International Journal of Mechanical and Thermal Engineering

E-ISSN: 2707-8051
P-ISSN: 2707-8043
IJMTE 2023; 4(2): 30-34
Received: 03-06-2023
Accepted: 08-07-2023

Jemal Nur
Oromia Agricultural Research Institute, Fedis Agricultural Research Centre, Agricultural Engineering Research Process P.O. Box. 904, Harar, Ethiopia

Corresponding Author:
Jemal Nur
Oromia Agricultural Research Institute, Fedis Agricultural Research Centre, Agricultural Engineering Research Process P.O. Box. 904, Harar, Ethiopia

Adoption and evaluation of engine driven groundnut stripping machine for small holder

Jemal Nur

Abstract
Groundnut stripping is necessary process subsequent harvesting because of pods are attached to most of low acreage groundnut growers. Manually groundnut pod stripping is time consuming and drudgery on farmers. The aim of this study was adoption, evaluation and fabrication easily affordable groundnut stripping machine. The machine operated by diesel engine capacity of 3.75 KW motor. The performance evaluation of machine was conducted on two-moisture content groundnut vine and three engine operating speed with three replication. Maximum threshing or stripping capacity of machine recorded as 501 kg per hour. The maximum and minimum stripping efficiencies of 98.2% to 94.7% produced by wet groundnut vine (60% moisture content) or stripping immediately after harvest with drum speed of 400 rpm and dry (17.5% moisture content) stripping with 600 rpm operating speed respectively. Both Moisture content of ground vine and operating speed had significant effect on stripping rate and percentage of unstripped pod. Maximum stripping rate (SR) and percentage unstripped pod (PUSP) of a machine was recorded by dry stripping with drum speed of 600 and 400 rpm respectively. While minimum SR and PUSP recorded at wet groundnut vine stripping with drum speed of 200 and 600 rpm correspondingly. Generally, it can be conclude that drying before stripping resulted in best output (total stripped pod) with (400-rpm) beater speed when compared with threshing immediate at harvest. More over drying after harvest with drum speed (S_{III}) stripping produce the highest stripping rate though it resulted in high pod scattering, percentage of unstripped pod and chaff and impurity. In terms of Economic benefits machine 15.67 times over manual or hand pulled with the same operation (stripping per 3 mans per day). Therefore, further promoting and expanding the machine can reduces work drudgery and time consuming of groundnut pod by hand pulling under smallholder's future.

Keywords: Stripper, groundnut, stripping rate, stripping efficiency, economic feasibility

Introduction
Groundnut stripping is necessary processes subsequent to harvesting because of pods are attached to groundnut vines or stem. Local farmers are encountered several difficulties in stripping as it required relatively high expenditure of human energy. Stripping has previously been accomplished either by hammering the pods on the ground to separate pods from it vine or stem. These methods results in serious bruising of human fingers. The most common practice for stripping in irrigated area is to strip within 1 or 2 days after harvesting Ghatge *et al,* 2014 [4].

Threshing operations also varies both within and among the developing countries. It varies from the age-old procedure of using sticks and racks to the modern power threshers. The smallholder and marginal farmers do manual threshing using sticks and rakes. Variations also exist in stripping pods of the plant. After harvest for example, bunch type plants are stacked in heaps with the pod-end exposed. After the crop has remained in this state for a week or so the pegs become brittle and the pods are plucked from the plants with labor. This operation is comparatively difficult as the attachment of peg to pod is stronger, but drying the plants for a few days facilitates this operation Nautiyal, 2002 [6].

According to Nautiyal, (2002) [6] stripping done by picking pod by pod with an average capacity of 25 kg of pod per person-day. Physical appearance of groundnut from this area is generally good *i.e.* less pods with vine attached and less impurities. For rain fed area, most of groundnut plants are dried in the fields for 4 to 5 days before stripping by pulling a handful of pods from plants.

Ghatge *et al,* 2014 [4] reported that for poor groundnut quality in term of physical appearance hand or manual stripping could reach up to 62 kg of pod per person-day).

Sometimes the stripping of the pods is also performed simultaneously with harvesting when the cropped area is small and laborers are available. In this case, the pods are dried immediately after stripping. The usual practice is to separate pods by beating the pod-end of the plants against a rough stone or a thick iron rod.

Though ground nut production is high, problem of the threshing or stripping have not yet get solution at all areas due to unavailability of modern technology in developing countries like Ethiopia. Unlike others, our farmers not aware of the groundnut threshing technology existence in the world or in home land. Hence, farmers' uses hand stripping by groups of family (Dabo), which is time taking activity and laborious. Therefore, the aim of this study was adopting engine driven groundnut stripper machine at farmer's level to reduce groundnut post-harvest loss.

Materials and Methods

Description of study area

The experiment was conducted on farmer's field at Jalele kebele of Bable woreda, Eastern Hararge Zone of Oromia Regional State during harvesting time of ground nut (November 2016). Babble is situated at 09^0 14′15″– 09^0 25′ 05″ north latitude and 42^0 17′ 28″ - 42^0 28' 20' east longitude at an altitude of 1670 m a.s.l. It is located at 587 km from Addis Ababa, and 31 km from Harar town. Major crops grown in the study area was sorghum, maize, chat and fruit and vegetable under irrigation. Commonly grown cash crops, in the vicinity of the site, under rain-fed at main season was ground nut and chat

Description of the machine components

The main components of the machine consists of frame, engine seat, stripping blade, feeding table shafts, bearing and pulley,

The frame was made from rectangular pipe size 40 mm × 30 mm with stand height of 1200 mm. Engine seat was manufactured from square pipes of 20 mm × 20 mm. It designed to hold engine with better balance and stability during operation.

Power transmission unit: The pulley, shaft and A-type V-belt connection used for power transmission. Shaft having 30 mm diameter was selected in order to transmit required power to different. The experiment was conducted by one cylinder KAMA engine, air cooling, and diesel fuel. The engine output power of 3.75 kW at full injection operate speed was 1500 - 1800 rpm

Stripping unit: This is a unit, which actually strips out the pods from the groundnut.

Table 1: General description of engine driven groundnut stripper

Description	Dimension
Dimensions (l x w x h) (mm)	1300 x 600x 1200
Cylinder concave (upper and lower cover) diameter x length (mm)	170 x 1100
Beater size diameter (mm)	300
Power source (HP)	3.75 KW diesel engine
No. of person required for operation	3 per feed (Used during operation)
Power transmission unit	
Shaft diameter (mm)	30
Diameter of driven pulley (mm)	460
Diameter of driver pulley (mm)	140
V-belt	84 -A-type
Bearings (Pair) P 205 internal Diam. 30 mm	P 205 internal Diam. 30 mm

Design preparation and prototype production

The detail drawing was prepared before starting manufacturing prototype of a machine. After complete set of drawing and necessary materials were procured, manufacturing of the prototype of stripper was made. Accordingly, the machine covers were prepared from sheet metal of a thickness 1.5 mm on bending and rolling machine. Then Beater was made from flat iron of 4 mm thickness arranged in circular pattern at an angle of 15^0 degree on flat circular plate at both side and directly hinged on shaft.

Frame was made from angle iron and rectangular pipe, which was used for complete support of assembled part of the machine.

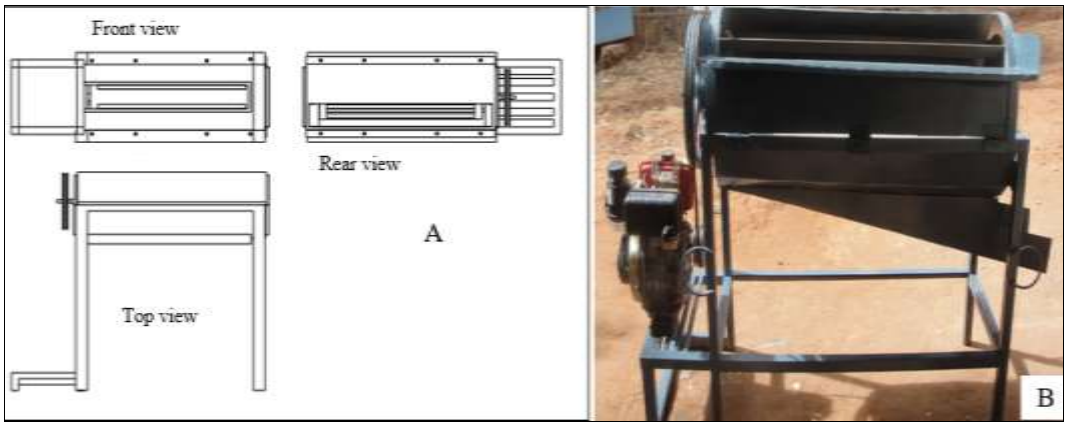

Fig 1: A) Machine drawing and (B) is Prototype of developed groundnut stripper machine

Performance evaluation of the adopted groundnut stripper

After manufacturing was machine performance, evaluated on the following parameters:

Stripping rate (SR): It was the quantity of the groundnut pods detached from the vein in unit time. It is calculated as according to Ghatge *et al*, 2014 [4]

$$SR = \frac{WP}{TS} \quad (1)$$

Where

SR - stripping rate (kg hr^{-1}), WP - weight of stripped pod (kg) and TS - stripping time (hr)

Percentage of unstripped pods: The quantity of the groundnut pods not detached from the vein in unit time and expressed as:

$$PUSP = \frac{WUSP}{TWP} x100 \quad (2)$$

Where

PUSP - Percentage of unstripped pods, WUSP - weight of unstripped pods (kg) and TWP - total weight of pods (kg)

Stripping efficiency (SE): SE (%) was calculated according to Afify *et al*., (2007) [1] following FAO 1994 outline equation

$$SE = \frac{WSP - LOSS}{TWP} X100 \quad (3)$$

Where: SE - stripping efficiency (%), WSP - weight of stripped pod (kg) and TWS - total weight of pod (kg)

Experimental procedure

The performance test of the machine was conducted with three levels of drum speed (200 rpm, 400 rpm and 600rmp) and two levels of moisture content (immediately after harvest at average moisture level as 60% in mass bases and drying for 5 days after harvest with normal sun shine moisture level as 17.5%). a total of 6 experiments with three replications were conducted in order to determine the range of drum speed and moisture content that gives the best performance of the machine. Moisture measurement was done by weighing wet sample at harvest and dry sample following procedures outlined by FAO, 1994 on weight base by taking leave and branch stem of groundnut. Moisture content was determined using oven dry at 105 ^{0}C for 24 hour.

Table 2: Combination of experimental treatments

Treatment	Combinations	
T_1	D x S_{II}	(Dry with speed of 200 rpm)
T_2	D x S_I	(Dry with speed of 400 rpm)
T_3	D x S_{III}	(Dry with speed of 600 rpm)
T_4	W x S_I	(Wet with speed of 200 rpm)
T_5	W x S_{II}	(Wet with speed of 400 rpm)
T_6	W x S_{III}	(Wet with speed of 600 rpm)

Performance evaluation made following FAO (1994) procedure and criteria for evaluation of threshing machine parameters, which includes stripping efficiency (SE), stripping rate (SR), stripping time (ST), and percentage of unstripped pods (PUSP).

Data analysis

All data were subjected to analysis of variance appropriate for factorial randomized complete block design (RCBD). The data were analyzed using statistix-8 software. The mean separation was made using fisher protected list significant difference (LSD) method.

Result and Discussion

The test was conducted with three persons at a time feeding for groundnut pod stripping machine operation. The constructed groundnut stripper was used to carry out the performance evaluation. The results of the mean performance parameter for the groundnut stripper at two moisture contents for different engine speeds are presented as follow;

Stripping rate

ANOVA result indicated that stripping rate (SR_{rate}) of machine was highly significantly (p<0.01) affected by both working speed and moisture levels (stripping immediately at harvest moisture level and drying time for 5 day after harvest with normal sunshine). The highest and lowest mean stripping rate of a machine obtained as 501 and 273 kg hr^{-1}) by treatment D x S_{III} and W x S_I respectively (Table 3). The result revealed that average stripping rate of the machine, at immediately after harvested moisture level stripping with drum speed of 200 rpm had 45.5% lower than drying with drum speed of S_{III} (600 rpm) with same average feeding rate of 345 kg hr^{-1} Table 3. This showed that treatment dried for a 5 days stripped with drum speed of 200, 400 and 600 rpm found as 25.54%, 33% and 21.77% higher than moist treatment (stripped immediate after harvest) with the same operating speed respectively. This is resulted from fresh stripping take more time than dry stripping.

In contrast dry stripping resulted in, more impurity, higher pod scattering/loss, and increase percentage of unstripped pod. On the other hand, from the result, SR rate more affected by moisture than operating speed. This find agrees with Gol and Nada (1991) [5] report; Percentage of stripping pods increased by increasing of peripheral drum speed which ranged from 473-675 rpm. The concluded as significant factors affecting the efficiency of mechanical pod stripping elements are operating speed and crop conditions. Similarly, Ajayi (1991) [2] discussed as, moisture content of the crop influences the capacity of a locust bean thresher. Threshing effectiveness found as affected by the cylinder speed. Ghatge, *et al*. (2014) [4] explained that, most of groundnut plants are dried in the fields for 4 to 5 days before stripping or pulling a handful of pods from plants, this method of stripping results in a relatively high capacity (62 kg of pod man^{-1} day^{-1}). From this result deduced value of stripping rate per person per hour for 8 hour working time 62 kg and for one hour is 7.75 kg hr^{-1}. Therefore average stripping rate per hour of dried groundnut pod stripped by machine was 10.74 times or 90.69% higher than when stripped by person or traditional hand stripping method.

Stripping efficiency

The stripping efficiency of a machine was affected by different operating parameters such as moisture content and stripping drum speed. ANOVA result shows that machine stripping efficiency was significantly (p<0.05) affected by drum speed, but moisture level had not significant (p<0.05) effect on machine stripping efficiency (Table 3). The highest mean stripping efficiency was found as 98.2% by wet stripping with S_{II} (400 rpm) drum operating speed and the lowest 94.7% was recorded by dry stripping with 600-rpm drum speed (Table 3). The result showed that increasing operating speed reduces stripping efficiency and increase pod loss. On the other hand dry threshing increases the excessive plants leaves or chaff drop, but stripping immediately at harvest or 60% Moisture content shows good stripped pod quality but slightly reduce output or stripping rate of machine.

The result confirmed with, Afify *et al*. 2007 [1] reported, they explained that increasing feed rate from 600 to 900 kg hr^{-1} at constant drum speed of 6.28 m s^{-1} and seed moisture content of 13.63%, decreased the stripping efficiency by 0.97%. According to Simonyan and Oni (2001) [8], there is an increase trend in threshing efficiency and extractor efficiency with decrease in moisture content. Threshing effectiveness affected by the cylinder speed.

Table 3: Interaction effect of moisture level and operating speed on groundnut stripping machine

Treatment	WSP (kg)	WUSP (kg)	SR $_{rate}$ (kg hr^{-1})	PUSP (%)	Loss (kg)	SE (%)
D x S_{II}	5.89^{a}	0.110^{a}	413^{b}	1.82^{a}	NA	97.3^{a}
D x S_{I}	5.74^{a}	0.095^{ab}	349^{bc}	1.61^{ab}	0.03^{b}	97.5^{a}
D x S_{III}	5.13^{b}	0.084^{b}	501^{a}	1.56^{ab}	0.10^{a}	94.7^{b}
W x S_{I}	5.46^{ab}	0.085^{b}	273^{c}	1.53^{ab}	NA	98.1^{a}
W x S_{II}	5.39^{ab}	0.074^{b}	276^{c}	1.35^{b}	0.02^{b}	98.2^{a}
W x S_{III}	5.50^{ab}	0.048^{c}	373^{b}	0.84^{c}	0.10^{a}	95.6^{b}
CV	4.9	14.8	12.7	15.2	54.3	0.9

Note D: Drying for 5 day before stripping, W: Wet (stripping immediately at harvest), S_{I}. S_{II}, S_{III} is operating speed at 200, 400 and 600 rpm operating speed

Percentage of unstripped pod (PUSP) and pod loss

Threshing capacity of a machine may affected by different physical characteristics of crop. ANOVA result indicated that percentage of unstripped pods (PUSP) pod loss were highly significantly (p<0.01) affected by moisture level and drum speed (Table 3). The highest mean PUSP of 1.82%, was recorded by 5 days drying after harvest (17.5% moisture level) stripping with 400 rpm drum speed and, the lowest PUSP 0.84% was found by wet stripping with 600 rpm (S_{III}) drum operating speed.

Similarly the highest pod loss was observed as 0.1% and the lowest 0% or no loss was observed in both treatment moisture level (wet and dry) stripping with 600 rpm and 200 rpm respectively. More over statistical output showed pod loss was not affected by moisture content of ground nut vine, whereas operated speed had significant effect on pod loss i.e. as beater speed increase pod scattered out increases. Moreover, the effect of beater/drum speed versus pods loss plotted indicated as; initial machine operating speed (200 rpm) there is no pod loss or negligible, whereas at second drum speed (400 rpm) pod scattering was slightly observed as shown in Table 3 and figure 1. While at 600 rpm and above drum speed stripped pod loss increase considerable.

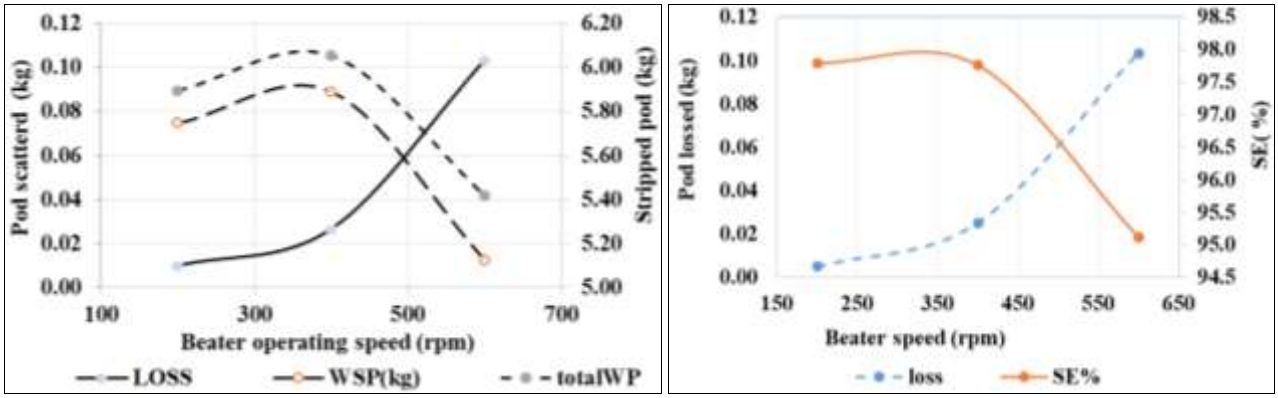

Fig 2: Effect of drum speed on pod scattering loss and SE (%)

Figure 3 indicates as drum speed increases pod loss or pod scattering increasing, which means, explicitly SE was also influenced by those operation. The SE initially low at 200 rpm and increasing gradually; reached at maximum at 400 rpm then decreasing gradually figure 3.

The result obtained by Afify *et al*. (2007) [1] confirmed with this study. The result showed that decrease in the percentage of stripping efficiency by increasing feed rate attributed to the excessive plants in the threshing chamber. Consequently, the seeds leave the device without complete stripping from the capsules. Additionally their finding reveals increasing drum speed from 4.19 to 7.32 m s^{-1} at constant feed rate of 600 kg hr^{-1} and seed moisture content of 13.63% increased the stripping efficiency by 1.31%.

Similarly, as drum speed, increases pod loss or pod scattering increasing, amount of pod stripped per unit time decreases; which means, explicitly SE (%) was also influenced by those parameters. Thus, SE (%) initially low at 200 rpm and increasing gradually; reached at maximum at 400 rpm then decreasing gradually figure 3.

The obtained result confirmed with Afify *et al*. 2007 [1]. The result showed that decrease in the percentage of stripping efficiency by increasing feed rate attributed to the excessive plants in the threshing chamber. Consequently, the seeds leave the device without complete stripping from the capsules. Additionally their finding reveals increasing drum speed from 4.19 to 7.32 m s^{-1} at constant feed rate of 600 kg hr^{-1} and seed moisture content of 13.63% increased the stripping efficiency by 1.31%.

Weight of stripped and unstripped pod weight

ANOVA output show that weight stripped or threshed pod weight (WSP) of groundnut was statistical significantly (p<0.05) affected by interaction effect of moisture level and operating speed. The highest mean stripping weight was produced by D x S_{II} as 5.89 kg and the lowest 5.13 kg by D x S_{III} (Table 3). This is due as beater speed increases pod scattering was increase. Similarly the unstripped pod weight of groundnut was highly significantly (p<0.01) influenced by both of moisture level and operating speed. The highest mean weight of unstripped pod recorded 0.11 kg and the lowest 0.048 kg by drying for 5 day after harvest stripping with 400 rpm operating speed and stripping immediately at harvesting at 600 rpm respectively Table 3. However, interaction result revealed that unstripped pod slightly increased on drying for 5 days by normal sun dried than fresh instantly stripped groundnut as shown in Table 3. This finding confirmed with Paulsen *et al.* (1980) [7] study, which pointed that the moisture content of grain is one of the major physical factors for the design and operation of the threshing machine that affect the mechanical damage to grains and threshing efficiency of machine.

Economic analysis of the machine

Handful pulling of pods from plants, stripping method results in a relatively 62 kg of pod/man-day this shows stripping rate per person per hour for one hour is 7.75 kg hr^{-} Ghatge, *et al* (2014) [4]. Economic benefit of stripper machine estimated following.

Hence, economic analysis described as follow:

Total stripping per man per hour = 7.75 kg

Working hour = 8 hour per day

Total stripping per 3 mans per day = 3*7.75*8= 186 kg

Cost of laborer per day =100 ETB

Total Cost of manual piking per day = 300 ETB

Fuel consumption per hour = 0.8 liter

Total fuel required 0.8* 8 hr. = 6.4 liter

Cost of fuel with oil = 20 per liter

Total fuel cost per day = 6.4*20 = 128 ETB

Average machine stripping per hour = 364.2 kg

Total machine stripping kg per day = 364.2*8 = 2913.6 kg

Total cost = Labor cost + Fuel cost = (3*100) + 128 = 428 ETB day^{-1}

Stripping cost per day = (Total machine stripping kg per day ÷ Total cost) = (2913.6 ÷ 428) = 6.81 ETB per day

Total stripping per 3 mans per day = 3*62= 186 kg (manual stripping)

From the calculation: manual stripping cost per 3 mans per day = 300 ETB to strip 186 kg and machine stripping cost per 3 mans per day = 428 ETB to strip 2913.6 kg

Conclusion and Recommendation

A groundnut-stripping machine was adopted and tested in mandate area of Babile district of East Hararge zone. This machine was tested under two factors namely, two moisture level (Immediate after harvest and stripping after drying for 5 days), and three machine operating speed, (200 rpm, 400 rpm and 600 rpm); from this experimental finding the following concluded and recommendation was drawn:

The highest mean interaction effect of stripping rate of a machine was 501 kg hr^{-1} 5 day drying (17.5%) and drum speed of 600 rpm (D x SIII) treatment recorded 1). While minimum mean stripping rare (SR_{rate}) of the machine found 273 kg hr^{-1} was obtained at immediate after harvest (60% ML) and drum speed of 200 rpm (W x S_I) treatment with same average feeding rate of 345 kg hr^{-1}. The highest and lowest mean stripping efficiency obtained as 98.2% and 94.7% by 400 and 600 rpm drum operating speed.

The highest mean machine stripping time was recorded by fresh harvested stripping with 200-rpm drum speed at immediate after harvest (60% ML) found 0.020 hr. While mean minimum stripping time was at drying for 5 day after harvested with drum, speed (D x S_{III}) was 0.0106 hr. Generally, it can be conclude that drying before stripping resulted in best output (total stripped pod) with (400-rpm) beater speed when compared with threshing immediate at harvest. More over drying after harvest with drum speed (S_{III}) stripping produce the highest stripping rate though it resulted in high pod scattering, percentage of unstripped pod, chaff and impurity.

Reference

1. Afify MK, El-Sharabasy MMA, Ali MMA. Development of a local threshing machine suits for threshing Black Seed (*Nigella Sativa*), Sisr J Ag. Eng. 2007;24(4):699-724.
2. Ajayi AO. design of a stripper for locust bean. Agricultural mechanization in Asia, Africa and Latin America (AMA). 1991;22(3):21-24.
3. FAO: testing and evaluation of agricultural machinery and equipment. Principles and practices. Food and agricultural organization (FAO) Agric. Services Bulletin No. 110; c1994.
4. Ghatge JS, Bandgar PS, Mehetre SA. Development and performance evaluation of pedal operated groundnut pod stripping machine. International journal of agricultural engineering. 2014;7(1):217-220.
5. Gol AK, Nada SK. Performance of power operated groundnut stripper. AMA. 1991;22(3):25-28.
6. Nautiyal PC. Groundnut: post-harvest operations. National research center for groundnut (ICAR); c2002. (www.icar.org.in)
7. Paulsen MR, Newberry RS, Nave WR. Soya bean quality with rotary and conventional threshing. Transaction of ASAE. 1980;23(2):303-308.
8. Simonyan KJ, Oni KC. Performance evaluation of a motorized locust bean decorticator. Journal of Agricultural Technology. 2001;9(1):55-65.