Repair and maintenance cost analysis of John Deere 5403 tractor in the Gambia

Análisis de costos de reparación y mantenimiento del tractor John Deere 5403 en Gambia

Tchotang Théodore[1], Lucien MEVA'A[1], Bienvenu Kenmeugne[1], Pa Tamba Jammeh[2]*

[1]National Advanced School of Engineering, Department of Industrial and Mechanical Engineering, University of Yaoundé I, Cameroon.
[2]Agricultural Engineering Service, Department of Agriculture, The Gambia.
Email: ptjammeh1812@gmail.com (*Author responsible)

ABSTRACT

The paper presents 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 tractor.

Key Words: statistical analysis, R&M cost, 2WD-Tractor, The Gambia.

RESUMEN

Este documento presenta un enfoque para derivar un modelo matemático que predice el costo de reparación y mantenimiento (R&M) de los tractores agrícolas en Gambia. Como los tractores John Deere (JD) son ampliamente utilizados por los agricultores gambianos, se realizó un estudio para predecir los costos acumulados de reparación y mantenimiento (Y) del tractor JD-5403 de dos ruedas motrices (2WD), en función de las horas de trabajo acumuladas (X). Con el fin de determinar el modelo matemático para el tractor estudiado, se realizó un análisis de regresión utilizando software analítico basado en el conocimiento (SPSS STATISTICS 21 y Excel versión 2016) sobre los datos calculados, para lo que se generaron cinco modelos de regresión: lineal, logarítmico, polinómico, de potencia y exponencial. Los resultados estadísticos mostraron que el modelo polinómico dio una mejor predicción de costos, mayor confianza y menos variación que otros modelos. Finalmente, se estableció que el costo de reparación y mantenimiento aumentó, pero hubo un incremento en las horas de trabajo del tractor JD-5403.

Palabras clave: análisis estadístico, costo R&M, 2WD-Tractor, Gambia.

INTRODUCTION

Machinery and equipment are major cost items in farm businesses. Larger machines, new technology, higher prices for parts and new machinery, and higher energy prices have all caused machinery and power costs to rise in recent years. However, good machinery managers can control machinery and power costs per acre. 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 (William, 2015).

Gambia's agricultural mechanization technology has continued to be import-oriented. Over the years, the government in response to the national plight of farmers to alleviate their labor shortage, has brought into the country agricultural machines and equipment. The maintenance of these machines is paramount in order to get the expected results of increasing the productivity of the Gambian farmer leading to increase in food production (Jammeh, *et al.*, 2015). Accurate prediction of repair & maintenance cost trends is critical in determining the optimum economical life of agricultural machines as well as making appropriate decisions for machinery replacements and general farm management purposes (Nyockeh, 2012).

MATERIAL AND METHODS

The study was conducted in Yundum agricultural station, The Gambia. Data on twenty active 2WD tractors were collected using structured questionnaires, direct survey and oral interview during the nationwide maintenance activities carried by the Agricultural Engineering Service (AES). The AES is the service unit of the Department of Agriculture (DOA), responsible for designing and introducing to farmers appropriate and

Figure 1. The John Deere JD-5403 model.

low-cost machinery for crop production and processing. For each tractor, information was sought on, tractor model, age initial purchase price, annual hours of use, annual repairs and maintenance of costs (fuel consumption cost, lubrication cost, oil and filter cost, spare parts costs and workmanship cost). After stratifying samples, the tractors were then classified according to their age (years) into 10 groups (*i.e.* 1 to 10).

The JD-5403 model selected for this study is 65 hp, 2-wheel drive (2-WD) tractor (figure 1). They are mainly used for yard work on livestock farms, orchards, vineyards and specialist production of some field-scale vegetable and salad crops. One advantage of two-wheel drive is better maneuverability and cheaper purchase price as compare to a 4-WD tractor.

In order to determine mathematical model for the studied tractor, regression analysis using SPSS 21 was performed on the data. Five models as shown below were used to carry out regression analysis, which included the following:

$Y = a+bx$ Linear model (1)
$Y = a+bx$ Polynomial model (2)
$Y = ae^{bz}$ Exponential model (3)
$Y = a+ln\ bx$ Logarithmic model (4)
$Y = ax^{b}$ Power model (5)

Where Y and x are dependent and independent variables; a, b, c, z: are regression coefficients.

Table 1. Accumulated Working Hours and Accumulated R & M cost percentage for the studied tractor.

	JD-5403	
Age (years)	**Accumulated working hours (h)**	**Accumulated R&M cost as a Percentage of list purchase price (%)**
1	1,020	0.38
2	2,150	1.19
3	3,380	2.45
4	4,318	3.98
5	5,461	6.65
6	6,506	7.89
7	7,381	11.03
8	8,406	14.33
9	9,318	18.86
10	10,284	24.43

Table 2. Model summary and parameter estimates for JD-5403.

Model	Model summary		Parameter estimate		
	R^2	F value	a	b	c
Linear	0.9148	4346.622	-5.2655	0.0025	
Logarithmic	0.6959	45.646	-68.445	9.1463	
Polynomial	0.9945	3980.293	1.2898	-0.0007	3E-07
Power	0.9931	2100.673	1E-06	1.7916	
Exponential	0.9427	71.898	0.4818	0.0004	

RESULT AND DISCUSSIONS

Table (1) presents the results of the calculated accumulated R&M cost (dependent variable) and accumulated working hours (independent variable), determined for the JD-5403 tractor. These results were used as data base for the trend function analysis, regression analysis and development of our mathematical model.

The relationship between the accumulated R&M cost and the accumulated working hours on the mathematical models is shown in Table (2). It illustrates the description, coefficient of determination (R^2) and Fisher (F) test results of the analysis obtained for the studied tractors. It was observed that the highest value of coefficient of correlation (R^2) amongst the models were found on polynomial model (R^2 = 0.9945), which indicate its higher conformity with the actual data trend in comparison with the other models. These findings are in agreement with results obtain by (Rashidi *et al.*, 2010) and (Khodabakhshian *et al.*, 2011) with R2 values of (0.996) & (0.998), respectively.

CONCLUSIONS

It was established that repair and maintenance cost increased with an increase in working hours of JD-5403 tractor.

The model developed has the tractor accumulated operating hours as the major determining factor of the repair and maintenance costs.

Repair and maintenance cost of the JD-5403 tractor as a percentage of initial purchase price (%) in The Gambia can be accurately predicted using the following mathematical model:

$$Y = 0.003\left(\frac{X}{100}\right)^2 - 0.07\left(\frac{X}{100}\right) + 1.2898 \qquad (6)$$

REFERENCES

Jammeh, Pa Tamba and Minteh, Mustapha. 2015. *Reports of the 3rd Nation-wide maintenance activity.* Yundum : Agric Engineering Service Unit, 2015.

Khodabakhshian, R. and Shakeri, M. 2011. *Prediction of repair and maintenance costs of farm tractors by using of preventive maintenance.* 2011. pp. 39-44.

Nyockeh, Abdoulie. 2012. Training for 50 farmers on tractor operating underway. *The Point Newspaper, The Gambia.* August Thursday, 2012.

Rashidi, Majid and Ranjbar, Iraj. 2010. *Modeling of Repair and Maintenance Costs of.* 2010. pp. 605-609. ISSN 1818-6769.

William, Edwards. 2015. *Estimating Farm Machinery Costs.* Iowa: Iowa State University Extension and Outreach, 2015.