Influence of Plane Blade Parameters on Cutting Energy of Sugarcane

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Abstract—*The harvesting of sugarcane is very difficult or hard, and double labours are required for cutting lower stalks and topping separately. Making the harvesting of sugarcane mechanized is a need of a day which will reduce the drudgery and save the time. Hence the study was under taken with the major objective i.e to determine cutting force of sugarcane stalk. The experimental material selected for the study was four different varieties Co-99004, Coc-671, Co-85004 and Co-86032. Rotary cutting mechanism was used for conducting trials. When the effect of single blade parameter with plane blade on lower portion of stalk was studied, the minimum force (0.708 N) was recorded at blade shear angle 25°, blade bevel angle 10°, (0.619 N) for the variety Co-85004 and minimum value of force observed at blade velocity 600 rpm, (0.617 N) for the variety Co-99004. Whereas the effect of single blade parameter with plane blade for cutting top portion of stalk revealed that the minimum force (0.563 N) was recorded at blade shear angle 25° for the variety Co-99004.In case of variety Co-85004,the minimum force was recorded at the blade bevel angle of 10° (0538 N) and blade velocity 650 rpm(0.509 N).*

Keywords*: Cutting force, bevel angle, shear angle, velocity*

1. INTRODUCTION

During the last ten years, India has been a net exporter of sugar. Maharashtra and the adjoining area of Karnataka, Gujarat and Andhra Pradesh record higher sugar recoveries. Average recoveries of Maharashtra and Gujarat are highest in the country. The harvesting of sugarcane is very difficult or hard, and double labours are required for cutting lower stalks and topping separately. The operation is time consuming and involves drudgery also. Making the harvesting of sugarcane mechanized is a need of a day which will reduce the drudgery and save the time. Hence the study was under taken with the major objective i.e to determine cutting force of sugarcane stalk.This data will be useful for design and development of cutting mechanism for harvesting sugarcane.

2. MATERIAL AND METHODS

The experimental material selected for the study was four different varieties Co-99004, Coc-671, Co-85004 and Co-86032 of sugarcane planted in the year 2013 on the experimental field at from Sugarcane Research Unit, Central Research Station, Dr. P. D. K. V, Akola. Stalks of physiologically matured and having different diameter sugarcane plants were selected.

Rotary cutting mechanism was used for estimation of the force required to cut sugarcane stalks at lower and top sections in the laboratory. The set up is equipped with a rotary disc, cutting blades, central shaft, torque sensor, electric motor and variable frequency drive (plate 1and 2) The cutting torque for sugarcane stalks was measured in the laboratory

measured in the laboratory

Plate 1 Cutting blades of different angles

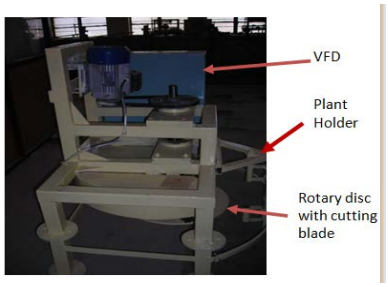

Plate 2 Experimental Set up

Variables for the study

The independent variables were four sugarcane varieties (Co-99004, Coc-671, Co-85004 and Co-86032), and straight plane blade were used. For blade shear angle two levels were used i.e. 25° and 30° and two levels of blade bevel angles were (10° and 15°) for straight plane blade (25° and 35°) and three levels of blade velocity were used i.e. 550rpm, 600rpm, and

650rpm. The dependent variable was cutting force. The experiments were replicated thrice and the results were analysed by using Factorized completely randomized design (FCRD).

3. RESULTS AND DISCUSSION

Cutting lower section of stalk with Plane blade

Effect of Blade shear angle

Table 1 Effect of blade shear angle on force for cutting stalk

Sr. No.	Blade shear angle, degree	Force, N			
		Variety			
		Co-99004	Coc-671	Co-85004	Co-86032
1	25	0.737	0.904	0.708	0.983
2	30	0.868	0.910	0.947	1.021
F-test		NS	NS	S	NS
SE(m)+		0.090	0.173	0.083	0.234
CD (5%)		1.143	2.198	1.054	2.973

S-significant, NS-non significant

From Table 1, it is revealed that the minimum value of force (0.708 N) for cutting sugarcane stalk was observed at blade shear angle 25° for the variety Co-85004 while the maximum value (1.021 N) was observed at blade shear angle of 30º for variety Co-86032. However, non-significant difference amongst the value of force as an effect of blade shear angle was observed in all variety except in variety Co-85004 having significant difference

Ghaharai *et.al.* (2011) reported that increasing shear angle from 25º to 30º led to an increase in cutting force. The results obtained are at par with the stated reviews.

Effect of blade bevel angle

Table 2 Effect of blade shear angle on force for cutting stalk

Sr. No.	Blade bevel angle, degree	Force, N			
		Variety			
		Co-99004	Coc-671	Co-85004	Co-86032
1	10	0.746	0.720	0.619	0.863
2	15	0.860	1.095	1.036	1.141
F-test		NS	NS	S	NS
SE(m)+		0.090	0.173	0.083	0.234
CD (5%)		1.143	2.198	1.054	2.973

S-significant, NS-non significant

From Table 2 revealed that the minimum value of force (0.619 N) for cutting sugarcane stalk was observed at blade bevel angle of 10° for the variety Co-85004 while the maximum value (1.141 N) was observed at blade bevel angle of 15° for variety Co-86032. However, Non-significant difference among the value of force as an effect of blade bevel angle was observed in each variety except in variety Co-85004 having significant difference. This may happen due to structural heterogeneity of the stalks.

Effect of blade velocity

The results of effect of three levels of velocity i.e. 550 rpm, 600 rpm and 650 rpm are given in the fig.1.

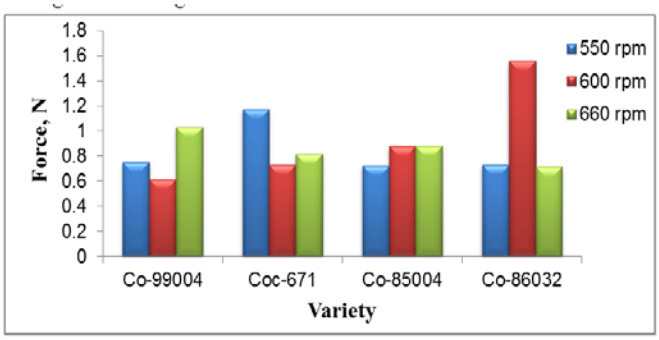

Fig. 1: Effect of blade velocity on force for cutting stalk

When the effect of three levels of velocity was studied for the variety Co-99004, it is observed that the force decreases when there is increase in velocity from 550 to 600 rpm and then significantly increases with further increase in velocity to 650 rpm. Same trend of force was observed for the variety Coc-671 whereas reverse trend of force was observed for the velocity Co-86032. When the variety Co-85004 was considered for experimentation, the force value increases non-significantly with increase in velocity to 600 rpm and the force values obtained at velocity 600 to 650 rpm had non-significant difference. This may be due to the variation in size, maturity and moisture content of the stalks (Chancellor 1958). Person, 1987 also reported that the species related material features which would be expected to influence the maximum cutting force are ultimate tensile strength of the fibre, stiffness of the fibre, thickness of the strong fibre and structure of the stem.

From all three parameter we observed that force increases with increasing shear angle and same at bevel angle but force was minimum at 600 rpm velocity.

Cutting top section of stalks with plane blade

Effect of blade shear angle

It describes the effect of shear angle 25° and 30° on force for cutting top section of stalks of sugarcane varieties.

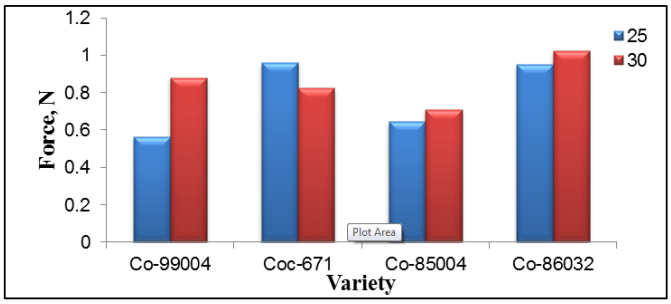

Fig. 2 Effect of blade shear angle on force for cutting top section of stalk

The Fig.2 shows that the force for cutting sugarcane stalk increase with increase in blade shear angle from 25° to 30° for selected three varieties Co-99004, Co-85004, Co-86032. But only in variety Coc-671 the force for cutting top section of sugarcane stalks decrease with increase in blade shear angle from 25° to 30°. This may due to variation in the size, maturity and moisture content of the stalks (Chancellor 1958).

Effect of blade bevel angle

It describes the effect of bevel angle 10° and 15° on force for cutting top section of stalks of sugarcane varieties.

Table 3 Effect of blade bevel angle on force for cutting stalk

Sr. No	Blade bevel angle, degree	Force, N			
		Variety			
		Co-99004	Coc-671	Co-85004	Co-86032
1	**10**	0.669	0.656	0.538	0.831
2	**15**	0.773	1.129	0.817	1.141
F-test		**NS**	**S**	**S**	**NS**
SE(m)+		0.087	0.186	0.057	0.206
CD (5%)		1.105	2.363	0.724	2.617

S-significant, NS-non significant

From Table 3, it is revealed that the minimum value of force (0.538 N) for cutting top section of sugarcane stalk was observed at blade bevel angle 10° for the variety Co-85004 while the maximum value (1.141 N) was observed at blade bevel angle 15° for variety Co-86032. However, significant difference amongst the value of force as an effect of blade bevel angle was observed in the varieties Coc-671 and Co-85004 whereas non-significant difference for the varieties Co-99004 and Co-86032. This may happen due to structural heterogeneity of the stalks.

Effect of blade velocity

The results of effect of three levels of velocity i.e. 550 rpm, 600 rpm and 650 rpm are given in the Table 2.

Table 4: Effect of blade velocity on force for cutting stalk

Sr. No	Blade velocity, rpm	Force, N			
		Variety			
		Co-99004	Coc-671	Co-85004	Co-86032
1	**550**	0.686	1.253	0.653	0.672
2	**600**	0.641	0.821	0.871	1.418
3	**650**	0.86	0.604	0.509	0.868
F-test		**NS**	**NS**	**S**	**NS**
SE(m)+		0.106	0.227	0.069	0252
CD (5%)		0.456	0.976	0.296	1.084

S-significant, NS-non-significant

From Table 4 represent the effect of blade velocities on force for cutting top section of sugarcane top using plane blade. The analysis of data shows significant difference amongst the values of force for the variety Co-85004 whereas non-significant difference amongst the values of force was observed for the varieties Co-99004, Coc-671 and Co-86032. The minimum value of force (0.604 N) for cutting top section of sugarcane stalk was observed at velocity of 600 for the variety Coc-671 while the maximum value (1.418 N) was observed at the velocity of 600 rpm for variety Co-86032. At higher velocity, the kinetic energy imparted by the impact is just wasted because more energy is transmitted to separate the parts of the stalk after cutting (Prasad and Gupta, 1975).

4. CONCLUSIONS

1. When the effect of single blade parameter with plane blade was studied, for cutting lower section of stalk it was observed that the minimum force (0.708 N) was recorded at blade shear angle 25°, blade bevel angle 10°, (0.619 N) for the variety Co-85004 and the minimum value of force was observed at blade velocity 600 rpm, (0.617 N) for the variety Co-99004.
2. In case of cutting top section of stalk the minimum force (0.563 N) was recorded at blade shear angle 25° for the variety Co-99004.In case of variety Co-85004,the minimum force was recorded at the blade bevel angle of 10° (0538 N) and blade velocity 650 rpm(0.509 N).
3. When the effect of single blade parameter with plane blade was studied, then cutting force increases with increasing in shear angle expect in variety Coc-671 in which cutting force decreases with increase in shear angle.
4. The minimum value of force observed at blade bevel angle 10° for the variety Co-85004 and at velocity 650 rpm for variety Coc-671 by using plane blade.

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