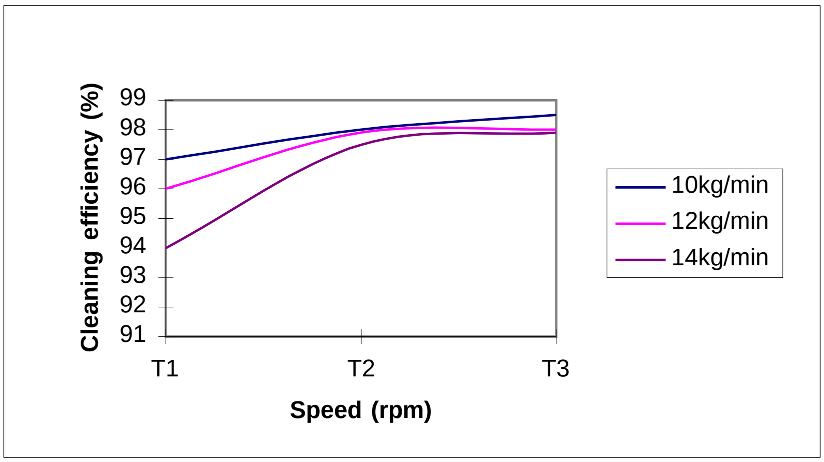

Figure 15: Effect of speed and feed rate on cleaning efficiency of sorghum

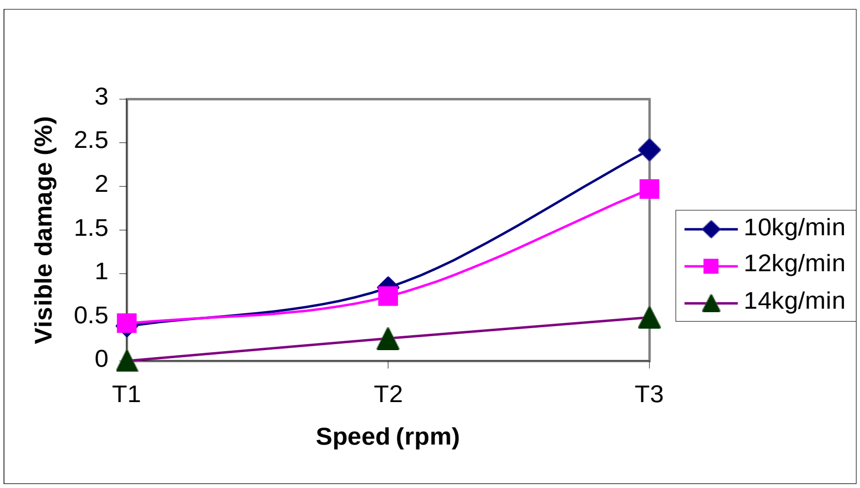

Figure 16: Effect of speed and feed rate on visible damage of sorghum

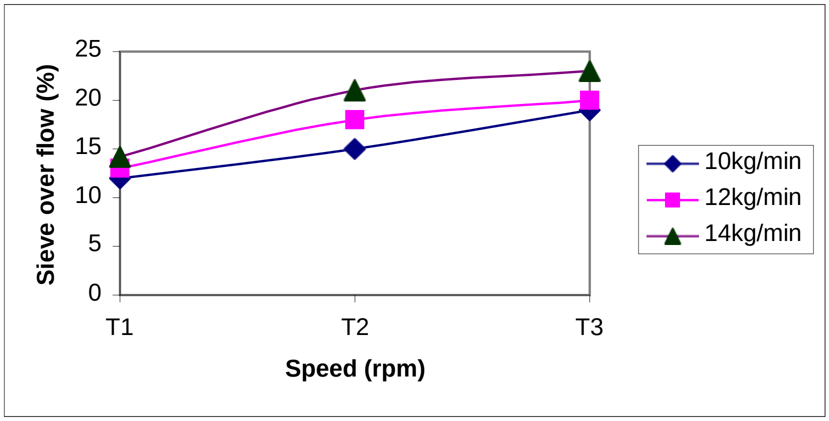

Figure 17: Effect of speed and feed rate on sieve overflow of sorghum

Test result on maize

During testing of multi-crop thresher on maize, two levels of feed rate (15 and 20 kg/min) and three level of speed (350, 400 and 450 rpm) were taken. For maize shelling fingers which are used for cutting straw are disassembled in order to avoid grain breakage. The test result shows that shelling efficiency increases with speed and feed rate increases and cleaning efficiency increases with speed increases and feed rate decreases. But visible damage and sieve over flow increases as the speed and feed rate increases (Table 5 and Figures 18, 19, 20 and 21).

Table 5: Performance of thresher on shelling maize

Treatment	Threshing efficiency(%)	Cleaning efficiency(%)	Visible damage(%)	Sieve loss(%)
F1,S1,T1	83	99.9	0.5	7.4
F1,S2,T2	94	99.6	1	10
F1,S3, T3	95.2	100	0.9	12.9
F2,S1, T4	85.9	99.5	1	7.7
F2,S2, T5	86	99.7	1.3	11
F2,S3,T6	93.7	99.8	0.93	12.7

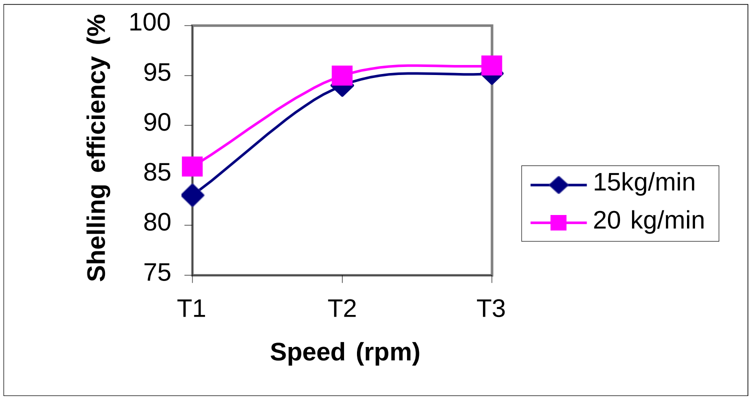

Figure 18: Effect of speed and feed rate on shelling efficiency of maize

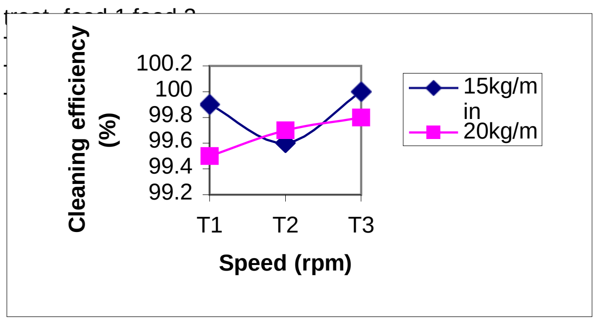

Figure 19: Effect of speed and feed rate on cleaning efficiency of maize

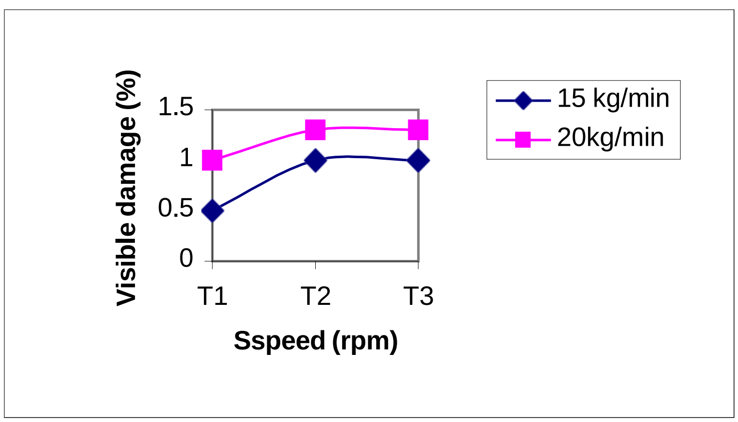

Figure 20: Effect of speed and feed rate on visible damage of maize

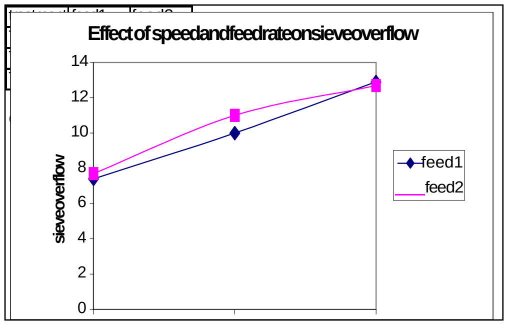

Figure 21: Effect of speed and feed rate on sieve overflow of maize

Conclusion

- The best combination for maximum threshing and cleaning efficiency with minimum visible grain damage and sieve loss are obtained as follows.
- During threshing of wheat the maximum output of 130kg/hr is obtained at a feed rate of 8kg/min and cylinder speed of 900rpm.
- During threshing of barely the maximum output of 120kg/hr is obtained at a feed rate of 8kg/min and cylinder speed of 900rpm.
- During threshing of *Teff* the maximum output of 194kg/hr is obtained at a feed rate of 10kg/min and cylinder speed of 1000rpm.
- During threshing of sorghum the maximum output of 636kg/hr is obtained at a feed rate of 14kg/min and cylinder speed of 600rpm.
- During Shelling of maize the maximum output of 665kg/hr is obtained at a feed rate of 15kg/min and cylinder speed of 400rpm.

Therefore, the machine can save labour and operation time by 50% when compared with conventional method of threshing for the abovementioned crop types.

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