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Development and Evaluation of Sugar Cane Harvester and Cutter

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Abstract

Sugarcane is an important crop widely cultivated for multiple purposes by smallholder farmers in sub-Saharan Africa (SSA), including Ethiopia. A report by the Central Statistics Agency (CSA) of Ethiopia showed that 1,090,575 households grew sugarcane in about 29,536.49 hectares of land and 13,470,350.06 productions in quintals and in Oromia region 324,526.00 households grew sugarcane and 3,162,239.03 productions in quintals. Harvesting is a process of cutting and gathering of mature crop from the field. Harvest laborers can easily fatigue due to excessive stress on the joints and muscles and are exposed to harmful pests from plantations, creating safety concerns. Mechanical harvesting also makes green cane harvesting possible, which reduces Green House Gas emissions from pre-harvest burning necessitated by manual harvesting. Statically analysis of ANOVA indicated that the cutting capacity of the prototype of sugar cane cuter was significantly ($P < 0.05$) affected by engine speed, sugarcane feed rate. The maximum cutting capacity of 1200.7 (stoke/h) was recorded when the engine speed was 400 rpm and the feed rate 3 (stoke/min). Increase in the engine speed resulted in increased cutting efficiency. The maximum cutting efficiency 99.48% was observed when the machine was operated at velocity of 400 rpm and at feed rate of 2 (stoke/min). Fuel consumption of the cutting machine increased with in increasing of engine speeds and increase with increasing of feed rates (from 100.33 to 124.33 ml/stoke with engine speed of 300 and 400 rpm and the feeding rate of 1, 2 and 3 stoke/min). Increase in the engine speed resulted in declined cutting efficiency. This could be due to the very fact that at higher engine speed the energy imparted to the sugarcane was high and hence causing disturbance for harmonic motion which leads to decline cutting uniformity. Maximum cutting uniformity 99.99% was observed when the machine was operated at velocity of 300 rpm and at feed rate of 1 (stoke/min). The average cut height (mm) remain on ground, Forward speed (km/hr), Actual width of cut (mm), Theoretical field capacity (ha/hr), Actual field capacity (ha/hr) and Field efficiency (%) were 50.75, 2.18, 600,1.31, 0.69 and 52.67 respectively.

Keywords: Harvesting, Sugar Cane, Development, Evaluation
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1. Introduction

According to World Crop and Livestock Statistics published by the Food and Agriculture Organization (FAO), world sugarcane growing area increased from 6.3 million hectares in 1950 to 25.4 million hectares in 2011 (FAOSTAT, 2013) in more than 90 countries, with a worldwide harvest of 1.69 billion tons. Sugarcane is an important crop widely cultivated for multiple purposes by smallholder farmers in sub-Saharan Africa (SSA), including Ethiopia. Sugarcane cultivation by smallholder subsistence farmers started centuries ago and preceded the commercial sector in Ethiopia (Esayas, 2014). A report by the Central Statistics Agency (CSA) (2017) of Ethiopia showed that 1,090,575 households grew sugarcane in about 29,536.49 hectares of land and 13,470,350.06 productions in quintals and in Oromia region 324,526.00 households grew sugarcane and 3,162,239.03 productions in quintals.

Harvesting is a process of cutting and gathering of mature crop from the field. Harvester is a machine used for harvesting. Different types of harvesting machines are available in the market namely paddy harvester, Tea harvester, Potato harvester, Wheat harvester and sugarcane harvester as mentioned above all are available in small scale except sugarcane harvesting machine. Hand knives, cutting blade or hand axes are used for manual harvesting. It requires skilled labors as improper harvest of cane leads to loss of cane and sugar yield, poor juice quality and problems in milling due to extraneous matter. Labors can't cut sugarcane properly at ground level. This conventional harvesting operation still continues in a large scale in developing and underdeveloped countries around the world. Manual sugarcane harvesting is a very labor-intensive and laborious activity.

Harvest laborers can easily fatigue due to excessive stress on the joints and muscles (Clementson and Hansen, 2008) and are exposed to harmful pests from plantations, creating safety concerns (Carvalho, 2012). In manual harvesting to cut one hector of sugarcane 16 - 17 labors are required and they take 3days to cut one hector and involves harvesting of 70 - 80 tons per hector with labors being paid 7.33 - 8.06 dollar per ton of harvest hence total cost of harvesting per hector comes up to 439.62 - 586.17 dollar. In mechanization now by using large scale harvesting machine takes about 6 - 7 hours for harvesting one hector averaging about 70 - 80 tons with labor costing around 51.29 - 58.58 dollar per hour hence the total cost of harvesting per hector comes up to 293.08 - 366.35 dollar.

The advent of mechanical harvesting systems frees harvest laborers from the drudgery of field operations. To harvest one hectare of sugarcane, it requires 3.3 - 4.2 machine/hour by mechanical harvesting whereas 850 - 1000 man/hour by manual harvesting (Yadav*et al*., 2002). Mechanical harvesting also makes green cane harvesting possible, which reduces Green House Gas emissions from pre-harvest burning necessitated by manual harvesting (Braunbeck*et al.,* 1999).

The chopping is a mechanism to reduce sugar cane stalks into uniform-sized pieces. Chopping mechanism is used to simplify sugarcane handling operation (DIISRTE, 2011). Cutting quality on stalks and stools is critically important to reduce cane (juice) loss and to avoid the possibility of reduction in ratoon (the shoot of new sugarcane plant). Therefore, a good cane cutter should produce a smooth cut surface with minimal splits or cracks in addition to minimizing cutting force and cutting energy consumption. **Rotating Cutting System** is used to cut thick stalks having greater resistance to cutting (maize, sorghum, sugarcane, elephant grass, bamboo, etc.).

Objective: To develop and evaluate performance of sugar cane harvester and cutter

2. MATERIALS AND METHODS

2.1. Experimental Site

Experiment will be conducted at W/shoa (Dandi Woreda) based on teff production potential on farmers farm field for trail in 2022/3 cropping season.

2.2. Materials used:

The following basic manufacturing machines, tools and instruments will be used:

- ✓ Sheet metal
- ✓ Engine
- ✓ Weighing balance
- ✓ Vernier caliper
- ✓ Lathe machine
- ✓ Fixed grinder
- ✓ Welding machines
- ✓ Drilling machine
- ✓ Milling machine

2.3. Method Design

An attempt was made to develop a workable procedure for designing the teff harvester and all the necessary components using CATIA V5R19 software.

2.4. Design Analysis and Calculation

Design Consideration: The major components of the machine include the cutter, shaft, belt and pulley and motor power.

2.5. Selection of pulley

The machine required two pulleys; one driving pulley were mounted on the crank shaft of the engine and the driven pulleys were mounted on cutter and harvester shaft. Pulleys made from cast iron with 0.25 m diameter for driving pulley and 0.12 m diameter for driven pulley were selected based on its availability, low cost and high performance. Based on the required revolution per minute, the diameter of driven pulley was determined according to Khurmi R.S. and Gupta J.K., (2013)

$$N_1 D_1 = N_2 D_2$$

where;

D_1 = diameter of the driver = 0.25 m
D_2 = diameter of the driven = 0.12 m
N_1 = speed of the driver = 3000 rpm
N_2 = speed of the driven = 1440 rpm,

2.6. Belt selection and determination of its length and center distance

V-belt and pulley arrangements were adopted in this work to transmit power from the engine to the shaft of cutter and harvester. The main reasons for adopting the v- belt drive was its flexibility, simplicity and low maintenance costs. Additionally, the v- belt has the ability to absorb shocks there by mitigating the effect of vibratory forces (Khurmi and Gupta, 2005). Appendix B Table 1 gives list of V-belts (A, B, C, D and E) and their standard dimensions and power carrying capacity. Length of the open belt was calculated according to

Khurmi and Gupta (2004) as given below:

$$Lp = 2C + \frac{\pi}{2}\left(Dp + dp\right) + \left(\frac{Dp + dp}{4C}\right)^2 \qquad (Equation\ \ 8)$$

$$2 \times 0.6 + \frac{\pi}{2}(0.12 + 0.25) + \frac{(0.12 + 0.25)^2}{4 \times 0.6} = 1.3m$$

where,

L_p= effective length of the belt, m
C = center distance, m

$$\frac{D_1 + D_2}{2} + D_1 \leq C \leq 2\left(D_1 + D_2\right)$$

$$0.43m \leq C \leq 0.75m$$

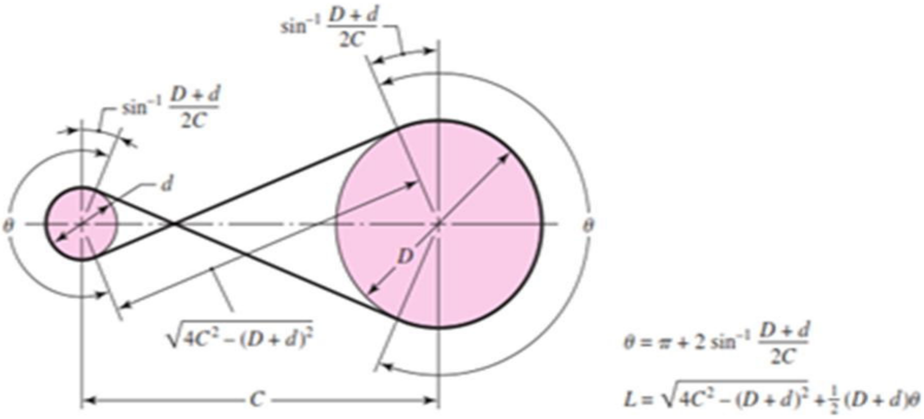

Fig.1. Crossed belt geometry

The closest standard length of the belt was selected from standard table and found to be 1.3 m (B 51 V-Belt) and C = 0.6m taken value.

2.7. Determination of belt contact angle

The belt contact angle was given by the following equation (Khurmi and Gupta, 2005).

$$\sin^{-1}\beta = \frac{R - r}{c},$$

$$\sin^{-1}\beta = \frac{0.125 - 0.06}{0.6}, \qquad \beta = 6.22^0$$

where;

R = radius of the larger pulley, m
r = radius of the smaller pulley, m

Wrap angle were determined using the equations given below.

$$\alpha_1 = 180 - 2\sin^{-1}\left(\frac{R - r}{c}\right)$$

$$= 180 - 2\sin^{-1}\left(0.1\right) = 167.56^0 = 2.92rad$$

$$\alpha_2 = 180 + 2\sin^{-1}\left(\frac{R - r}{c}\right)$$

$$= 180 + 2\sin^{-1}\left(0.268\right) = 192.43^0 = 3.35rad$$

where;

α_1= angle of wrap for the smaller pulley, rad.
α_2= angle of wrap for the larger pulley, rad.
C = center to center distance between small and large pulley, mm

2.8. Determination of power transmitted to the shaft

Power transmitted per belt to the shaft was determined according to Barber (2003).

$$V = \frac{\pi DN}{60} = \frac{\pi \times 0.12 \times 600}{60} = 3.77 m/s$$

$$P = (T_1 - T_2)V$$

$$7 = (T_1 - T_2) \times 3.77 m/s$$

$$1.86 = (T_1 - T_2)$$

2.9. Determination of the belt tension

The belt tension developed in the slack side was determined according to Barber (2003)

$$2.3 \log \frac{T_1}{T_2} = \frac{\mu \alpha_1}{\sin(\theta/2)}$$

$$\frac{T_1}{T_2} = e^{1.23} = 3.43,$$

$$T_1 = T_2 \times 3.43$$

$$P = 3.43T_2 - T_2$$

$$T_2 = 147.12N$$

$$T_1 = 3.43 \times 147.12 = 504.62N$$

$$T_r = R(T_1 - T_2)$$

$$T_r = 0.23(504.62 - 147.12) = 82.22Nm$$

where;

T_r = resultant torque
T_1 and T_2 = tension in tight and slack side of the belt, N
R = radius of the bigger pulley, m
θ = Groove angle = 34°
m = mass per unit length of belt, (kg/m),

$$m = bt\rho = 204 \times 10^{-6} m^2 \times 1140 kg/m^3 = 0.23 kg/m$$

= 0.42 (coefficient of friction between rubber belt and pulley, Khurma and Gupta, (2005)

Permissible angle of twist caused by torque on the shaft was determined according to the following equation.

$$\theta = \frac{584 RtL}{Gd^4} = \frac{0.123^0}{m} \qquad (Equation\ 16)$$

Where;

θ = angle of twist, in degree
M_t = torsional moment, Nm;
L = length of shaft = 0.55 m
G = modules of rigidity 84 × 10^9
d = diameter of shaft, m

Note that the maximum permissible angle of twist = 1°/m., hence the shaft with in safe limit. The calculated angle of twist was less than the permissible angle of twist (1°/m). Hence, torsional deflection was satisfied.

2.10. Determination of the harvester shaft diameter

The diameter of the main shaft for a solid shaft having little or no axial loading will be calculated according to (Khurmi and Gupta 2008).

Therefore, 20 mm shaft diameter was selected.

$$ds^3 = \frac{16}{\pi\tau}\sqrt{(K_b M_b)^2 + (K_t M_t)^2}, ds = 1.95mm$$

where,

ds = shaft diameter, m;
M_b = bending moment, Nm;
M_t = torsional moment, Nm;
Kb = Combined shock and fatigue factor applied to bending moment
Kt = Combined shock and fatigue factor applied to torsional moment
τ = Allowable shear stress of the shaft material, MN/m^2

The values of K_b and K_t were taken as 3 and 2 respectively for the suddenly applied load on the rotating shaft and the allowable shear stress of the shaft (τ) as 40 MN/m^2 based on American Society of Mechanical Engineers (ASME).

2.11. Ground wheel

Ground Wheel upward thrust pressure will be calculated according to equation below (Mahilang *et al.,* 2017).

$$Q = b\gamma\left[r^2\cos^{-1}\left(\frac{r-h}{r}\right) - r - h\sqrt{2rh-h}\right]$$

where,

Q = upward thrust in kg,
b = width of wheel (cm) and gamma is specific weight of soil
r = radius of wheel (cm) and
h = sinkage of wheel (cm).

2.12. Determination of cutting speed:

The Cutting process is a dynamic process; therefore, increasing the cutting velocity decreases initial compaction as a result of the material's inertia and plastic behavior whereby energy requirements are lowered.

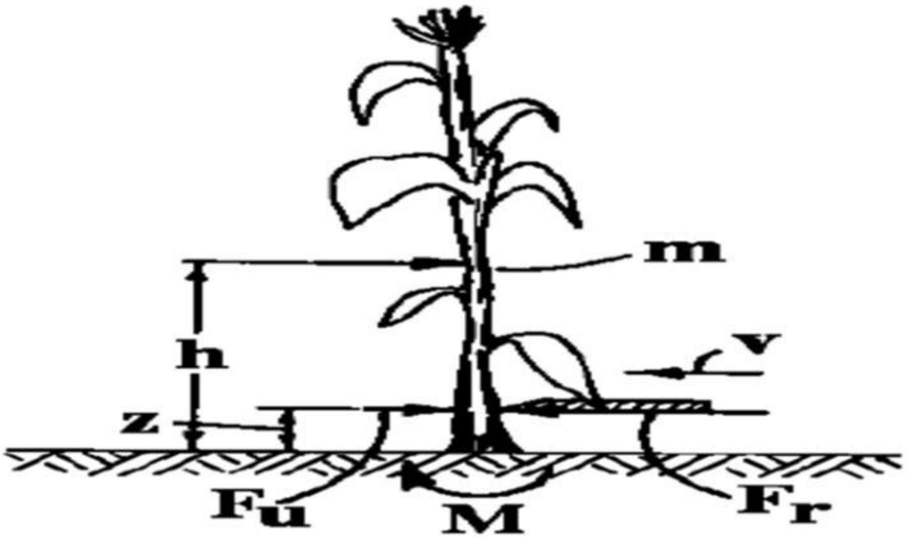

Fig. 2. Forces on stalk in impact cut (Persson, 1987)

The moment equilibrium can be written, using variables indicated in the figure above.

$$\sum M = 0 \qquad a = \frac{\Delta v}{t}$$
$$F_r \times z - F_u \times z - m \times a \times h = 0$$

Since the initial velocity of stalk is 0, it follows that: -

$$F_r \times z - F_u \times z - m \times \frac{v^2}{2d} \times h = 0$$
$$a = \frac{v}{t};\ v = \frac{2d}{t} \Rightarrow t = \frac{2d}{v} \Rightarrow a = \frac{v^2}{2d} = \frac{\left(\frac{1m}{s}\right)^2}{2 * 0.045m} = 11.11\frac{m}{s^2}$$

The minimum knife speed at impact cut can be calculated according to Persson (1987).

where $$v = \sqrt{(F_r - F_u)\frac{2zd}{mh}} = 3.77\frac{m}{s}$$

F_r = cutting force N;
F_u = average bending force at the point of deflection of stalk for value d, N;
z = height of the cutting level above ground, m;
h = height of stalk center of gravity above ground, m;
d = the approximate diameter of the stalk, m; and
m = the mass of stalk, kg

Determination of height of cut above the ground

The four different fields of sugarcane after harvesting operation were inspected for determining height of cut. Ten cut of stalks left after harvest in mechanical harvested was chosen randomly in different rows. Height of cuts was noted by placing the scale along the left over cut stalks in both mechanical and manual harvested fields. These heights of cuts of machine harvested fields were computed to evaluate its performance.

Determination of time taken to harvest

The harvesting operation was made to start in both mechanical and manual harvested fields and the time of start of harvest was noted using a stopwatch. Additionally, the machine operational time of single row was noted for about five rows and also the total time taken to harvest one hector is noted by using a stopwatch. The noted mechanical and manual time reading was compared to evaluate the harvester performance.

Determination of field capacity

Field capacity is the total area covered in an operation to the total time taken to complete the operation. The total area covered in each of the field trials was taken as one hector to make a standard. The total time taken to harvest is noted already during both mechanical and manual harvesting trials. The field capacity was obtained by dividing area covered in harvesting operation with the total time taken to harvest in both mechanical and manual trials.

Actual performance rate (Pr)

$Pr = Ha / Tc$
Where:
Ha = total harvested area,
Tc = total consumed time, h

Field efficiency (ηt):

$\eta t = \{(Th - Tu)/ Th \} * 100$
Where:
Th = total time for harvesting, h;
Tu = total un-productive time during harvesting, h.

Cutting efficiency: Average lengths of 100 plants from different 10 locations in the field during and after harvesting were measured to calculate cutting efficiency.

$\eta c = (hh / ht) * 100$
Where:
hh = average height of plant after cutting, cm ;
ht = average height of plant before cutting, cm.

Percentage breakage: Estimated by Counting from random locations.

$Pb = \{(Gy - Wg) \div Gy\} * 100$
Where:
Gy = total harvested
Wg= Number of breakage

Data management and statistical analysis

After the machine is developed primary test will be made at BAERC and necessary data will be collected on the field. The parameters to be considered during the test are speed of operation, actual performance rate, field efficiency, cutting efficiency, percentage breakage, fuel consumption, time taken to harvest, suitability to operate, feedback of operators, capacity to finish work within a given time. Collected data will be subjected to the statistical analysis according to the techniques of analysis of variance for split plot block design and then combined analysis will be done by means of Gen-stat computer software package.

3. Performance evaluation of the Prototype Machine

During the field test; speed of operation, actual performance rate and field efficiency were recorded as mentioned in table (1).

Table 1. Mean results of field test on theoretical field capacity (ha/hr), actual field capacity (ha/hr) and field efficiency (%)

Plot	Average cut height remain (mm)	Forward speed (km/hr)	Actual width of cut (mm)	Theoretical field capacity (ha/hr)	Actual field capacity (ha/hr)	Field efficiency (%)
A	50.74	1.90	600	1.14	0.54	47.37
B	50.49	2.20	600	1.32	0.68	51.52
C	60.01	2.45	600	1.47	0.85	57.78
Aver.	**50.75**	**2.18**	**600**	**1.31**	**0.69**	**52.67**

The average cut height (mm) remain on ground, Forward speed (km/hr), Actual width of cut (mm), Theoretical field capacity (ha/hr), Actual field capacity (ha/hr) and Field efficiency (%) were 50.75, 2.18, 600,1.31, 0.69 and 52.67 respectively.

In order to determine the effect of cutter bar of machine; angular speeds and sugar cane feed stoke on the performance of the prototype machine; fuel consumption (Fc), cutting efficiency (Ee), and cutting capacity (Cc) and uniformity of cut (Cu) were calculated respectively.

1. Cutting capacity

The mean cutting capacity and analysis of variance were presented in (Table 2). The statically analysis of ANOVA, clearly indicated that the cutting capacity of the prototype of sugar cane cuter was significantly ($P < 0.05$) affected by engine speed, sugarcane feed rate. The combined effect of engine speed and feed rate was also significant at the same level. The maximum cutting capacity of 1200.7 (stoke/h) was recorded when the engine speed was 400 rpm and the feed rate 3 (stoke/min).

Generally, cutting capacity increased by increasing the engine speed and feed rate. Refaay et al. (2016) showed the relationships between drum speed and machine productivity (ton/h) at different feed rates. Increasing the speed increased the product with increasing the treatments with direct relationships.

Table 2. Cutting capacity (Cc in (stoke/hr)) of sugarcane cutter at various engine speeds, feed rates.

Rpm	Fs(stoke/min)	Cc(stoke/hr)	Lower bound	Difference	Upper bound	Grand mean
300	1	400.0	-807.2	-800.7*	0.0	
	2	798.7	-408.5	-402.0*	0.0	
	3	1199.3	-8.2	-1.3	5.5	
400	1	400.7	-806.8	-800.0*	0.0	
	2	799.7	-407.8	-401.0*	0.0	
	3	1200.7	-5.5	1.3	8.2	**799.83**
Cv		**0.38**				

2. Cutting efficiency

The mean percent cutting efficiency of the prototype and analysis of variance are given in (Table 3). Analysis of variance revealed that engine speeds and feed stoke had significant ($p < 0.01$) effect on cutting efficiency. The effect of feed rate and the interaction of engine speed and feed rate were significant at 5% level. As can be seen from (Table 3), increase in the engine speed resulted in increased cutting efficiency. This could be due to the very fact that at higher engine speed the energy imparted to the sugarcane was high and hence causing high cutting efficiency. The maximum cutting efficiency 99.48% was observed when the machine was operated at velocity of 400 rpm and at feed rate of 2 (stoke/min); whereas the minimum cutting efficiency of 98.6% was observed when the machine speed was 400 rpm and feed rate 3 (stoke/min) as can be seen from Table 2.

Table 3. Cutting efficiency (%) of sugarcane cutter at various engine speeds, feed rates.

Rpm	Fs	Ee(%)	Lower bound	Difference	Upper bound	Grand mean
300	1	99.330	-0.828	-0.153	0.522	
	2	99.280	-0.878	-0.203	0.472	
	3	98.610	-1.548	-0.873*	0.000	
400	1	99.407	-0.338	-0.077	0.185	
	2	99.483	-0.185	0.077	0.338	
	3	98.600	-1.145	-0.883*	0.000	**99.118**
CV(%)		**0.12**				

3. Fuel consumption

The analysis of variance, on fuel consumption of the cutting machine revealed that engine speed and feed rate had highly significant ($P < 0.01$) effects on the fuel consumption of the prototype machine. In general, fuel consumption of the cutting machine increased with in increasing of engine speeds and increase with increasing of feed rates. The mean fuel consumption ranged from 100.33 to 124.33 ml/stoke with engine speed of 300 and 400 rpm and the feeding rate of 1, 2 and 3 stoke/min. It could be noticed that the lowest values of fuel consumption were obtained at engine speed (V) 300 rpm and feed rate (Fr) of 1 stoke/min, however the highest values of fuel consumption were obtained at engine speed (V) 400 rpm and feed rate (Fs) 3 stoke/min.

Table 4. Fuel consumption (ml/stoke) of sugarcane cutter at various engine speeds, feed rates.

Rpm	**Fs**	**Fc (ml/stoke)**	**Lower bound**	**Difference**	**Upper bound**	**Grand mean**
300	1	100.33	-31.51	-24.00*	0.00	
	2	102.00	-29.84	-22.33*	0.00	
	3	103.67	-28.17	-20.67*	0.00	
400	1	117.33	-8.49	-7.00*	0.00	
	2	120.00	-5.82	-4.33*	0.00	
	3	124.33	0.00	4.33	5.82	
						111.28
CV(%)		**0.62**				

4. Cutting uniformity

The mean percent cutting uniformity of the prototype and analysis of variance are given in (Table 5). Analysis of variance revealed that engine speeds and feed stoke had significant ($p < 0.01$) effect on cutting uniformity. The effect of feed rate and the interaction of engine speed were significant at 5% level. As can be seen from (Table 4), increase in the engine speed resulted in declined cutting efficiency. This could be due to the very fact that at higher engine speed the energy imparted to the sugarcane was high and hence causing disturbance for harmonic motion which leads to decline cutting uniformity. The maximum cutting uniformity 99.99% was observed when the machine was operated at velocity of 300 rpm and at feed rate of 1 (stoke/min); whereas the minimum cutting efficiency of 98.59% was observed when the machine speed was 400 rpm and feed rate 3 (stoke/min) as can be seen from Table 4.

Table 5. Cutting uniformity (%) of sugarcane cutter at various engine speeds, feed rates.

Rpm	**Fs**	**Cu (%)**	**Lower bound**	**Difference**	**Upper bound**	**Grand mean**
300	1	99.993	-0.936	0.047	1.030	
	2	99.647	-0.987	-0.347	0.294	
	3	98.520	-2.114	-1.473*	0.000	
400	1	99.947	-1.030	-0.047	0.936	
	2	99.593	-1.383	-0.400	0.583	
	3	98.593	-2.383	-1.400*	0.000	
						99.382
CV(%)		**0.30**				

4. Conclusion and Recommendations

Conclusion

Sugarcane is an important crop widely cultivated for multiple purposes by smallholder farmers in sub-Saharan Africa (SSA), including Ethiopia. Even if many households grew sugarcane in about 29,536.49 hectares of land in Oromia region it's harvested by conventional method. Harvesting is a process of cutting and gathering of mature crop from the field. Harvest laborers can easily fatigue due to excessive stress on the joints and muscles and are exposed to harmful pests from plantations, creating safety concerns. The advent of mechanical harvesting systems frees harvest laborers from the drudgery of field operations. Mechanical harvesting also makes green cane harvesting possible, which reduces Green House Gas emissions from pre-harvest burning necessitated by manual harvesting. Statically analysis of ANOVA indicated that the cutting capacity of the prototype of sugar cane cuter was significantly ($P < 0.05$) affected by engine speed, sugarcane feed rate. The maximum cutting capacity of 1200.7 (stoke/h) was recorded when the engine speed was 400 rpm and the feed rate 3 (stoke/min). Increase in the engine speed resulted in increased cutting efficiency. The maximum cutting efficiency 99.48% was observed when the machine was operated at velocity of 400 rpm and at feed rate of 2 (stoke/min); whereas the minimum cutting efficiency of 98.6% was observed when the machine speed was 400 rpm and feed rate 3 (stoke/min). Fuel consumption of the cutting machine increased with in increasing of engine speeds and increase with increasing of feed rates (from 100.33 to 124.33 ml/stoke with engine speed of 300 and 400 rpm and the feeding rate of 1, 2 and 3 stoke/min). Increase in the engine speed resulted in declined cutting efficiency. This could be due to the very fact that at higher engine speed the energy imparted to the sugarcane was high and hence causing disturbance for harmonic motion which leads to decline cutting uniformity. Maximum cutting uniformity 99.99% was observed when the machine was operated at velocity of 300 rpm and at feed rate of 1 (stoke/min); whereas the minimum cutting efficiency of 98.59% was observed when the machine speed was 400 rpm and feed rate 3 (stoke/min). The average cut height (mm) remain on ground, Forward speed (km/hr), Actual width of cut (mm), Theoretical field capacity (ha/hr), Actual field capacity (ha/hr) and Field efficiency (%) were 50.75, 2.18, 600,1.31, 0.69 and 52.67 respectively. Regarding to those, it can be concluded that the machine can be used and solve the problems of the farmers.

Recommendation

From obtained result the machine has a very good performance for cutting of sugarcane similar to performance result mentioned above. But, it can be more efficient if re-evaluated and extra work is done on it, particularly in harvesting of sugarcane.

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