Development and testing of pedal operated seed cleaner

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Abstract

Seed cleaning is one of the most challenging agricultural tasks facing the farmers in the countryside. Farmers still use traditional ways of seed cleaning using equipment such as 'sefed' and 'wonifete' (sieve) so as to blow by wind. These methods are time and energy consuming; besides, there is a great loss of grain and chaff (straw) during the blowing and removing time. To alleviate the drudgery, pedal operated seed cleaner suitable for smallholder farmers has been designed, manufactured and tested. The test result has shown that the machine can clean up teff at the rate of 200 kg hr^{-1} with 97% efficiency. Whereas, by traditional methods, a woman can clean up 10 kg $manhr^{-1}$, which is ten times less than the capacity of the machine. Hence, this pedal operated seed cleaner can play an important role in alleviating drudgery in areas where electric motor and diesel engine is costly or not available.

Key words: Cleaning, efficiency, threshing.

Introduction

Seed cleaning, in agricultural processing operation, generally does mean the removal of dissimilar and undesirable materials such as low quality seeds, infested seeds of different species (weeds that are foreign to the samples) etc, from the desired grains. This activity can be done by screening, blowing and hand picking methods. The conventional method of threshing, which is being practiced by farmers, is mainly done by the use of animal treading and beating by stick on level ground. Grain threshed by these methods usually contain chaff, pieces of straw, sand, soil, animal waste, dust and sometimes insects.

Cleaning seeds is often one of the most tedious and challenging agricultural tasks facing the farmers every year in Ethiopia. Sowing clean seeds is advantageous to reduce cultivation costs and give increased yields. The price received from grains/seeds can often be substantially increased by a relatively insignificant expenditure of cleaning methods. During storing seeds, rubbish and damage seeds can be susceptible to infections. So, only good

quality/viable seeds should occupy the store, but damage or non viable seeds should not be put in the store to prevent the spread of storage pests. Foreign materials get into cereals during transportation, harvesting and handling times. These unwanted materials should be removed from grains and their products for good market values. The quality of flour for bread and macaroni is highly affected by the degree of cleanliness of seeds that go to the product (Hall, 1972). The traditional practices of seed cleaning are by using local equipment such as *sefed, wonifit* (sieve) and *Mankia* (wide basket) to blow the chaff by wind. This classic method of winnowing involves placing seeds in a wide basket and tossing the seeds and chaff into the air. Winnowing by this method is extremely difficult, and the results are not satisfactory. The most vexing part of the process is that wind is always changing in velocity and direction. The method of cleaning is so laborious, time and energy consuming and there is also high loss of grains/seeds during blowing.

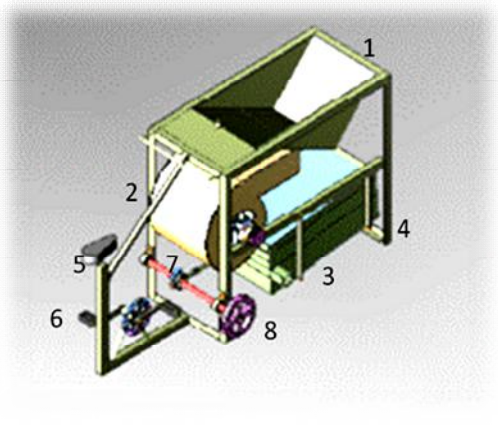
Uhl and Lamp (1966) observe that chaff-like materials were removed from cereals like wheat, rye and soybeans at air velocities of 3.05 m/s which are less than their terminal velocities. Igbeka (1984) has done a test on a cereal cleaner to determine the optimum tilt angle of sieve and found that this angle should be between 4^0 and 5^0 when operating speed is between 300 and 350 r.p.m. Gordn (1986) noted that a person can generate a power of about 0.25 hp by pedalling, which is four times more than by hand cranking. Pedal power enables a person to drive device driven by hand cranking but with less effort and fatigue. Pedal power also enables generation of more power to work at faster rate and even to operate devices requiring much power than that can be delivered by hand cranking. Application of pedal power is possible when the power level required is below a quarter of horsepower (that is below about 200 watts).

To alleviate grain cleaning related problems and drudgery, different kinds of seed cleaning machines were developed by research institutions working in agricultural machinery. One of such machines is a pedal operated seed cleaner developed by Central Institute of Agricultural Engineering based at Bohpal, India. So the aim of this work was to redesign and manufacture this pedal-driven seed cleaner and to evaluate its performance at local conditions.

Material and methods

Pedal-operated seed cleaner

A pedal-operated seed cleaner (Figure 1) is made from angle iron and iron sheet parts. It mainly consist of grain hopper with a slide gate mechanism, sieve box and blower unit. The eccentric mechanism on main shaft is driven by pedal-shaft through sprocket-chain drive and provides reciprocating motion to the cleaning box. The pulley on blower shaft receives the power from main shaft pulley by V-belt. Air draft is created by the blower, which is directed to a free falling grain from the hopper and thus separates the grain from the chaff or light impurities.



1. Hopper
2. Blower
3. Shaking sieve
4. Frame
5. Seat
6. Pedal
7. Eccentric
8. Pulley

Figure 1. Pedal-operated seed cleaner and its parts.

The machine separates impurities from the grain on the basis of size and weight (specific gravity) difference. The feed control mechanism is adjusted so that the grains fall in the form of thin sheet in the cleaning box. The sieves in the cleaning box are selected to suit the grains to be cleaned and are mounted in the cleaning box at their positions. The cleaning box, holding reciprocating sieves, separates grain in grades according to size and removes the heavier and larger impurities from the top sieve.

A mass of grains from the hopper are directed to the upper sieve by gravity and controlled by flow metering device. The lighter foreign materials like chaff, leaves and other impurities are

first blown off by air blast, while the heavier straws, stalk and grains slide over the top sieve and fall off as overflow. Separation of grain with the two sieves is achieved by difference in size in which undersized particles and weed seeds pass through sieve to the bottom delivery chute for collection in the rejected container while larger impurities are retained over the top screen and discharged through the outlet located at the end. The cleaned grain are retained over the bottom screen and delivered outside clea

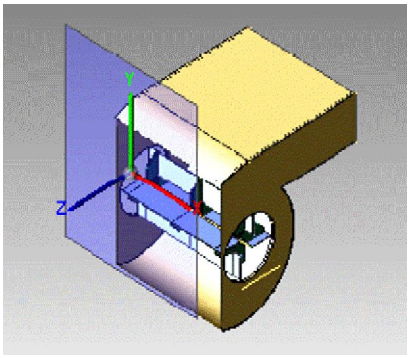


Figure 2. Centrifugal blower.

Screen mechanism

The two screens (Figure 3) were fixed inside screen casing which is suspended by hangers in such a manner that they have horizontal oscillatory and slightly vertical motions. The hanger angle was fixed at 5^0 and both sieves were fixed at 15^0. Since the stroke length of the screen affects the separation of efficiency, it is made to be adjusted by changing the eccentric size, according the crop type. The material for test, which is left, was spread uniformly over the full width of the screen surface and the thickness of the bed was kept to be not more than four times the size of the screen aperture (Sahay and Singh, 1994).

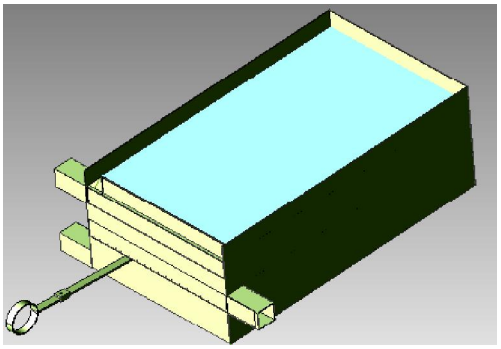


Figure 3. Sieve box.

Machine testing

Two women, an average weight of 60 kg, are randomly selected to perform the experiment. One woman is to clean seed using traditional methods, *Sefed* and *wonifit*, and another woman is to clean seed by pedal operated seed cleaner. The size of the screen opening was selected

depending upon the size and shape of the grain to be handled. The teff seed used for the experiment was bought from the market. The cleaning mechanism was first adjusted to the type of seed *(teff)* and tested at three different grain flow rates, 84, 118, and 209 kg hr^{-1}.

For each test run , 5 kg of *teff* was added to the hopper using one variety of crop and three feeding rates with three replications using 60 RPM pedalling speed. During test period three samples of cleaned grain, chaff and dust have been taken at their respective outlets. These samples were further cleaned by hand, and weighed by sensitive balance. During working on the machine, two persons were required: one to operate the machine and another to load and unload the grain.

The machine was tested for its ability to separate whole grain, chaff, stalks and tiny stones. There were four collection points for the test materials, namely:

1. Air passage away from the machine for light chaff, glumes and stalks.
2. Sieve end near to the fan, for heavy materials (over tailings).
3. Container for undersize impurities.
4. Container for whole clean grain.

Cleaning capacity (CC) refers to the quantity of seeds cleaned per unit time. CC was determined by:

$$CC = \frac{W}{T} \times 60$$

Where, CC = Cleaning capacity (kg/hr), W = Clean seed at clean seed outlet (kg), T = Cleaning time (min).

Cleaning Efficiency (η) -The cleaning efficiency of the grain cleaner was determined by:

$$\eta = \frac{(D_{bc} - F_{ac})}{D_{bc}} \times 100$$

Where, η = Cleaning efficiency (%), D_{bc} = The mass of grain and impurities in the sample before cleaning (kg), F_{ac} = The mass of foreign matter left in the sample after cleaning (kg)

The test flow rates, 84,118 and 209 kg/hr, were obtained by adjusting a slide-gate mechanism. The grain and impurities collected from the four containers are separated manually and weighed, then for each feed rate, cleaning capacity and cleaning efficiency were calculated.

Results and discussion

Table 1 shows the result of the grain cleaner tested at three different grain flows. The flow rate 84,118 and 209 kg/hr were obtained by adjusting a slide-gate mechanism. The grain and impurities collected from the four containers were separated manually and weighed, then for each feed rate, cleaning capacity and cleaning efficiency were calculated.

Table 2 shows the performance of manual cleaning using traditional seed cleaning procedures. From the *test* result, it can be seen that the machine can clean *teff* in the ranges of 80-190 kg/hr with an efficiency of 80-97%, respectively. On the other hand, by traditional method, a woman can clean 9-10 kg/man hr which are ten times less than the capacity that can be achieved by using the cleaning machine.

The tables also show that the cleaning capacity of the machine increases from 79.67 to 189 kg/hr as feed rate increased from 84 to 210 kg/hr, respectively. But, the cleaning efficiency barely reduced from 97.46 to 96.97% which is very small change to be any concern at all. Grain loss figures are also more optimal at higher feed, high capacity ranges than at reduced rate.

Table 1. Test result of winnowing by machine.

Test	Hopper outlet (mm)	Time taken (min)	Quantity of seed (kg)	Feed rate (Kg/h)	Samples from different out let			Cleaning efficiency (%)	Cleaning capacity (Kg/h)	Grain loss (%)
					Outlet	Clean seed	Impurity			
T1	2.0 mm	3:57	5	84.03	Chaff	75.56	57.6	97.46	79.67	3.42
					Grain	4706.4	18.6			
					Dust	-	3.0			
					Blown	91.5	47.4			
T2	2.5	2:54	5	118.11	Chaff	24.6	60.9	97.02	110.79	2.33
					Grain	4690.3	28.9			
					Dust	-	2.7			
					Blown	87.6	54.6			
T3,	3.0mm	1:43	5	209.79	Chaff	32.6	69.2	96.95	189.0	2.14
					Grain	4505.6	30.9			
					Dust	-	6.1			
					Blown	66.3	38.5			

Table 2. Test result of manual winnowing.

No	Quantity of seed (kg)	Number of persons	Time taken (min)	Total Time (min)	Samples		Cleaning efficiency (%)	Winnowing capacity (Kg/man h)	Grain loss (%)
					Clean seed (kg)	Impurity (kg)			
1	6	2	18:00	0:36:00	5.415	0.190	100	9.28	---
2	6	2	15:28	0:30:56	5.264	0.235	100	10.21	----

Conclusion

From this experiment it can be concluded that cleaning seed at household level is one of the demanding operations in terms of human labor requirement and this labor need can be reduced by 10 folds using this simple manually operated cleaning device, pedal-operated cleaner. Besides, since women are always the main actors highly involved in grain cleaning operation, besides family responsibility and other agricultural tasks, the pedal operated seed cleaner can play an important role in alleviating their seed cleaning related problems and drudgery in areas where electric motor and diesel engine are costly or not available.

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