Design, fabrication and performance evaluation of drum type potato grader

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Abstract: Grading potatoes by size is an important operation for preparing tubers for seed and for commercial purposes. If potatoes were sold after grading, this would be beneficial to both producers and consumers. Since mechanical graders are not locally available, potatoes are graded, when necessary, by hand. This is a time consuming, costly, and inefficient method. This work concerns the development of a potato-grading machine for small-scale farmers. The grader consisted of a hopper, grading unit, prime mover and catchment tray fitted on a frame. The grading unit was made up of plastic oil container, hopper and catchment tray made up of mild steel sheet and the frame was made up of mild steel angle bar. A 0.56 kW, single phase electric motor was used as a prime mover with a gear box (30:1) for reducing the rotational speed. Machine parameters for the evaluation included the speed of the grading unit (RPM) and inclination of the grading unit (degree). These were tested on potato tubers taking note their influence on grading system efficiency, capacity, damaged tubers and power consumption as independent variables. Data were analyzed and the results indicated that optimum set-up of the grader was at 6 RPM speed of the grading unit, inclination of 3^0 giving a system efficiency of 91.57%, capacity 420.10 kg hr^{-1}, damaged tubers of 1.17% and low power consumption of 9.30 W-hr. The cost of the grader was estimated to be US$434 (1US$ equals 84.25 BDT) with a break-even quantity of 29 tons of tubers in one year.

Keywords: potato grader, capacity, power consumption, efficiency, damage tubers, break event point

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1 Introduction

Potato is a prominent crop in consideration of production and its internal demand in Bangladesh. It is the third largest food crop in Bangladesh and has recently occupied an important place in the list of major food and cash crops of Bangladesh (Ali and Haque, 2011). Potato cultivation has been getting popular over the last many years Bangladesh maintained its eighth position among top potato-producing countries in the world and third in the Asia by showing consecutive bumper production in the last four years (Saifullah and Ashish, 2018). Potato output was a record 10.21 million tons on 4.99 million hectares in Fiscal Year-17, against 9.47 million tons on 4.75 million hectares in Fiscal Year-16 (Bangladesh Bureau of Statistics, 2018).

Potato production was 9.254 million tons in Fiscal Year-15, 8.95 million tons in Fiscal Year-14 and 8.60 million tons in Fiscal Year-13, the BBS data showed (Bangladesh Bureau of Statistics, 2017).

Grading is an important factor in production and in the marketing process of potato. Grading of fresh product may be defined as ‘sorting according to quality’, as sorting usually upgrades the product (Brennan et al., 1990). Grading is basically separating the material in different homogenous groups according to its specific characteristics like size, shape, color and on quality basis (Narvankar et al., 2005). In the south-east Asian country like Bangladesh grading is mainly done for the separation of seed and table potato. In Bangladesh, seed potatoes are graded by hand through eye estimation when necessary.

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This is a very laborious, costly and inefficient method. If a low cost grader could be developed and extended to cold storage owners and whole sale businessmen, then graded potatoes could be available in the market. Marketable tubers will command a premium price in the market when properly graded. Bringing ungraded tubers in the market will affect marketing system making a delay on the disposal of other products. This causes significant loss due to physiological degradation of the crops as a result of long queue.

Different methods have been applied for gradation and developed for various zones and needs since many years ago. Now, history and done works are stated briefly in the grader machines field.

Shyam et al. (1990) designed and made a potato grader machine with oscillating screen and operation of 250 kg hr^{-1}. Gradation precision was reported 80%-90% using a person for tendance and avoiding screens obstruction. Damages were measured 2% while operation. Machine required 10-14 workers.

Roy et al. (2005) designed and fabricated a potato grader with oscillating sieve. The average capacity of the grader was 2030 kg hr^{-1} in the laboratory and 1500 kg hr^{-1} in the field. The cost of grading was 0.03 Taka kg^{-1}.

Ghanbarian et al. (2010) reported a potato grader system with drum made of Capron net as gradation surface with square cells. The cells of net had dimensions of 35×35 mm and 45×45 mm. Machine could grade products in three sizes: small (bellow 50 g), medium (50 to 80 g) and large (above 80 g). Its gradation accuracy was about 74% and mechanical damages of potatoes were 5.5%.

Hossain et al. (2013) designed and made a power operated farmers size potato grader. The grader was operated by 0.5hp electric motor or 4hp diesel engine. The capacity of the grader was 1.3 ton hr^{-1} with 95% efficiency and the cost of grading was 75 Taka ton^{-1}.

Each machines and mechanisms had advantage and defect. For example, optical and machine vision graders were not economical for some users because of heavy cost. Some had much construction cost due to complex mechanism and at some, required workers was high and so on. In view of this fact, the present work was undertaken to design, fabricate and evaluate the performance of a small scale low cost rotary type potato grader.

2 Materials and methods

2.1 Physical properties of potato tubers

Diamant, Cardinal and Granola are most commonly grown varieties in Bangladesh. Among these three varieties physical characteristics of Cardinal and Granola were measured. From each variety 100 samples were randomly selected. Their mass and diameter were measured using digital balance with accuracy of 0.01 g and slide caliper (0.1 mm). The mean, standard deviation, maximum, minimum, coefficient of variation, quartile and percentile (33, 66 percent) were calculated using data analysis software SPSS version 22.

2.2 Design considerations and machine construction

Figure 1 and Figure 2 shows the schematic and 3-d isometric view of the potato grader that was initially fabricated. The unit comprised of a hopper, grading unit, prime mover, catchment tray mounted on a frame. The hopper serves as guide for the potato tubers into the grading unit. The grading unit of the grader was cylindrical in shape, made by connecting three empty plastic oil containers having equal diameter with the help of mild steel sheet and star joint bolts.

The grading unit were divided into three parts; in the first part 40 mm diameter holes were made for separating small size potato, in the second part 55 mm diameter holes were made for separating medium size potato with the help of specially constructed drill bit and in the last part extra-large holes were made for separating the remaining large size potato. Below the grading unit was a catchment tray for the graded tubers. The tray had three divisions to separate the graded tubers from the regions of the grading unit. A 0.56 kW, single phase electric motor was used as a prime mover with a gear box (30:1) for reducing the speed.

2.3 Working principle of the grader

Potato tubers were fed into the hopper and then rolled down into the grading unit. The principle of operation of the device begins with the rotating motion of the grading unit through the prime mover. Tubers with small, medium and large diameters pass through the respective holes during rotation and are collected in the respective tray provided below the grading unit.

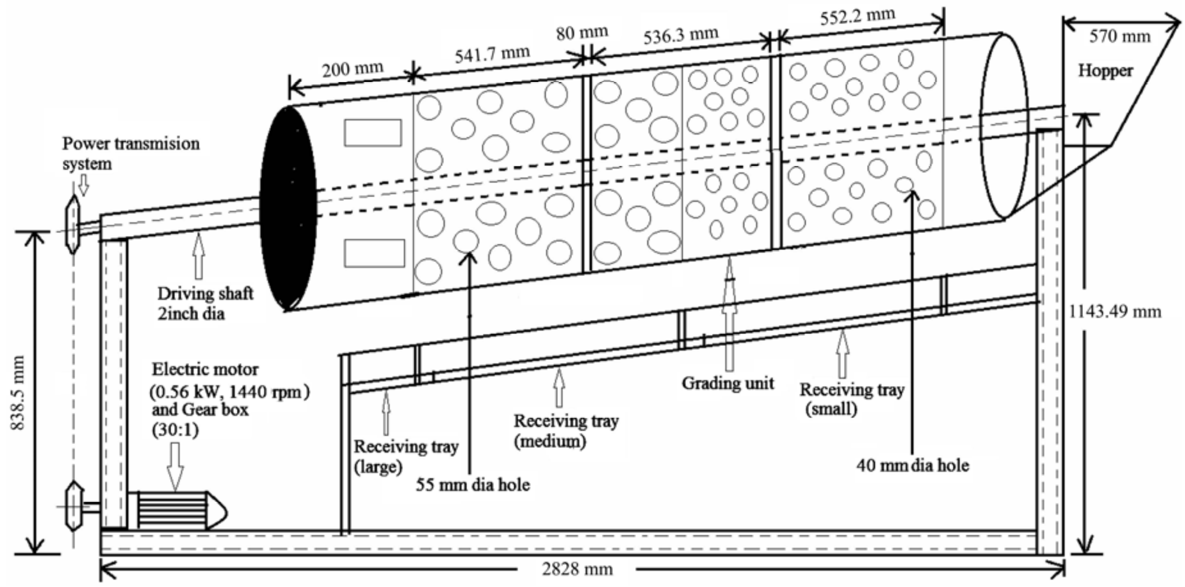

Figure 1 Schematic diagram of the grader

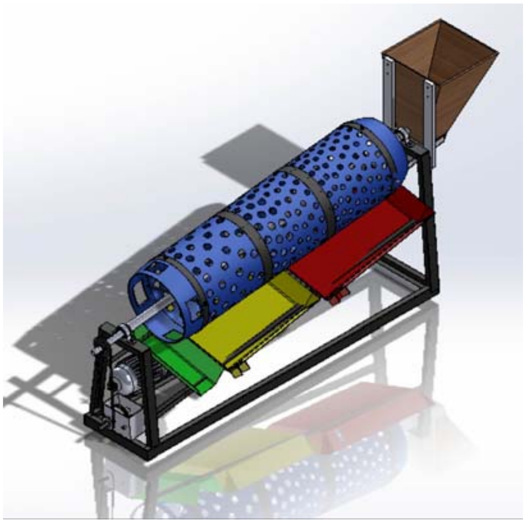

Figure 2 3-D isometric view of the grader

2.4 Performance test

2.4.1 Design of experiments

The experimental design for performance test of the grading machine was done for three rotational speed of the rotating unit and three degree of inclination of the grading unit with the horizontal. The experimental design is shown in Table 1.

Table 1 Experimental design for performance test

RPM of the grading unit	Inclination angle (degree)
6	3
	6
	9
9	3
	6
	9
12	3
	6
	9

2.4.2 Machine parameters

Two machine parameters were used during the evaluation. These were the speed of the grading unit (6, 9 and 12 RPM) and the inclination of the grading unit (3, 6 and 9 degrees). The influence of these machine parameters to the performance of the machine during the evaluation was observed. Machine performance, response variables, was indicated by the grading system efficiency (GSE) in percent, capacity (C) in kg hr^{-1}, percent damage tubers and power consumption in W-hr.

The grading system efficiency was determined by taking the products of the efficiency of small, medium and large regions as shown in Equation (1) (Valentin et al., 2016).

$$GSE=(eff_S \times eff_M \times eff_L)\times 100,\ \% \qquad (1)$$

where, eff_S is the efficiency, in decimal, of the small region of the grader to classify the small tubers; eff_M is the efficiency of the medium region and eff_L is the efficiency of the large region.

The capacity of the grader was determined by considering the time it takes to grade the given quantity of tubers. In this study 7 kg of tubers were used for each experiment. The capacity is expressed in kg hr^{-1} as shown in Equation (2) (Valentin et al., 2016).

$$C=\frac{W}{t},\ \text{kg/hr} \qquad (2)$$

where, W is the quantity of potato in kg and t is the time in hr.

The power consumption was taken by simply taking products of the rated size of the prime mover of the grader and the time of operation. In this study 0.56 kW motor was used. Power consumption is related by Equation (3) (Valentin et al., 2016).

$$Power\ consumption = kilowatts \times t, \text{ W-hr} \quad (3)$$

where, t is the time of operation in hours.

Injury was accounted as those tubers with abrasion after the grading operation. The percentage of injured tubers was taken by considering the total number of tubers with abrasion after the operation against the total number of tubers prior to the operation. Abrasion was visually inspected and those tubers with abrasion of 5% higher than the surface area were considered damaged as shown in Equation (4) (Valentin et al., 2016).

$$Injury, \% = \frac{Total\ number\ of\ tubers\ with\ abrasion}{Total\ number\ of\ tubers\ in\ the\ sample} \times 100 \quad (4)$$

2.4.3 Sample preparation for performance test

A quantity of 200 kg of Potato tubers for the chosen variety (Cardinal) were procured from the market in August 15, 2017. Tubers with initial damages such as scratches, abrasion, decay and greening were not considered in the sample. Thus, there was no initial damage during the testing of the device. The samples were divided into 27 groups with 7 kg each containing small, medium and large. On the average, each group had 50% small, 30% medium and 20% large-sized tubers. Each tuber was manually measured with slide caliper to determine the size and was given a label to easily distinguish after grading. The samples were prepared by following Valentin et al. (2016).

2.4.4 Test run

A two factor completely randomized design test runs of 27 were used in the study with 9 treatment combination and 3 replications. Each replication used 7 kg of potato tubers as initially prepared.

2.4.5 Evaluation procedure

As initially prepared, each 7 kg of potato tubers were loaded into the hopper while the grading unit was rotating. After the grading operation, tubers that dropped on the appropriate region and number of damaged tubers were counted and recorded. This was to determine the grading efficiency of each region as shown in Equations (4), (5), (6) and (7) (Valentin et al., 2016). The time, in seconds, it took to grade the samples were also recorded.

$$eff_S = \frac{Number\ of\ correctly\ graded\ small\ tubers}{Total\ number\ of\ small\ tubers\ in\ the\ sample} \quad (5)$$

$$eff_M = \frac{Number\ of\ correctly\ graded\ medium\ tubers}{Total\ number\ of\ medium\ tubers\ in\ the\ sample} \quad (6)$$

$$eff_L = \frac{Number\ of\ correctly\ graded\ large\ tubers}{Total\ number\ of\ large\ tubers\ in\ the\ sample} \quad (7)$$

2.4.6 Cost analysis of the potato grader

A Simple cost analysis was done for the potato grader. The analysis included the actual cost of the device, annual fixed cost and variable cost. The annual fixed cost included depreciation, interest and shelter cost. Variable cost included repair and maintenance cost, labor cost and electricity cost. Assumption was made as interest 13%, shelter 0.01% per year; repair and maintenance cost 0.01% per hr, operation per day 8 hrs, annual use 250 hrs and estimated life span 7 yrs of the machine.

The cost was calculated using following formulas:

The annual depreciation was calculated as

$$D = P - S/L \quad (8)$$

where, D is the depreciation; P is the purchase price of the machine; S is the salvage or selling price and L is the time between buying and selling.

Interest on investment was calculated as

$$I = [P + S/2] \times i \quad (9)$$

where, I is the interest on investment; P is the purchase price of the machine; S is the salvage or selling price; i is the current interest rate.

Total cost per year calculated as

$$Total\ cost = Annual\ fixed\ cost + Variable\ cost \quad (10)$$

Break-even point of the device was considered in this study which is expressed in terms of the amount of tubers needed to grade per year. Break even cost of the device is given by Equation (11) (Valentin et al., 2016).

$$BEP = \frac{AFC}{CR - VC} \quad (11)$$

where, CR is the custom rate; AFC is the annual fixed cost and VC is the variable cost.

3 Results and discussion

3.1 Physical properties of potato tubers

The mean, standard deviation, maximum, and minimum, coefficient of variation, quartile and percentile (33, 66 percent) of physical properties (mass and diameter) of the Cardinal and Granola (oval shape) potato varieties are shown in the Table 2.

Results in the Table 2 indicated that the maximum and minimum diameters of the selected potato variety were 108 mm and 22.20 mm. The mean diameter was 48.91 mm. Also the maximum and minimum mass of the potato tubers were 194.10 g and 6.10 g with a mean of 40.36 g. Diameter ranges of product separation were under 40, 40-55 and above 55 mm selected according to the percentiles. The relationship between mass and diameter of measured potatoes could be expressed by the equation,

$$Y = 10.986^{X0.4179} \quad (R^2 = 0.89)$$

where, Y= Mass, g and X= Diameter, mm.

Table 2 The physical characteristics of the potatoes

Properties	Maximum	Minimum	Mean	Standard deviation	Coefficient of Variance	Percentiles	
						33	66
Mass (g)	194.10	6.10	40.36	31.29	979.29	23.60	41.32
Diameter (mm)	108.00	22.20	48.91	15.56	242.13	39.56	55.23

3.2 Specifications of the potato grader

The fabricated machine tested in the study was a drum type potato grader which had the following components: hopper, grading unit, receiving tray and power transmission system. Table 3 presents the final specifications of the device after fabrication.

Table 3 Specifications of the drum type potato grader

Item	Specification
A. Capacity, kg hr^{-1}	420.10
B. Grading Efficiency, %	91.57
C. Injury,%	2.22
D. Main structure	
Overall Dimensions	
Length, mm	3031
Width, mm	610
Height, mm	1676
E. Grading unit assembly	
Length, mm	2286
Diameter, mm	584
F. Feeding mechanism type	Manual feeding, hopper type
G. Prime mover	220 V, 0.56 kW single phase, capacitor type electric motor
H. Gear box	30:1
I. Transmission system	Open drive belt and pulley combination
Pulley 1	38.1 mm
Pulley 2	101.6 mm
Pulley 3	50.8 mm, 76.2 mm, 101.6 mm
Pulley 4	152.4 mm
Belt type	V-belt, A-36, A-64,A-65, A-66

3.3 Performance evaluation of the grader

The overall performance of the grader was determined by measuring different parameters considered in the study. The grading capacity, grading system efficiency (GSE), injury percentage and power consumption of the grader as affected by speed and inclination angle of the grading cylinder were computed and analyzed.

3.3.1 Combined effect of speed and inclination angle on the performance

Table 4 shows the summary of the results on the performance evaluation of the device.

Table 4 Interaction effect of the speed and inclination of potato grader

RPM	Angle (degree)	GSE (%)	Capacity (kg hr^{-1})	Injured (%)	Power Consumption W-hr/sample
6	3	91.57^{a}	420.10^{i}	1.17^{a}	9.30^{a}
	6	85.50^{b}	494.20^{h}	0.92^{ab}	7.13^{c}
	9	77.76^{d}	586.52^{g}	0.67^{abc}	6.20^{d}
9	3	84.40^{b}	547.71^{f}	0.83^{abc}	7.91^{b}
	6	80.13^{c}	600.17^{e}	0.67^{abc}	6.51^{d}
	9	67.40^{e}	741.34^{d}	0.58^{bc}	5.43^{e}
12	3	77.57^{d}	630.00^{c}	0.67^{abc}	6.67c^{d}
	6	66.17^{e}	720.60^{b}	0.58^{bc}	5.22^{e}
	9	60.77^{f}	900.53^{a}	0.33^{c}	4.39^{f}

Note: * Means separation in column followed by the same letter (s) are not significantly different at P=0.05.

The Table 4 shows that the maximum capacity of the grader was found to be 900.53 kg hr^{-1} at 12 rpm and 9^{0} of inclination angle. But at the same time the grading system efficiency was very low (60.77%). At the same time the percentages of injured tubers were low (0.33%) and power consumption also low (4.39 W-hr/sample). On the other hand, the grading system efficiency was high (91.57%) at 6 rpm and 3^{0} inclinations angle with the lowest capacity (420.10 kg hr^{-1}). At the same time the percentage of injured tubers were high (1.17%) and power consumption also high (9.30 W-hr/sample). It shows from the table that there are variations of grading capacity, efficiency, damaged tubers and power consumption with variations of RPM and angle of inclination.

3.3.1.1 Grading system efficiency (GSE)

Comparison of means in table 4 showed that the best combination to achieve the highest grading system efficiency was operating the machine at 6 RPM with 3degree inclination. The lowest grading system efficiency was found when operating at 12 RPM with 9 degree inclination. The grading system efficiency gradually decreased with increasing the speed and inclination of the grading unit. This was because with increasing the speed and inclination of the grading unit, the potato tubers moved first through the grading unit. For this reason some of the small size potato tubers moved into the region of hole for medium size classification and some of the medium size moved into the large size region which decreased the grading system efficiency.

3.3.1.2 Capacity

Table 4 shows that the highest grading capacity achieved when the machine was operated at 9 degree inclination and speed of operation of the machine 12 RPM, with a value of 900.53 kg hr^{-1}. The lowest grading capacity was found when the grader was operated at 6 RPM with an angle of 3 degree inclination with a value of 420.10 kg hr^{-1}. The results showed that grading capacity gradually increased with increasing the speed and inclination of the grading unit and decreased with decreasing the speed and inclination. This is because the potato tubers move first through the grading unit with increasing the speed and inclination of the grading unit. For this reason greater amount of potato was graded with less time hence the capacity was increased. For the grading operation it will therefore important to select suitable combination on the basis of use and grading efficiency requirements.

3.3.1.3 Injured tubers

Table 4 shows that minimal injured tubers were found when the grader was operated at 12 RPM and 9 degree inclination with a value of 0.33%. Highest injured tubers were found when grader was operated at 6 RPM and 3 degree inclination. Percentage of tuber injured increased with decreasing the speed and inclination of the grading unit. Slow speed and small inclination angle caused accumulation of the tuber in the grading unit that induced greater impact as result of their weight which increased the percentages of injured tubers.

3.3.1.4 Power consumption

Table 4 shows that power consumption was highest when the grader was operated at 3 degree inclination in combination with speed 6 RPM and lowest power consumption was found when operated at 12 RPM and 9 degree inclination. Power consumption was increased with decreasing the speed and inclination of the grading unit. This was because when the grader was operated at a high speed and inclination causing shorter time of operation. Thus the power consumption was less.

3.3.2 Influence of speed

Data in Table 5 shows the performance of the grader at different RPM. It shows that the grader had the highest GSE when operated at 6 RPM. Extremely fast RPM of the grading unit were observed to cause the tubers a fast random movement through the grading unit. This mechanical reaction caused some tubers to move over one region to another to the extent that small-sized tubers even move to the region of the hole for medium-sized classification. This unwanted motion of tubers during extreme rotation significantly affected the grading system efficiency of the device. On the other hand lower RPM of the grading unit were observed to cause the tubers move slowly through the grading unit hence the tubers got enough time for grading accurately. For this reason grading system efficiency was high in lower RPM than higher RPM of the grading unit. Meanwhile, analysis of variance on the influence of machine parameters to grading system efficiency showed significant effect.

Table 5 Effect of speed on efficiency, capacity, injury and power consumption of potato grader

Machine Parameters	Speed (RPM)		
	6	9	12
GSE (%)	84.51^{a}	77.27^{b}	68.64^{c}
Capacity (kg hr^{-1})	532.60^{c}	605.00^{b}	742.80^{a}
Injured (%)	0.89^{a}	0.72^{ab}	0.53^{b}
Power Consumption (W-hr)	7.96^{a}	6.29^{b}	5.34^{c}

Note: *Means separation in raw followed by the same letter (s) are not significantly different at P=0.05.

The capacity of the grader using speed of 9 and 12 RPM is significantly higher than using a speed of 6 RPM. High speed (12 RPM) induces more velocity to the tubers causing them to travel along the unit at a faster rate. Conversely, lowest speed (6 RPM) resulted to slow material flow through the grading unit resulting to longer time of operation that caused lower capacity.

Power consumption was lowest at 12 RPM. The grader operated at a faster rate causing shorter time of operation. Lowest speed (6 RPM) resulted to more power consumption. Tubers stayed at a longer time in the unit causing more power inputs. Although power consumption is very minimal, the differences on the mean values are significant.

Injured tubers were found to be minimal at a speed of 12 RPM. Highest injury of 0.89% at 6 RPM could be due to large accumulation of tubers in the unit creating significant impacts as a result of weight of the large quantity of tubers. Abrasion of tubers resulted not only with the high RPM of the grader but also due to large quantity of tubers. The combined effect of the speed of the grading unit and the heavy weight of tubers causes greater impact to the tubers.

3.3.3 Influence of Inclination

Table 6 shows the mean values for the machine parameters as affected by the inclination of the grading unit. Highest grading system efficiency of 84.94% was observed at an inclination of 3 degrees whereas; lowest efficiency was obtained at an inclination of 9 degrees. Extremely high inclination caused fast transfer of tubers to the next region as caused by gravity plus the effect of the rotation of the grading unit. This also reduces the time of operation causing significantly high capacity of 750.38 kg hr^{-1} and lower power 5.43 W-hr. Tubers in this scenario especially the smaller ones at the first region move to the next selection region without passing to the succeeding region.

Table 6 Effect of inclination on efficiency, capacity, injury and power consumption of potato grader

Machine Parameters	Inclination (degrees)		
	3	6	9
GSE (%)	84.94^a	77.31^b	68.17^c
Capacity (kg hr^{-1})	500.27^c	629.74^b	750.38^a
Injured (%)	0.91^a	0.69^{ab}	0.53^b
Power Consumption (W-hr)	7.54^a	6.62^b	5.43^c

Note: * Means separation in raw followed by the same letter (s) are not significantly different at *P*=0.05.

Injured tubers as influenced by the inclination of the grader were observed to decrease with higher inclination as shown in Table 6. As shown earlier in Table 5, injured tubers were observed to be influenced by the large amount of tubers in the grading unit along with very high RPM. The large number of tubers in the grading unit tends to create a heavier impact among each other during the rotation of the grader. For the inclination of the grader, it was observed that at very low inclination which is 3 degrees, there were more number of tubers injured which is almost 0.91% of the total samples as shown in Table 6.

3.4 Cost analysis of the potato grader

3.4.1 Cost estimation

The present potato grader was designed and fabricated in such a way as to keep its cost low. Table 7 shows the cost factors and items of the potato grader. From the table, it can be seen that the cost of grading with the present grader was only Taka 0.28 per kilogram.

Table 7 Cost factors and items of the potato grader

	Cost factors/items	Unit	Amount
A.	Cost of the grader	US$/Unit	
	Materials	US$	261.14
	Gear box	US$	83
	Electrical motor	US$	47.5
	Construction cost	US$	142.4
Total Cost		US$	534
B.	Life of the grader	Year	7
C.	Annual use	Hrs	250
D.	Annual fixed cost		
	a. Depreciation	US$/yr	68.67
	b. Interest (13%)	US$/yr	38.19
	c. Shelter(0.01% of *P*)	US$/yr	0.05
Total		US$/yr	106.91
Total		US$/hr	0.43
E.	Variable Cost		
	a. Repair and maintenance (0.01% of *P*)	US$/hr	0.05
	b. Labour (two labours, 3.5 US$/day)	US$/hr	0.88
	c. Electricity	US$/hr	0.04
Total		US$/hr	0.97
F.	Total cost	US$/hr	1.4
G.	Cost of grading (assuming 420.10 kg/hr)	US$/kg	0.003

3.4.2 Break-even point

From Table 7 shows that the device has an initial cost of US$534 with an estimated life span of 7 years. With basic assumptions and current market practice the annual fixed cost of operating the device is US$ 106.91. Assumptions include: interest, 13%, shelter 0.01% per yr, repair and maintenance 0.01% per hr, operation per day 8 hr, annual use 250 hr and custom rate US$ 0.006 kg^{-1}. The grader needs to grade a quantity of 29 tons of potato tubers in one year to break-even the cost of fabrication. Figure 3 shows the cost curve emphasizing the break-even quantity. If available quantity of tubers is greater than the break-even quantity, the use of the grader will result to profit. Otherwise, the machine is expensive to use when available quantity is less than the break-even quantity.

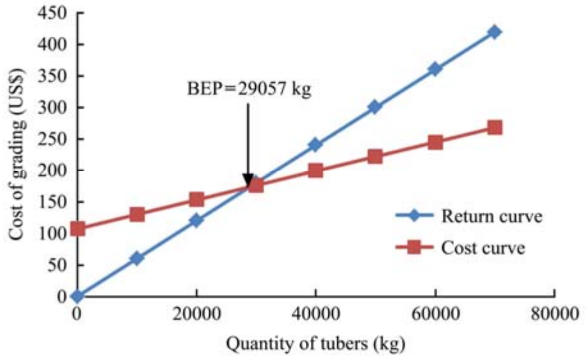

Figure 3 Relationship of the cost of operation of the grader and the quantity of tubers for grading

3.5 Simple comparison between manual and mechanical grading

Using the data for manual grading of potato by hand from the research work of Widodo et al., (2013), a simple comparison between manual and mechanical grading of potato is shown in the Table 8.

Table 8 Simple comparison between manual and mechanical grading

	Manual	Mechanical
Grading capacity, kg hr^{-1} person^{-1}	75	420
Hours of operation per day	8	8
Average volume that can be graded per day	600	3360
Cost of grading US$ kg^{-1}	0.005	0.003

From Table 8 it was seen that the mechanical grading cost 44% lower than the manual grading cost.

4 Conclusion

The optimum operating parameters for the machine was established at a speed of 6 RPM and inclination of 3 degrees giving a system efficiency of 91.57%, capacity of 420.10 kg hr^{-1}, less damaged tubers of 1.17% and a power consumption of 9.30 W-hr. The initial cost of the grader was US$534 and is expected to last for 7 years. The annual use of the grader in the village is approximately 250 hrs. Cost of operating the machine is affected by several factors such as: depreciation, shelter, repairs and maintenance at a current custom rate of Tk. 0.50 kg^{-1}, the grader has an annual fixed cost of US$106.91 and variable operating cost of US$0.97. A quantity of 29057 kg (29 tons) of tubers is needed to be graded by the device in one year to break-even the cost. Grading by using this machine will cost US$0.003 kg^{-1}.

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