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Determination of repair and maintenance cost factor of power tiller used in Bangladesh

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ABSTRACT

The cost of repairing and maintaining a power tiller in Bangladesh is estimated using American standards which is not suitable with as the soil condition of Bangladesh. Hence, the specific objective of this study was to determine the actual unit factor for the repair and maintenance cost of power tiller used in Bangladesh. A structured questionnaire was prepared through active consultation with subject matter specialists. Data was collected from the 154 key informants who were involved in operating and maintaining the power tiller for at least 5 years. The study was conducted in Dinajpur, Bogura, Sirajganj, Sherpur, Jamalpur, Mymensingh, Tangail, Jashore, Narail, Khulna, and Sathkira districts of Bangladesh from 4 September 2020 to 17 September 2021. The key informants were identified using the Snowball Sampling Technique. Data such as purchase price of power tiller, the average working hour in a day and the total number of working days in a year, and repair and maintenance cost of power tiller for consecutive five years were collected in this study. A new power tiller provides service for the first one year without any major repairing. But after that time, the power tiller needs to be repaired 2-3 times a year. The percentage cost factor of the power tiller was found at 0.00223, 0.0041, 0.00563, 0.00706, and 0.00877 respectively, based on the repair and maintenance data of the power tiller for the consecutive five years. The average percentage cost factor of the power tiller varied within the range of 0.00486 to 0.00905. The average unit factor of repair and maintenance cost of power tiller was found 0.00651 in the Bangladesh context and analysis by Mean, square-R in the regression model. The regression equation for the R&M cost factor of power tiller concerning annual use was Y (hr./yr.) = 1478 + 112963 X; where X: Accumulated cost factor in % and Y: Accumulated annual use hr./yr.p-value is less than 0.00001 and variation of the data value was significant. This cost factor data needs to be introduced to the researchers and academicians for further use instead of using cost factors based on foreign data.

INTRODUCTION

Power tiller was popularized in Bangladesh through the trade liberation act in the year 1988 following a catastrophic cyclone hit that had reduced the oxen population to a colossal number (Gisselquist et al., 2002). Then, the trade of diesel engines had increased by 400% and trade of power tillers had increased by 100% compared to three years before the liberalization (Mottaleb et al., 2016). Almost 100% of power tillers were being imported from China. DONGFENG and SIFENG are the most widely used power tiller models in the country (Islam, 2018). Power tiller is suitable for tilling operation in the small fields of 0.1 ha like the average field size of Bangladesh. Now, about 7,00,000 units of power tiller are being operated for 90% of total land preparation in Bangladesh (DAE, 2019). Though power tiller and tractor can be used for almost all tillage operations farmers have easy access to custom hiring service of power tiller by 94% whereas access to the tractor is only 3% (Rahman et. al., 2020). Moreover, the cost of a power tiller is ten times lower than a tractor. That's why the use of power tiller has become

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widespread in Bangladesh for complete rotary tillage operations.

The total annual cost of use of field machines including charges for ownership and operation. Ownership costs are usually assumed to be independent of amount of use and are often called fixed costs or overhead costs. Operating costs vary directly with the amount of use and are referred to as variable costs. The distinction between fixed and variable costs is clear for all items except depreciation and repair and maintenance costs (Khodabakhshian, 2013). The more frequently a power tiller is used, the more repairs are required to maintain its dependability.

The cost of repair is an important factor, as it indicates when a machine is to be replaced. Maintenance costs (adjusting for wear and lubrication) and the cost of labor, required for maintenance should be included as repair costs (Anon *et. al.*, 2012). Good maintenance increases machine life and decreases unexpected breakdowns and repair costs. It will help the farmers to decide on proper machinery and power selection by determining the actual repair and maintenance cost factor. The increasing rate of repair and maintenance costs may be attributed to quality in the design and manufacturing as well as higher costs of spare parts (Syntetos, 2009). Agricultural engineers have done many studies regarding the repair and maintenance of power tillers which help the farmers to know the actual unit of repair and maintenance cost. It will help the farmers to decide on proper machinery and power selection by determining the actual repair and maintenance cost factor. Accurate cost estimates play an important role in power tiller management decisions, namely, when to trade, which size to buy, how much to buy, etc.

Repair and maintenance costs tend to increase with machine age (Markus, 2013). The rate of the percentage repair cost of power tiller is 1.2% per 100hr. in the USA and 5% per 100hr. in Pakistan. According to the American standard, so far, 5% of the purchase price of the power tiller is assumed for repair and maintenance costs in Bangladesh (ASAE, 1999). But, repair costs for a particular type of machine vary widely from one geographic region to another because of soil type, rocks, terrain, climate, and other conditions. Even, within a local area, repair costs vary from farm to farm because of different management policies and operator skills. As a result, estimating repair and maintenance costs based on the initial purchase price will be erroneous. The operator's records of past repair expenses are the best source of data for estimating repair costs. Good records show whether a machine has had above-average or below-average repair costs, as well as when major overhauls may be required. As a result, determining the accurate cost factor of a power tiller from the records of power tiller owners or operators in Bangladesh is critical. However, field data are scarce on the cost of repairing and maintaining a power tiller in Bangladesh. As a result, gathering field data from various regions of Bangladesh on the repair and maintenance of power tillers has become an urgent need for further analysis.

Because of soil type, rocks, terrain, climate, and other conditions, repair costs for a particular type of machine vary greatly from one geographic region to another. Repair costs vary even within a local area due to the differences in management policies and operator skills. As a result, estimating repair and maintenance costs based on the purchase price will be incorrect.

The cost of repairing and maintaining a power tiller in Bangladesh is estimated using American standard units, which is inaccurate because the soil conditions in Bangladesh and the skill of the power tiller operator in Bangladesh differ from those in America. As a result, it is necessary to calculate the actual repair and maintenance cost factor of commonly used agricultural machinery such as power tillers in Bangladesh. Hence, this study was undertaken to collect data on the repair and maintenance cost of a power tiller based on the experience of its owner and operator from various regions of Bangladesh to estimate the repair and maintenance cost unit factor in the case of a power tiller in Bangladesh context. The specific objective of this study is to determine the actual unit factor for the repair and maintenance cost of power tiller in Bangladesh.

MATERIAL AND METHODS

Location and duration of the study

The study was conducted in Dinajpur, Bogura, Sirajganj, Sherpur, Jamalpur, Mymensingh, Tangail, Jashore, Narail, Khulna, Modhupur, Rangpur, Panchagarh, Naogaon, Kustia, Kurigram, Gopalganj, Faridpur, Chuadanga, Chandpur, and Sathkira districts of Bangladesh as shown in (figure 3.2). Data from the key informants of the selected regions were collected from 4 September 2020 to 17 September 2021. It took about twenty-five minutes to complete each questionnaire. A maximum of six questionnaires could be filled-up in one day during the study.

Survey tools and sampling unit

A structured questionnaire was prepared through active consultation with subject matter specialists. Three operators of power tiller were purposively selected for pretesting the questionnaire so that the final questionnaire best fit during the actual data collection time. Only the owners, operators, and mechanics of power tillers who had at least 5 years of experience in repairing and maintaining power tillers were selected in this study as key informants for collecting the necessary data of the repair and maintenance of power tiller. The primary data was collected from 154 key informants. Following the snowball sampling technique, the key informants were identified.

Unit cost factor evaluation system

Data such as purchase price of power tiller, the average working hour in a day and the total number of working days in a year, repair and maintenance cost of power tiller for consecutive five years were collected in this study. Above mentioned data of 154 power tillers were collected. The following formulae were used to calculate the unit factor of repair and maintenance cost of the power tiller.

The annual use of each power tiller was calculated by multiplying the average working hour in a day with the average working day in a year according to equation number 1 and only the annual use data was recorded during the field survey (Dahab *et al.*, 2021).

$$\text{Annual use } (hour/year) = \text{working hour(day)} \times \text{working day(year)}$$

Then the annual repairing cost of each power tiller for consecutive five years was converted into the cost of repairing in an hour by dividing each respective year repairing cost with annual use of power tiller as below(Ward *et al.*, 1985):

$$\text{R\&}M\ cost\ (\text{BDT/Hour}) = \frac{\text{Annual repair and maintenance cost } \left(\frac{\text{BDT}}{\text{year}}\right)}{\text{Annual use of power tiller (Hour/year)}}$$

After that the percentage cost factor of each power tiller for consecutive five years was calculated by dividing repair and maintenance cost of power tiller in one year by the purchase price of the power tiller as below (Lips 2012):

$$\text{Percentage R\&}M\ cost\ factor\ /Year\ of\ Purchase\ Price\ (P) = \frac{\text{R\&}M\ cost\ (BDT/year) \times 100}{\text{Purchase price of power tiller (BDT)}}$$

The average percentage R&M cost factor of each power tiller was then calculated by adding the percentage cost factor of power tiller for years considered and then dividing the summation by the number of years as below (Lips 2012):

$$\text{Average percentage R\&}M\ cost\ factor = \frac{\sum_1^n \text{Percentage cost factor}}{\text{n}} = \frac{\sum_{i=1}^{n} c_i U_i}{\sum_{i=1}^{n} U_i}$$

Where,
n = number of data years.
c_i = Cost factor of i^{th} year
U_i = Hour of use of i^{th} year

Finally, the unit cost factor in the percentage of power tiller was calculated by adding the average percentage cost factor of all the power tillers under the study and then dividing the summation by the total number of power tillers as below (Lips 2012):

$$\text{Unit R\&}M\ cost\ factor\ (\%) = \frac{\sum_1^z \text{Average percentage cost factor}}{\text{z}}$$

Where,

z = number of power tillers under the study.

Regression analysis with fitted line plot model

Regression analysis in between accumulated annual use to the accumulated R&M cost factor was investigated by using MINITAB: statistical software package 2019. A linear fitted line plot was observed from the analysis. The relationship between several factors was shown with the use of EXCEL.

RESULT AND DISCUSSION

Annual use of power tiller

Power tillers in the selected regions were found to be used for a maximum of 30 days in one season. During the peak tillage season, power tillers were used in the field for tilling operation to a maximum of around 10 to 12 hours a day. The average annual use of power tiller in the selected regions of Bangladesh was found at 729 hours.

Repair and maintenance status of power tiller in the selected regions

According to the collected data from the field survey a new power tiller provides service for the first two years without any major repairing service. But after that time, the power tiller needs to be repaired 2-3 times a year. With the increase in use, the frequency of repair and maintenance of power tiller also increases. Field survey indicated that a power tiller can provide service for 7 years with sufficient repair and maintenance. Owners and operators of power tillers can solve the minor breakdown problem. Local technicians and workshops provide repairing services during major breakdowns. Respondents also claimed that the repair and maintenance cost of power tiller increases due to the lack of skilled technicians. Respondents expressed that; lubrication cost increases tremendously after 2 years of operation.

Spare parts

Amongst the various spare parts of the power tiller, the items mentioned below were found most common in the study area.

Engine parts like piston liner (Taka 450), piston ring (Taka 260), nozzle (Taka 220), plunger (Taka 210), belt (Taka 120), gear shift lever (Taka 70), head valve (Taka 200), fuel pump, oil chain (Taka 30), bearing (Taka 280). The spare parts of the power tiller are widely available in the local market.

Unit factor of repair and maintenance cost of power tiller

The percentage cost factor of 154 power tillers for consecutive five years is shown in figure 1. The percentage cost factor was found at 0.00223, 0.0041, 0.00563, 0.00706, and 0.00877 respectively in the consecutive five years. From the bar chart, it is clear that percentage cost factor gradually increases with the increase in use.

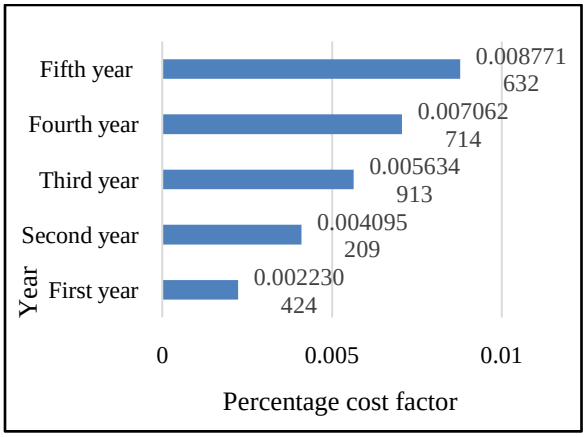

Figure 1: Percentage cost factor of power tiller over five years

Percentage cost factor of each power tiller varies from each other and also varies from location to location. The average percentage cost factors of power tiller of each location under the study are tabulated in Figure 1. The minimum average percentage cost factor was found 0.00486 in kushtia and maximum average percentage cost factor was found 0.00905 in Narail region of Bangladesh.

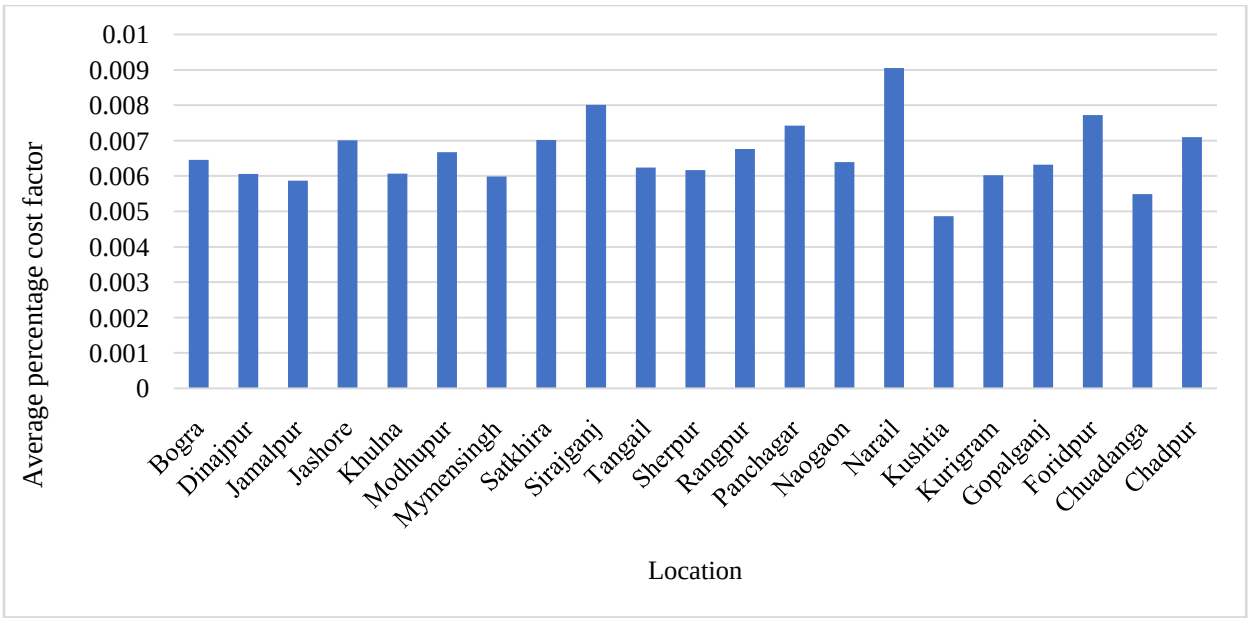

Figure 2: Average Percentage R&M cost factor of power tiller in different location

However, the average unit factor of repair and maintenance cost of power tiller was found 0.00651 in the Bangladesh context.

Regression analysis model

The regression equation for the R&M cost factor of power tiller concerning annual use was Y (hr./yr.) = 1478 + 112963 X

X=f(y)

Where,
X: Accumulated cost factor in %
Y: Accumulated annual use hr./yr.
Model Summary

The model showed that the square value of R was 99.84% which pretends worth relation between accumulated annual uses to the accumulated unit cost factor. Analysis of variance showed that the p-value is less than 0.00001 and variation of the data value was significant (data not shown)

There was a significant relationship between the accumulated annual use and the accumulated cost factor in percent (Figure 3). The numerical value was plotted as a significant fitted line plot very close to the red line.

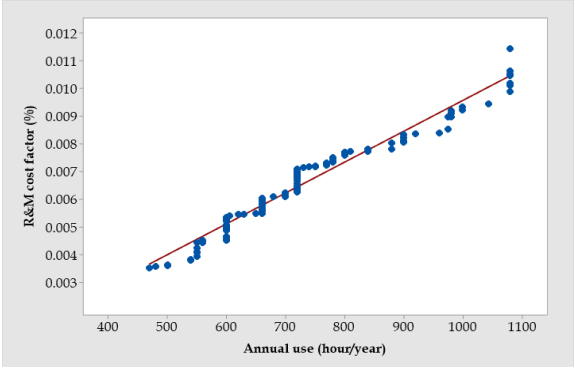

Figure 3: Fitted line plot between accumulated annual use and accumulated cost factor.

Relation between annual uses to the accumulated cost factor

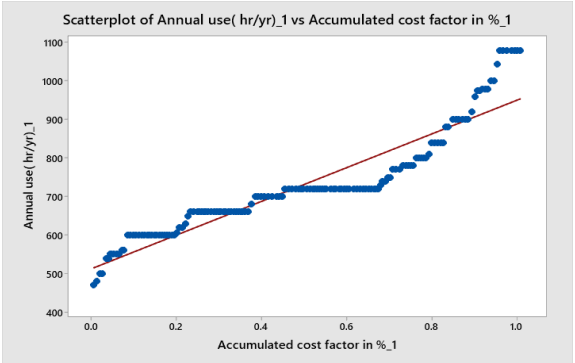

Figure 4: Relation between accumulated annual use and accumulated cost factor.

Figure 4 showed a significant relationship between accumulated annual use and accumulated cost factor in percent. The numerical value was plotted as a significant fitted line plot very close to the red line.

Relation between annual use to fuel cost

The relationship between annual use and fuel cost was demonstrated in figure 5. It appeared that fuel costs had risen in tandem with the annual cost. When the annual usage was 600 hours, the fuel cost 114 Tk./hr. When the annual use was increased to 10,000 hours per year, the fuel cost 143 Tk./hr. The maximum data points were plotted on a liner line. Though the practice of using a power tiller was not consistent with an international pattern, overall tractor usage over time made a pleasant sense to the annual use.

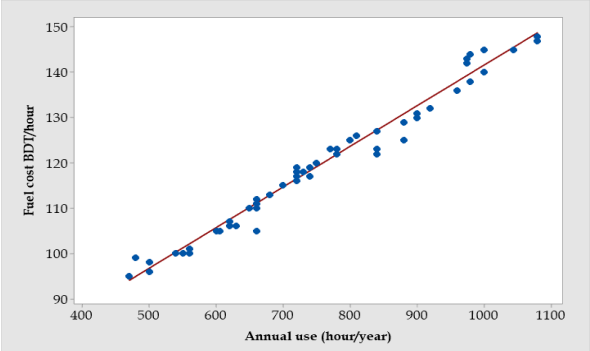

Figure 5: Relation between annual use to fuel cost.

Relation between annual uses to the profit

Figure 6 demonstrate that there is a significant relationship between accumulated annual use and profit. When the annual usage is 600 hours per year, the profit per year is 35000 BDT. When the annual use was increased to 10000 hours per year, the profit per year was 62000 BDT. Maximum data were plotted on a liner line. The numerical value described how profit rises as annual use rises.

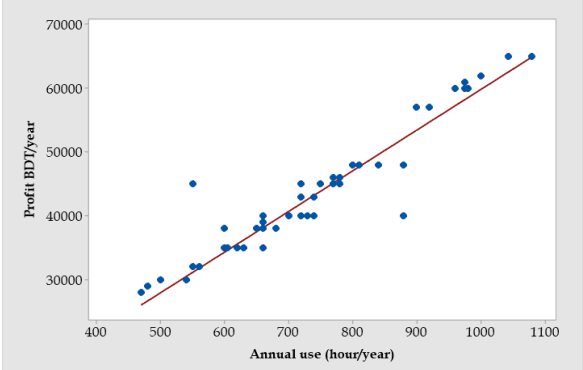

Figure 6: Relation between annual uses to profit.

Relation between annual uses the machine life

There was significant relationship between annual use and machine life (Figure 7). At 430 hr./yr. annual usage, the machine has a maximum life of 11 years in new condition. The life was reduced by about 7-8 years at annual use of 1080 hr./yr., with the numerical value indicating that the machine life decreased with increased annual use.

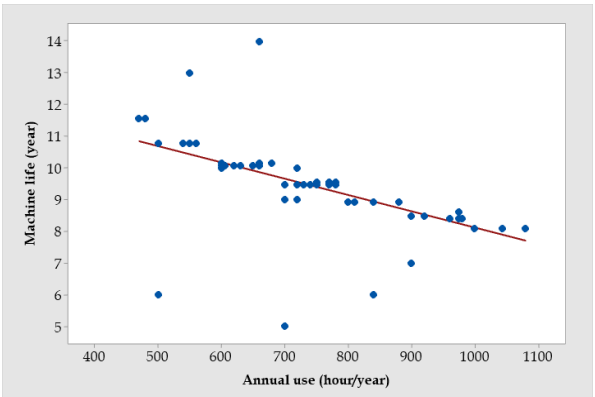

Figure 7: Relation between annual uses the machine life.

Relation between annual uses to the first repairing after purchase

The figure 7 revealed a significant relationship between annual uses and the first repair after purchase. The maximum period for first repairing after purchase in new condition was 1.1 years. This value was reduced by 0.3 in order to increase the machine's annual use. The numerical value

demonstrated that as annual use increased, so did the need for the first repair after purchase.

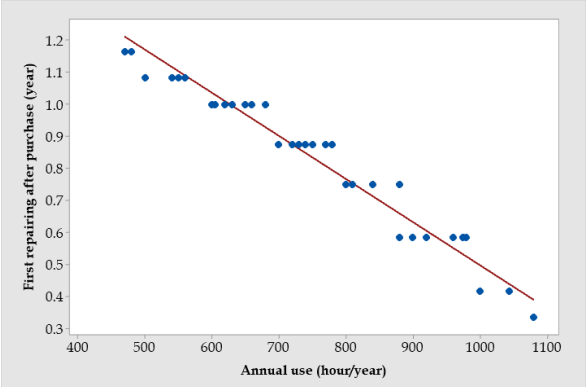

Figure 8: Relation between annual uses to the first repair after purchase.

When observing the questionnaire, the owner said that they didn't find problems in a year of operation. But due to less skilled operators with heavy load operation, the spare parts failed to do their operation, and the need for repair and maintenance occurred. They went to the local workshop and eventually, they need to service several spare parts regularly such as belt, tine, rotary chain, nozzle plunger, liner piston, etc.and there are more problems with engine parts which was increasing the cost. Repair costs are increasing on the use of power tillers. With the age of using the fuel cost went high.

CONCLUSION

Power tiller is a well-known farming machine to the farmers of Bangladesh. A power tiller is operated for approximately 729 hours in a year in every condition. Repair and maintenance of power tiller increased with the usage of hours. Owners or operators of power tillers usually do the necessary repairing of power tiller whenever it is needed and spare parts are readily available in the local market.The minimum average percentage cost factor was found 0.00486 in Kushtia and the maximum average percentage cost factor was found 0.00905 in the Narail region of Bangladesh. The average unit factor of repair and maintenance cost of power tiller was found 0.00651 in Bangladesh. This cost factor data needs to be introduced to the researchers and academicians for further use instead of using cost factors based on foreign data. Mechanics of power tiller must be trained up so that they can provide better repairing service of power tiller. The R&M cost factor finally provides a basis for cost estimation.

RECOMMENDATION

The actual repair and maintenance cost of a unit could be determined by collecting all data from the only actual power tiller operator. Agricultural engineers should develop a model to determine the cost during a certain period or to get absolute numbers to represent owning and operating power tiller.

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