On Farm Evaluation of Locally Available Animal Feed Choppers

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***Abstract*– The research was conducted at Bako Agricultural Engineering Research Center to evaluate the machine performance in terms of cutting efficiency, chopping efficiency throughput capacity and fuel consumption at different speeds on two Animal feed choppers. The primary goal of this study was aimed for on farm evaluation of locally available animal feed choppers of Asella AERC model and selam model chopper for crop locally adopted forage varieties in Bako with treatments of the engine seed, feed rate and crops using split plot design with three replications. Asela model animal chopper have mean cutting efficiency (94.88%), chopping efficiency (94%), throughout capacity (389.3 kg/hr)and mean fuel consumption 121ml on elephant grass and have cutting efficiency (96.25%), chopping efficiency (96.9%), throughout put capacity (1063.3 kg/hr) and mean fuel consumption 120ml/kg on Maize Stalk .Selam model animal chopper have mean cutting efficiency (97.47%), chopping efficiency (97.39%) , throughout capacity (700.8kg/hr) and mean fuel consumption 31.67ml/kg on elephant grass and have mean cutting efficiency (94.39%), chopping efficiency (97.21%) , throughout put capacity (645.45 kg/hr) and mean fuel consumption 40.9ml/kg on Maize Stalk was recorded . From the result obtained both animal feed chopper have best cutting efficiency, chopping efficiency and throughout put capacity, though according to their capacity of the engine they have the customers or farmers can these animal feed choppers at speed of 800rpm and 5kg/min feeding rate, but using greater than the above speed may affect the machine specially Asela model chopper .So, It recommend, these machine must be go to extension and reach to farmers.**

***Keyword*– On Farm Evaluation, Animal Feed Chopper, Elephant Grass and Maize Stalk**

I. INTRODUCTION

ETHIOPIA has the largest livestock population of any country in Africa. How ever nutritional factors are the binding constraint to sustaining livestock production in Ethiopia. Feed shortage becomes very critical in most of the areas mainly due to the high population pressure which leads farmers to cultivate grazing land (Getinet et al, .2004).

Ethiopia has large livestock population, but still the demand of animal source foods for its human population is not met. This is mainly due to poor animal productivity that is compounded by inefficiencies in the input (feed, genetic material and veterinary services) and output. Among these, feed shortage in terms of quantity and quality is considered as a major factor that hinders sustainable development of the sector in Ethiopia (FAO, 2018 and Getahun, 2019).

In Ethiopia natural pasture is the primary feed resource throughout the wet season while crop residues play a substantial role during long dry season (CSA, 2017). However, as the productivity of grazing lands in most parts of Ethiopia is getting extremely low, due to various reasons, that include conversions of the natural pasture in to crop lands, some adopted improved forage varieties and the crop residues become considerable feed sources in wet and dry seasons in most mixed farming areas of the country (Demeke et al., 2017).

In contrast to the natural pasture grazing, most locally available feed sources; crop residues and locally available protein sources, such as improved forage types, legume residues, tree pods, green fodder from multi-purpose trees are fibrous and limited by their low value of voluntary intake as feed, thus, efficient utilization of these resources need correct harvesting and physical treatments to improve their palatability for livestock feeding (M. Jamshidpouya, et al., (2018).

Feed treatment and processing in basic terms can be physical treatment which primarily comprising of their size reduction that can be achieved by using hand operated or power-driven cutters and choppers, but in Ethiopia, there is limited experience in treatment and processing methods for improving the nutritional value of crop residues (Abera et al., 2014).

In Ethiopia, most farmers usually used to harvest grass and crop residues as forage and cut them into short lengths for livestock. But, as feeds' size bulkiness and fibrous nature can restrict intake by livestock, and it is common to see significant feed wastage attributed partly to selection of palatable and/or refusal of unpalatable fodder parts by animals. In this regard, studies showed that, appropriate chopping of forage to proper size of particles can improve the physical characteristic, that can stimulate rumination, boost feed intake, lower feed rejection and consequently reduce feed wastage (Devries T. et al., 2008). In addition to increasing feeds' intake, the chopping technologies can help in rapid removal of residues from field after grain harvest; reduces leaf loss and senescence, homogenize the plant material by mixing small and large particles that allows benefiting of medium and low-quality forages, timely storage and reduction in space for storage as well as transportation.

Western part Oromia, is a region, commonly known as the major production hub for livestock and crops such as maize, sorghum and other similar crops of dominant sources of the crop residues, however, as there is no tradition of utilizing the abundant feed resources in the area and it is common to leave the most crop residues on the field without any use and burn them down for land preparation, while local livestock are solely dependent on subsistent grazing and known for their lower output. To complement this paradox, it is vital to introduce the methods and technologies for improved utilization of the crop residues and other fibrous fodders in the area.

Elephant grass is a tropical species of the family Panacea with a high potential for biomass production. Nutrition is the foundation of a livestock production system and proper nutrition is imperative for achieving high and sustained livestock productivity. The success of animal reproduction and health program rests on proper nutrition. The cutting of crop resides into small pieces then feeding to the cattle, increases the consumption and palatability of feed, hence reducing the wastage. Animal feeding is very important aspect of livestock husbandry. It is very necessary to have effective utilization of available feed sources. Chaff is hay cut into small pieces for feeding to livestock (Mohan and Kumar, 2004); it is a good fodder, and at its best is cleanly and evenly cut, free of dust, of good color and with a fresh aroma.

In Ethiopia, farmers used to use feed chopping by manual choppers that includes traditional tools such as sickle, machetes and knives, that are too labor intensive and tiresome, especially in dry and fibrous materials, while it is also associates with dangers of cutting worker's fingers. However, some Non-governmental organizations and Research institutions have imported and or adopted different types of small and medium power-driven forage choppers, for solving the feed resources utilization problems in some other parts of the country in Ethiopia.

According to Yonas Mulatu (2020) performance of the Animal feed chopper machine was evaluated using sorghum forage variety and obtained mean chopping capacity of (581.24 kg/h), the finest of (shortest) mean cut length (6.23 mm), the highest chopping efficiency of (0.97) and the mean lowest fuel consumption of (0.50 ml/s) was recorded.

According to Abyna (2019) the chopping efficiency was decreased from 97.28 to 92.43 % on maize stalk and 95 to 90.2 % on sorghum stalk as rpm increases from 1150 to 1850 respectively. Throughput capacity of chopper was increases from 8.13 to 12.6 kg/min on maize stalk and 10.26 to 14.5 kg/min on sorghum stalk as rpm increases from 1150 to 1850 respectively. The mean of chopping length and cutting efficiency of also 3.5 cm and 96.64 % on maize and 2.53 cm and 97.63 % on sorghum stalk respectively, Therefore, this study was aimed for on farm evaluation of locally available animal feed choppers of Asella AERC model and selam model chopper for crop locally adopted forage varieties (Elephant grass and Maize Stalk) in Bako, west Oromia.

II. MATERIALS AND METHODS

A) Experimental Site

Constructions of prototypes for both machines were done at Bako Agricultural Engineering Research Center (BAERC), which is located in Western Shoa Zone of Oromia National Regional State, Ethiopia and the evaluation of the machines were done at Bako Agricultural research center, Dambi Gobu and 02 kebele around Bako Tibe woreda West Shoa Zone of Oromia in Ethiopia

B) Materials

The basic experimental materials used; Asela AERC Model Animal feed chopper, Selam Model animal feed chopper (Fig. 1), 12 HP ACME engine, 10hp Lombard engine, Tachometer, digital balance weight, a stopwatch, spring balance and measuring cylinder.

C) Maize Stalk and elephant grass Collection

The raw materials such as elephant grass and Maize Stalk were collected from Bako Agricultural Research Center and from farmer's farm.

D) Machines description

The overall length, width and height for Asela AERC machine were 148, 188 and140 cm respectively and for the Selam chopper were 150, 100 and146 cm respectively. Both machines consisted of five major components are as follows: The feeding table, the cutting assembly, the frame stand assembly, the power transmission assembly, and the material outlet. The selam chopper additional contain feeding table, sieve and outlet for milling maize and cereal grain as additional purpose.

E) Performance Evaluation

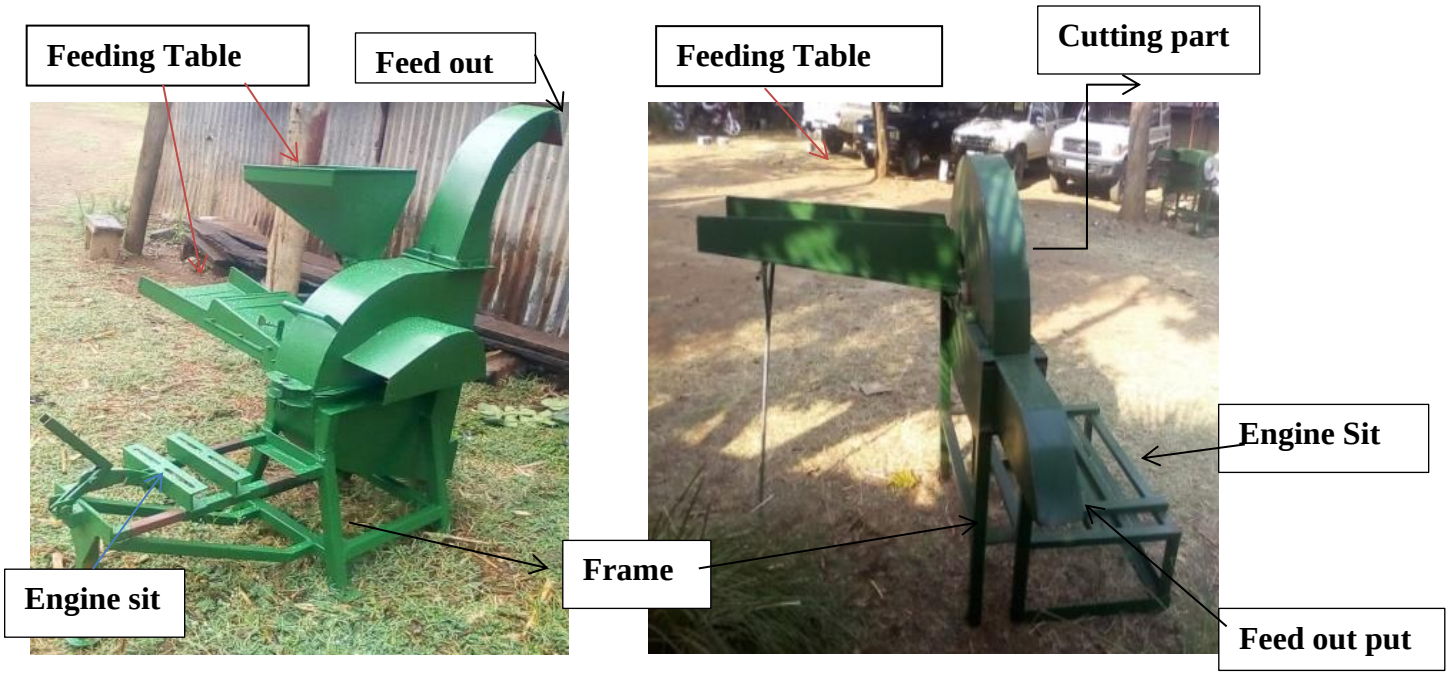
The performances of the choppers were evaluated using Maize Stalk and elephant grass. For each testing run, 4 and 5kg of chopping material was weighed using a digital mass balance and the length of materials were measured using measuring tape. The materials were then fed into the cutting chamber of the chopper via feeding table. The chopped materials were then collected in a sack to determine the length of the chop and weight. The time taken to chop quantity of fodder was recorded using a stopwatch. A total of three test runs were made in order to obtain an average measure of the performance parameters.

Evaluation and data were collected by using the two machines animal feed chopper (AAERC and Selam Choppers), by three levels drum speed (600, 700 and 800rpm) and by two feeding rate (4 and 5 kg/min) for evaluation of elephant and Maize Stalk. Those drum speeds are at ideal operating machine. The time taken for each treatment was accurately checked and recorded. The following parameters were taken to determine the performance of the machine:

Cutting efficiency: Cutting efficiency for both animal feed choppers were calculated by measuring the stem length before cutting and the size or length of particles after cutting (Elfatih et. al, 2010). The length of materials was measured using measuring tape.

$$C_E = \frac{(L_b - L_a)}{L_b} x100\%$$

Where:
C_E = cutting efficiency (%).
L_b = Particles length before cutting (cm).
L_a= Residual length after cutting (cm).



(A) (B)

Fig. 1. Selam Animal Feed Chopper (A) and Asela AERC Animal Feed Chopper (B)

Chopping efficiency

Chopping machine Efficiency is the ratio m.i id.;igyrx of the weight of the accepted output and input expressed in percent. Chopping efficiency for both animal feed choppers machines were calculated by dividing total weight of samples for Total weight of chopped out as (Khope and Modak, 2013).

$$C_o = \frac{W_c}{W_f} x100$$

Where, Co = Chopping efficiency
Wf = Total weight of samples fed in
Wc = Total weight of chopped out.

Throughput capacity

Throughput, defined herein as the number of materials (elephant grass and Maize Stalk) chopped per hour when the machine is operating at optimal capacity (Harry and John, 2007). This was assessed by chopping a known amount of elephant grass and Maize Stalk in a given time period. The quantity of forages was measured by a digital mass balance while the time taken was measured using a stopwatch.

$$C_r = \frac{W_f}{t_c} * 100$$

Where, tc = Chopping time in seconds.

Estimation of Fuel consumption

To measure the fuel consumption, first chopper machine kept on leveled surface. The fuel tank was filled up to top of the tank before the test started. After the completion of the chopping operation the engine was stopped and then the tank refilled to the original level. The quantity of fuel filled in the tank was measured using graduated measuring cylinder. The difference between amount of fuel prior to and after chopping was used to estimate fuel use efficiency.

F) Statistical Analysis and Interpretation

The experimental was conducted in a factorial experimental analysis of variance. It was made using statistics 8 software. All significance pairs of treatment means were compared using the Least Significant Difference Test (LSD 5%).

III. RESULT AND DISCUSSION

Tables I shows the results obtained from the analysis of the data collected after the evaluation of both machines. These comprised the mean values of the performance parameters and the analysis of variance (ANOVA) table which describes the significance of the treatments in affecting the performance of the machine. The prototypes were tested using Maize Stalk and elephant grass and the results were presented in Table I.

Table I shows the mean values of cutting lengths (mm) and efficiency (%), chopping capacity (kg/min) and efficiency (%), fuel consumption (l/h) and the analysis of variance (ANOVA). The machines were evaluated using Maize Stalk and elephant grass at two different feed rates of 4 and 5 kg with three different machine operation speeds of 600,700 and 800 rpm.

Table I shows the results obtained from the analysis of the data collected after the evaluation of both animal feed machines on elephant grass and Maize Stalk. These comprised the mean values of the performance parameters and the analysis of variance (ANOVA) tables which describes the significance of the treatments in affecting the performance of the machine. Table I shows the mean values of cutting lengths (m), cutting efficiency (%), chopping efficiency (%), throughput Capacity

(kg/min) and fuel consumption (kg/ml). The machine was evaluated with two feed rates of 4 and 5 kg with two machines at operation speeds of 600,700 and 800 rpm.

Animal feed chopping process is intended to reduce on farm labor demand and drudgery while improving feed intake and feed use efficiency. As shown in Table II the mean chop length of both elephant grass and Maize Stalk was decreased from 397.4 to 20.5 cm and 228.2 cm to 8.3 cm on Asela Model Chopper and from 360 cm to 9.6 cm and 217 cm to 16 cm on selam Model Chopper Respectively. Forage particle length has a critical influence on feed intake and the functionality of the rumen in dairy cattle (Bhandari et al., 2007; Yang and Beauchemin, 2009). The mean chop length produced by the prototype was near to the acceptable range of between 1 to 4 cm required to maintain proper rumination and salivation (Moharrery, 2010) as sited by Kiggundu M, 2018. When subjecting the data to Analysis of Variance there are no significant pairwise differences among the means chop length.

A) Asela AERC Model Animal feed chopper

The highest mean cutting efficiency (96.8%) for elephant grass was attained when the machine was fed by 4 kg at operation speed of 800 rpm and the highest mean cutting efficiency (96.9%) for Maize Stalk was attained when the machine was fed by 5kg at operation speed of 700 rpm. There are no more significant pairwise differences among the means at 95% confidence level.

The highest mean chopping efficiency (91.67%) for elephant grass was attained when the machine was fed by 4 kg at operation speed of 600rpm and the highest mean chopping efficiency (100%) for Maize Stalk was attained when the machine was fed by 5kg at operation speed of 600rpm.The highest mean throughput Capacity (496.2kg/hr.) for elephant grass was attained when the machine was fed by 4 kg at operation speed of 800rpm and the highest mean throughput capacity (1214.4kg/hr.) for Maize Stalk was attained when the machine was fed by 5kg at operation speed of 800rpm.The finest (shortest) mean cut length (12cm) for elephant grass was obtained when the machine was fed by 4kg of at operation speed of 800 rpm and the finest (shortest) mean cut length (7.2cm) for elephant grass was obtained when the machine was fed by 4kg of at operation speed of 600rpm. Fuel consumption of chopper machine was a little varies from crop-to-crop residue but not significant. As shown from Table I the average fuel consumption of machine for chopping of Elephant grass and Maize Stalk was 121.7ml/kg and 121ml/kg respectively.

B) Selam Model Animal feed chopper

The highest mean cutting efficiency (98.24%) for elephant grass was attained when the machine was fed by 5kg at operation speed of 800 rpm and the highest mean cutting efficiency (95.27%) for Maize Stalk was attained when the machine was fed by 4kg at operation speed of 600 rpm. The highest mean chopping efficiency (99.3%) for elephant grass was attained when the machine was fed by 5kg at operation speed of 700rpm and the highest mean chopping efficiency (100%) for Maize Stalk was attained when the machine was fed by 4kg at operation speed of 700rpm and5kg operation speed of 800rpm.The highest mean throughput Capacity (946.8kg/hr.) for elephant grass was attained when the machine was fed by 5kg at operation speed of 800rpm and the highest mean throughput Capacity (968.4kg/hr.) for Maize Stalk was attained when the machine was fed by 5kg at operation speed of 800rpm.The finest (shortest) mean cut length (8cm) for elephant grass was obtained when the machine was fed by 4kg of at operation speed of 800 rpm and the finest (shortest) mean cut length (9cm) for Maize Stalk was obtained when the machine was fed by 4kg of at operation speed of 700rpm.Selam model animal feed chopper have the milling capacity of maize 102.5kg/hr that used for feeding poultry when machine was operated at speed of 920Rpm.Fuel consumption of chopper machine was a little varies from crop to crop residue but not significant. As shown from Table I. The average fuel consumption of machine for chopping of 70.1kg of Elephant grass and 64.542kg Maize Stalk was 0.19 and 0.2456 liter respectively.

IV. CONCLUSIONS AND RECOMMENDATIONS

Ethiopia has the largest livestock population of any country in Africa. However nutritional factors are the binding constraint to sustaining livestock production in Ethiopia. Feed shortage becomes very critical in most of the areas mainly due to the high population pressure which leads farmers to cultivate grazing land. The performances of the choppers were evaluated using Maize Stalk and elephant grass. For each testing run, 4 and 5 kg of chopping material was weighed using a digital mass balance and the length of materials were measured using measuring tape. In general, as observed in the evaluation result, the machine can attain its highest capacity based on the operation speed. As the machine operates at higher speed the capacity increases to its highest possible performance. The speed of the machine also affects the length of cut of the feed, the machines efficiency, machine chopping efficiency, throughout put capacity and fuel consumption. Asela model animal chopper has 94.8%, 88.20% and 6.49 kg/min cutting efficiency, chopping efficiency and throughout capacity on elephant grass and 96.25%, 96.77 % and 1063.2 kg/hr. on Maize Stalk respectively. Selam model animal chopper has 97.47%, 97.38% and 718.8kg/hr. cutting efficiency, chopping efficiency and throughout capacity on elephant grass and 92.63%, 98.65 % and 645.6kg/hr on Maize Stalk respectively Table I.

Based on result obtained the following Recommendations was made.

- ✓ From the result obtained both animal feed chopper has best cutting efficiency, chopping efficiency and throughout put capacity, though according to their capacity of the engine they have the customers or farmers can these animal feed choppers at speed of 800rpm and 5kg/min feeding rate, but using greater than the above speed may affect the machine specially Asela model chopper.
- ✓ carefully attention should be taken while operating both animal feed choppers specially Asela model have no safety guard on pulling of belt.
- ✓ So, it recommends, these machines must be going to extension and reach to farmers.

Table I: Summarized performance evaluation result of the two prototype choppers

No	Parameters	**AAERC Model Animal feed chopper**								
		(1) Elephant Grass								
1	Speed (Rpm)	600rpm		700rpm		800rpm		Ground Mean	CV	SEM
2	Feed Rate kg/min	4	5	4	5	4	5			
3	Cutting Efficiency (%)	94.86^{a}	95.6^{a}	90.7^{b}	96.2^{a}	96.8^{a}	95.2^{a}	94.89	1.19	0.65
4	Chopping Efficiency %	91.67^{a}	87.3^{a}	89.2^{a}	88.7^{a}	85^{a}	87.3^{a}	88.20	4.97	2.53
5	Throughput(kg/hr)	402.6^{a}	314^{a}	338.2^{a}	361.8^{a}	496.2^{a}	423^{a}	389.3	41.6	93.5
6	Chop length(cm)	21.1^{b}	17.6^{bc}	38.8^{a}	14.9^{bc}	12.4^{c}	18.2^{bc}	20.5	21.8	2.57
7	Fuel Used (ml/kg)	120		120		125		121.7	0	
No	Parameters	(2) Maize Stalk								
1	Speed (Rpm)	600rpm		700rpm		800rpm		Ground Mean	CV	SEM
2	Feed Rate kg/min	4	5	4	5	4	5			
3	Cutting Efficiency (%)	96.7^{a}	96.5^{a}	95.7^{a}	96.9^{a}	95.3^{a}	96.4^{a}	96.3	1.4	0.8
4	Chopping Efficiency %	97.92^{a}	100^{a}	97.9^{a}	96.7^{a}	91.8^{a}	96.3^{a}	96.7	5.5	3.1
5	Throughput (kg/hr)	1001.2^{ab}	945.6^{b}	1179.4^{ab}	998.6^{ab}	1042.4^{ab}	1214.4^{a}	1063	45.9	97.3
6	Chop length (cm)	7.8^{a}	7.2^{a}	9.5^{a}	7.3^{a}	9.4^{a}	8.3^{a}	8.3	24.3	1.16
7	Fuel Used (ml/kg)	120		120		120		120		
No	Parameters									
		Selam Model Animal feed chopper								
		(1) Elephant Grass								
1	Speed (Rpm)	600Rpm		700 Rpm		800 Rpm		Ground Mean	CV	SEM
2	feed rate	4	5	4	5	4	5			
3	Cutting Efficiency (%)	95.6^{a}	97.25^{a}	97.71^{a}	97.8^{a}	98.2^{a}	98.24^{a}	97.47	0.59	0.33
4	Chopping Efficiency %	97.9^{a}	96.67^{a}	95.83^{a}	99.3^{a}	96.3^{a}	98.3^{a}	97.38	3.7	2.10
5	Throughput (Kg/hr.)	540.2^{c}	558.4^{c}	629^{bc}	792^{ab}	738.6^{abc}	946.8^{a}	700.8	19.8	79.9
6	Chop length (cm)	11.9^{a}	10.1^{a}	10.2^{a}	9.4^{a}	8.1^{a}	8.3^{a}	9.6	18.14	1.014
7	Fuel Used ml/kg	47.5		22.5		25		31.67	0	
No	Parameters	(2) Maize Stalk								
1	Speed (Rpm)	600rpm		700rpm		800rpm		Ground Mean	CV	SEM
2	Feed Rate	4	5	4	5	4	5			
3	Cutting Efficiency (%)	95.27^{a}	93.6^{a}	95.07^{a}	95^{a}	95.1^{a}	94.37^{a}	92.63	1.57	0.86
4	Chopping Efficiency %	97.92^{a}	98.33^{a}	100^{a}	99^{a}	100^{a}	96.67	98.65	1.42	0.81
5	Throughput (Kg/hr.)	450.6^{b}	596.4^{b}	488.6^{b}	522.7^{b}	846^{a}	968.4^{a}	645.6	15.4	52.3
6	Chop length (cm)	14.67^{a}	13.13^{a}	9^{a}	9.7^{a}	10.23^{a}	12.2^{a}	11.54	30.04	2
7	Fuel Used ml/Kg	40		25		57.8		40.93		

Table II: Ground mean of length before cutting, length after cutting and cutting efficiency (%)

No	parameter	Asela Model Chopper		Selam Model Chopper	
		For elephant Grass	For Maize Stalk	For elephant Grass	For Maize Stalk
1	Length before (cm)	397.4	228.2	360	217
2	Length after(cm)	20.5	8.3	9.6	16
3	Cutting efficiency (%)	94.84	96.36	97.5	92.63

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Some Pictures While Prototypes Production




Asela Agricultural Engineering Research Center Model Animal Feed Chopper



Selam vocational company Model Chopper

Some Pictures While Evaluation and Data Collection