Project ID 748

Competitive Research Grant

Sub-Project Completion Report

on

Design and development of efficient and low cost sugarcane power crusher for goor production

Project Duration

April 2017 to September 2018

Agricultural Engineering Division
Bangladesh Sugarcrop Research Institute
Ishurdi-6620, Pabna

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

September 2018

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(Back page of inner cover page)

Citation
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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

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New Airport Road, Farmgate, Dhaka – 1215
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Published in: September 2018

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Acronyms

BARC: Bangladesh Sugarcrop Research Institute

BSRI: Bangladesh Sugarcrop Research Institute

CSO: Chief Scientific Officer

hp: Horse Power

hr: hours

kg/hr: Kilogram per hour

kg: Kilogram

kw: Kilowatt

max: Maximum

MS: Mild steel

PCR: Project Completion Report

PIU: Project Implementation Unit

PP: Project Proposal

rpm: Rotation per minute

SS: Stainless steel

SSO: Senior Scientific Officer

tk: Taka

w: watt

yr : Year

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Executive Summary

In Bangladesh, sugarcane is the main source of sugar and goor. Goor making is one of the important cottage industries in Bangladesh. Goor forms an important component of Bangladeshi diet. About 53% of total produced cane is used for goor production. Crusher machine is only tools and technology for juice extraction. At present, juice extraction capacity of sugarcane crusher is around 40- 45% of cane weight. Due to low extraction capacity of crusher, processing loss is high. A study was conducted to increase juice extraction rate and crushing capacity by less power consumption. For achieving the targets, a 10.5 hp diesel engine, five numbers of rollers having 4 inch diameter were used to develop a power crusher. For improving feeding, chevron groove was introduced to the cutting roller and Knurling operation was done on other rollers for improving crushing capacity as well as feeding also. Central pressing roller had been fixed up with collar at both sides of roller for jamming free operation. Other pressing rollers were run within this collar made by 10 mm MS plate. A semi automated lubricating system was added to the machine. Several parts of the crusher can be easily dismantled, hence it can be carried easily to long distances and any remote areas of Bangladesh. BSRI Akh 39, BSRI Akh 42, BSRI Akh 43, BSRI Akh 45 and Madhumala were selected for crushing purposes to evaluate the performance of this BSRI power crusher. It was found that the juice extraction capacity was 55-60% for BSRI Akh 39, BSRI Akh 43 and BSRI Akh 45 and those were 62-68% for BSRI Akh 42 and Madhumala respectively. Feeding capacity was found 300-370 kg/hr. About 10-20% processing loss could be reduced by using this improved BSRI power crusher. Production cost of goor was 35 Tk/kg using developed modern crusher instead of 46 Tk/kg in existing system. Benefit cost ratio (BCR) were 1.75 and 1.32 for BSRI power crusher and conventional crusher respectively.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project**: Design and Development of Efficient and Low Cost Sugarcane Power Crusher for Goor Production.

2. **Implementing organization**: Bangladesh Sugarcrop Research Institute.

3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

Principal Investigator : Sayed Shams Tabriz
Senior Scientific Officer & PI (08.05.17-19.04.18)
Agricultural Engineering Division
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Co-Principal Investigator: Md. Sanowar Hossen
Scientific Officer & Co-PI (08.05.17-19.04.18)
PI (20.04.18-30.09.18)
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Ishurdi-6620, Pabna.
Phone: +8801719000812.
Email: sanowar@bsri.gov.bd

Co-Principal Investigator: Md. Rokonuzzaman
Maintenance Engineer & Co-PI (20.04.18-30.09.18)
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Ishurdi-6620, Pabna.
Phone: +8801723748938.
Email: rokon.me@gmail.com

4. **Sub-project budget (Tk)**: 27, 90,000/-

4.1 Total: 27, 90,000/-

4.2 Revised (if any): 26,10,568/-

5. Duration of the sub-project:

5.1 Start date (based on LoA signed): 08.05.2017

5.2 End date: 30 September 2018

6. Justification of undertaking the sub-project:

In Bangladesh, sugarcane is the main crop grown for processing of sugar. At present, the cultivated area under sugarcane is about 0.17 million ha which is used to meet the sugar demand of the country. The estimated demand is about 2.1 million ton (13 kg/capita/yr. for 160 million population). But Bangladesh produces about 0.1 million ton of sugar and 0.6 million ton of goor

annually where, deficit is 1.4 million ton of sugar and or goor (Anon, 2013). To meet up this deficit of sugar and or goor either we have to increase our production per unit area or have to increase our production area. To increase production area is almost impossible due to decreasing of agricultural land at 1% per year (Mondal, 2010).

Goor making is one of the important cottage industries in Bangladesh. Goor forms an important component of Bangladeshi diet and is consumed by human directly or for sweetening food items. About 53% of total produced cane in the country is used for goor production and total cane cultivation area coverage in non mill zone is about 50% (Anon, 2014). In spite of large scale production of goor, the technology used still remains crude and old, which results in low production efficiency. Farmers are always thinking about marketing facilities of produced product prior to cultivate the crop. Crusher machine is only tools and technology through which sugarcane is processed for goor production in non mill zones areas.

At present, juice extraction capacity of sugarcane crusher is around 40-45% of cane weight where prime mover is a 12 hp diesel engine having two pressing rollers with 14 inch diameter and one cutting roller with 5 inch diameter in vertical arrangement. On the other hand due to some mechanical short falls sometimes the crusher becomes jam. Due to low extraction capacity of crusher, processing loss is high. So to keep remaining the area under sugarcane especially in non mill zone area, development and dissemination of a suitable, efficient and modern crusher machine among the goor producers is utmost need.

7. **Sub-project goal**: Hygienic goor production as well as farmer's livelihood improvement.

8. **Sub-project objective (s):**

i) Design and development of sugarcane crusher for efficient juice extraction;
ii) Development of a low cost sugarcane crusher;
iii) Reducing process loss of goor production.

9. Implementing location (s): BSRI Agricultural Engineering Workshop, Agricultural Machineries manufacturing workshops in Dhaka, Bogra, Sylhet, Faridpur and Chuadanga were used for manufacturing and BSRI regional station (Gazipur) and Sub-stations (Khagrachari, Bandarban, rahamatpur and chunarughat) were used for testing.

10. **Methodology in brief:**

A Sugarcane power crusher was designed considering several shortfall and trouble. On the basis of design, crusher was fabricated. In the developed crusher machine five (5) rollers were used and the diameter of each roller was 4 inch. In this crusher sugarcane was crushed in three stages. One chevron grooved roller was used to cut cane and make it easy for feeding to the crushing rollers. Another four rollers were used for pressing. Two callers were fixed at both ends of the central roller and two pressing rollers moves between those callers. This system made feeding laminar and protects the machine from side jamming. A 10.5 hp diesel engine was the power source of this crusher which supplied power to gear box by bell-pulley system. There were four stages spur gear and pinion gear box, used for transmission of power to the rollers to reach required 18 rpm.

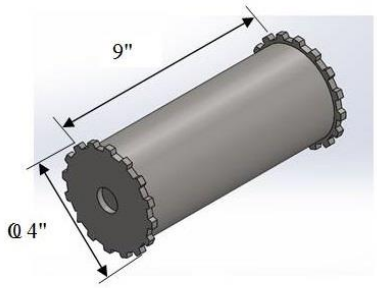

Figure-1: Design of roller

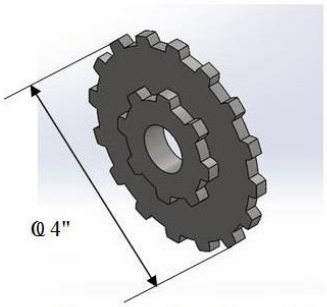

Figure-2: Design of gear pinium

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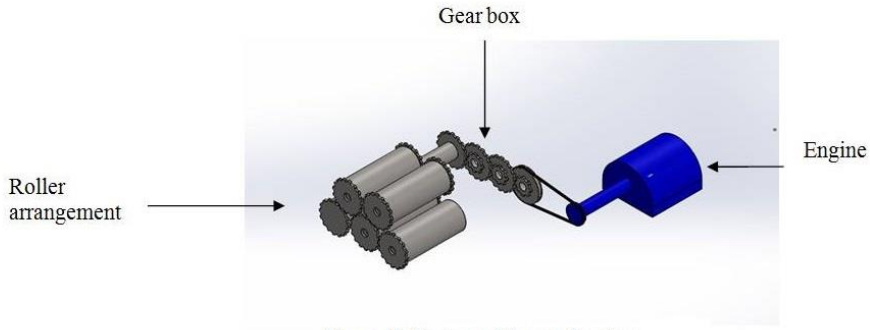

Figure-3: Design of Power Crusher

efficiency of crusher = 90 %

input power = $\frac{output}{efficiency} = \frac{9.05}{0.90}$ =10.05 hp

For gear design,

whole depth: 18 mm, working depth: 16 mm, face width: 35 mm,

pitch circle, Pc = $\frac{\pi D}{T} = \frac{\pi \times 0.1016}{32}$ = .025 m = 25 mm

For belt pulley design,

Speed, $\frac{N1}{N2} = \frac{D2}{D1}$, $N_2 = \frac{130 \times 2200}{400}$ = 715 rpm

gear ratio: 40:1

Component	Specification
Diesel Engine:	Power: 10.5 hp, rpm: 2200 (Bhp-10) water cooling system,
Roller	Number of rollers: 05 (Pressing roller: 04 nos, Cutting roller: 01 nos)
Pressing roller	10 mm thickness, Φ100 mm and length 225 of carbon steel hollow shaft (bush pipe) attached with Φ50 mm and length 650 mm carbon steel shaft at 4 points by using 19 mm MS plate.
Cutting roller	Φ90 mm and length 200 mm carbon steel solid shaft with bearing shaft of 700 mm length and Φ50 mm having circumferential and chevron grooved.
Collar (15 mm)	Central roller has been fixed up with collar at both ends of roller. Other pressing roller will run within this collar made by 15 mm MS plate.
Roller pinion	All gear- pinions are carbon steel metal and spur gear type. Total pinion : 08 (Circular thickness: 12.5 mm, circular pitch: 25 mm, whole depth: 18 mm, working depth: 16 mm, face width: 50 mm, tooth space: 25 mm, Thickness of rim: 23 Top land : 5 mm
Power Transmission system	1st: Bell pulley system : (Diameter of driving pulley: 130 mm, 2 step, diameter of driven pulley: 400 mm, 2 step) 2nd: Strong gear box (16 hp) consists of spur gear, made of carbon steel metal which enclosed by cover made of 10 mm MS plate. Gear ratio: 40:1, 3 step
Cost of fabrication	2.50 lakh Taka

final speed $= \frac{715}{40} = 17.88 \sim 18$ rpm

Pic.-1: Sugarcane Power crusher

Pic.-2: Sugarcane Crushing capacity test at Bandarban

Pic.-3: Sugarcane Crushing capacity test at BSRI

11. **Results and discussion**:

Different types of crusher had been tested at BSRI Head quarter and Bandarban sub-station of BSRI to justify the crushing capacity of machine. The performance of crushers are given bellow:

Table-1: Performance report of BSRI developed sugarcane power crusher for goor variety

; Sl. No.	Cane variety	Net wet of Sugarcane (kg)	Time Required to crush (hr)	Wet of extracted juice (kg)	Crushing Capacity/ Feeding Capacity (kg/hr)	Juice extraction rate (%) of cane weight	Fuel consumption (L/hr)
01	BSRI Akh 39, BSRI Akh 43 & BSRI Akh 45	416	1.15	235	**333**	**56.69**	0.670
02		502	1.25	279	**355**	**55.57**	0.847
03		415	1.15	238	**332**	**57.34**	0.750
04		450	1.20	269	**338**	**59.77**	0.782
05		444	1.15	268	**355**	**60.36**	0.725

Table-2: Performance report of BSRI developed sugarcane power crusher for chewing variety

Sl. No.	cane variety	Net wet of Sugarcane (kg)	Time Required to crush (hr)	Wet of extracted juice (kg)	Crushing Capacity/ Feeding Capacity (kg/hr)	Juice extraction rate (%) of cane weight	Fuel consumption (L/hr)
01	Modhumala	400	1.05	252	**370**	**63.0**	0.60
02		530	1.30	329	**353**	**62.07**	0.855
03		415	1.10	263.5	**356**	**63.5**	0.730
04	BSRI AKh 42	220	0.35	146	**325**	**66.36**	0.55
05		150	0.20	102	**320**	**68.00**	0.25

Juice extraction capacity of BSRI developed power crusher was 55%-60% of cane weight for variety BSRI Akh 39,43,45 and 62-68 % of cane weight for chewing cane(variety BSRI Akh 42 and Modhumala), where 40-45% of cane weight was extracted by conventional crusher. Sugarcane crushing capacity was about 300-370 kg/hr by BSRI power crusher which was 250-300 kg/hr capacity of conventional crusher. For improving feeding, chevron groove was introduced to the cutting roller and Knurling operation was done on other rollers for improving crushing capacity as well as feeding also. The bagasse quality was more suitable because of less fuel consumption than conventional one. Several parts of the crusher can be easily dismantled hence it can be carried easily to long distances and any remote areas of Bangladesh. Fuel consumption is less, so carbon emission will be minimized. Unclean sugarcane made jamming inside rollers which reduced capacity and serious jamming causes trouble.

Production cost of goor by BSRI power crusher machine:

Fixed cost =(Crusher machine + Chula + pan + shed) depreciation cost

Crusher depreciation cost = $\frac{Cost-salvage\ value}{Usefull\ life}$ = $\frac{250000-50000}{10}$ = $\frac{200000}{10}$ = 20,000 Tk/yr

Let, depreciation cost of (Chula + pan + shed) = 10,000 Tk/yr

Running time per year = 120 days

So fixed cost = 20,000 + 10,000 = 30,000 Tk/yr = 250 Tk/ day

Running time of crusher = 8 hr/day

Variable cost =(Cane price + fuel cost + labor cost + maintenance cost) Tk, = (3200×3.25 + 500 + 2000 + 40) = 12940 Tk/day

So total cost = fixed cost + variable cost = 250 + 12940 = 13190 Tk

Benefit = Return = amount of goor = amount of juice obtain × brix rate

Amount of juice obtain = cane weight × juice extraction rate = 3200 × 0.60 = 1920 kg

So return = amount of juice obtain × brix rate = 1920 × .20 = 384 kg

Production cost of goor by new developed crusher machine = $\frac{13190}{384}$ = 34.44 ~ 35 Tk/kg

let, sales Price of goor = 60 Tk/kg

Value of goor = 396.8 ×60 = 23040 tk

So Benefit cost ratio = $\frac{23040}{13190}$ = 1.75

Payback period:

benefit by per kg goor = (60 – 35) = 25 Tk/ kg

benefit per day = 25 ×384 = 9600 Tk/day

payback period = $\frac{250,000}{9600}$ = 26.04~ 26 days

Production cost of goor by conventional crusher machine:

Crusher depreciation cost = $\frac{Cost-salvage\ value}{Usefull\ life}$ = $\frac{150000-30000}{8}$ = $\frac{130000}{8}$ = 16,250 Tk/yr

So fixed cost : 16250 + 10,000 = 26,250 Tk/yr = 219 Tk/ day

So total cost = 219 +12940 = 13159 Tk

Benefit = Return = amount of goor = amount of juice obtain × brix rate

Amount of juice obtain = cane weight × juice extraction rate = 3200 × 0.45= 1440 kg

So return = amount of juice obtain × brix rate = 1440 × .20 = 288 kg

Prodaction cost of goor by new developed crusher machine = $\frac{13159}{288}$ = 45.70~ 46 Tk/kg

Suppose, market Price of goor = 60 Tk/kg

Value of goor = 288 ×60 = 17280 Tk

So Benefit cost ratio = $\frac{17280}{13159}$ = 1.31

Pay back period:

benefit by per kg goor = (60 – 46) = 14 Tk/ kg

benefit per day = 14 ×288 = 4032 Tk/day

payback period = $\frac{150,000}{4032}$ = 37.20~ 38 days

Table-3: **Cost comparison of goor production between BSRI power crusher and conventional crusher:**

item	BSRI power crusher	Conventional power crusher
Production cost (tk/kg)	35	46
Benefit cost ratio	1.75	1.32
Payback period (days)	26	38

12. Research highlight/findings (Bullet point – max 10 nos.):

i) Juice Extraction capacity was 55%-68%
ii) Sugarcane crushing rate was 300-370 kg/hr
iii) Length of bagasse is larger than conventional crusher, was suitable for burning.
iv) Fuel consumption rate of engine (10 .5 hp) was comparatively less than conventional crusher engine (12 hp).
v) Weight and size was comparatively smaller and it made easy transportation.
vi) Operation was more reliable
vii) Machine durability was longer

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment					
Laptop	1	60,000/-	1	60,000/-	
Desktop Computer	1	60,000/-	1	60,000/-	
Digital Camera	1	25,000/-	1	25,000/-	
Laser Printer	1	20,000/-	1	20,000/-	
Toolbox	2	17,500/-	2	17,500/-	
UPS (offline)	1	10,000/-	1	10,000/-	
Executive Table	1	20,000/-	1	20,000/-	
Executive Chair	1	10,000/-	1	10,000/-	
Computer Table	1	5,000/-	1	5,000/-	
Computer Chair	1	3,5,00/-	1	3,5,00/-	
File Cabinet	1	20,000/-	1	20,000/-	
Scanner	1	10,000/-	1	10,000/-	
(b) Lab &field equipment					
Refractometer	1	25,000/-	1	25,000/-	
Digital Balance	1	25,000/-	1	25,000/-	

2. Establishment/renovation facilities: N/A

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: N/A

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig. in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	177075	177075	177075		100.0	
B. Field research/lab expenses and supplies	1813825	1813825	1813825		100.0	
C. Operating expenses	240538	240538	240538		100.0	
D. Vehicle hire and fuel, oil & maintenance	85000	85000	85000		100.0	
E. Training/workshop/seminar etc.	-	-	-	-	0.0	
F. Publications and printing	0	0	0		0.00	
G. Miscellaneous	15660	15660	15660		100.0	
H. Capital expenses	278470	278470	278470		100.0	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	**Major technical activities performed in respect of the set objectives**	**Output(i.e. product obtained, visible, measurable)**	**Outcome(short term effect of the research)**
Design and development of sugarcane crusher for efficient juice extraction	i)Required power was determined by trial and error method ii) Rollers diameter was minimized to reduce dead load iii) Three steps crushing was included to increase crushing efficiency iv) Chevron groove was introduce in cutting roller	i) 10.5 hp power source was sufficient for this crusher. ii) Dead load of crusher was reduced iii) Crushing efficiency was increased iv) Feeding was easy	i) Juice Extraction capacity was 55%-68% ii) Sugarcane crushing rate was 300-370 kg/hr
Development of a low cost sugarcane crusher	i)Seven KW diesel engine was used ii) Rollers diameter was only 4 inch iii) 4 inch diameter spur gear and pinion was used	i)Price and fuel consumption rate was reduced. ii) Roller weight was sufficiently reduced iii) Power transmission system get much simpler.	i)Price of diesel engine was minimized. ii) roller cost reduced
Reducing process loss of goor production	I)Steps of crushing was increased Perforating net and Stainless steel tray ware included ii) Scraper and brush were included	i)Juice Extraction rate was increased ii) Clean Juice was received ii) bagasse was longer	i) Juice extraction rate about 10-15% was increased. ii)length of bagasse is larger than conventional crusher, was suitable for burning iii) Juice was clean

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication			
Information development			
Other publications, if any			

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

A sugarcane power crusher has developed having 55-68% juice extraction capacity which is 10-20% more than the conventional crusher.

ii. **Generation of new knowledge that help in developing more technology in future**

a) Juice extraction capacity can increase using less power by well designed crusher.
b) Roller number, size, weight, position and RPM are important factor for efficient crusher
c) Trained operator is important for efficient operation of the machine.

iii. Technology transferred that help increased agricultural productivity and farmers' income

BSRI developed power crusher is already trialed in Bandarban and Khagrachari. Where it was successfully tested. In future this crusher will be introduced in all regions of Bangladesh. As a result, the agricultural productivity and farmer's income will be increased.

iv. Policy Support

To popularize this crusher among farmers and entrepreneurs a subsidy program from the govt is necessary.

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring[description & output of consultation meeting, monitoring workshops/seminars etc.):

a) Comparative study of four Sugarcane Power Crusher models.
b) Percentage of juice extraction from different crusher and different varieties (BSRI Akh 39, BSRI Akh 42, BSRI Akh 43, BSRI Akh 45 and Modhumala) of sugarcane.
c) Cost analysis of sugarcane power crusher should be included in the report

ii) Field Monitoring (time& No. of visit, Team visit and output):

a) Internal Monitoring:

Name of visitor(s)	Designation	Date(s) of visit	Total visit till date (No.)
Dr. Md. Saidur Rahman	Chief Scientific Officer (CSO)	17.01.2018 13.02.2018 26.02.2018	03
Md. Shamsul Arefin	Senior Scientific Officer (SSO)	17.01.2018 13.02.2018 26.02.2018	03
Dr. Md. Rahimul Alam	Senior Scientific Officer (SSO)	1701.2018	03

		13.02.2018 26.02.2018	

b) External Monitoring:

Name of visitor(s)	Designation	Date(s) of visit	Total visit till date (No.)
Md. Abdur Rahaman	Monitoring Associate, PIU-BARC	08.03.2017	01
Dipok Kumar	Monitoring Associate, PIU-BARC	08.03.2017	01

H. Lesson Learned/Challenges (if any)

i) Rollers diameter and size was less responsible for juice extraction rate
ii) Jamming chance was eliminated by using caller
iii) Juice extraction rate was increased by increasing crushing stages.

I. Challenges (if any)

i. It was difficult to increase simultaneously juice extraction rate as well as crushing capacity.
ii. Fully jam free running condition achieved
iii. To reduce manufacturing cost of quality crusher.

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal