EFFECTS OF MANUAL AND MECHANIZED AGRICULTURAL BUSH CLEARING METHODS ON FUEL CONSUMPTION OF TILLAGE MACHINERY IN THE DERIVED SAVANNAH ZONE OF NIGERIA

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ABSTRACT

Economic and technical evaluations of crop production require quantifying and costing fuel consumption. Fuel, mainly premium motor spirit (PMS) and auto grade oil (AGO), are indispensable in mechanized crop production. In Nigeria, these products are not only scarce but costly requiring continued studies for optimizing the consumption. A field experiment carried out to determine the effects of two agricultural bush clearing methods on fuel consumption of tillage machinery in the derived Savannah zone of Nigeria is presented. The tillage operations carried out were ploughing, harrowing and ridging. The machinery used are 41 kW two-wheel drive tractor, one meter width disc plough, an offset disc harrow of width 3 m and a 3 m width disc ridger. Before mobilizing the tractor to site, the tank was calibrated using SATAM model Rz calibration machine capable of recording fuel consumption to 0.01 litre. The fuel consumed was obtained by subtracting the reading on the dipstick after the operation from the reading before the operation in each plot. Results showed that the fuel consumption of tillage machinery was slightly influenced by the manual and mechanized methods of agricultural bush clearing. The areas cleared mechanically showed small but statistically insignificant increase in fuel consumption when compared with the results obtained from the areas cleared manually. Results show that the average quantity of fuel needed to carry out conventional tillage operation in areas cleared using manual and mechanized bush clearing methods in the derived Savannah are; 60.63 lit/ha for manual clearing, 62.13 lit/ha for area cleared using D6 crawler tractor, 61.97 lit/ha for area cleared using D7 crawler tractor and 63.53 lit/ha for area cleared using D8 crawler tractor. The fuel consumption for ploughing operation was higher than those for other operations (harrowing and ridging) in the two sites and for all the seasons. The least consumption was recorded for harrowing operation. It was recommended that further analysis be done on the data to determine the fuel consumption on the areas cleared using different clearing machinery. That is, a comparative analysis of the consumption be done among the machinery.

KEYWORDS: Bush Clearing, Fuel, Consumption, Tillage, Machinery

1. INTRODUCTION

Tillage is a post bush clearing physical manipulation of the soil aimed at modifying the soil structure (Ojeniyi, 1997). Tillage methods include conventional, reduced, conservation, zero, etc. Conservation and minimum tillage systems are increasing in importance in farming systems of many countries in recent years. For instance, in some countries, conservation tillage systems are financially supported in agri-ecological programs and thus farmers receive special payments for implementation or lose out on subsidies if conservation tillage is not used (Rücknagel *et al.,* 2004). Inspite of these, conventional

tillage system is still the most common tillage system especially in the tropics. This is probably due to the nature of soils in the sub-region which are characterized by presence of hard pans, high weed density, high bulk density, prevailing water erosion, etc.

Petroleum products mainly premium motor spirit (PMS) called petrol and Auto Gasoline Oil (AGO) called diesel are needed for operation of the machinery used in tillage operations. The fuel consumption of a diesel engine is governed by the amount of energy demand at the drawbar or the power take off or blades for rubber and track tractors (Witney and Saadoun, 1989). Due to rising cost of fuel, research has shown that in Nigeria variable costs mainly fuel are surpassing all cost items in machinery management (Adama, 2013; Adama, 2014a; Adama and Akubuo, 2017).

Except for the works of Nwuba (1979a and b) Onuigbo (1982) Nwuba and Onwuji (1983), Nwuba (1984), Nwuba and Onwuji (1986), Nwuba and Fashina, (1987); Oni and Adeoti (1995), Ojeniyi (2011), Elesa (2003), Okore, et al. (2006), Adama, (2014) most field studies on soils/tillage, crop and machinery in Nigeria focused attention on post bush clearing activities. For instance, Grisso *et al.* (2004) developed a factsheet for predicting tractor fuel consumption. Safa and Tabatabaeefar (2008) measured fuel consumption in wheat production in irrigated and land farming in Saveh city of Iran. Fathollahzadel et al. (2008) used turbine type fuel flow meter sensors to determine average and instantaneous consumption of tranian conventional tractor with moldboard plow in tillage. Ajav and Adewoyin (2012) conducted a field experiment to determine the effect of ploughing depth and speed on tractor fuel consumption in a sandy loam soil of Oyo state. Nigeria. The effects of bush clearing methods on fuel consumption of the tillage machinery are missing inmost of the works on tillage studies. This is a fundamental gap.

The objective of the study was to determine effects **of** manual and mechanized agricultural bush clearing methods on fuel consumption of tillage machinery in the derived savannah zone of Nigeria

2. MATERIALS AND METHODS

The tillage operation was carried out using a 41kW-two-wheel drive tractor. A one meter width disc plough was used for the ploughing operation. For harrowing, an offset disc harrow of width 3m was used. The ridging operation was carried out using a 3 m width disc ridger. Data for the ploughing and harrowing operations were collected for first and second cropping seasons of 2012 and 2013 while data for the ridging operation were collected for first and second cropping seasons of 2013 and 2014. The ridging operation was not considered when the field experiment started in 2012 due to the scope and objective of the first part of the study (Adama, 2013; Adama *et al.,* 2020; Adama *et al.,* 2021).

Before mobilizing the tractor to site, the tank was calibrated following standard procedure (Adama, 2013). SATAM model Rz calibration machine was used to carry out the calibration process. The objective of the calibration was to ensure accurate recording of the diesel consumption in tillage operation. The fuel consumed was obtained by subtracting the reading on a dipstick after operation from the reading before the operation in each plot.

The experimental design, field layout and bush clearing operations were as described and reported by Adama, 2013; Adama, 2014a and b; Adama and Akubuo, 2017.

3. RESULTS AND DISCUSSION

3.1 Ploughing

The average fuel consumption of tillage machinery for ploughing operation in Agu Ukehe site in two farming seasons of 2012 and 2013 is shown in Table 1. The average fuel consumption in areas cleared using manual method was obtained as 25.32 litres/ha. For areas cleared using mechanical method, the average fuel consumption of the tillage machinery were 25.98 liitres/ha, 25.85 litres/ha and 26.02 litres/ha for D6, D7 and D8 respectively.

Table 1. Fuel Consumption (lit/ha/) in ploughing operation on areas cleared using manual and mechanized methods at Agu Ukehe for two seasons 2012 and 2013

S/N	Operation	Fuel Consumption, litres/ha				
		2012 First Season	2012 Second Season	2013 First Season	2013 Second Season	Mean Consumption litres/ha.
1	Hand slashing (H_0)	25.22	25.40	25.33	25.31	25.32
2	Crawler tractor (D6)	25.90	26.33	25.69	26.0	25.98
3	Crawler tractor (D7)	25.50	25.9	26.15	25.85	25.85
4	Crawler tractor (D8)	26.90	26.05	26.04	26.00	26.02
	Grand mean					25.75

*Not significant (p< 05)

At Ako Nike site in the zone, the fuel consumption of the tillage machinery are shown in Table 2. The average consumption for the four seasons in the years under study were 24.15 litres/ha for areas cleared manually, 25.65 litres/ha in the areas cleared using D6, 25.83 liitres/ha in the areas cleared using D7 and 25.93 litres/ha in the area cleared using D8.

Table 2. Fuel consumption (lit/ha/) in ploughing operation on areas cleared using manual and mechanized methods at Ako Nike for two seasons of 2012 and 2013

S/N	Operation	Fuel Consumption, litres/ha				
		2012. First Season	2012 Second Season	2013 First Season	2013 Second Season	Mean Consumption litres/ha.
1	Hand slashing (H_0)	25.2	25.41	25.7	24.89	25.30
2	Crawler tractor (D6)	25.48	25.72	25.45	25.25	25.65
3	Crawler tractor (D7)	25.87	25.73	25.55	25.25	25.83
4	Crawler tractor D8)	26.00	25.90	25.71	25.19	25.93
	Grand mean					25.68

*Not significant (p< 05)

3.2 Harrowing

The average fuel consumption in Agu Ukehe site for the 2012 and 2013 are shown in Table 3. For the area cleared manually, the average fuel consumption was 16.10 litres/ha. For areas cleared with D6, the result was 16.63 litres/ha. The fuel consumption in areas cleared using D7 and D8 were 16.38litres/ha and 16.75/litre/ha respectively.

Table 3. Average fuel consumption (lit/ha/) in harrowing operation on areas cleared using manual and mechanized methods at Agu Ukehe in two seasons of 2012, 2013.

S/N	Operation	Fuel Consumption, litres/ha				
		2012 First Season	2012 Second Season	2013 First Season	2013 Second Season	Mean Consumption itres/ha.
1	Hand slashing (H_0)	16.01	16.19	16.30	19.90	16.10
2	Crawler tractor (D6)	16.25	16.25	16.48	16.32	16.63
3	Crawler tractor (D7)	16.30	16.27	16.40	16.37	16.38
4	Crawler tractor D8)	16.35	16.55	16.60	16.20	16.75
	Mean					16.47

*Not significant (p< 0.5)

At Ako Nike (Table 4), the average fuel consumption were obtained as follows, 14.78 in area cleared manually, 15.48 litres/ha in area cleared using D6, 15.60 litres/ha in areas cleared using D7 and 16.05 litres/ha in areas cleared using D8

Table 4. Average fuel consumption (lit/ha/) in harrowing operation on areas cleared using manual and mechanized methods at Ako Nike in two seasons of 2012, 2013

S/N	Operation	Fuel Consumption, litres/ha				
		2012 First Season	2012 Second Season	2013 First Season	2013 Second Season	Mean Consumption litres/ha.
1	Hand slashing (H_0)	15.00	14.72	14.40	14.38	14.78
2	Crawler tractor (D6)	15.25	15.15	15.50	15.30	15.48
3	Crawler tractor (D7)	15.30	15.45	15.65	15.40	15.60
4	Crawler tractor D8)	15.0	16.00	16.10	16.05	16.05
	Mean					15.48

*Not significant (p< 0.5)

3.3 Ridging

The average fuel consumption of tillage machinery for ridging operation in Agu Ukehe and Ako Nike sites in two farming seasons of 2012 and 2013 is shown in Tables 5 and 6 respectively.

The average fuel consumption in areas cleared using manual method at Agu Ukehe was obtained as 19.98 litres/ha (Table 5). For areas cleared using mechanical method, the average fuel consumption of the tillage machinery at Agu Ukehe were 20.30 liitres/ha for D6, 20.08 litres/ha for D7 and 21.29 litres/ha for D8.

Table 5. Fuel consumption (lit/ha/) in ridging operation on areas cleared using manual and mechanized methods at Agu Ukehe in first and second seasons of 2013 and 2014 seasons

S/N	Operation	Fuel Consumption, litres/ha				
		2013 First Season	2013 Second Season	2014 First Season	2014 Second Season	Mean Consumption litres/ha.
1	Hand slashing (H_0)	20.00	19.97	20.83	19.12	19.98
2	Crawler tractor (D6)	20.20	20.00	19.98	20.60	20.30
3	Crawler tractor (D7)	19.99	20.40	20.00	19.93	20.08
4	Crawler tractor (D8)	20.02	21.20	21.99	21.95	21.29
	Grand Mean					20.41

*Not significant (p< 0.5)

At Ako Nike, the results were 19.78 litres/ha for areas cleared manually. For areas cleared mechanically, the results were recorded as 20.20 litres/ha for D6, 20.19 litres/ha for D7 and 21.00 litres/ha for D8.

Table 6. Fuel consumption (lit/ha/) in ridging operation on areas cleared using different bush clearing methods and machinery at Ako Nike first and second seasons of 2013 and 2014 seasons

S/N	Operation	Fuel Consumption, litres/ha				
		2013 First Season	2013 Second Season	2014 First Season	2014 Second Season	Mean Consumption litres/ha.
1	Hand slashing (H_0)	19.40	18.96	20.00	20.76	19.78
2	Crawler tractor (D6)	20.00	19.91	20.49	20.40	201.20
3	Crawler tractor (D7)	19.87	20.20	20.69	20.00.	20.19
4	Crawler tractor D8)	20.52	21.60	20.88	21.00	21.00
	Grand Mean					20.29

*Not significant (p< 0.5)

4. OVERALL RESULTS

The overall results of the effects of manual and mechanized methods of agricultural bush clearing on fuel consumption of tillage machinery in the derived Savannah zone of Nigeria are presented in Table 7. The results were average values from the two sites in 2012 and 2013 for ploughing and harrowing operations and 2013 and 2014 for ridging operation in areas cleared using manual and mechanized bush clearing methods in the derived Savannah are; 60.63 lit/ha for manual clearing, 62.13 lit/ha for area cleared using D6 crawler tractor, 61.97 lit/ha for area cleared using D7 crawler tractor and 63.53 lit/ha for area cleared using D8 crawler tractor. operation. From the results, the quantity of fuel needed to carry out conventional tillage

Table 7. Fuel consumption (lit/ha) for conventional tillage operation in the derived Savannah of Nigeria for areas cleared using manual and mechanical methods of bush clearing

S/N	Treatment	Operation and fuel consumption, litres/ha			
		Ploughing *	Harrowing *	Ridging**	Overall total
1	Hand slashing (H_0)	25.31	15.44	19.88	60.63
2	Crawler tractor (D6)	25.82	16.06	20.25	62.13
3	Crawler tractor (D7)	25.84	15.99	20.14	61.97
4	Crawler tractor (D8)	25.98	16.40	21.15	63.53

* Average values over 2012 and 2013 farming seasons. ** Average values over 2013 and 2014 farming seasons.

5. CONCLUSIONS AND RECOMMENDATION

The effect of manual and mechanized bush clearing methods on fuel consumption of tillage machinery in the derived Savannah zone of Nigeria has been determined.

The fuel consumption for ploughing operation was highest when compared to other operations (harrowing and ridging) in the two sites and for all the seasons.
The least fuel consumption was recorded for harrowing operation when compared to other two operations (ploughing and ridging).

The fuel consumption of tillage machinery was slightly influenced by the manual and mechanized methods of agricultural bush clearing. The areas cleared manually showed lower but statistically insignificant increase in fuel consumption when compared with the results obtained from the areas cleared mechanically.

It is recommended that the data should be further analyzed to compare the fuel consumption the tractor among the areas cleared using the three bush clearing machinery.

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