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Original Research Article

Performance Evaluation of Sugarcane Cleaner-cum-Washer for Jaggery Production

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A B S T R A C T

Jaggery (*Gur*) is one of the important products of sugarcane in India. For quality jaggery making, sugarcane needs to be cleaned before crushing. A sugarcane cleaner-cum-washer (SC-c-W) has been developed at ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow for cleaning and washing of sugarcane prior to crushing for jaggery making. The unit consists of six rollers; two feed rollers having rubber flaps for gripping and cane feeding and four scrapping rollers (02 sets of 02 rollers each) having steel wire brush for removal of impurities sticking to sugarcane stalks. Washing arrangement has also been provided at two places. The unit was evaluated for best performance. For this, three combinations of roller speed were evaluated. It was found that the best combination of roller set was that in which upper rollers moved with 50.63 and 75.95 rpm and lower rollers moved with 60 and 90 rpm in 1st and 2nd set respectively. It was due to differential speed of rollers which gave best rubbing and scrapping action. Maximum capacity (613.61 kg/h) was also obtained with this combination with three canes feeding in single pass. Maximum 4.338g impurity removal increases with number of cane feeding at a time and maximum-0.769g impurity removal increases with number of passes from roller I to III. SC-c-W, when used with washer, appeared giving very good results based on visual observation of cleaned canes. The developed machine may also be useful for sugarcane juice vendors.

Keywords

Sugarcane, sugarcane cleaner-cum-washer, jaggery, sugarcane juice

Introduction

Sugarcane (*Saccharum officinarum*) is a giant grass belonging to the family Graminae. The Sanskrit word 'SARKARA', from which the word 'SACCHARUM' has been derived also indicates the antiquity knowledge of sugarcane in India (Lakshmikantham, 1983). It has five species *viz. S. officinarum*, *S. barberi*, *S. sinense*, *S. robustum*, *S. Elude* and *S. spontaneum* of which the first three are cultivated and others are wild. The sugarcane plant is composed of four principal parts *viz.*, the leaf, the stalk, the root system and the flower (Verma, 2004).

Major sugarcane producing states in India are Uttar Pradesh, Karnataka, Tamil Nadu, Maharashtra, Bihar and Andhra Pradesh. It is grown in about 5 million hectare of land producing about 350 millions of sugarcane annually. It is used for making sweeteners like sugar, jaggery (*gur*) and *khandsari*.

The word *'Gur'* exists in the Sanskrit language which is enough to show that it has been made in India from the times immemorial.

It is known by many different names; '*gur*' or jaggery in India and Pakistan, *'Rapadura'* in Brazil, *'Chancaca'* in Chile and Peru, *'Panela'* in Colombia, Ecuador, Guatemala and other Central American countries, *'Panela'* or *'Piloncillo'* in Mexico, and 'Papelón' or *'Panela'* in Venezuela (Guerra and Mujica, 2009).

Hundred gram of jaggery contains sucrose (65-85g) and invert sugars (3-15g). Besides carbohydrates, it also contains important minerals *viz.* Calcium (40-100 mg), Magnesium (70-90 mg), Potassium (1056 mg), Phosphorus (20-90 mg), Sodium (19-30 mg), Iron (10-13 mg), Manganese (0.2-0.5 mg), Zinc (0.2-0.4 mg), Copper (0.1-0.9 mg), and Chloride (5.3 mg).Vitamins are present in jaggery (Vitamin A-3.8 mg, Vitamin B1-0.01 mg, Vitamin B2- 0.06 mg, Vitamin B5-0.01 mg, Vitamin B6-0.01 mg, Vitamin C-7.00 mg, Vitamin D2-6.50 mg, Vitamin E-111.30 mg, Vitamin PP-7.00 mg, and protein-280 mg per 100 g of jaggery, which can be made available to the masses to mitigate the problems of mal nutrition and under nutrition (Singh *et al.*, 2013).

There are lots of impurities sticking to sugarcane stalk like trash, dust, roots, wax, gum, dry leaves, soil particles, chlorophyll and other colour compounds *etc*. In jaggery making, mostly sugarcane is crushed directly and all these unwanted materials go into the sugarcane juice. Although sugarcane juice clarification is performed using vegetative clarificants; yet it is advisable to clean cane prior to crushing.

ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow has developed a "Sugarcane cleaner-cum-washer (SC-c-W)" for cleaning of sugarcane prior to crushing so that impurities sticking to sugarcane stalk are removed. This machine needed to be evaluated for its performance in terms of quantity of impurities removed, speed of rollers, capacity of machine (number of cane feeding at a time) *etc*.

Materials and Methods

The present study was conducted on a sugarcane cleaner-cum-washer (SC-c-W) developed at ICAR-Indian Institute of Sugarcane Research, Lucknow (U.P.).

Description of machine

The machine consists of six rollers. Two feed rollers having rubber flaps for gripping and cane feeding and four scrapping rollers (two sets of two rollers each) having steel wire brush for scrapping of impurities have been provided. The size of upper and lower feed rollers is 30 cm x 88 cm (L x D) and 30 cm x 56.8 cm respectively whereas the size of scrapping rollers is 30 cm x 57 cm. Upper and lower rollers move in opposite direction thus giving forward movement to the cane. Steel wire brush (40 mm length, 1.5 mm thickness) have been provided on scrapping rollers for scrapping of impurities from the surface of cane stalk. The wire has enough flexibility to remove canes without damaging. These rollers are mounted on 40 mm angle iron frame. Suitable power transmission arrangement has been provided in terms of gear box, spur gears, chain-

sprocket *etc*. for transmitting power from motor (1 h.p., 1425 rpm) to different components. The speed and direction of movement of all the rollers are mentioned in table 1.

A washing unit with water pump (0.50 h.p., 2780 rpm self-priming moonset pump-Crompton Greaves Ltd. Co.) and water spray arrangement is used for washing of canes. The whole machine is shown in Figure 1 and 2.

Materials and Methods

Change of speed of different scrapping rollers

Speed of scrapping rollers was changed using different combinations of chain-sprocket system. Three speed combinations (roller sets) were used. In the first and second combination speed sets, sprocket with 54 teeth and 64 teeth was fixed respectively.

Existing system was taken as the third combination where all the scrapping rollers moved with different speed. Speed and direction of rollers in all the roller sets are given in table 2.

Sugarcane cleaning in sugarcane cleaner-cum- washer

In this experiment, three samples each of single cane, two canes and three canes were taken for all selected combinations of roller sets. These canes were cleaned in sugarcane cleaner-cum-washer in single, two and three passes and time of operation was recorded for each case. The removed impurities were weighed each time. These canes were subjected to crushing and the juice thus obtained was analyzed for colour values. Later on jaggery was prepared from juice obtained from uncleaned, manually cleaned and sugarcane cleaned with sugarcane cleaner-cum-washer and colour values, density and hardness were compared.

Results and Discussion

Sugarcane cleaning by sugarcane cleaner-cum-washer

Effect of roller set on impurity removal

Effect of roller sets on impurity removal for single pass for single, two and three cane feeding is shown Figure 3. It may be observed from Figure 3 that maximum impurity was removed in case of roller set III and minimum with roller set I. Impurity removal also increased with increase in number of cane feeding due to more resistance provided by canes.

Effect of roller set on capacity of SC-c-W

Effect of roller set on capacity of SC-c-W for all the cases of cane feeding and single pass is shown in Figure 4.

It may be observed from Figure 4 that capacity increased with number of cane feeding. With different roller sets it ranged from 124.61 kg/h to 615.32 kg/h. Capacity of SC-c-W in roller set I was found to be 124.61, 290 and 409.69 kg/h for single, two and three canes respectively. In roller set II, it was found to be 179.73, 383.99 and 548.58 kg/h while in roller set III, it was 190.18, 389.89 and 615.32 kg/h in all the case of cane feeding.

Effect of number of passes on impurity removal

Effect of no. of passes on impurity removal for all the cases of roller sets for single cane feeding is shown in Figure 5

It may be observed from above figure that impurities removal is deceases with number

of passes with all the roller sets. This is due to the fact that available impurities reduces with number of passes *i.e.* once impurities are removed in a pass less impurities are available for subsequent passes for further removal.

Fig.1 and 2 Sugarcane cleaner-cum-washer

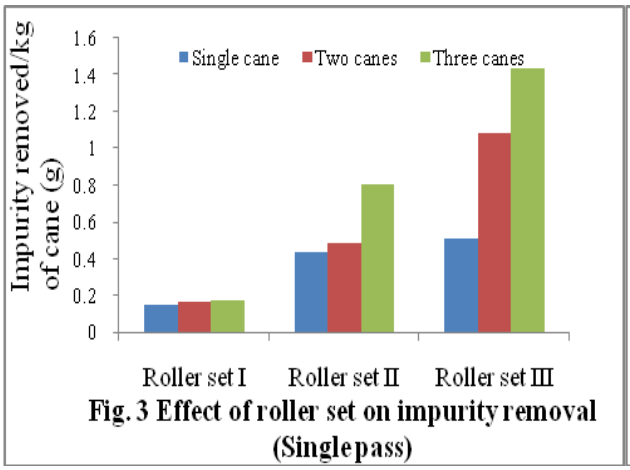

Fig. 3 Effect of roller set on impurity removal (Single pass)

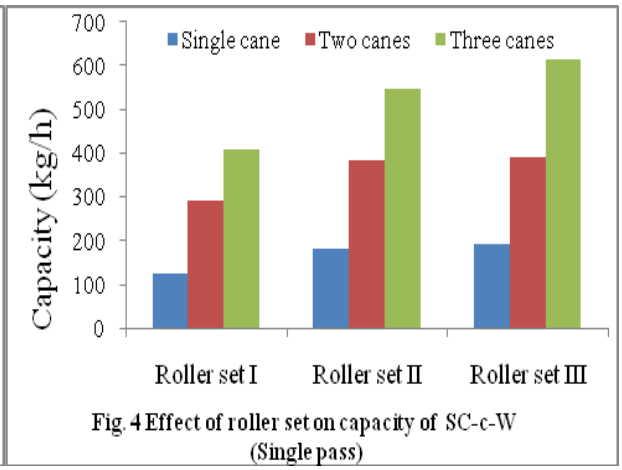

Fig. 4 Effect of roller set on capacity of SC-c-W (Single pass)

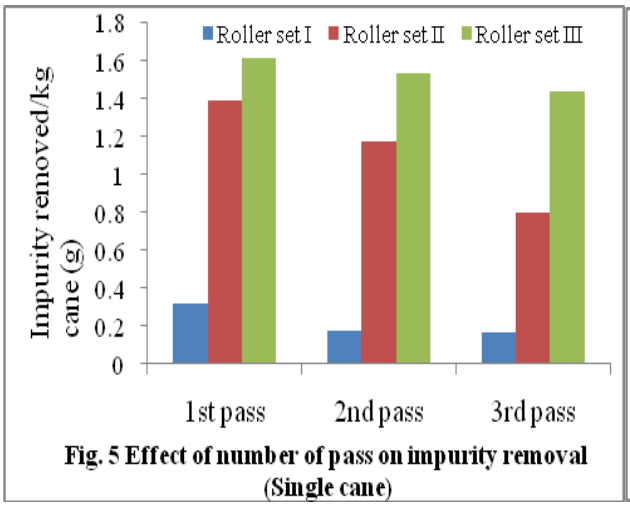

Fig. 5 Effect of number of pass on impurity removal (Single cane)

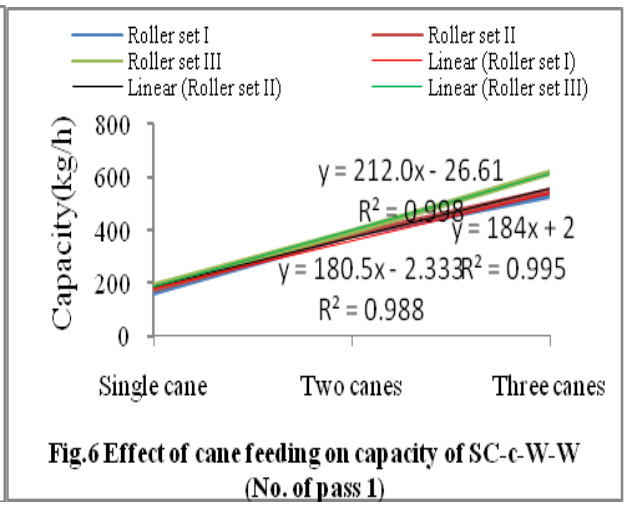

Fig.6 Effect of cane feeding on capacity of SC-c-W-W (No. of pass 1)

Table.1 Speed and direction of movement of rollers of SC-c-W

Speed of motor	Direction of rollers		Speed of feed rollers (rpm)		Speed of 1st set of scrapping rollers (rpm)		Speed of 2nd set of scrapping rollers (rpm)	
1425rpm	Upper	Forward	Upper	15	Upper	50.63	Upper	75.95
	Lower	Backward	Lower	15	Lower	60	Lower	90

Table.2 Speed and direction of rollers in different roller sets

Roller set	Position of rollers	Direction of rollers	Speed of feed rollers (rpm)	Speed of 1st set of scrapping rollers (rpm)	Speed of 2nd set of scrapping rollers (rpm)
I	Upper	Forward	15	50.63	75.95
	Lower	Backward	15	50.63	75.95
II	Upper	Forward	15	60	90
	Lower	Backward	15	60	90
III	Upper	Forward	15	50.63	75.95
	Lower	Backward	15	60	90

Effect of cane feeding on capacity of SC-c-W

Effect of cane feeding on capacity of SC-c-W for single pass is shown in figure 6. The capacity increases with number of cane feeding due to obvious reasons. Roller set III resulted in maximum capacity followed by roller set II and I.

Conclusion

Sugarcane is a major cash crop of India, which is used for making sugar jaggery and *khandsari*. Quality of jaggery largely depends on the cleaning and clarification process in jaggery production. There are many impurities sticking to sugarcane stalks, which go into juice when sugarcane is not cleaned prior to crushing. To ease out this operation, ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow has developed a 'sugarcane cleaner-cum-washer'. Roller speed combination III, where all scrapping rollers move with different speed (upper-50.63 & 75.95 and lower-60 & 90), is the best from impurity removal point of view. The capacity of machine matches with normal sugarcane crushers being used by jaggery manufacturers. Better results may be achieved with more speed of rollers in III roller sets combination. Maximum capacity of cleaner-cum-washer 615.32 with three canes (3rd pass) could be achieved with above roller speed combination with three-cane feeding. Maximum capacity (613.61 kg/h) was also obtained with this combination with three canes feeding in single pass. Maximum 4.338g impurity removal increases with number of cane feeding at a time and maximum-0.769g impurity removal increases with number of passes from roller I to III. The machine may be useful for large scale juice extraction for juice sale purpose.

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