Effect of Blade Parameters on Force for Cutting Sorghum Stalk

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ABSTRACT

Cutting of stalks is an important process in sorghum harvesting. The study was aimed to develop cutting mechanism for harvesting Sorghum. The experiments were conducted to determine force for cutting stalks at different combinations of blade parameters. The minimum value of force (1.75 N) for cutting sorghum stalk was observed at bevel angle of 45˚ for the variety CSH-9 while the maximum value (7.69 N) was observed at bevel angle of 35˚ for variety CSV-20. The minimum value of force (1.79 N) for cutting sorghum stalk was observed at blade shear angle of 35˚ for the variety CSH-9 while the maximum value (7.39 N) was observed at blade shear angle of 25˚ for variety CSV-20. The force for cutting sorghum stalk decreases with decrease in blade rake angle from 20˚ to 0˚ for selected three varieties. The force was maximum at 350rpm for cutting stalks of variety CSV-20 and obtained minimum for CSH-9. Similar trend was also obtained as an effect of blade velocity of 500 and 650rpm.

Keywords: Bevel angle, Shear angle, Rake angle, torque sensor

1. INTRODUCTION

The India covers 34 % of the total Sorghum area in the world and produces around 17 % of the world production of sorghum grain per annum. It is being cultivated in Maharashtra for both grain and fodder during *kharif* (area 13.84 lakh ha) and *rabi* (area 30.17 lakh ha). Harvesting operation is achieved by four different actions, i)Slicing action with a sharp smooth edge; ii)Tearing action with a rough, serreted edge; iii)High velocity single element impact with sharp or dull edge and iv) A two element scissors type action.

The present practice of harvesting is carried out using a mannually operated sickle. Generally manual harvesting involves slicing and tearing actions that result in plant structure failure due to compression, tension or shear. The total harvesting of Sorghum requires two stages cutting of plant, one at the top for separating cobs and second at the bottom for fodder. Hence double labour is required for harvesting of this crop and about 25% of the total labour for grain production is consumed by harvesting operation alone.In case of hybrid Jowar when the crop attains maturity, the stand is erect and the cobs at the top of the plant are nearly at uniform height.

This genetic factor is favourable for introducing a mechanical harvesting device. Thus mechanized harvesting of Sorghum is a need of a day which will reduce the drudgery and save the time. Also it will be the solution for labour problem. Hence the present study was aimed to develop cutting mechanism for harvesting Sorghum.

2. MATERIALS AND METHODS

The experimental material selected for the study was three different varieties CSV-20, CSV-23 and CSH-9 of sorghum planted in the year 2012 on the experimental field at Western Block of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Stalks of physiologically matured sorghum plants were selected and the experiments were conducted to determine cutting force of stalks at different combinations of blade parameters.

Moisture content : The moisture content of the sorghum stalk was measured according to ASAE Standard S.352 (ASAE Year Book 1979).

Stalk diameter

The Sorghum stalk diameter was determined with the help of a slide calliper having a least count of 0.01mm. Three repeated measurements were taken for upper, middle and lower sections to get average value.

Experimental Techniques

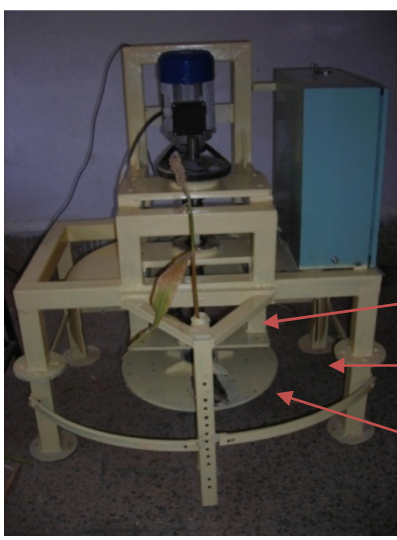
The laboratory set up of cutting mechanism was developed to measure force required for cutting sorghum stalks of three selected varieties at different combinations of various blade parameters such as blade bevel angle; shear angle; rake angle and blade velocity (Plate 1). The plane blade having dimensions 230 X 60 X 10 mm was used for the experiment. Different parameters selected for the study are described herewith as follows.

Parameters selected for the study:

Independent variables:		I) Varieties – 3 (CSV-20, CSV-23 & CSH-9)
		II)Blade bevel angles – 3 levels (25º, 35º, 45º)
		III) Blade shear angles – 3 levels (25º, 30º, 35º)
		IV) Blade rake angles – 3 levels (20º, 0º, -20º)
		VI) Blade velocity – 3 levels (350, 500, 650 rpm)
Dependent variables :		Peak force
Replications	:	3
Design	:	CRD

The developed laboratory set up of cutting mechanism had different components such as central shaft, rotating disc, torque sensor, electric motor with variable frequency drive (VFD) etc. Rotating disc was mounted on central shaft at lower end for cutting stalks. The blades were fitted on the rotating disc with different shear angle and rake angle sims according to the treatment combinations. Torque sensor was mounted on the central shaft in between rotating disc and middle bearing. Torque sensor was used to measure the cutting torque (Plate 2). The power for operating set up was supplied by electric motor and the speed of rotation was varied with the help of variable frequency drive.

The samples for investigations were collected at random. The stalks of an average equal diameter were selected for the experimentation. The experiment was planned on the same day to avoid the fluctuation in the moisture content of the stalk. Before starting the trials, the diameter of the Sorghum stalks were measured at three different points and was averaged and the moisture content was also determined. The samples of three varieties of sorghum stalks were hold in the stalk holder and the disc was rotated at three different speeds selected for study. The torque observations were noted for each speed separately from the excel sheet data of torque sensor. The trials were repeated thrice for different treatments selected for study.



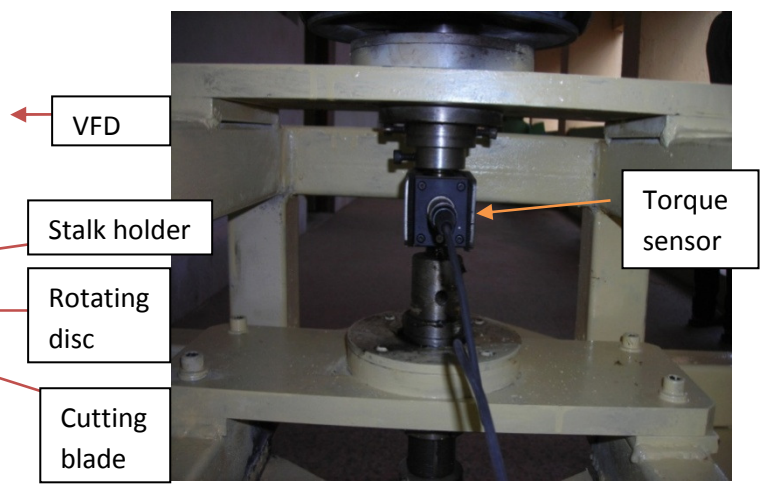


Plate 1 Laboratory set up of cutting mechanism Plate 2 Torque sensor

3. RESULTS AND DISCUSSION

The effect of each parameter i.e.blade bevel angle, blade shear angle, blade rake angle and blade velocity on force for cutting sorghum stalk of three selected varieties are tabulated in the following tables.

Effect of blade bevel angle

Table 1 Effect of blade bevel angle on force for cutting stalk of three sorghum varieties

Sr.No.	Bevel angle, (º)	Force, N		
		CSV-20	CSV-23	CSH-9
1	25	3.94	3.27	1.84
2	35	7.69	4.57	3.11
3	45	3.14	2.89	1.75
	F-test	S	S	S
	SE(m)+	0.554	0.108	0.042
	CD (5%)	2.384	0.465	0.181

The table reveled that the minimum value of force (1.75 N) for cutting sorghum stalk was observed at bevel angle 45˚ for the variety CSH-9 while the maximum value (7.69 N) was observed at bevel angle 35˚ for variety CSV-20. However, significant difference amongst the value of force as an effect of blade bevel angle was observed in each selected variety. Fig 1 (a) shows that the force for cutting sorghum stalk increases with increase in blade bevel angle from 25 to 35º and decrease with further increase in blade bevel angle from 35 to 45º for selected all thee varieties. When the effect of blade bevel angle on each variety was compared, it was found that the force for cutting stalk was maximum for variety CSV-20 and significantly decreases for variety CSV-23. The minimum values of force for cutting stalk were observed for the variety CSH-9 for all three levels of blade bevel angle.

Effect of blade shear angle

The table 2 reveled that the minimum value of force (1.79 N) for cutting sorghum stalk was observed at blade shear angle 35˚ for the variety CSH-9 while the maximum value (7.39 N) was observed at blade shear angle 25˚ for variety CSV-20. However, significant difference amongst the value of force as an effect of blade shear angle was observed in each selected variety. The data revealed that the force for cutting sorghum stalk decreases with increase in blade shear angle 25˚ to 35˚ for selected three varieties (Fig 1b). When the effect of blade shear angle 25˚ was studied with respect to sorghum varieties, it was found that the maximum value of force obtained for variety CSV-20 whereas minimum was obtained for the variety CSH-9. The similar trend of force was observed with blade shear angle 30˚ and 35˚.

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

Sr.No.	Shear angle, (º)	Force, N		
		CSV-20	CSV-23	CSH-9
1	25	7.39	4.28	2.93
2	30	4.79	3.62	1.99
3	35	2.60	2.83	1.79
	F-test	S	S	S
	SE(m)+	0.554	0.108	0.042
	CD (5%)	2.384	0.465	0.181

Effect of blade rake angle

Table 3 Effect of blade rake angle on force for cutting stalk of three sorghum varieties

Sr.No.	Rake angle (º)	Force, N		
		CSV-20	CSV-23	CSH-9
1	20	8.82	5.02	3.44
2	0	2.45	2.34	1.49
3	-20	3.50	3.37	1.78
	F-test	S	S	S
	SE(m)+	0.554	0.108	0.042
	CD (5%)	2.384	0.465	0.181

The table 3 shows the effect of blade rake angles, 20˚, 0˚ and -20˚ on force for cutting sorghum stalk using plane blade.The minimum value of force (1.49 N) for cutting sorghum stalk was observed at rake angle 0˚ for the variety CSH-9 while the maximum value (8.82 N) was observed at rake angle 20˚ for variety CSV-20. However, the difference amongst the value of force as an effect of blade rake angle was observed significant in each selected variety. The data revealed that the force for cutting sorghum stalk decreases with decrease in blade rake angle from 20˚ to 0˚ for selected three varieties. When the effect of blade rake angle -20˚ was studied with respect to sorghum varieties, it was found that the maximum value of force obtained for variety CSV-20 whereas minimum was obtained for the variety CSH-9 (Fig 1c). The similar trend of force was observed with blade rake angle 20˚ and 0˚.

Effect of blade velocity

The table represents the effect of blade velocities, 350, 500 and 650 rpm on force for cutting sorghum stalk using plane blade. The analysis of data shows significant difference amongst the

values of force for the variety CSV-23 whereas non significant difference amongst the values of force was observed for the varieties CSV-20, and CSH-9. The minimum value of force (2.19 N) for cutting sorghum stalk was observed at velocity of 650 for the variety CSH-9 while the maximum value (5.15N) was observed at the velocity of 350rpm for variety CSV-20. It was observed from the data that the value of force decreases with increase in blade velocity for variety CSV-20. When the effect of blade velocity was tested for cutting stalk of variety CSV-23, the force obtained was maximum at 500rpm and decreases with decrease or increase in blade velocity. From the Fig 1(d) it was observed that the force was maximum at 350rpm for cutting stalks of variety CSV-20 and obtained minimum for CSH-9. Similar trend was also obtained as an effect of blade velocity of 500 and 650rpm.

Table 4 Effect of blade velocity on force for cutting stalk of three sorghum varieties

Sr.No.	Velocity(rpm)	Force, N		
		CSV-20	CSV-23	CSH-9
1	350	5.15	2.94	2.20
2	500	5.01	4.02	2.33
3	650	4.61	3.76	2.19
	F-test	NS	S	NS
	SE(m)+	0.554	0.108	0.042
	CD (5%)	2.384	0.465	0.181

4. CONCLUSIONS

1. The minimum values of force for cutting stalk were observed for the variety CSH-9 for all three levels of blade bevel angle.
2. The force for cutting sorghum stalk decreases with increase in blade shear angle from 25˚ to 35˚ for selected three varieties.
3. The variety CSH-9 required minimum values of force for cutting stalk for all three levels of rake angles.
4. At all levels of velocity, the force was maximum for cutting stalks of variety CSV-20 and obtained minimum for CSH-9

5. REFERENCES

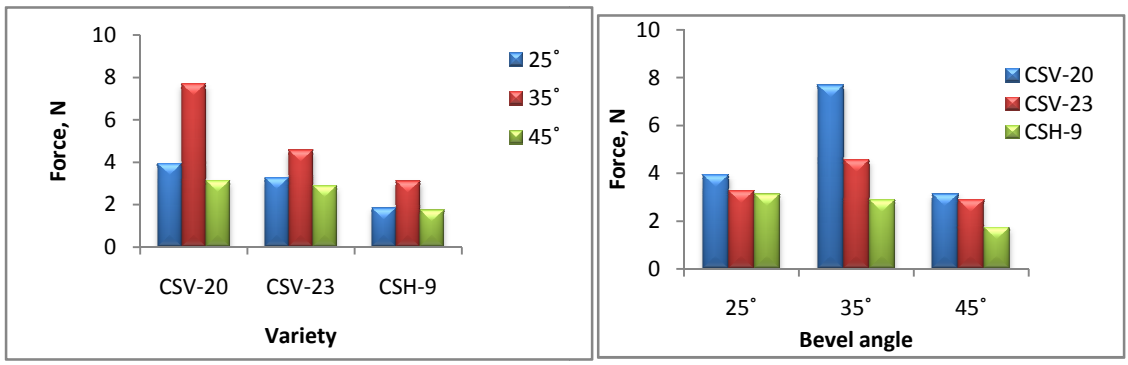
[1] ASAE, (1979). Agricultural Engineering Handbook of Standards. American Society of Agricultural Engineers, St.Joseph, Michigan, USA.

[2] Chattopadhyay PS and KP Pandey (2001). Impact cutting behaviour of Sorghum stalk using a flail-cutter— A mathematical model and its experimental verification. J.Agril.Engg. Res., Vol. 78(1):369-376.

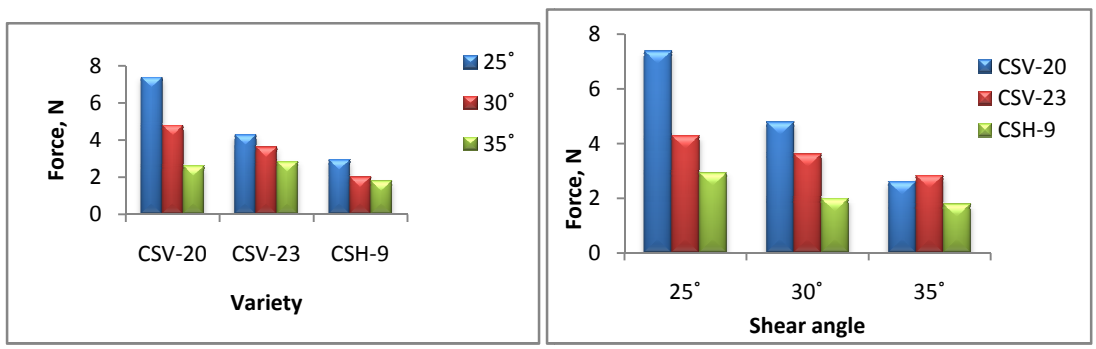
[3] Ghahraei, O.D.; Ahmad, A.; Khalina, H. Suryanto and J. Othman, 2011. Cutting tests of Kenaf stems. Transactions of ASABE. 54(1): 51-56.

[4] Ige, M.T. and M. F. Finner[c], 1976. Forage harvester knife response to cutting force. Transactions of ASAE.Vol. 19 (3): 451-454.

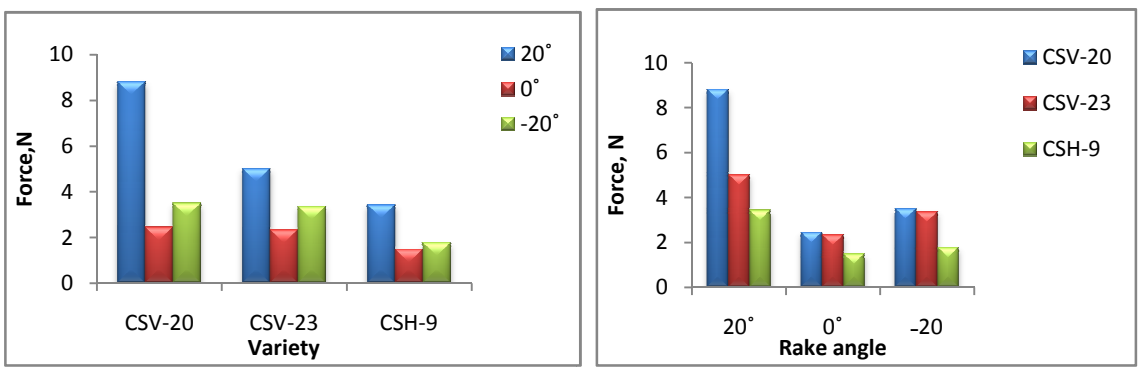
[5] Moroe G.E. and H. R. Sumner, 1985. A Harvesting and handling system for sweet Sorghum. Transactions ASAE, Vol. 28: 562-567 & 570.



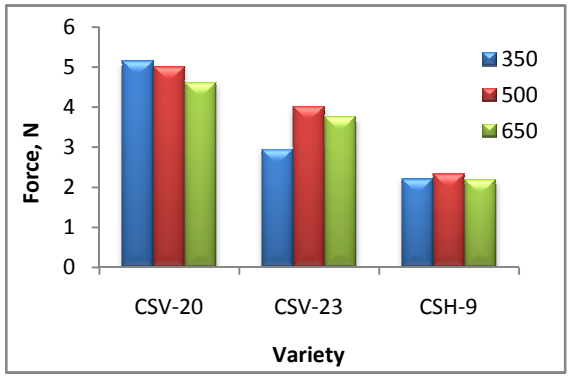
a) Blade bevel angle

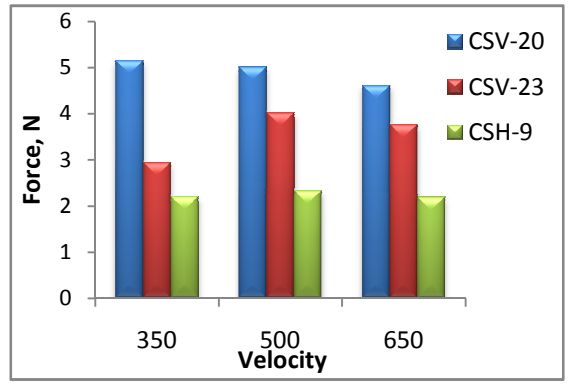


b) Blade shear angle



c) Blade rake angle





d) Blade velocity

Fig.1 Effect of blade parameters on cutting force of three Sorghum varieties