International Journal of Research in Agricultural Sciences
Volume 2, Issue 2, ISSN (Online): 2348 – 3997)

Fuel Consumption Pattern of Some Selected Tillage Systems on the Atabadzi Soil Series of Ghana

Adewunmi Taiwo
email: padetaiwo@yahoo.com

Abstract: **This paper developed and tested a tillage system that will optimize fuel consumption in primary and secondary tillage operations for farmers in Ghana and other West African countries with similar soil and socio-economic environments. The general objective of this study was to investigate the effects of four different tillage systems (A, B, C, and D) on the fuel consumption of tractor providing power to the attached tillage implements during the tillage of Atabadzi soil series of Ghana at the beginning of the cropping season. The specific objectives were to: 1. use mounted 2-bottom and 3-bottom disk plough as well as offset disk harrow/tractor aggregates to develop four different tillage systems (A, B, C and D) and use to carry out field tests in the selected soil series. 2. Test the effect of the four different tillage systems on the fuel consumption pattern of the two-wheel tractor providing power to the attached tillage implements.3.Perform an analysis of variance with a view to determine whether there is a significant difference between the fuel consumptions of the investigated tillage systems.**

A one-way classification or one-factor experiment was carried out in three replications using complete randomization design (CRD) for the experimental plots. A study area of 2,025m ^{2}(or 0.2025 ha) was demarcated and divided into three plots of 675m^2 (36.66m × 18.33m) each.

It was concluded from the study that carrying out first ploughing operation on the Atabadzi soil series of Ghana with the use of mounted 2-bottom disk plough made the tractor providing power for the tractor/implement aggregate to consume more fuel than when a mounted 3-bottom disk plough was used when the soil moisture content was 1.67 % (w.b.); The mean fuel consumption for the use of 2-bottom and 3-bottom disk ploughs for the first ploughing operations on the soil series were 21.0 and 13.13 L/ha respectively. Similar results were obtained for the second ploughing operation although the mean fuel consumption were 12.4 and 11.43 L/ha respectively.

It was also be concluded from the study that the fuel consumption for harrowing on the soil series initially ploughed with 3- and 2-bottom disc plough using off-set disc harrow immediately after the second ploughing operation were 7.5 and 7.63 L /ha respectively, although the difference was not statistically significant (p>0.05) despite the differences in the widths of cut for the two mounted plough types.

Keywords: **Atabatzi Soil Series, Fuel Consumption Pattern, Mounted Offset Disc Harrow, Tillage Systems.**

I. INTRODUCTION

Tillage is the mechanical manipulation of soil for any desired purpose, but in agriculture the term is usually restricted to the changing of soil conditions for the enhancement of crop production [11]. With this definition, it could also be inferred that one of the basic goals of tillage is to produce the necessary soil physical condition on the basis of utilitarian and/ or economic considerations. There several types of tillage (including primary and secondary tillage), tillage systems, specific tillage operations as well as tillage tools and implements. There is also an interplay between soil reaction, soil type as well as soil and surface characteristics during tillage operations [1]. It is therefore mandatory for the modern day farm manager to thoroughly understand the interrelationships between the soil/tool interface, tillage and all the inputs required in order to have an agricultural production outfit that is economically competitive in this era of globalization and dwindling world's resources. Most tillage operations carried out for agricultural purposes make use of implements which derive their power from tractors. Unless the engine power of a tractor is converted to traction power efficiently, it is either that the tractor has enough power and less energy than that required to do the work is getting to the implement or that the tractor does not have enough power to provide the energy required to do the job to the implement [15]. Agricultural tractors belong to a group of machines which are of great importance in modern day agricultural production systems. It is the belief among many stakeholders in agriculture any increase in the working efficiency of the machine will translate to an increase in the agricultural production enterprise. For example [17] estimated that for each 1% improvement in traction efficiency of the tractor, 285-300 million liters of fuel could be saved annually in the US. Due to the fast worldwide dwindling supply of nonrenewable fossil energy resources, it is essential to optimize fuel consumption. Agricultural mechanization alone consumes approximately 40 to 50% of total agricultural production inputs from soil preparation to product harvesting [12], [14].

Quoting from[16] "Depending on the type of fuel and the amount of time a tractor or machine is used, fuel and lubricant costs will usually represent at least 16 to over 45 percent of the total machine costs.…" In order words, considerations for fuel consumption occupy a very significant position in the selection, operation and management of tractors and equipment.

A. Atabadzi Soil Series

There are five different types of soil series in the Cape Coast area of Ghana; they are ethnopedologically named: Edina, Benya, Udu, Bronnyibima and Atabadzi soil series (2, 1973). They were confirmed as StagnicLixisol, HaplicRegosol, EutricGleysols, HaplicLixisol and PlinthicLixisol respectively by the World Reference base, (2006). The Atabadzi series (PlinthicLixisol) consists of yellowish red to red, well to moderately drained clay loams and clay developed in colluvial material over gravely

clay on middle slopes [19], [6].

B. Fuel

Fuel is a chemical energy-containing substance which is put in an engine with a view to make it convert its chemical energy content into mechanical energy. It could be described as the lifeblood of modern-day agricultural and transportation systems. For example petrol, Diesel, Liquefied Propane Gas (LPG) and Liquefied Natural Gas (LNG) are the commonest fuel types used in modern-day farm tractors.

The price of fuel in Ghana is relatively unstable, because it keeps increasing almost on a daily basis. With such a high price as is currently being paid in the country no farmer or farm manager that is out for sustainability and competitiveness will want even a drop of fuel purchased to be wasted during tillage or any operation on the farm.

C. Fuel Consumption

Fuel consumption is the amount of fuel consumed by the farm tractor for a specific work.

D. Fuel Consumption Measurement

It can be measured in several ways, some of which include, filling method and flow meter sensors method.

Filling Method

In this method the fuel tank of the tractor is completely filled up before and after a field operation, noting the area covered during the field operation. The amount of fuel consumed in liters is divided by the size of area covered to give fuel consumption in liters per square meter (L/m^2) as shown in Equation (1):

$$\text{Fuel Consumption, L/m}^2 = \frac{\text{Volume of Fuel Consumed,L}}{\text{Area Covered ,m}^2} \quad (1)$$

Fuel consumption can also be measured by the amount of fuel consumed during a specific time period as shown in Equation (2):

$$\text{Fuel Consumption, L/s} = \frac{\text{Amount of fuel used,(L)}}{\text{Specific time period,(s)}} \quad (2)$$

Flow Metre Sensors Method

In this method, an electronic board is used to receive and save digital pulses sent by the flow metre sensors. One of the sensors is installed where fuel enters the injector pump while another flow metre is located where fuel returns to the tank [7]. Fuel consumption at various tillage depths and speeds were successfully measured by [13] by making use of an oval flow metre sensor. Similarly, Natsis et al.,(1999) used a small cylindrical fuel container branched to the main fuel line and equipped with a transparent fuel level indicator to measure fuel consumption.

E. Objectives

The general objective of this study was to investigate the effects of four different tillage systems(A, B, C, and D) on the fuel consumption of tractor providing power to the attached tillage implements during the tillage of Atabadzi soil series of Ghana at the beginning of the cropping season.

The specific objective were to: 1. use mounted 2-bottom and 3-bottom disk plough as well as offset disk harrow/tractor aggregates to design four different tillage systems (A, B, C and D) and use to carry out field tests in the selected soil series. 2. Test the effect of the four different tillage systems on the fuel consumption pattern of the two-wheel tractor providing power to the attached tillage implements. 3. Perform an analysis of variance to determine whether there is a significant difference between the fuel consumptions of the tillage systems.

II. MATERIALS AND METHODS

A. Study area

The study was conducted on the Teaching and Research Farm of the University of Cape Coast which lies within the coastal savanna zone in the Central Region of Ghana. The test site which has been under continuous cultivation for several years and only allowed to fallow during the dry seasons is located around longitude 1^o $15^{'}$ West and latitude 5^o North of the equator. The vegetation with which it was covered before use for the test was Indian grass interspersed with shrubs and, at times, crop residues of maize cultivated during the previous cropping season.

It has an average annual rainfall of about 920 mm with bi-modal rainy seasons. The long rainy season runs from March to July with maximum rainfall occurring in June while the second rainy season which is shorter runs from September to November. Temperatures are generally high throughout the year with mean annual minimum temperature of about 24^oC and a maximum of about 30.5^oC. High relatively humidity is usually recorded between December and February, when the dry monsoon wind from the Sahara Desert blows down towards the coastline thus creating harmattan across the entire country. Despite all these, the relative humidity never fell below 60% during this period because of the influence of the sea (2, 1973).

B. Experimental design

A one-way classification or one-factor experiment was carried out in three replications using Complete Randomization Design (CRD) for the experimental plot in order to eliminate various sources of error such as rock outcrops.

C. Randomization and Plot layout

A study area of 2,025 m^2(or 0.2025 ha) was demarcated and divided into three plots of 675 m^2 (36.66 m × 18.33 m) each. Essentially, the experiment was a one-factor experiment involving four levels of tillage types viz: A-First ploughing with 3-bottom disk plough, second ploughing with 3-bottom disk plough, and harrowing with offset disk harrow; B-First ploughing with 2-bottom disk plough, second ploughing with 2-bottom disk plough, and harrowing with offset disk harrow; C- First ploughing with 3-bottom disk plough, second ploughing with 2-bottom disk plough, and harrowing with offset disk harrow; D-First ploughing with 2-bottom disk plough, second plo-ughing with 3-bottom disk plough, and harrowing with offset disk harrow.

The figures in Table 1 were multiplied by 10 to convert to fuel consumption in liters per ha as shown in Table 2 for Minitab analysis. The data in Table 2 were rearranged for Minitab analysis as shown in Table 3.

III. RESULTS

Table 1: Fuel Consumption Data obtained from Three Tillage Operations carried out with Three Types of Implements (L/m^2)

Tillage operation	Soil Surface Condition	Implement used	R1	R2	R3	Total
First Ploughing	Hard Surface	B1	1.29	1.33	1.32	3.94
		B2	1.96	2.22	2.12	6.3
Second Ploughing	Tilled Surface	B1	0.59	1.48	1,36	3.43
		B2	0.74	1.57	1.41	3.72
Harrowing	Soft Surface	$B1_a$	0.62	0.84	0.79	2.25
		$B2_b$	0.67	0.86	0.76	2.29

Legend: B1……. 3-bottom disk plough, B2…….. 2-bottom disk plough, $B1_a$……. Offset disk harrow used on area ploughed with 3-bottom disk plough, $B2_b$……. Offset disk harrow used on area ploughed with 2-bottom disk plough; Hard surface- Soil surface condition before ploughing, Tilled surface- Soil surface condition after the first ploughing operation, Soft surface- Soil surface condition after the second ploughing operation.

Table 2: Fuel Consumption Data obtained from Three Tillage Operations carried out with Three Types of Implements (L/ha)

Tillage operation	Soil Surface Condition	Implement used	R1	R2	R3	Total	Mean
First Ploughing	Hard Surface	B1	12.9	13.3	13.2	39.4	13.13
		B2	19.6	22.2	21.2	63	21
Second Ploughing	Tilled Surface	B1	5.9	14.8	13.6	34.3	11.43
		B2	7.4	15.7	14.1	37.2	12.4
Harrowing	Soft Surface	$B1_a$	6.2	8.4	7.9	22.5	7.5
		$B2_b$	6.7	8.6	7.6	22.9	7.63

$$A = B1+B1 + B1_a \quad \text{……(3)}$$

$$B = B2+B2+ B2_b \quad \text{……(4)}$$

$$C = B1+B2+\left(\frac{B1_a + B2_b}{2}\right) \quad \text{……(5)}$$

$$D = B2+B1+\left(\frac{B1_a + B2_b}{2}\right) \quad \text{……...(6)}$$

Table 3 shows the fuel consumption in litres per hectare for the four treatments A, B, C and D in Three replicates each as explained in Table 2 and equations (3), (4), (5) and (6).

Table 3: Fuel Consumption in L/ha In Atabadzi Soil with Tillage Treatments A, B, C, and D

A	25	36.5	34.7
B	23.7	46.5	42.9
C	26.75	37.5	35.05
D	31.95	45.5	42.55

IV. DISCUSSIONS

The fuel consumption patternof the tractor during primary and secondary tillage operations on the Atabadzi soil series with the use of 3-bottom and 2-bottom disk plough as well as the offset disk harrow in Litres per square metre are as shown in Table 1 while Table 2 shows the consumption pattern in Liters per hectare. For Tillage treatment A, the first experimental plot was ploughed with a 3-bottom disk plough after which it was ploughed again with the same type of plough after a two-week interval. Thereafter, it was harrowed with the mounted offset disk harrow on the same day. The fuel consumed during each of these operations were added together and recorded as treatment A as shown in Equation (3) .This was repeated for the remaining two replications. The entire process was repeated tillage treatments B, C and D in accordance with the equations presented in Equations (4), (5) and (6).All the generated data presented in Table 2 were rearranged as shown in Table 3 for a one-way analysis of variance using the General Linear Factorial Model of the GenStat Statistical Software package, version 9.2.

A. Fuel Consumption Pattern for First Ploughing Operations Using Mounted 3-Bottom and 2-bottom Disc Plough

The fuel consumption pattern presented in Table 2 shows the fuel consumption pattern for first ploughing during primary tillage operation on Atabadzi soil with moisture content of 1.67% (wet basis) and a constant ploughing speed of 2.53 kilometers per hour (kph) using gear selection of high range, gear one, constant ploughing depth of 25 cm for both the 3-bottom and 2-bottom disk plough. The mean fuel consumption for the use of 2-bottom and 3-bottom disk ploughs for the first ploughing operations were 21.0 and 13.13 L/ha respectively(Table 2).These are generally higher than those obtained for the two other operations at the same soil moisture content with the maintenance of the same ploughing depth. However, those obtained for the use of the mounted 2-bottom disk

plough were observed to be higher than those obtained for the use of mounted 3-bottom disk plough in all the three replicates. With the use of the offset disk harrow, average fuel consumption was observed to be highest in plots initially ploughed with 2-bottom disk plough.

Complete Examination of the results shows that tractor fuel consumption seems to be closely related to the width of cut by the three tillage implements tested. For example, the width of cut for the3-bottom and 2-bottom Disc plough were 0.75 and 0.5 m respectively. These results corroborate the findings of [14] that that in order to minimize fuel consumption during primary and secondary tillage operations, the width of cut should be maximized. greater the width of cut, the lower the fuel consumption during ploughing operation. The reason for this is probably because the tractor did more turns per plot during ploughing with the use of the 2-bottom disc plough than it did withthe 3-bottom disc plough.

B. Fuel consumption pattern for second ploughing operation using a mounted 3-bottom and 2-bottom disc plough

Table 2 also shows the fuel consumption pattern for the second ploughing operation on the Atabadzi soil when the moisture content was 1.67% (wet basis)and the same constant ploughing speed used in first ploughing was maintained with a gear selection of high range, gear one while the ploughing depth was maintained at a constant depth of 25 cm for both the 3-bottom and 2-bottom Disc ploughs. Just as in the case of first ploughing operations, the tractor was observed to have consumed higher fuel consumption when mounted with 2-bottom Disc plough than it did when mounted with the 3-bottom disc plough because the mean fuel consumptions were 12.4 and 11.43 L/ha respectively when tested on the same plot size of 675 m^2.Although, there was higher fuel consumption for the 2-bottom disc plough than for the 3-bottom disc plough, the result of the one way analysis of variance shows that this difference was not statistically significant ($p>0.05$) despite the fact that the widths of cut for the 3-bottom and 2-bottom Disc plough were 0.75 m and 0.5 m respectively. This observation still corroborates the findings of [14] despite the fact that it is statistically insignificant. The statistical insignificance observed in this experiment must have been due to the fact that the plot size was not large enough relative to the size of the tractor used (Farmtrac 60 with a rated PTO Shaft power of 60 hp or approx. 45 kW).

C. Harrowing On an Area Ploughed with 3-Bottom Disc and 2- Bottom Disc Plough Using the Off-Set Disc Harrow

Table 2 also shows that at a constant harrowing depth of 15 cm, soil moisture content of 1.67% (wet basis) and harrowing speed of 9kph with a gear selection of three, high range,on plots initially given first and second plough operation, the fuel consumption pattern for harrowing on the plots ploughed with 3-bottom disc and 2-bottom disc plough using off-set disc harrow immediately after the second ploughing operation were 7.5 and 7.63 L /ha respectively. Shallower secondary tillage has the added benefits of not only saving fuel, but helping in reducing soil compaction, and lessening the amount of wet soil and weed seeds brought to the soil surface [10].

These findings indicates that in order to minimize fuel consumption the harrowing depth should be reduced, the width of cut should be maximized for primary tillage operations and the soil surface should not be too dry as well as reducing tillage operation since, all these factors contribute to high fuel consumption during tillage operation as attested to by the findings of (3, 2000).

V. Conclusions

This study developed four tillage systems A, B, C and D with the use of a mounted 2- and 3-bottom disk plough as well as a mounted off set disk harrow. The developed tillage systems were tested for fuel consumption in the Atabadzi soil series of Ghana. It could be concluded from this study that carrying out first ploughing operation on the atabadzi soil series of Ghana with the use of mounted 2-bottom disk plough made the tractor providing power for the tractor/implement aggregate to consume more fuel than when a mounted 3-bottom disk plough was used when the soil moisture content was 1.67 % w.b.; The mean fuel consumption for the use of 2-bottom and 3-bottom disk ploughs for the first ploughing operations were 21.0 and 13.13 L/ha respectively. Similar results were obtained for the second ploughing operation although the difference in fuel consumption was not statistically significant; the mean fuel consumptions for carrying out second ploughing operation with the use of 2-bottom and 3-bottom mounted disk ploughs were 12.4 and 11.43 L/ha respectively.

It could also be concluded from the study that harrowing with mounted offset disk harrow in atabadzi soil series initially ploughed with mounted 2-bottom disk plough made the tractor providing power for the tractor/implement aggregate to consume more fuel than when carrying out the same operation with the same implement in soil series initially ploughed with a mounted 3-bottom disk plough. The fuel consumption for harrowing on the soil series initially ploughed with 3- and 2-bottom disc plough using off-set disc harrow immediately after the second ploughing operation were 7.5 and 7.63 L /ha respectively, although the difference was not statistically significant ($p>0.05$) despite the differences in the widths of cut for the two mounted plough types.

These findings indicate that in order to minimize fuel consumption during primary and secondary tillage operations, the width of cut should be maximized.

VI. Acknowledgement

The authors would like to express their sincere appreciation to the Farm Manager of the Teaching and Research Farm of the University of Cape Coast, his tractor operators and, in fact, his entire team for the support and cooperation accorded us while carrying out the field experiments for this study.

REFERENCES

[1] ASAE "Planning and Reporting Tillage Experiment," ASAE Standard EP 236.1 American Society of Agricultural Engineers. St. Joseph. Michigan. USA. 2002.
[2] G. K. Asamoah, "Soils of the proposed farm site of the Univ. of Cape Coast," Soil Research Institute Technical Report No. 88. (insert page no.). University of Cape Coast, GHANA. (insert month). 1973.
[3] F. Bonciarelliand R. Archetti., "Energy Saving Through Reduction of Soil Tillage," Proceedings of the 15th ISTRO Conference, Fort Worth,Texas. USA. [CD-ROM] Davenport, Iowa. USA. 2000.
[4] H. W. Downs and R. W. Hansen., "Estimating Farm Fuel Requirements," No. 5.006, Colorado State University Extension..www.ext.colostate.edu/pubs/farmmgt/05006.html. Updated, August, 2012.
[5] FAO, "Tractor fuel consumption in tillage as a function of soil texture, water content and plot size," Agricultural Segment: 3(2) AGS/1580, 2012. February, 2013.
[6] FAO. FAO/UNESCO Digital Soil of the World and derived soil properties. Land and Water Digital Media Series #1 rev 1. Food and Agricultural Organization of the United Nation.FAO, Rome. 2002.
[7] H. Fathollahzadeh, H. Mobli, A. Jafari, D. Mahdavinejhadand S.M.H. Tabatabaie, "Design and Calibration of a Fuel Consumption Measurement System for a Diesel Tractor," Agricultural Engineering International: the CIGR Journal. Manuscript No.1408. Volume 13, Issue 2. June, 2011.
[8] D. Filipović, S. Košutić and Z. Gospodarić, " Influence of Different Soil Tillage Systems on Fuel Consumption, Labour Requirement and Yield in Maize and Winter Wheat Production," ISSN 1330-7142.2004.
[9] R. B. Grisso, J. V. Perumpral, D. Vaughan, G. T. Robertson and R. Pitman, "Predicting Tractor Diesel Fuel Consumption," Publication 442-073. Virginia Cooperative Extension. Virginia Tech. and Virginia State University, Virginia. USA.http://pubs.ext.vt.edu/442/442-073/442-073.html .*2010.*
[10] Z. R. "Helsel, Fuel Requirements and Energy Savings Tips for Field Operations," Cooperative Extension Fact Sheet FS 1068. Rutgers Publishers. The State University of New Jersey, New Brunswick. NJ. USA.2007.
[11] J.P. Ikisan, "Tilling equipment," (http://www.ikisan.com/Agriculture %20Machinery/Tilling%20Equipment.htm). November 2012 .
[12] A. Işık, "Sulu TarımdaKullanılanMekanizasyonAraçlarının Optimum MakineveGüçSeçimineYönelikİşletmedeğerlerininBelirlenmesiveUygunSeçimModellerininOluşturulmasıÜzerindeBirAraştırma (in Turkish)," MSc Thesis, University of Çukurova, Adana, Turkey. http://www.segmentjournals.com/?id=1580.1988.
[13] A .F. Kheiralla, A. Yahya,M. Zohadie and W. Ishak , "Modelling of power and energy requirements for tillage implements operating in Serdang sandy clay loam," Malaysia. Soil & Tillage Research 78, pp 21–34.2007.
[14] A.Rucins,andA.Vilde, "Impact of working width of the plough body on the tillage efficiency. In: Research for rural development" 2005. International scientific conference proceeding. Jelgava, 19-22 may, 2005. Jelgava, Latvia, pp 36-42.2005b.
[15] A.Sabancı,"TarımTraktörleri [Agricultural Tractors],"Ç.Ü. Ziraat Fakültesi Ders Kitapları Genel Yayın No: 46, Adana, Turkey s: 113- 167.1997.
[16] J. C. Siemens, W. W. Bowers, "Machinery Management: How to Select Machinery to Fit the Real Needs of Farm Managers," Farm Business Management Series. John Deere Publishing.1999.
[17] J. H. Taylor, "Energy Savings Through Improved Tractive Efficiency,"1 Publication 4-81. American Society of Agricultural Engineers, St. Joseph, MI 49085. USA. 1980.
[18] USDA, "Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys," Agricultural Handbook No. 436. United States Department of Agriculture Soil Survey Staff.2nd edition. Washington DC.USA.1999.
[19] USDA Keys to Soil Taxonomy. United States Department of Agriculture Soil Survey Staff.9th edition. Natural Resources Conservation Service. United States Department of Agriculture. Washington, DC. USA.2003.

AUTHOR'S PROFILE

Dr. A. Taiwo was born in Lagos, Nigeria on October 9th 1952. He obtained his B.S. degree in Agricultural Engineering from the California State Polytechnic University, Pomona, California, USA, his Master of Science degree in Agricultural Engineering was obtained from the University of Ibadan, Ibadan, Nigeria in 1984. He graduated with a PhD degree in Agricultural Engineering with specialization in Farm Power and machinery from the University of Ilorin, Ilorin, Nigeria in 2010.

Three years(1988-1991) of his career was spent outside Nigeria to work in a Rice-based Inland Valley Swamp Development Project implemented by the Food and Agricultural Organization of the United Nations in Moyamba District of SierraLeone as a UNV Mechanical Engineer/Small Tools Specialist. He was also a visiting scholar for Two and a half years(2011-2013) in the Agricultural Engineering Department of the University of Cape Coast, Cape Coast, Ghana. He is Currently an Associate professor of Farm Power and Machinery in the Agricultural Engineering Department of his Home University-LadokeAkintola University of Technology, Ogbomoso, Nigeria.

He has published 21 journal articles in reputable Local and International Journals. He has also published and contributed chapters in ten books and monographs. Some of his published journal articles are: Taiwo, A., Oje, K. "Theoretical Performance Simulation of a High Pressure Agro-Forestry Swirl Nozzle" International Journal of Agricultural and Biological Engineering(IJABE), 5(4):31-38. ISSN:1934-6344. http://www.ijabe.org ,2012 . , Taiwo, A." Study of Some Performance Parameters of a High Pressure Swirl Nozzle : An experimental high pressure agro-forestry swirl nozzle for use in studying the geometric and performance parameters" Deutschland, Germany. ISBN 978-3-8465-9846-7.Pp 268. 2012. **,**Taiwo, A. "Cassava Utilization Without Waste : performance Evaluation of a Continuous-Flow Rotary Cassava Peeler" In: Jekayinfa, S.O. (ed) : Building a Non-Oil Export Based Economy for Nigeria: The Potential of Value-Added Products from Agricultural Residues. Gottengen, Germany. ISBN: 978-3-86955-937-7. Pp. 421-425.2012.http://dnb.d-nb.de.

Dr. Taiwo is a Corporate Member of the Nigerian Society of Engineers (NSE), Nigerian Institution of Agricultural Engineers (NIAE), Member American Society of Agricultural Engineers(ASABE). He is a Registered Engineer with the Council for the Regulation of Engineering in Nigeria(COREN).

He is also an awardee of the Alpha Kappa Miew(AKM) Honours Award of the Florida A&M University, Tallahassee, Florida, USA in 1975, President club of the American Society of Agricultural Engineers (ASAE) now (ASABE) in 1982.

Finally, he is also a recipient of the Raw Materials Research and Development Council (RMRDC) grant for National Research Work on 'Production of Cassava Chips and Utilization of Peels for Energy Source in Animal Feed Production.' Several technical reports emanated from the project, some of which include: Taiwo, A., Tewe, O. O) "Replacement of Maize with Cassava Peels in Broiler Rations'. A Technical Report on National Cassava Research Project on Production of Cassava Chips and Utilization of Peels as Energy Source in Animal Feed Formulation submitted to the Raw materials Research and Development Council(RMRDC), Abuja Office, Nigeria. 2009. Taiwo "Evaluation of a Continuous Flow Rotary Cassava peeler". A Technical Report on National Cassava Research Project on production of Cassava chips and Utilization of Peels as Energy Source in Animal Feed Formulation submitted to the Raw materials Research and Development Council (RMRDC), Abuja Office, Nigeria.2009.Taiwo, A. 'Evaluation of a Rotary Cassava Chipper'. A Technical Report on National Cassava Research Project on production of Cassava chips and Utilization of Peels as Energy Source in Animal Feed Formulation submitted to the Raw materials Research and Development Council (RMRDC), Abuja Office, Nigeria.2009.