Development of a Cost Effective Two Wheel Tractor Mounted Mobile Maize Sheller for Small Farmers in Bangladesh

M. Israil Hossain, T. P. Tiwari, Ashrafuzzaman Gulandaz, Nusrat Jahan

Abstract—Two-wheel tractor (power tiller) is a common tillage tool in Bangladesh agriculture for easy access in fragmented land with affordable price of small farmers. Traditional maize sheller needs to be carried from place to place by hooking with two-wheel tractor (2WT) and set up again for shelling operation which takes longer time for preparation of maize shelling. The mobile maize sheller eliminates the transportation problem and can start shelling operation instantly any place as it is attached together with 2WT. It is counterclockwise rotating cylinder, axial flow type sheller, and grain separated with a frictional force between spike tooth and concave. The maize sheller is attached with nuts and bolts in front of the engine base of 2WT. The operating power of the sheller comes from the fly wheel of the engine of the tractor through 'V' belt pulley arrangement. The average shelling capacity of the mobile sheller is 2.0 t/hr, broken kernel 2.2%, and shelling efficiency 97%. The average maize shelling cost is Tk. 0.22/kg and traditional custom hire rate is Tk.1.0/kg, respectively (1 US$=Tk.78.0). The service provider of the 2WT can transport the mobile maize sheller long distance in operator's seating position. The manufacturers started the fabrication of mobile maize sheller. This mobile maize sheller is also compatible for the other countries where 2WT is available for farming operation.

Keywords—Cost effective, mobile maize sheller, maize shelling capacity, small farmers, two-wheel tractor.

I. INTRODUCTION

MAIZE is the third most important cereal crop in Bangladesh after rice and wheat. It is now considered as a secure cereal crop. At present, maize growing area, maize production, and average yield of maize are 0.35 mha, 2.36 mton, and 6.65 t/ha, respectively [1]. The demand of maize is increasing as this is used for poultry and fish feed purposes. Currently, farmers are getting 2-3 times higher financial advantages in *rabi* season maize compared to wheat and *Boro* rice production. Maize demand is high, but local production can meet only 40% which is about 1.2 million ton per year.

Early 1990s, maize is not a popular crop among the farmers due to its usages and shelling constraints. During that period, there were no mechanical maize shellers in Bangladesh and female workers engaged in maize shelling, which was very tedious task and human drudgery. Farmers were not willing to

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cultivate maize considering the shelling problem and constraint. Some of non-governmental organizations (NGOs) tried to introduce maize in the farmer's field, but it did not success. That time, Agricultural Engineering Division of Bangladesh Agricultural Research Institute (BARI) developed a tubular type mechanical small device for maize shelling by hand which helps farmers to some extent, but it was not accepted by the farmers [2]. Later on, BARI developed hand maize sheller which is very convenient to use, and this is accepted by the farmers. Still this hand sheller is popular among the small individual maize farmers. Department of Agricultural Extension (DAE) and progressive farmers reported that farmer's expectation is a higher capacity power maize sheller which can reduce shelling cost and can finish job within a short period of time. Considering the circumstances and farmers feedback, in 1993, Farm Machinery & Postharvest Process Engineering Division of BARI developed power maize sheller whose capacity is 3-4 ton/hr [3]. During that period, BARI Power Maize Sheller was demonstrated in the different farmer's field of Debigonj, Dinajpur, Bogra, Gazipur, Pabna. Looking the effective performance of the sheller, JK Industries, Mohamadpur, Dhaka (1993-94) took the leading manufacturing of the BARI maize sheller and started sell to the farmers. Later on (1995-6), BRAC initiated mega project on maize promotion all over the country and provided BARI maize sheller to the progressive farmers through regional BRAC office. Now, there are several hundreds of local manufacturers fabricating BARI power maize sheller with their own name in different districts of Bangladesh. The manufacturers are given the maize sheller name such as – Uttaran model, Sarker model, Farida model etc. BARI maize sheller changes the maze farming system, creates opportunity custom hire business, facilitates farmers taking crop planning decision, and increases farmers income.

At present, it is visualized that transportation of maize sheller from place to place is a problem. It needs additional carrier to move the sheller or another van to pull it for placing sheller at the farmers' home yard. The service providers of maize sheller ask for extra cost, time, energy arranging the maize shelling environment at farm level. To consider this transportation problem and to overcome this constraint, a small cost effective mobile maize sheller has to be developed, which is mounted on front side of the two-wheel tractor (2WT). So, the driver of the 2WT can carry and move the sheller along with the 2WT driving position. The engine of

World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:11, No:5, 2017

2WT is to be used as power source for operating the maize sheller.

The specific objectives of this study were:

i) To develop a low cost 2WT mounted mobile maize sheller;
ii) To test and expand the maize sheller both on station and in the farmers' field;
iii) To compare the cost of shelling maize with traditional shelling method.

II. MATERIALS AND METHOD

A low cost simple 2WT (power tiller) front mounted spike tooth type mobile maize sheller has been developed in Farm Machinery & Postharvest Process Engineering Division of BARI, Gazipur, 2015 with a view to easy way shelling maize in the farmers' field of rural areas and eliminating botheration of transportation of traditional maize sheller from place to place. The main components of the sheller are hopper, rotating cylinder, concave, grain delivery outlet, shelled cob delivery outlet, sheller fixing arrangement, main pulley with power transmission arrangement. The isometric view of the mobile maize sheller is shown in Fig. 1.

The materials of mobile maize sheller are mobile maize sheller sheet, mobile maize sheller angle, and steel rod. All materials are collected from local market. The specification of the mobile maize sheller is shown in Table I.
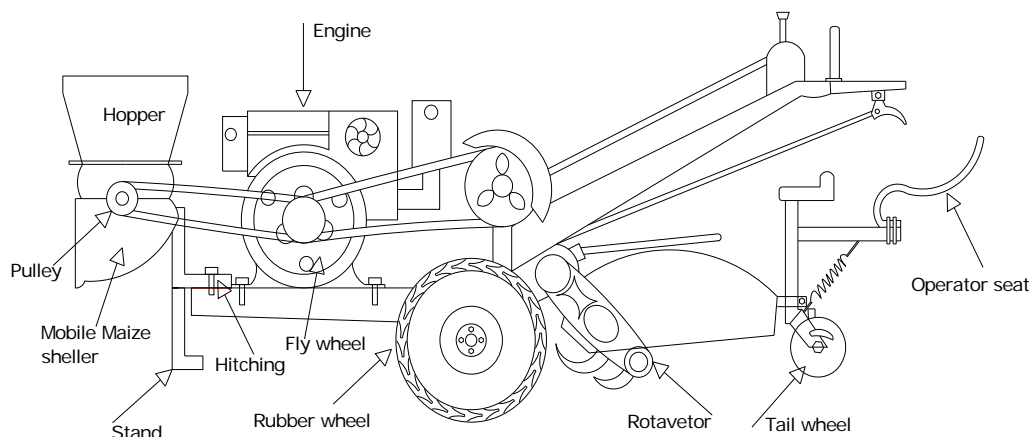

Fig. 1 Side view of power tiller with mobile maize sheller

TABLE I
SPECIFICATIONS OF BARI MOBILE MAIZE SHELLER

| #.	Items	Specification	Remarks
1	Power	12-16 Hp, 2WT; one operator	Dongfeng/ Sifeng type 2WT
2	Hitch plate	260 x 195 mm; Steel plate	Clump and lock pin used
3	Fixing frame	2 x 38 mm, Angle box	Fix with power tiller engine base frame
4	Feeding hopper	535 x 415 mm; 20 gauge steel plate	Hinch with main cylinder
5	Shelling main roller	790 x 76 mm; 158 mm dia Spike: 50 x 5 mm; 56^0	3 row, 8 number Ms Rod
6	Cylinder	810x240 mm, Steel sheet	50 mm apart; 19 mm dia
7	Main pulley	V pulley, 140 mm; double	Cast iron
8	Power transmission	V belt; B-60; double	Power from engine flywheel
9	Concave clearance	41 mm	
10	Over all dimension	1270x480x710 mm weight: 56 kg (without engine)	
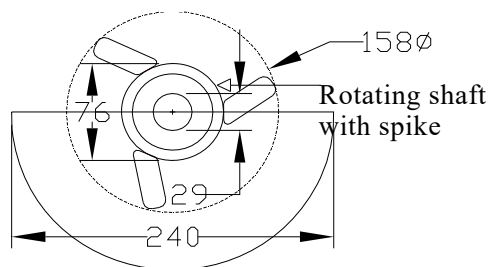
Fig. 2 Side view of mobile maize sheller

The maize sheller is hitched in front of the 2WT with engine base through nuts and bolts. There is a flexible stand bottom part of the base frame which facilitates standing maize sheller in level position. Before starting shelling operation, the outer most two "V" belts released from the fly wheel and introduced another two special "V" belts and fixing fly wheel of the 2WT and main pulley of the mobile maize sheller. The cross section of the mobile maize sheller is shown in Fig. 2. The maize sheller was tested in the research farm of BARI, Gazipur at two separate dates of May 2015. The maize was collected from experimental plots of Irrigation & Water

World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:11, No:5, 2017

Management Division, BARI Gazipur and Plant Breeding Division (Maize section) of BARI Gazipur. The harvested maize was dried in open floor, and relevant information was recorded. The maize sheller is also intensively tested in the farmers' field of maize growing areas like Rangpur, Lalmonirhat, Dinajpur districts.

The mobile maize sheller is attached in front of 2WT and the main rotating shaft of the mobile maize sheller rotates taking power from 2WT engine through 'V' belt pulley (Fig. 3).

During the shelling operation, the shaft rotates inside the concave (Fig. 4) of maize sheller.

A. Data to be Collected

The following data are recorded for evaluating the mobile maize sheller performance. (i) Cob-kernel ratio (ii) Moisture content (%) (iii) Shelled grain (kg) (iv) Broken kernel (kg) (v) Unshelled grain (kg) (vi) Speed of rotating cylinder (rpm), (vii) Time of operation (min) (vii) Fuel consumption (l/hr), (viii) Cost of operation. Data to be analyzed are shelling capacity (kg/hr), shelling efficiency (%), shelling loss (%) [4].
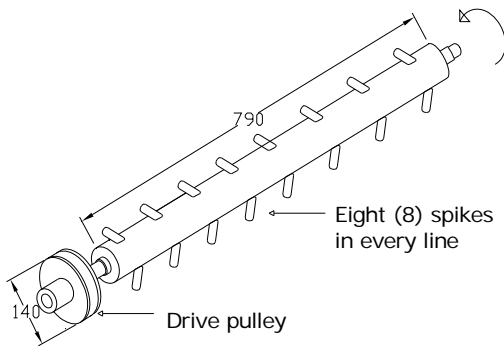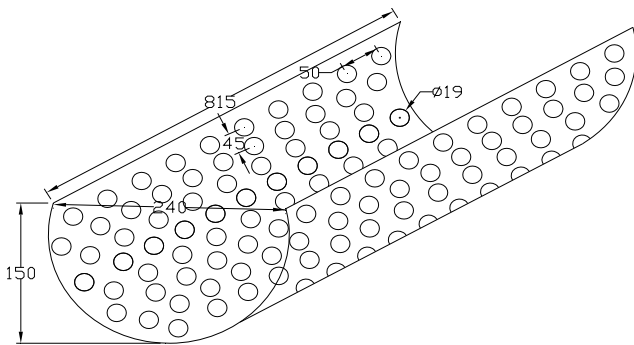

Fig. 3 Pulley with rotating shaft

Fig. 4 Concave of mobile maize sheller

B. Cost Calculation

Cost calculation was done on the basis of fixed cost and variable cost of the mobile maize sheller. The related cost parameters were as follows: (i) Purchase price of the sheller, (ii) Salvage value of the sheller, (iii) Machine life, year (iv) Bank interest rate (%) (v) Sheller annual use (hrs), (vi) Operator charge (Tk./day) (vii) Fuel consumption (lit/h) (viii) Repair and maintenance cost and (ix) Power tiller hire price for maize sheller operation. Cost of custom hire rate was also

recorded for cost comparison. Thus, the total cost of planting was the sum of fixed cost and variable cost of the maize sheller [5].

$$AC = FC + VC \qquad (1)$$

where AC is the annual cost per year, sum of yearly fixed cost (FC) and variable cost (VC).

Detailed cost calculation for the maize sheller was given in Table V. Net benefit was also calculated as deducting cost from total benefit.

C. Fixed Cost (FC)

Fixed costs are independent of maize sheller use and it occurs whether the sheller is used or not. This cost of the maize sheller was estimated on annual basis. Fixed cost of maize sheller was calculated on the basis of capital consumption (CC) method. A capital recovery factor (CRF) is used to combine the total depreciation with interest changes into a series of equal annual payments at compound interest. This payment plus the interest on the underappreciated amount is used to estimate the capital consumption of farm machinery [6].

$$CC = (P - S)CRF + S \times i \qquad (2)$$

where CC is the fixed cost under capital consumption method. P, S, i denotes purchase price, salvage value, and bank interest rate, respectively. CRF is the capital recovery factor. It can be defined:

$$CRF = \frac{i(1 + i)l}{(1 + i)^l - 1} \qquad (3)$$

where l is the number of life of mobile maize sheller.

D. Variable Costs (VC)

Variable cost (VC) is associated with the operation of maize sheller and they occur only when the sheller is used. VC of the maize sheller is usually expressed on an hourly basis. VC of the sheller was calculated on the basis of following items:

E. Annual Costs

Annual costs are determined by summing up fixed cost and variable costs. The two parts of (4) represent the fixed cost and variables costs, respectively. The part (A/EFC) represents the approximate hours of use per year. The equation of annual cost can be rewritten again as following for annual cost estimation.

$$AC = FC + \frac{A}{EFC}(R \& M + L + H) \qquad (4)$$

where EFC is the effective capacity of the maize sheller. A is the annual area use in ha, L is the labour wage rate per hour, H

World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:11, No:5, 2017

is 2WT hire price hourly, R&M is the hourly repair and maintenance cost.

Fig. 5 Operation view of BARI mobile maize sheller

III. RESULTS AND DISCUSSION

A. Mobile Maize Sheller

The basic concept of the mobile maize sheller is that the shelling unit is to be assembled with the transportation power unit and the service providers freely carry the maize sheller from farmers to farmers' home yard in assembling position. So, it can reduce the maize sheller installation and starting time. The operational view of the mobile maize sheller is shown in Fig. 5.

B. Shelling Operation

TABLE II
SHELLING PERFORMANCE OF THE MOBILE MAIZE SHELLER

Performance parameter	Measured value
Cylinder speed (rpm)	1250
Throughput capacity (kg/hr)	3150
Average shelling capacity (kg/hr)	2100
Cylinder loss (%)	0.35
Separating loss (%)	0.40
Broken kernel (%)	2.20
Shelling efficiency (%)	97

TABLE III
EFFECTIVE USE HOURS OF MOBILE MAIZE SELLER COMPARE TO TRADITIONAL MAIZE SHELLER

Name of maize sheller	Average effective use hour/day	Time savings (hrs)/day
Mobile maize sheller	6.5	2
Traditional maize sheller	4.5	

TABLE IV
COMPARATIVE SHELLING COST WITH TRADITIONAL CUSTOM HIRE COST

Cost items	Shelling cost, Tk./kg	Shelling cost, Tk./yr	Net return, Tk./kg	Net return, Tk./yr	BCR
Shelling cost of BARI Mobile maize sheller	0.22	290423	1.00	1500000	5.16
Traditional maize sheller (custom hire rate)	1.00	-	-	-	-

TABLE V
COST CALCULATION AND NECESSARY ASSUMPTION OF BARI MOBILE MAIZE SHELLER

Serial Number	Description of cost items		Total cost (Tk.)
1		Purchase price of mobile maize sheller (P); without 2WT price	20,000
2	Fixed cost calculation	(P-S)*CRF+S*i	4048
		where, P= Purchase price, S= Salvage value (10% of P), L= life (6 years), i= Bank interest rate (8%)	
3	Capital Recovery Factor (CRF)	$(i*(1+i)^L)/((1+i)^L-1) =0.216$	
4		Fixed cost ; Tk./yr	4,048
5	Required labour	3	
6	Labour charge, Tk/day	300	
7	Working period days/yr	150	
8	Labour cost, Tk/yr	3*300*150	135,000
9	Required fuel ,l/yr	150*5*1.5 (@1.5 l/hr)	
10	Fuel cost	150*5*1.5 *65 (@65Tk/l)	73,125
11	Oil cost	150*5*3(@ 3Tk/hr)	2,250
12	Repair & maintenance, Tk/yr	150*5*1.33(@Tk 1.33/hr)	1,000
13	Power tiller hiring, Tk/yr	100*150*5 @Tk100/hr	75,000
14		Variable cost (8+10+11+12+13), Tk/yr	286,375
15	Total shelling cost (4+14), k/yr		290,423
	Average shelling capacity, kg/hr	2000/hr	
	Shelling capacity, kg/yr	150*5*2000 (@2000kg/hr)	1500,000
	Shelling Cost, Tk./kg		0.22
	Gross return		
16	Custom hire rate, Tk./kg	Rate, 1 Tk./kg	
17	Total net return, Tk/yr	Tk 1.0/kg*1500000	1500,000
18	BCR (17/15)		5.16

1 US$=Tk.78.0

The cylinder of maize sheller rotates counterclockwise. Maize shelled with the frictional force between the spike tooth and concave. The average speed of the cylinder was 1250 rpm. Shelled grains pass through the concave openings diameter 19

World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:11, No:5, 2017

mm, and shelled cobs move in axial direction and pass out through the outlet. It was observed that broken kernel percentage increases and shelling capacity decreases with the cylinder rotating speed (Fig. 7). It was found that shelling capacity decreases and shelling loss increases with the increases of moisture content (Fig. 6).

The shelling performance of the mobile maize sheller is described in Table II.

The working performance of the mobile maize sheller is shown in Table II. The selling capacity, shelling broken kernel, and cylinder loss of the mobile maize sheller were 2100 kg/h, 2.3%, 0.35%, respectively. The efficiency of the mobile maize sheller was 97%.

Effective operating hours of mobile maize sheller is more (Table III) compared to traditional power sheller which normally used by the 2WT. The effective hours used of mobile maize sheller and traditional maize sheller were 6.5 hrs and 4.5 hrs, respectively in a day. Mobile maize sheller saves 2 hours/day, i.e. this sheller can be used additional two hours in a day compared to the traditional maize sheller.
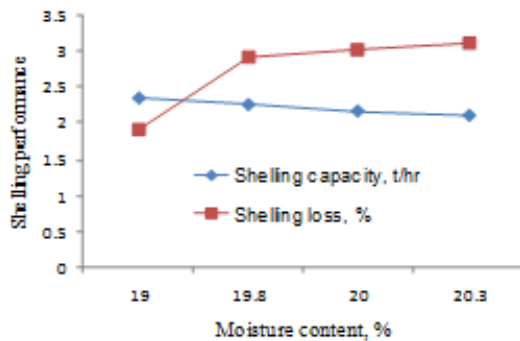

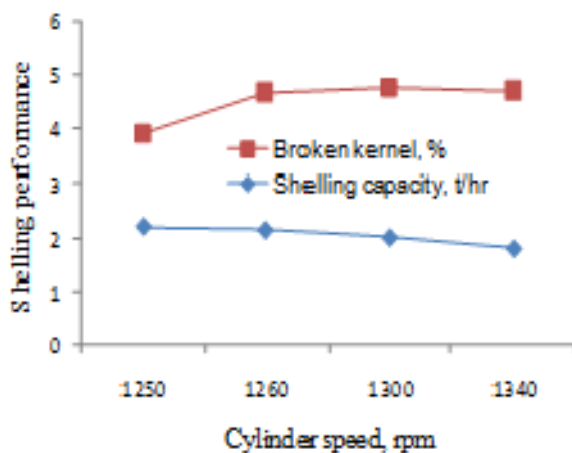Fig. 6 Effect of moisture content on shelling capacity and shelling loss

Fig. 7 Effect of cylinder speed on shelling capacity and broken kernel

The maize shelling cost of BARI mobile maize sheller is shown in Table IV, and detail cost calculation is given in Table V. The shelling cost was Tk. 0.22/kg of grain. Shelling cost was much lower than custom hire rate of shelling (Tk. 1.0 /kg). The BCR of the mobile maize sheller was 5.15. It can be

mentioned here that manufacturer starts making and sells this mobile maize sheller in Rangpur area. Few service providers start custom hire business in that locality.

IV. CONCLUSION

Based on the results and discussion, following conclusions were drawn:
i) The BARI mobile maize sheller successfully attached with front side of the 2WT, and the operator can move long distance along with the attached position of the maize sheller. It eliminates the fitting fixing hazard of maize sheller and transportation problem.
ii) The shelling performances of the mobile maize sheller are satisfactory. The working capacity, broken kernel percentage and shelling efficiency of the mobile sheller are accepted by the farmers.
iii) The average cost of shelling maize is Tk. 0.22/kg compared to the traditional custom hire rate Tk.1.0/kg.
iv) The manufacture can make this mobile maize sheller within a short period of time.
v) The service provider can use this sheller with less hazard compared to the traditional 2WT driven maize sheller.
vi) This mobile maize sheller can be used successfully any other countries where 2WT used as a farming implement.

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