Journal of Research in Forestry, Wildlife & Environment Vol. 13(3) September, 2021
E-mail: jrfwe2019@gmail.com**;** jfewr@yahoo.com
http://www.ajol.info/index.php/jrfwe
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ISBN: 2141 – 1778

Shani and Musa, 2021

DEVELOPMENT OF A MODEL FOR ESTIMATING REPAIR AND MAINTENANCE COST FOR MAHINDRA 6005TRACTOR: A CASE STUDY OF TRACTOR OWNERS AND OPERATORS ASSOCIATION OF NIGERIA (TOOAN) IN KADUNA STATE, NIGERIA

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ABSTRACT

A Mathematical model was developed to predict optimum repair and maintenance cost for Mahindra 6005 model tractor, with a view to providing such decision-making aids as machine's replacement and overall farm budgeting for machinery managers. Information on 75 Mahindra 6005tractors was obtained through a structured questionnaire. Data collected was sought on tractor characteristics and economic costs such as use of tractor each year, fuel consumption cost, lubrication oil cost, oil and fuel filters replacement cost and labour cost. Result showed that the cost of tractor spare parts replacement had the highest percentage share (54.2%) from the total percentage cost followed by cost of fuel (20.4%), labour cost (13.0%), and then cost of lubrication oil (10.3%) while cost of oil and fuel filter replacement had the least (2.1%) percentage share.

Keywords: Repair, maintenance, cost, tractor, Mahindra 6005, Nigeria.

Correct Citation of this Publication
Shani B. B.and Musa A. (2021). Development of a model for estimating repair and maintenance cost for mahindra 6005tractor: a case study of tractor owners and Operators Association of Nigeria (tooan) in kaduna state, nigeria. *Journal of Research in Forestry, Wildlife & Environment* Vol. 13(3): 50 - 54

INTRODUCTION

One of the difficulties in analysing repair and maintenance costs is that they change over time. Depreciation tends to be great at first, especially for a machine purchased new, but declines over time. Likewise, interest expense is high initially but gradually diminishes.(Shani et al.,2019) This is true whether the interest cost is cash interest paid on a loan, or an opportunity cost based on revenue foregone by continuing to own a machine year after year. On the other hand, repair costs may amount to little or nothing when a machine is still under warranty, but eventually increase as parts wear out and maintenance requirements rise. Fuel and lubrication costs usually do not change much over time, although an older engine may eventually lose some degree of fuel efficiency (Theodorea *et al*., 2016).

Tractor costs have great influence on farm business profit. Knowledge of tractor costs for farm operations has a prime importance in making management plans and decisions especially in comparing different tractor types and models thereby assisting in the selection of a more appropriate farm tractor. Costs of owning and operating farm machinery represent 35 to 50% of the costs of agricultural production when the land is excluded. Making smart decisions about how to acquire machinery, when to trade, and how much capacity to invest in can reduce machinery costs as much as $50 per acre. All these decisions require accurate estimates of the costs of owning and operating farm machinery, (Williams E, 2015). The repair and maintenance (R&M) cost is an important item in the costs of ownership and operation. R&M cost is a function of machine age and use (Hunt, 2001). In

general, the costs other than those for R&M usually decrease with increasing usage, but the reverse is true with respect to R&M costs and established that the cost of R&M is usually about 10% of the total cost; as the machine age increases the cost increases until it becomes the largest cost item of owning and operating the farm machines.

Abuabkar *et al*. (2013) in his findings on research on MF375 showed that the cost of tractor spare parts replacement had the highest percentage share (54.2%) from the total percentage cost followed by cost of fuel (20.4%), workmanship cost (13.0%), and then cost of lubrication oil (10.3%) while cost of oil and fuel filter replacement had the least (2.1%) percentage share. Tchotang *et al*. (2016) in their research presented an approach for deriving a mathematical model that predict repair and maintenance (R&M) cost of farm tractors in The Gambia. As John Deere (JD) tractors are widely used by Gambian farmers, a study was conducted to predict accumulated repair & maintenance costs (Y) of the two-wheel drive (2WD) JD-5403 tractor based on accumulated working hours (X). In order to determine the mathematical model for the studied tractor, regression analysis using knowledge based analytical software (SPSS STATISTICS 21 and Excel 2016 version) was performed on the calculated data generating five regression models: linear, logarithmic, polynomial, power and exponential. The statistical results showed that the polynomial model gave better cost prediction with higher confidence and less variation than other models. Finally, it was established that repair and maintenance cost increased with an increase in working hours of JD-5403 traFarm power, machinery and equipment are major cost items in agriculture. Shani et,al. (2019) in their research to develop a mathematical model to forecast repair and maintainance of John Deer 5065e model in Nigeria, obtained results that the cost of tractor spare parts replacement had the highest percentage share (54.2%) from the total percentage cost followed by cost of fuel (20.4%), labour cost (13.0%), and then cost of lubrication oil (10.3%) while cost of oil and fuel filter replacement had the least (2.1%) percentage share..

Repair and maintenance (R&M) costs of farm machinery are difficult to estimate because of variability among machines and operating conditions from one farm to another and also due to unavailability of good records keeping (Lazarus and Selley, 2005). Therefore, the aim of this study is to provide a model for the repair and maintenance costs for Mahindra 6005tractor for Kaduna State of Nigeria. The results of the study could serve as benchmark information to tractor owners in the study area regarding optimum use of tractors for minimizing repair and maintenance cost per operating hour and for making replacement policy. Thus, it could be used by policy makers, farm managers and other agencies for future planning in the provision of tractor services to the farmers at relatively lower repair and maintenance cost.

MATERIALS AND METHODS

Experimental Design and Data Collection

The study was conducted in Rigachikun town of Kaduna State, Nigeria. Data were collected from 50 MAHINDRA 6005tractor operators using structured questionnaire. Tractor operators were selected randomly from the study area. Information was sought on tractor characteristics and economic costs such as use of tractor each year, fuel consumption cost, lubrication oil cost, oil and fuel filters replacement cost and labour cost. The tractors were then classified according to their age (years) into 20 groups that is 1 to 20. Thereafter the mean operating hours per year was calculated separately then the mean annual repair and maintenance costs were also calculated separately for each group. The accumulated operating hours per group was calculated using equation given as reported by Khoubbakht (2008):

$$X_n = \sum_{i=1}^{n} x_i \quad \ldots\ldots\ldots [1]$$

where X is the accumulated operating hours for the 'n' group in hour (h), n is the tractor age group in year (y), x is the mean annual operating hours per group in hour per year (h/y) for the group I. Also accumulated repair and maintenance cost was calculated using equation 2 below as reported by Ward et al., (1985):

$Y_n = \sum_{i=1}^{n} y_i$ …….[2]

where Y is the accumulated repair and maintenance cost based on percentage of list price for the 'n' group and y is the mean annual repair and maintenance cost based on percentage of list price for the group I. Based on the above relationships, the ratio of the cumulative repair and maintenance costs per group based on the list price was estimated as the dependent variable and the cumulative operating hours were computed as independent variable. In order to determine mathematical model for the study, regression analysis was performed on the data using the Statistical Analysis Software (SAS, 2009). Five models were used to perform regression analysis, linear (equation 3), polynomial (equation 4), exponential (equation 5); logrithmic (equation 6); and power (equation 7), models.

$Y = a + bx$ …….[3]

$Y = a + bx + cx^2$…[4]

$A = ae^{bx}$ …. [5]

$Y = a + b \ln x$ …. [6]

$A = ax^b$ ……[7]

Both the dependent and independent variables were used to obtain the best equations to estimate repair and maintenance costs from the five models above.

RESULTS

Determination of repair and maintenance costs of the Mahindra 6005tractor

Repair and maintenance costs of the Mahindra 6005tractor were sought from the following: fuel consumption cost, lubrication oil cost, oil and filter replacement cost, spare parts cost and labour cost. Table 1 presents the result of the calculated mean annual repair and maintenance costs of the Mahindra 6005tractor with the cost of each variable and percentage share of the total. It was observed that the cost of tractor spare parts replacement (54.2%) had the highest percentage share compared to another variables' cost. This could be due to the fact that majority of the spare parts used were substandard which led to continuous replacement of spare parts

.

Table 1: Mean annual repair and maintenance costs of the Mahindra 6005 tractor Variable Cost N ($)* Percentage

S/N	Variable	Cost n	Percentage
1	Fuel consumption	3,774,000 (24,192)	20.4
2	Lubrication oil	1,905,500 (12,215)	0.3
3	Oil and fuel filters	388,500 (2,490)	2.1
4	Spare parts	10,027,000 (64,276)	54.2
5	Labour	2,405,000 (15,417)	13.0
	Total	18,500,000 (118,590)	100

** Exchange rate of N360.00 per 1.00$ as at 2018.*

The next single variable with high cost of the percentage total was the fuel consumption (20.4%). While the least cost was obtained from oil and fuel filters variable (2.1%). Also this may be attributed to the age of the tractors which could lead to consumption of more fuel. The result reported in this study was similar to the one obtained by Khoubbakht *et al.,* (2008).

The accumulated repair and maintenance and the operating hours of values Mahindra 6005 obtained were used to analysis and determine the mathematical model. The relationship between the accumulated repair and maintenance cost and the accumulated operating hours were used to develop the mathematical models are shown in Fig. 1,2,3,4 and 5 respectively. It was observed that the highest value of coefficient of correlation (R2) amongst the models was found on polynomial model (R2 = 0.9973) then followed by the power, linear, exponential and logarithmic models with R2 of 0.9908, 0.9907, 0.9332 and 0.8608 respectively. These findings are in agreement with results of many researchers Abubakar *et al.,* (2013), (Adekoya and Otono, 1990; Khoub bakht *et al.*, 2008; Konda and Shani *et al.,(*2019).

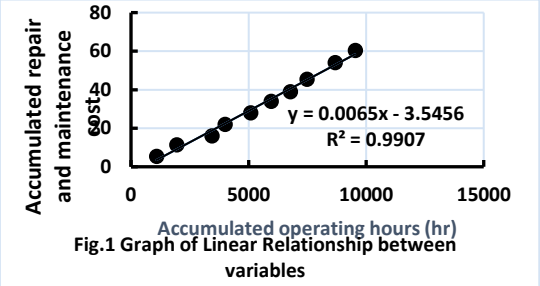

Fig.1 Graph of Linear Relationship between variables

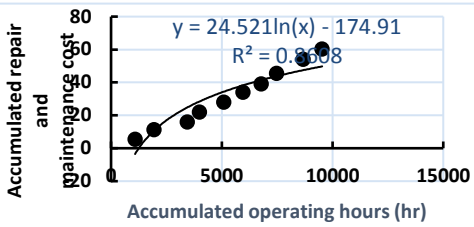

Fig.2: Graph of logarithmic relationship between variables

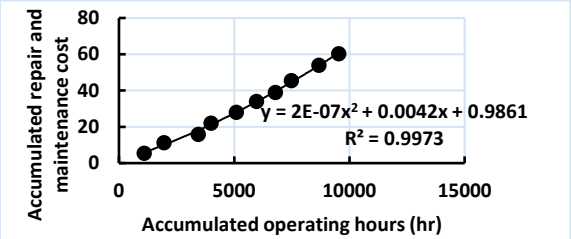

Fig. 3. Graph of Polynomial relationship between variables

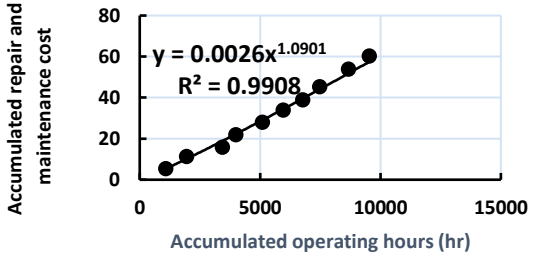

Fig. 4. Graph of Power relationship between variables

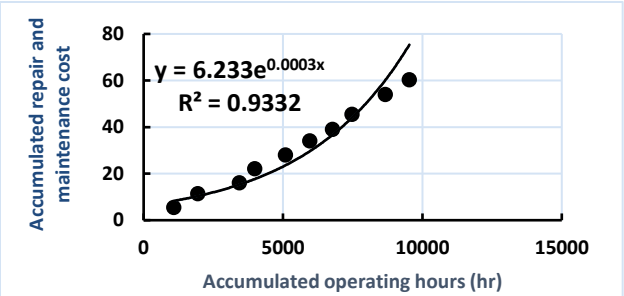

Fig. 5. Exponential relationship between variables

DISCUSSION

Mathematical model to predict the repair and maintenance costs of the Mahindra 6005tractor

The accumulated repair and maintenance and the operating hours of values Mahindra 6005 obtained were used to analysis and determine the mathematical model. The relationship between the accumulated repair and maintenance cost and the accumulated operating hours were used to develop the mathematical models are shown in Fig. 1,2,3,4 and 5 respectively. It was observed that the highest value of coefficient of correlation (R2) amongst the models was found on polynomial model (R2 = 0.9973) then followed by the power, linear, exponential and logarithmic models with R2 of 0.9908, 0.9907, 0.9332 and 0.8608 respectively. These findings are in agreement with results of many researchers Abubakar et al., (2013), (Adekoya and Otono, 1990; Khoub bakht et al., 2008; Konda and Shani *et al*.,(2019). The regression model (s) having the highest coefficient of determination (R2) was chosen as the best model(s) for the modelling of actual R&M costs evaluation. Further to it, in the most recent published researches in this field power and polynomial models gave better cost prediction with higher confidence and less variation than that of linear exponential and logarithmic models. Because of, its easiness in calculations, high correlation coefficients and using of this model by many researchers, the polynomial model as given in equation (4) was suggested as final form of the repair and maintenance cost model in the present study. The following repair

and maintenance cost components of the Mahindra-6005 tractor were determined.

CONCLUSION

The conclusions drawn from this study was that the repair and maintenance cost increased with an increase in operating hours of Mahindra 6005 tractor and the mathematical model developed has the tractor accumulated operating hours as the major determining factor of the repair and maintenance costs. It is therefore recommended that the mathematical models developed be use for tractor repair and maintenance and should be applied only to those conditions for which they were developed.

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