Analysis of the Tractor Age and its Effect on Fuel Consumption: Case Study of Sudan

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Abstract--**Agricultural machinery maintenance has a crucial role for successful agricultural production. A field survey was carried out in Gezira Scheme, Blue Nile State and North Kordofan State, to collect data about tractor repair and maintenance costs, Tractor age and fuel conception of four models of Farm Tract tractors farmtrac80 (FT80), farmtrac70 (FT70), farmtrac60(FT60) and powertrac55 (PT55). The results showed significant (P> 0.05) differences between repair and maintenance costs in different systems of tractors. It's clear that the fuel conception rate increases as the age of the tractor, but the rate of increases is relatively low at the early stages of the four tractorsselected. Different mathematical regression models were also developed for nature of relationship fuel conception rate (gal/hr) and age of tractor (yrs) for each of the selected. The coefficients of correlation determination for the four tractor selected (FT80), (FT70), (FT60) and (PT55) are 0.97, 0.95, 0.90, and 0.83 respectively, which indicated that fuel conception rate was effected manly by age. This result may be attributed to determination conditions accompanied with increases with age (yrs) or may be due to the frequent fuel system failures because of the worse operation condition.**

Key words: Maintenance; modeling; fuel conception; Tractor age; 55HP to 80HP.

1. INTRODUCTION

Kasmi and Ahmed[1].Stated that fuel and lubricants consumption vary with use of machine. When accurate records are lacking the cost of fuel and lubricants can satisfactory be calculated. They developed a quantitative relationship between diesel fuel consumption, tractor age, annual use, and labor cost for maintenance for different tractor as follows:

a) H.M.T zetor 2511: $y=2.435 - 0.06x_1 - 0.000234x_2 + 0.00015x_3$
b) Massy Ferguson 1035: $y= 3.201 + 0.039x_1 + 0.00063x_2 – 0.00053x_3$
c) Escort 335: $y= 3.215 + 0.011x_1 – 0.000077x_2 + 0.00041x_3$
d) International B 275: $y= 4.278 + 0.011x_1 – 0.0011x_2 + 0.00034x_3$

Where: y = Diesel fuel consumption, x_1 = Accumulated hours of use and x_2 = Annual hours of use. They found that there highly positive correlation between the age of tractor and the diesel fuel consumption. A negative correlation has been observed between the annual hours, labor cost of maintenance and diesel fuel consumption. Fuel costs depend on the hours of operation and the size of the tractor or power unit. To determine hourly fuel consumption, multiply the tractor power-take-off horsepower by a constant that provides a value in gallons per hour. That value is 0.06 for gasoline engines and 0.044 for diesels [2].

Machinery costs are substantial; control of them is important. Custom charges are often based upon them. No one should do custom work unless the charge will cover operating costs and use-related depreciation plus a return for one's risk and time. Ideally, all allocated per acre or hour overhead costs should also be covered by anyone offering to do custom work. The market for custom work usually does not cover all costs. The market is usually somewhere in between the Use-related costs and total costs[3].Prediction of repair and maintenance costs has significant impacts on proper economic decisions making of machinery managers, such as machine's replacement and substitution [4].

(Abdallah F. E [5]. Find that, the mean repair and maintenance cost of the four tractor models showed higher repair and maintenance costs occurred from year 5-10. The engine and hydraulic unit with for more than 60% of the total repair and maintenance cost for tractor FT80 and FT60. In general the difference between four tractors subsystems may be due to the rain fed agricultural areas must be given more breakdowns since the operation condition are different from those of irrigated areas and may be due to variation in soil type.

Siemens and Bowers[6].Declared that tractors usually operate at an average of 55% of related power on a year round basis; multipliers have been determined to estimate fuel requirements. These multipliers are listed in the center column in table [1]

Table 1: Multipliers' fuel requirements.

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Engine fuel type	Average fuel consumption (gal/hr/rated P.t.o hp)	Typical Ib/gal
Gasoline	0.068	6.1
Diesel	0.043	6-9
L.P.Gas	0.080	4.25- 4.5

Some mathematical relations were developed in Sudan for repair and maintenance costs estimation for agricultural tractors [7,8and 9].They are varied in structural components due to differences in tractors specifications and conditions and locations of work, therefore, it is difficult to depend on one mathematical model for proper repair and maintenance management decisions. The aims of this study are: (i) to specify the fuel conception for different selected tractor makes. (ii) To develop appropriate mathematical models relating fuel conception and tractor age for four tractor models with different power sizes (iii) to compare the derived model with other models in Sudan.

2. MATERIALS AND METHODS

The data of the study was collected from three sites namely Gezira Agricultural scheme, Blue Nile State and North Kordofan State, which are described as follows:

2.1 Gezira Agricultural scheme: It is located in the central clay plain between the Blue Nile and White Nile of the Central Sudan. It is the first largest irrigated scheme and it covers about 9240 Km^2 or 924000 ha. Topographically the area is flat with few isolated small rocky hills [10].

2.2 Optimization experiments Blue Nile State

Blue Nile state lies between latitude 9.30 – 13.34 North with 33.8 – 35.15 South, approximately in area Of 36,708.5 km^2 included 2500 Km^2 or 252000 Hectares. Good for growing crops.

2.3 North Kordofan State: North KordofanState lies between longitudes 21.2-23 East and 56.30 – 26 West and latitudes 36.16 – 16 North and 14 – 12 South and approximately in an area of 244,700 km2.

*2.4 Tractors:*There many models of tractors working in the three states under the study. Farm tract 80, farm tract 70, farm tract 60 and power tract 55 tractors are one of the common makes available in these areas and are chosen to carry out this study. The power of these tractors mostly in the range of 45-72hp the total number of the selected tractors for the study is 100 units. The technical specifications of the four tractor models are shown in table 1& Fig 2.Many sources were used to collect data concerning tractor repair and maintenance costs they included Gezira Board, Blue Nile State and North Kordofan State. (Tractor owners companies, agricultural inspectors, mechanics, manufacturer's catalogues and tractors dealers). All these sources were interviewed and some data was collected from the field.

2.5 Data Collection:A direct meeting with customer was prepared to collect the required data then a survey was carried out in the site of the study to interview the target sources of data [5].

Table 2: Tractors technical specifications.

	Tractor Models			
Description	FT80	FT70	FT60	PT55
Engine power HP (KW)	72.4 HP	60 HP	50 HP	45
Maximum PTO power HP	64	52	48.8	40.8
Maximum torque (kgm)	28.8 @ 1420 RD	21.5	18.2 @ 1166 RPM	16.8
RPM	2200 RPM	2200	2000	2000
Engine type	4 stroke, perkins	4 stroke DI	4 stroke / DI	4 stroke / DI
Number of cylinders	4	3	3	3
Air cleaner	Dual dry/air cleaner	Dual air cleaner	Dry dual plate	Dry
Transmission	2WD	2WD	2 WD	2 WD
Brakes	Oil disc brakes	Oil disc brakes	Foot operated dry	Foot operated dry disc
PTO	540 @ 2115 RPM	450 @ 2115 RPM	540 @ 1810	540 @ 1810
Cooling system	Water cooling	Water cooling	Water cooling	Water cooling
Tyres front	7.5 x 16.8	7.5 x 16.8	6.00 x 16	6.00 x 16
Tyres rear	16.9 x 30	16.9 x 28	13.6 x 200	13.6 x 28

Source of data www.scortsagri.com

Fig. 1:Farmtrac 80HP [FT80],Farmtrac 70HP [FT70], Farmtrac 60HP [FT60] &Powertrac 55HP [PT55]

2.6 Parameters calculation

*2.6.1 Maintenance costs calculation:*The annual maintenance which includes, changing oils, greasing, cleaning, changing of filters, and labor cost for maintenance was recorded. The annual maintenance costs were calculated according to market prices of oils, greases, filters and small adjustments. The accumulated maintenance costs were calculated by summation of the mean annual costs and time for all years for each age model of the selected tractors [11].

*2.6. 2 Data recording:*First of all, it has to be assumed that the data were completely and accurately collected by the company (Danfodio commercial). It's not possible to go back and verify all expenditures; hence the existing records have to be trusted.Records of the repair and maintenance costs, including parts, labor, fuel and oil, were available for 200 two-wheel drive (2WD) tractors, over 10 years. These tractors were used for various operations such as tillage, planting and harvesting as well as transportation.The available data contain: monthly usage, monthly repair costs (including parts and labor), monthly maintenance costs (including fuel, oil, fuel filter and oil filter), and year of make purchase and tractor and model.

2.6.3 Tractor age: in this study, we are aiming to provide an effective tool for accurately forecasting fuel consumption of tractors. Tractor age, as well as initial purchase price, can differ considerably among different models of tractor. Despite this variation, it is essential to create the accumulative repair and maintenance costs of different models of tractor relatively. The calendar age is conveniently obtained by subtracting the original purchase date from the current date. Because of natural uncertainties associated with tractor repair and maintenance costs, they do not accrue as a result of elapsed calendar time. Tractor age as cumulative hours of use is a measure of how many hours the tractor physically operated. It dampens many of the cyclical variations in repair and maintenance costs. The times of oil-change in machines' life are usually recorded in terms of a calendar date. Considering the calendar date of the engine oil change and the associated monthly cost data, the cumulative costs for a given number of cumulative hours is determined.

2.6.4 Accumulated repair and maintenance costs computation:

The annual repair and maintenance costs for each age model were calculated as follows:

Annual repair and maintenance costs = annual repair costs + annual maintenance costs.

Tractors of the same models and age were grouped together and the annual repair and maintenance costs of these groups were calculated, then the annual repair and maintenance costs were expressed as percentage of the initial purchase price of the tractor model for the period of study. Statistical analysis was performed using the computer statistical package (SPSS) and excel software to perform the correlation regression relations, Regression analysis of data for all tractors was done using Version, 16.0. Linear, exponential, power and polynomial regression types were tried [12].

2.6.5 Fuel consumption determination Fuel consumption for the selected tractors was determined records and personal contact with operator in the field. Fuel consumption in gal/fed was calculated as follows:

$$\text{Fuel consumption (gal/fed)} = \frac{\text{Total consumption in a shift work}}{\text{Total feddans covered in this shift work}}$$

Then the fuel consumption (gal/fed) were calculated finding out the duration of the shift work in hours.

3. RESULTS AND DISCUSSION

3.1 Repair and maintenance costs as affected by tractor **age:**The accumulated repair(R) and maintenance (M) cost at different age of tractor selected (FT80), (FT70), (FT60) and (PT55) are shown in table [3]. The regression method was used for data analyses and the derivation equations for the four selected tractors makes are shown in table [4] and fig [2]. The accumulated R&M cost was significantly affected by the tractor age and accounted for 99% of the observed variation in age.Its observe that the cost of four selected makes increase with age, but with different rate between them FT80 have a higher cost with age followed by FT70 and FT 60 while PT55 showed the least cost throughout. This different between four tractors selected may be due to variation in preventive maintenance and operator skills. In general this high rate of cost with age may be due to attributed to high, higher charges of repair and poorer operation condition. This increases with age of cost agreed with)[9]

Table 3: Accumulated R and M costs ($) for different age groups of the four tractors makes.

Age (Yrs)	Accumulated Rand M COSTS ($)			
	FT 80	FT70	FT 60	PT 55
1-3	748	750	855.2	-
4-6	1949	971	2071.4	414.6
8-10	2863.6	1821	3348.2	1012.5

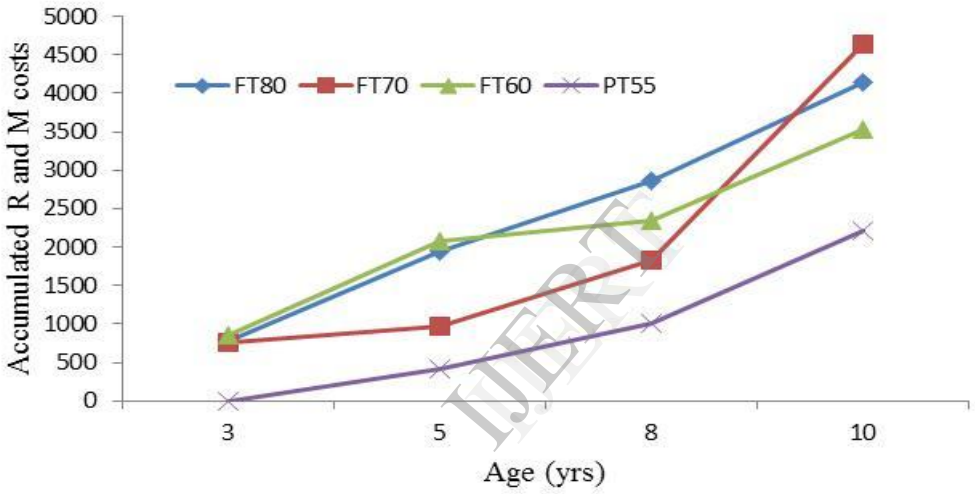

Fig. 2: R and M costs ($) as effected by age (yrs) for the selected tractor makes.

Table 4: Accumulated R and M costs ($) and tractor age (yrs) equations for the four selected makes.

Tractor makes	Equation	R^2	Multiple R	Adjusted R	F	Sign. F
FT80	$P= 423.3S^{0.9978}$	.99	.99	.997	1337.3	.0000
FT70	$P= 336.9S^{1.047}$	.99	.99	.999	10039.7	.0000
FT60	$P= 380.6S^{0.047}$	.99	.99	.990	10021.3	.0000
PT55	$P= 9.9262S^{2.234}$	.99	.99	.998	208.2	.0441

P= Accumulated R&M cost ($) - S= Tractor age (yrs)

3.2 Accumulated repair rate/1000 hours and age relationships:It'sobvious that the accumulated repair rate increases with age but with different amount of the four tractors makes. FT60 showed the highest accumulated repair rate followed by FT 80 and FT 70, while PT55 accounted for the lowest repair rate throughout all selected makes. Regression analyses were used to predict the relationship between accumulated repair rate/1000 hrs and age are shown in table [5].The repair rate was significant affected by the tractor age. This may be attributed to the operators' negligence and many breakdowns accompanied with increases of tractor age. The developed models for the selected tractors makes as power function in fig [3].

Table 5:Accumulated repair rate/1000 hrs and tractor age equations for the selected tractors makes.

Tractor makes	Equation	R^2	Multiple R	Adjusted R	F	Sign. F
FT80	$A= 2.0012G^{0.9031}$	.99	.99	.997	1823.7	.0000
FT70	$A= 1.9112G^{0.047}$	.99	.99	.999	1523.2	.0000
FT60	$A= 1.8296G^{0.9518}$	.99	.99	.990	16105.7	.0000
PT55	$A= 0.0696G^{2.337}$	.99	.99	.993	219.8	.0372

A= Accumulated repair rate/1000 hrs - G= Age of tractor (yrs)

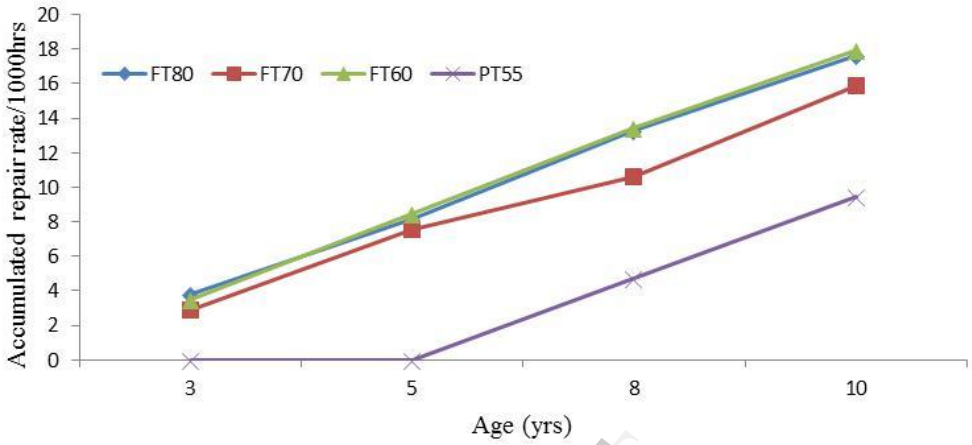

Fig. 3: the relationship accumulated repair rate/1000 hrs and tractor age for the selected tractors makes.

3.3 Fuel consumption, annual maintenance cost annual hours of use and tractor age relationship:

The Fuel consumption against annual maintenance cost ($), annual hours of use and tractor age (yrs) for the four selected tractors are shown in table [6]. It's clear that the fuel consumption rate increases as the age of the tractor increases, but the rate of increase is relatively low at the early stage of the four selected makes. At the firstly years the fuel consumption almost same for FT 80 and FT 70, FT 80 shown the highest rate of fuel consumption (2.13 gal/hr) followed by FT60, FT70 and PT55. The result showed in general, the fuel consumption rate is significant deferent for the four makes may be due to variation in technical specification e.g. engine condition, speed rate and the amount of power available at the drawbar. The confection of correlation determination for the four selected makes FT 80, FT 70, FT 60 and PT 55 are 0.97, 0.95, 0.90, and 0.83 respectively, which indicated that fuel conception rate was affected manly by age. This result may be attributed to determination conditions accompanied with increases with age (yrs) or may be due to the frequent fuel system failures because of the worse operation condition.

Table 6: Fuel consumption (gal/hr) for four selected tractors.

Age (Yrs)	Fuel consumption (gal/hr)			
	FT 80	FT70	FT 60	PT 55
1-3	1.9	1.8	1.05	1.01
4-6	2.0	1.97	1.34	1.22
8-10	2.13	2.11	2.11	1.89

4. CONCLUSION

The following conclusions were drawn from the present study: The relationship between repair rate/1000, age (yrs) and fuel consumption as percentage for the four tractor models in the three states (Gezira Agricultural Scheme, Blue Nile State and North Kordofan State) are showed. The fuel consumption rate (gal/hr) of the four selected tractors makes was found greatly affected by tractor age (yrs), annual maintenance cost and annual hour of use. Further studies must be carried out to cover more areas of the country and more tractors makes to achieve precise estimations for repair and maintenance costs for different types of soil under different operations conditions. The governmental companies and schemes that deal with agricultural tractors must concentrate on the effects of repair and maintenance costs determination on the economic life of agricultural tractors, and therefore must keep very precise records about them.Thus, the increased competition in agricultural production demands maintenance improvement, aiming at the reduction of

maintenance expenditures while keeping the safety of operations.

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COMPETING INTERESTS

Authors declare that they have no competing interests and commercial names and details of machines and equipment's are for the guidelines only.

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