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FARM MECHANIZATION LEADING TO MORE EFFECTIVE ENERGY-UTILIZATION FOR CASSAVA AND YAM CULTIVATION IN RIVERS STATE, NIGERIA

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ABSTRACT

Surveys have been conducted, under the auspices of the Ministry of Agriculture and Agricultural Development Projects (ADPs), in the 23 local-government areas of the Rivers State, Nigeria. A structured questionnaire, personal visits to farms and interactions with information repositories were used. The quantities of energy consumed by tractors used in activities associated with the growing of cassava and yam crops in those areas were compared with traditional operations, using just manual labour. Within the period of 1986 → 2004, the total energy utilizations in the production of these crops, in the 23 local government areas, were 2738.87 MJ and 33.5 MJ for traditional manual and tractor power operations respectively. The tractorization intensity (TI) dropped from 0.352 hp/ha in 1986 to 0.345 hp/ha in 2004. This result was below the presently advocated 0.5 hp/ha for agricultural operations in order to increase crops production. This study identified the causes of this shortfall and recommended, at least for the short-term future, that farm industrialization of all sectors should be subsidized.

Keywords: farm mechanization, energy utilization, Rivers State.

Nomenclature / Abbreviations

A_c	Total land-area subjected to mechanization
ADP	Agricultural Development Project
FCMS	Farmers' Cooperative Management System
FGOMS	Federal-Government Owned Management-System
h	Weighted average size of tractors
$h_{\bar{P}}$	Average tractor power
IOMS	Individual Owned Management System
m	4 group of tractors with respect to capacity
N	Number of tractors available
n	Number of tractors in a capacity range
P_u	Total tractor power in use
SGOMS	State-Government Owned Management-System
TI	Tractorization intensity

%0p	Percentage of operational tractors
∑	Summation

HISTORIC PERSPECTIVE

In the pre-independence era of Nigeria, the dominant role of agriculture in the nation's economy was taken for granted. The first decade, after the country's independence, was a period during which Regional Governments became involved directly in agricultural production in order to enhance the output of the private sector, peasant farmers and fishermen [1]. During this period, the main agricultural productions were mainly for export crops, e.g. cocoa in the Western Region, groundnuts and cotton in the Northern Region, as well as palm produce and rubber in the Eastern Region. Also national self-sufficiency in food production did not pose any problems worthy of public attention. However, after two decades of independence, despite the greater involvement of the Government, there was a rapid deterioration in the national and Rivers State's agricultural situation. Food shortages worsened as a result of the "Oil Boom" which led to the migration of labour from the agricultural sector. Before 1971, Rivers State practised both subsistence and cash-crop agriculture and relied solely on human beings as the source of power. Among the major crops grown were rubber, oil palm, cassava, yam, cocoyam and pepper. However, their productivities were low, because, as Liljedahl et al [2] stated, human beings are limited to less than 0.1 kW continuous power output. To overcome this limitation, the introduction of agricultural mechanization in the State started during the period of the first military administration (1967-1976) with the procurement of the first batch of tractors and associated farm implements in 1971. The State established several farms and tractor-hiring programmes, as well as trained the requisite manpower at the Agricultural Mechanization Training Centre in Oyo State in 1971 to handle the machinery fleet. Thereafter, successive military and civilian government administrations procured various tractors as the need arose.

In Rivers State, the farm holdings are small, ranging from 0.25 to 5 ha. They are owned and operated by farmers and their households but often widely dispersed spatially [3, 4]. Each farmer and his household cultivated between 2 and 4 non-contiguous plots in a farming season. During this period under review in Rivers State, the land-preparation operations, namely tillage and cultivation, break and stir up the soil in readiness for crop planting [5] were predominantly manual operation actions using universally accepted implements.

According to Kepner et al [6], the increased production that has been achieved during the past century resulted from the growing of better crop varieties, the more effective use of fertilizers, improved cultural practices, and, more importantly, the increased utilization of (i) more appropriate non-human energy and (ii) employing functionally-appropriate machines and implements.

Thus, the objective of this investigation was to collate information on the present acceptances of farm mechanization energy-utilization and TI in the Rivers State. This

knowledge it is hoped will assist the government in encouraging Nigerian farmers to adopt the more profitable utilization of machine power.

THE INFORMATION

The main sources of evidence for this investigation were obtained from the State Ministry of Agriculture, through personal visits to the farms and discussions with record holders. Field surveys were conducted in the 23 local-government areas of the State. Further data were obtained from answers to a structured questionnaire concerning agricultural mechanization procedures; farm sizes, cultivation practices; use of tractors and implements; labour utilization and requirements; energy utilization; timeliness of agricultural operations, availability of credit facilities; farmers' social conditions, such as education, knowledge of farm machines; availability of repair facilities; as well as make, model, number, capacity and year of purchase of each tractor.

DATA COLLECTION AND PROCESSING

Information collected for each of the 23 local-government areas, using both primary and secondary sources, have been analysed. The primary data were obtained from the structured questionnaire, personal contact and oral interviews. Some physical inspections were also undertaken. By a secondary method, relevant information was obtained from agricultural documents (such as bulletins), workshops and seminars.

The assessment of the degree of mechanization achieved was accomplished in two ways. The first was the method whereby the current tractorization intensity (TI) in hp/ha units in the State was computed using the definition proposed by Anazodo et al. [7], viz:

$$TI = \frac{P_U}{A_C} \qquad (1)$$

The second assessment was based on an energy analysis. Suitable energy equivalents for human and tractor powers were used to convert the man-hr and tractor-hr expenditures into MJ of energy consumed [8] as kWh = 3.600 x 10^6J and 0.5hp/ha = 0.373kW/ha.

For the important crops grown in Rivers State, the energy utilized in the various operations namely land-clearing, ridging, mound making, planting, weeding and harvesting were analysed from the gathered information.

DISCUSSION

An appraisal of tractor acquisitions (1971→2004) revealed those that were available for farming in Rivers State are shown in Table I: 17 different designs of tractors were used in the State. Table 2 shows the percentage distribution of purchases according to models: a total of 10 different tractor makes were used.

In Table 3, tractor procurement, by the State government, has been grouped into three decades, 1971→1980, 1981→1990, and 1991→2000 as the first, second and third decades respectively because ten-year service life was expected of each tractor [9]. Overall, FIAT tractors were the most common in Rivers State, Nigeria.

The appalling statistic revealed in Table 4, concerning actual tractor availability, could be attributed to the poor maintenance-programmes and repair facilities with respect to farming Nigeria.

TILLAGE AND CULTIVATION

Table 5, compares the field operation rates by farmers in Rivers State using either (i) hand-tools or (ii) machine power. The total of mean manual and machine indicated field works of 317.0 man-days/ha and 1.04 machine-days/ha, respectively, to achieve the same task, are shown. An analysis indicated that 32.6 man-days/ha of manual labour were used for land preparation to achieve the same as 0.10 machine days/ha when machine power was employed. The ridging and cassava planting field work utilized 0.24 machine-days/ha or 43.8 man-days/ha. Mound making and yam planting used 57.8 man-days/ha or 0.18 machine-days/ha to achieve the same end. The field work which involved, first, general weeding used 40.0 man-days/ha or 0.14 machine–days/ha. After which root weeding consumed 36.7 man-days/ha or 0.12 machine-days/ha. Manual field work is time-consuming and requires a large amount of human labour. This situation widespread amongst Rivers State farmers, who were predominantly hand-tool farmers.

ENERGY UTILIZATION IN HUMAN AND MACHINE POWERED AGRICULTURAL TECHNOLOGIES

Most traditional technologies practised in Rivers State are highly ineffective. From Table 5, it is clear that for the same cassava production per hectare, a total of 1468 MJ and 18 MJ of energy was expended for manual and machine power, respectively. The production of yam per hectare utilized a total of about 1524 MJ and 18 MJ for manual and machine power, respectively. This makes an overwhelming case for the use of tractors, in these agricultural operations.

Figures 1 and 2, showed that overall manual labour energy utilization for the same end-product was approximately 83 times the energy required when using the tractor. Energy utilization for tillage and cultivation operations in regards to land preparation, weeding and harvesting was far greater when supplied by manual labour rather than by machine.

Stout et al [10], reported specific human energy consumption for bush clearing as 1680MJ, and 19.4 man-days were required to prepare a hectare of land, whereas for the same task, the machine required as 0.88MJ energy utilization and 0.019 machine-days per hectare.

Energy utilization for manual weeding was 1320MJ and 2.29 MJ for machine field operation: 32.6 man-day/ha and 0.015 MJ machine effort were reported [10]. Energy-related data from a number of tropical cultivation systems and products for which cassava was one of them have been averaged by Leach [11] as 0.749 MJ for manual labour and 0.0487MJ when using machine power.

CONCLUSIONS

Farmers in the Rivers State employed only a low level of mechanization. The resulting low productivities were due to: poverty; ignorance; lack of incentive to use of machinery in agricultural practices; and traditional tools being cheap, simple and readily available to the poor farmer. However, the latter was very time consuming. The total energy utilizations for the manual and machine operations per hectare for achieving the same outcome were 2738.9MJ and 33.5MJ. The human energy utilization was so much for manual methods that farmers are reduced to subsistence levels. The cultivations of yam and cassava crops require more energy expenditure per hectare of land for manual than mechanical operations in Nigeria.

Tractorization intensity (T.I) decreased from 0.352hp/ha in 1986 to 0.345hp/ha in 2004 because agricultural activities in Rivers State were in decline. The 0.345hp/ha tractor-power utilization remained far below the 0.5hp/ha, as recommended for effective agriculture operations [12]. Hence the much needed food self-sufficiency has continued to elude the State. A similar conclusion applies for the entire country. Planting and harvesting of all the major crops need to be mechanized and more land used for agriculture.

A concerted effort towards achieving standardization of the components for tractors suited for the peculiar agro-physical and climatic conditions is needed in Nigeria, as this would ensure that tractors are more likely to function well throughout their service lives.

Government encouragement and incentives for farmers to use farm machinery is a desirable challenge.

TABLE 1: TRACTORS PURCHASED BY THE RIVERS STATE GOVERNMENT (1971 → 2004)

YEAR	TRACTOR MANUFACTURER	MODEL	POWER (kW)	QUANTITY	TOTAL NUMBER OF TRACTORS PURCHASED IN THE SPECIFIED YEAR
1971	MASSEY FERGUSON MASSEY FERGUSON FORD	135 165 5000(D)	48 60 48	20 3 2	25
1972	MASSEY FERGUSON	165	60	8	8
1976	JOHN DEERE DAVID BROWN	- 1990	60 53	12 7	19

1977	DAVID BROWN	1990	60	3	3
1978	FIAT FIAT	80 (DT) 640 (DT)	- 82	10 15	25
1984	STEYR STEYR	8120A 8080A	80 52	3 10	13
1985	STEYR STEYR	FIAT 666 768	52 52	5 15	20
1986	STEYR STEYR STEYR MARSHAL / LEYLAND MARSHAL / LEYLAND MARSHAL / LEYLAND	768 8130 8075 - - -	97 52 52 52 52 60	5 9 9 7 3 8	41
1989	STEYR	8075	52	50	50
1990	BELORUS	-	60	50	50
1992	ZETOR	7745	60	21	21
1996	FIAT	8066 (DT)	60	20	20
1997	FIAT FIAT	8066 70.56	52 52	14 10	24
2001	FIAT	70.56	52	3	3
2002	NEW HOLLAND	70.56	52	10	10
2003	-	-	-	-	-
2004	-	-	-	-	-
				TOTAL	**332**

TABLE 2: NUMBER OF TRACTORS (ACCORDING TO MANUFACTURER) PURCHASED BY RIVERS RIVERS STATE GOVERNMENT IN THE PERIOD 1971→2004

TRACTOR MANUFACTURER	NUMBER	% OF TOTAL
MASSEY FERGUSON	31	9.32
FORD	2	0.60
JOHN DEERE	2	3.61
DAVID BROWN	10	3.10
FIAT	77	23.18
STEYR	101	30.40
MARSHALL / LEYLAND	18	5.41
BELORUS	50	15.05
ZETOR	21	6.32
FIAT / NEW HOLLAND	10	3.01
TOTAL	**332**	**100**

TABLE 3: TRACTORS PURCHASED BY THE RIVERS STATE GOVERNMENT WITHIN SPECIFIED PERIODS

YEARS	TRACTOR MAKE	NUMBER	PERCENTAGE OF TOTAL NUMBER PURCHASED WITHIN THE DECADE (%)
1971 ⟶ 1980	MASSEY FERGUSON	31	38.75
	FORD	2	2.50
	JOHN DEERE	12	15.00
	DAVID BROWN	10	31.25
	FIAT	25	12.50
SUB TOTAL FOR THE 1ST DECADE		80	100
1981 ⟶ 1990	STEYR	101	58.05
	MARSHAL / LEYLAND	18	10.34
	FIAT	5	2.87
	BELORUS	50	28.74
SUB TOTAL FOR THE 2ND DECADE		174	100
1991 ⟶2000	ZETOR	21	32.30
	FIAT	44	67.70
SUB TOTAL FOR THE 3RD DECADE		65	100
2001 ⟶ 2004	FIAT	3	23.08
	NEW HOLLAND	10	76.92
SUB TOTAL FOR YEARS 2001 - 2004		**13**	**100**
GRAND TOTAL		**332**	

TABLE 4: SOME FARMS IN RIVERS STATE AND THEIR LEVELS OF INVOLVEMENT IN MECHANIZATION

Name of Farm	Type of management system	Size of farm (Hectares)	Number of tractors available	Staff Strength	Number of Tractors in operational condition	Number of Tractors in day-to-day use
School-to-land Authority Farm, Iriebe, Obio/Akpor L.G.A.	SGOMS	150	6	>25	4	1
Agricultural Development Programme Farm, Okoro-Odo, Obio/Akpor L.G.A.	SGOMS	100	4	>25	2	1
Nigeria Prosins Farm, Eleme, Ikwerre L.G.A.	FGOMS	80	4	>25	1	1
Zuru Farm, Rumuigbo, Odo, Obio/Akpor L.G.A.	IOMS	20	-	<10	-	-
Joel Nwala Farm, Omuma, Omuma L.G.A.	IOMS	30	-	<10	-	-
Chief N. U. Njoku Farm, Etch, Etche L.G.A.	IOMS	30	-	<20	-	-
Bionu Bangha Farmers, Cooperative Society Ltd. Bionu Bangha, Khana L.G.A.	FCMS	90	-	<10	-	-

Amadi Electrical / Farms, Igwurata, Ikwerre L.G.A.	IOMS	20	-	<10	-	-
Antali Farm Atali Obio/Akpor L.G.A.	SGOMS	100	2	>25	1	1
Rupheiza Farms, Atali, Obio/Akpor L.G.A.	IOMS	15	-	<10	-	-
Areta Farm, Atali, Odo, Obio/Akpor L.G.A.	IOMS	20	-	<10	-	-
Total		**655**	**16**	**-**	**8**	**4**

TABLE 5: COMPARISON OF THE FIELD-OPERATION RATES AND MANUAL ENERGY UTILIZATUION WITH THE MECHANIZED ALTERNATIVES IN RIVERS STATE

Field operations	**Mean manual field-work rate (man days / ha)**	**Mean machine field-work rate (machine-days/ha) for achieving the same previous section**	**Crop**	**Total energy used per ha**	
				Manual (MJ)	**Machine (MJ)**
Land clearing	32.6	0.10	Yam / Cassava	281.66	3.22
Ridging for cassava planting	43.8	0.15	Cassava	378.43	4.83
Mound making for yams	57.8	0.18	Yam	499.39	5.80
Cassava planting	57.8	0.18	Cassava	244.51	2.90
Yam planting	17.3	0.06	Yam	149.47	1.93
Weeding (root crops)	36.7	0.12	Yam / Cassava	317.09	3.87
Weeding (General)	40.0	0.14	-	345.60	4.51
Cassava harvesting	28.5	0.09	Cassava	246.24	2.90
Yam harvesting	32.0	0.11	Yam	276.48	3.54
Total	346.5	1.14		2738.87	33.50

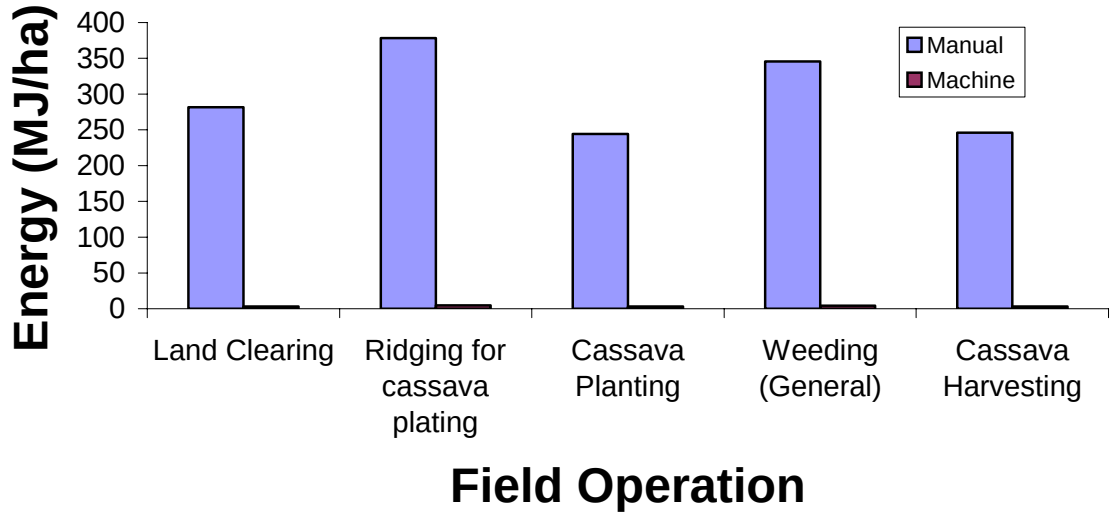

Fig.1: Energy utilization in cassava cultivation in Rivers State.

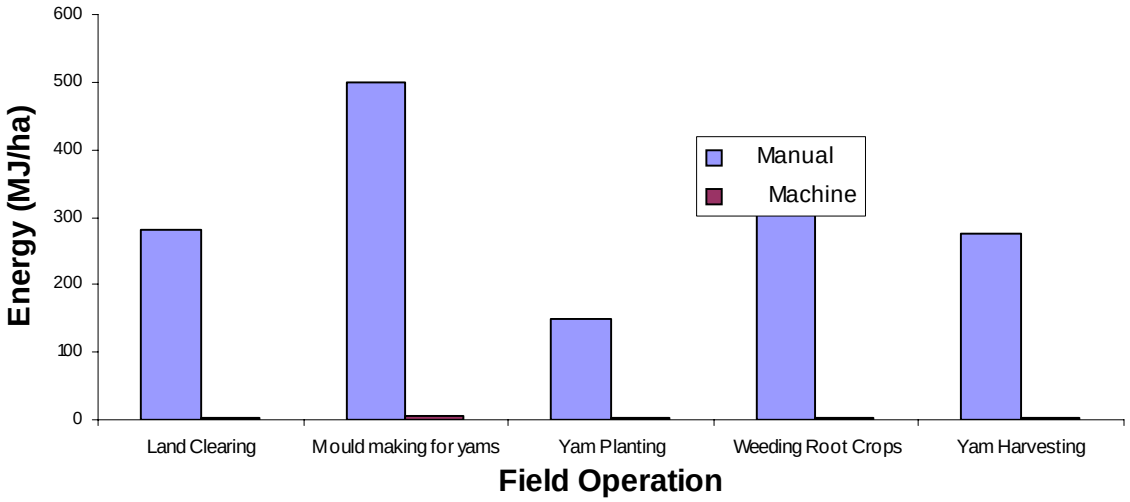

Fig.2: Energy utilization in yam cultivation in Rivers State.

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