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FARM MACHINERY SELECTION FOR AGRICULTURAL PRODUCTION BASED ON GROSS-MARGIN COSTING ANALYSIS IN LAFIA L .G .A OF NASARAWA STATE, NIGERIA

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ABSTRACT

A Survey was conducted in Lafia ,Lafia North and East Local and development areas of Nasarawa State, Nigeria to compare the costs of using hired tractors with the costs of operating privately – owned tractors. The results of survey showed that the State land areas cultivated by the survey farm enterprises was 245ha.The State number of tractors was 15 and all the tractors have the same power rating of 53.7kW (72hp).The total annual fixed cost for operating the tractors was ₦888,425.36 while the total variable cost was ₦218,535.36. The cost of hiring by government was less than that of privately-owned enterprise. It was discovered that a tractor ploughing at the rate of 1.2ha/hr and working for an average of 8hrs/day will plough 9.6ha of land per day. The result of the study also highlighted the factors that affect farm machinery selection and how best these factors could be influenced by well-planned selection practices. A gross-margin cost analysis was used in the profit evaluation of specific machinery work combination. It was found that the allocation of capital to purchase machinery can be made as effective as possible with machinery being chosen on the basis of which one will give the beneficial productivity. The paper also identified poor selection and in efficient operation as factors partly responsible for the increase in machinery operation. The study recommended among other things that the selection of farm machinery for agricultural production should be area specific due to ecological conditions and also based on the type of farm enterprise.

Keywords: Farm machinery, selection, Agricultural production, Gross-margin cost, Lafia, Nigeria

1. INTRODUCTION

The Agricultural industry, like manufacturing, utilizes labour, power and the resources of production in a planned programme of activity. In agriculture, the resources of production include land, fertilizer and a planned programme that involves the agronomic or cultural

method and a general system of farming, which are practiced. Farm machinery is recognized as the medium by which farm labour applies to the various production processes (McColly and Martin, 1955, Yohanna, 2006 & 2007). With the shift from hand –operated implements to power – operated machines, the farmer has become a larger producer with a decrease in the effort and time necessary to obtain a unit of production. The management of an organized farming enterprise now involves the selection of agricultural machines to perform the necessary operations. The proper choice and management of the power and machinery plant are ever – present problems (Smith, 1965 and Yohanna, 2007).

The satisfactory performance, efficiency and economy of a tractor and its complement of machines depend on their adaptability to the crops produced, the hectare involved and the conditions under which the machines must operate. In the production of crops certain field operations must be carried out. The machines selected must not only be adapted to use with the tractor, they must also satisfactorily perform the desired operations. Since a tractor is usually used for more than one crop, there are some machines that will be employed with all the crops such as a plough. Other machines may be special and used in connection with only one crop e.g. a potato planter. Some machines are selected for special conditions and may not serve every season; yet the lack of such machines at a critical time could mean the loss of a crop. A rotary hoe or a crust breaker is an example of such a machine (McColly and Martin 1955, Kumar et al., 2012, Ojha and Michael, 2003 & 2011 and Sahay, 2004).

Smith (1955) and Onwualu et al (2006) stated that the factors to be considered in selection of an agricultural machine over another include the trade mark, trade name, models, repairs, designs, ease of operation, ease of adjustment, adaptability to factors such as power requirement, cost of operation, initial cost (of machine), year of service expected and purchase of equipment is economical in relation to the size of farm and the work to be performed by the equipment. Anazodo (1985) observed that the application of human, animal and mechanical equipment in agriculture with reference to technical, socio – economic and cultural constraint of farm can be acknowledged in the continuing official promotion of primitive hand tool technology characterized by low production efficiency. Olaoye (2007) stated that timeliness of tillage and planting, weeding and/or harvesting are critical factors

where affordable labor is insufficient to permit timely operation. Other factors that influence successful mechanization include supporting infrastructures, land and agro-ecological conditions, technical skills and services.

Farming is generally rain fed and of the subsistence variety (IFPRI, 2010). The solution to the hunger problem lies in serious farm mechanization, high yielding varieties of seeds and the availability of fertilizer, pesticide and other farm inputs. Farm mechanization has been seen as the pivot to agricultural revolution in many parts of the world, and has contributed greatly to increased output of food crops and other agricultural products to meet the demands of the ever increasing world population. Through farm mechanization, many industrial raw materials are produced for the rapidly expanding world industries (Ituen, 2009). Tools, implements and power machinery are essential and major inputs to agriculture. The mechanization is generally used as an overall description of the application of these inputs (Clarke, 2000); while the term agricultural machinery is generally referred to as the collection of machines for agricultural production (Yohanna, 2007).

Mechanization pattern is a function of size of the farm holding, which is the limiting factor on the choice of different categories of agricultural tool, implements and machinery applied to each farm size. Therefore, to fully utilize the potential power available from agricultural machinery, care must be exercised in the manner to selecting economic, adequate and efficient machinery selection for optimum agricultural production (Ogunlowo, 1997). A rational machinery selection consists of four segments namely power requirement, tractor – implement combination, field machine matching and cost analysis. There are two types of ownership of tractors in Nigeria namely private and government. The government ownership, which has been the dominant source of power for farm operations, is administered in the tractor hiring units (THU) of the Ministry of agriculture and natural resources, Farm mechanization agencies, Agricultural development projects/programmes in the States of the federation. The major factors militating against full mechanization in Nigerian agriculture is the fact that the costs of owning and operating a tractor are the greatest factors in farm production costs (Ogunlowo, 1997). Other factors as stated by Onwualu et al (2006) include prevalence of fragmented farm holdings, prevailing agronomic practices, lack of classified data

and information, inadequate repairs and maintenance facilities, lack of trained machinery operators, poor credit facilities, inadequate research programmes, inadequate agricultural extension services, absence of incentives for indigenous design and manufacture of machines, inadequate infrastructural facilities and problem of unemployment. Thus, by selecting the optimum size tractor and undertaking properly formulated tractor job matching procedures; a substantial profit can be sustained. Whitson et al (1981) pointed out that a farm operator who operates primarily with owned machinery is faced with the task of selecting the proper size and number of equipment items to perform field operation within a given time frame.

Cervink and Chancellor (1975), Ogunlowo (1997) and Olaoye and Rotimi (2010) opined that capital costs, operating costs and energy requirement of farm machinery were important budgeting factors on most commercial farms. Murray and De-Beer (1978) viewed it as costly practice not to fully utilize the potential power available from agricultural machinery. They concluded that an effective mechanization plan needed to take into account the tractor and implements, which must be chosen so that the tractor is fully utilized with respect to the power available and so that the tractor – implement combination is matched to the size of the job at hand.

Mechanization involves many tools and machines, usually available from which farmer could choose, but when deciding on a particular machine, Booysen and De-Beer (1977) and Fernandes et al (2008) stated that it was necessary to consider the rest of the system such as availability and type of labor and implements already on the farm. Also Witney (1988), Williams (1992), Aked (1991 &1992), Onwualu et al (2006) and Olaoye and Rotimi (2010) stated that there is need to minimize service and maintenance as factors to be included in the process of choosing new tractor and equipment. Field machinery capacity requirement depends upon the amount of work to be done and time available to complete the job (Singh and Holtman, 1979, 2004 and Murase, 2007). In Hughes and Holtman (1979) and Ojha and Michael (2003), it was found that selecting the best size machine and implements for a given farm operation helps to avoid yield loss from untimely field work and excessive fixed costs of oversized machines.

Yohanna (2006) and Onwualu et al (2006) stated that there is proliferation of brands of tractors in Nigerian markets with little or no attention paid to those factors that guarantee efficiency and long service life. The irony of this situation is that the majority of these imported tractors and implements often break down within 1000 hours of operations and in most cases, the tractors become totally grounded and eventually abandoned due to non-availability of spare parts for replacement. Through personal experiences and information gathered from field officers, it was discovered that in most cases lack of genuine spare parts come directly from wrong choice of machine type and inefficient attention to the manufacturer recommendations.

The objective of this paper is to determine the factors affecting farm machinery selection and use for effective and efficient machine-implement matching that will increase agricultural productivity and maximize profit.

2.0 MATERIALS AND METHODS

2.1 AREA OF STUDY

The study reported here is carried out in Lafia Local Government and Development Areas of Nasarawa State, Nigeria. The State lies within the tropics (lat. 8.5^0N and long. 8.5^0E). It is bounded in the North by Kaduna State, in the East by Plateau and Taraba States, in the West by Abuja, the Federal capital territory (FCT) and in the South by Benue and Kogi States. It covers a land area of 27,117sq. Km and has an estimated population of two million. The State has a tropical climate with two distinct seasons, the raining season (March – October), followed by the dry season (November – February). The annual mean temperature is between 21^0C and 37^0 C and the annual rainfall is between 1100 to 1600mm. The topography is undulating, flat and hilly in most parts (Wikipedia 2014).

2.2 SAMPLING TECHNIQUES

The primary and secondary data were used in the study. The primary data was obtained through the use of structured questionnaires. The questionnaire was administered to both literate and

illiterate farmers/workers to extract information from them. For the illiterates, an assistant was used to interpret and fill the questionnaires for them. The primary data included farm size, cropping pattern, kinds of farm machines, type of tools, time required for each stage of farm operations, hiring rates, power ratings of machines, models of tractor etc. The secondary data was obtained from Nasarawa State Development Programme (NADP) newsletter and monthly seminar reports, Journals, State ministry of agriculture and water resources and Farm mechanization Agency (FAMA). For consistency of records, only farm enterprises in the State and not individual farmers were used in the primary data collection stage. This was because only few individuals could buy tractors and because individual farmers have very small farm areas. Another reason for the restriction was that most of these individual farmers are illiterates and hardly kept records. The farm enterprises used had a minimum farm area of 10 ha and most of them had records or documentations where records of the previous years were kept.

Within the three Local Government/Development areas under study, 7 farm enterprises were randomly selected from each area. Ten questionnaires were distributed in each of the farm enterprises. At the end of the survey, responses were retrieved from 6, 5 and 4 farm enterprises in Lafia municipal, Lafia East Development area and Lafia North Development area respectively. In all 75 of the farmers from 21 farm enterprises approached responded to the survey representing 71.4%, retrieved for analysis.

Gross Margin analysis (GMA) of each farm enterprise was calculated and the resulting net farm income per hectare was determined for each farm. This was used to determine which enterprise was making more profit than others with regards to the use of farm machinery at their disposal. The following relationship was used to calculate the Gross Margin (GM)

GM = R- TVC_____(1)

Where, R = Revenue generated and

TVC = Total variable or operating cost.

Total operating or variable costs include the cost of ploughing, harrowing, ridging, spraying, planting, harvesting, procurement of inputs, cost of tractor services, maintenance, repairs and

spare parts. Fixed cost includes depreciation of machines, shelter, insurance and interest on investment. There are no taxes on agricultural machinery in Nigeria.

3.0 RESULTS AND DISCUSSIONS

In the study area surveyed, farm less than 5ha and 9ha were designated as small and medium farms respectively while with a size of 10ha and above were classed as large farms based on the level of mechanization practiced in Nigeria (Ogunlowo, 1997). From this classification, most of the areas covered were in the medium – to – large farm categories. Table 1 is a compilation of the survey results from the respondents. The diverse use of tractors on some large farms resulted in less numbers of labour used per unit land area as one multipurpose machine could do the job of many farm workers. The tractor models used on most farms visited were the Massey Ferguson 375, Steyr 768 and Steyr 8075. These makes have the same average power of 53.7kW (72Hp) and the average cost of operating these tractors was ₦20, 000=00 per day. Table 2 shows the relationship between farm size and total average cost per hour for government (THU) and privately owned tractors based on the number of hours used per annum. It also shows that the larger the farm size and the number of tractors used, the higher the total variable cost (TVC). A farmer hiring a tractor has the right over the tractor for the period of time he/she pays for it. The tractor will therefore only be available to him/her despite his/her hiring power when the owner of the tractor releases it, since farm operations are time specific and as such the farmer hiring the tractor has to beat the time and the farmer leasing the tractor has to finish his/her own farm work before leasing out his/her tractor. This is responsible for the increase or higher number of labour normally found on farms that depend on hiring tractors for their farm operations. These reasons contribute to high costs of labour for hiring tractors when compared to privately – owned tractor operations. In the tractor hiring situation, the farmer pays for all farm operations the machines will perform while the owner of the machine takes care of the cost of fuelling, repairs and maintenance and wages of the operators.

Table 3 gives the relation of annual use and cost of the hired and privately –owned tractor. The annual use of privately-owned tractors is higher than the hired tractors. This was responsible for the difference in the operating costs (Table 4). The other reasons for the difference in price were

that the hired tractors' operators did not give careful attention to the tractors and these operators were also randomly selected to operate any of the tractor models. These caused frequent tractor breakdown and in such cases, the costs of spare parts for hired tractors were excessive.

The results of tractor annual use on these costs of operating tractors in the study areas are shown in Table 4. These tractors have the same power ratings of 53.7KW, age and operating under similar conditions. The total annual fixed cost with the 53.7kW MF or Steyr tractor was N888,425.36 while the total cost per hour were N721.12 and N464.40 for 1232 hours and 2184 hours annual use respectively. The table shows the cost advantage of owning farm machinery (tractors). When the tractors and implements belong to the farmer, he/she does not need to pay for the use of his/her operations, rather he/she accounts for the operating costs, cost of labour and all the inputs he/she needed on the farm. These form his/her total variable costs (TVC). From the table, the larger the farm size, the higher the TVC, and the more the tractors and implements, the higher the TVC. It should be noted that the cost of labour or labour size is a function of the number of tractors and different types of jobs the tractor could do. The investigation also revealed that the repair and maintenance costs are proportional to the tractor age i.e. as the tractor gets older, the cost of repairs and maintenance increases (Table 5 and Fig.1). The regression equation for tractor repair and maintenance cost in terms of age is given as:-

$$R_C = 1170T_A - 1735 \quad (R^2 = 0.979) \text{----------} (2)$$

$$R = 0.994$$

Where, R_C = Repair cost (N), and

T_A = Age of tractor (year).

3.1 DETERMINATION OF PROFIT BY GROSS-MARGIN ANALYSIS

Gross margin is the difference between total revenue and cost before accounting for certain other costs in calculating margins and in the ways they analyze and communicate these important

figures. Gross-Margin Analysis (GMA) is an economic process used to determine whether an enterprise is operating at profit or loss level (Wikipedia, 2014). From the survey, it was discovered that a tractor ploughing at the rate of 1.2ha/hr and working for an average of 8 hours will plough 9.6 ha of land per day. It then means that for an area of 20ha, it will take one tractor 2 days for the working period. This is so because the tractor will spend some time out of the 8 hours of each day for loading, fuelling and turning in the field. Hence the effective operating time will be enough to finish the ploughing. This survey revealed that when the tractors were under-utilized, the farmers incurred high TVC, lower profit per ha per tractor (Table 6). As the number of tractors on the farms are reduced, the profit per ha per tractor will be significantly changed thus reducing the TVC. What this shows is that it is profitable to use the exact optimum number of tractors for a particular farm operation. It was also observed that the higher the number of tractors with regards to the farm size, the lower the profit. Table7 shows the profit accruing to the farmers practicing mixed cropping operation. The total operating cost in the Table includes costs of farm inputs, labour, repair and maintenance, fuel, oil and lubrication used for the crop production in the local and development areas under study. The land limitation, available hours of field time, farm machinery size and cropping alternatives found in the survey area were also taken into consideration in the course of results compilation.

4.0 CONCLUSION

From the survey carried out, it is necessary to take into consideration the economic factors that affect the choice of tractor and implement for effective machinery use. Tractors perform farm jobs effectively only when they are properly matched with their implements. Farm machines operate over uneven terrain, through dust, sand, mud, and stones, it is therefore essential that the machinery to be employed must be ready to face the stress and strain under which it must operate without efficiency loss. The tractor and implement must be chosen so that the tractor is fully utilized with respect to the power available. Since the size of a tractor is expressed in terms of its weight, horse power and implements capacity, adequate matching of implement with tractor is ensured when the tractor power is known with respect to the number of furrow it can normally

pull on any particular soil and the width of other standard implements it may be expected to handle.

From this survey, it pays to select appropriate number of tractors for farm operations as this ensures high profit, minimizes the possibility of under-utilizing farm resources and thus saves costs. Also the use of Gross margin approach to farm machinery selection will enhance profitable decision on tractor-implement combination to accomplish a specific farm job. The expected benefits of GM approach include reduction in loss in values in terms of quality and quantity of crops and better utilization of man and machine.

The study showed that the selection of farm machinery should be area-specific and also based on the type of farm enterprise; since timeliness of operation affects crop yield and hence profitability of using machinery/equipment chosen must be reliable. This includes timely completion of all operations. The study also shows that for the use of a privately-owned tractor to be profitable, the annual use should be at least 2184 hours because this is the least number of hours that gives minimum costs of using the tractor. Also for cost of operating THU to be minimized, the tractor operators should be trained to acquire the necessary basic skills in tractor use and maintenance. It was also found that substantial profit can be obtained by selecting the optimum number of tractors and undertaking properly formulated tractor job matching processes.

The qualitative assessment of the performance of equipment is highly essential and is achieved by evaluating its suitability to the ecological condition, ease of operation and how good the quality of job the equipment does under the prevailing condition. The suitability and adaptability of imported equipment to Nigeria climate and ecological conditions constitute the problem that should be solved in assessing the effective performance of agricultural equipment.

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TABLE 1. Farm Group, farm Area and Tractor use of Respondents

Farm Group	Total Area Cultivated	% farm Area	No of tractor	Hectare per tractor
Small	22	8.89	2	11
Medium	75	30.61	4	18.8
Large	148	60.41	9	16.4

Source: Field survey. 2013.

Table 2: Relationship Between farms Area and total average cost per hour for government and privately-owned tractor.

Farm Enterprises	Each farm enterprise Area (ha)	No of tractors	Govt hiring unit Cost per hour (N)	Privately –owned unit Cost per hour (N)
1	10	1	2,500	3,125
2	12	1	2,500	3,125
3	15	1	2,500	3,125
4	18	1	2,500	3,125
5	20	1	2,500	3,125
6	22	1	2,500	3,000
7	25	2	2,500	3,000
8	30	2	2,500	3,000
9	45	2	2,500	3,000
10	48	2	2,500	3,000

Source: Field survey, 2013.

Table 3: Average Annual use and costs of government (THU) and privately owned Tractor

Ownership	Average use (hr)	Cost per hour (N/hr)
Government	1232	2,500
Private	2184	3000- 3,125

Source: Field survey, 2013.

Table 4: Effects use on costs

Tractor initial cost: N4, 200,000.00	Seasonal use of Tractor (N)	
Power: 53.7Kw (72 Hp)	1232 hours	2184 **hours**
Fixed costs		
Depreciation of 10% of initial cost	378,000	378,000
Interest on investment (9%)	207,900	207,900
Insurance and shelter at (2%)	84,000	84,000
(a) **TOTAL FIXED COST**	669,900	669,900
Variable costs		
Fuel cost	99,800	180,500
Lubrication at 2% fuel cost	6,336	12,100
Repairs and maintenance	100,000	188,500
Interest on operating cost		
@ 6% & 4% respectively.	12,369.36	13,244
(b) **TOTAL VARIABLE COST**	**218,525.36**	**344,344**
Total costs = a + b	**888,425.36**	**1,043,444**
Total costs per Hour	**721.12**	**464.40**

Source: Field survey, 2013

Table 5: Relationship between Tractor Age and Repair and Maintenance Cost

Tractor Age	**Average Repair and Maintenance cost per hour (N/hr)**
1	283.68
2	844.60
3	1604.82
4	2552.52
5	3490.64
6	4796.68
7	6106.80
8	7534.32
9	9072.12
10	10,711.80

Source: Field survey 2013

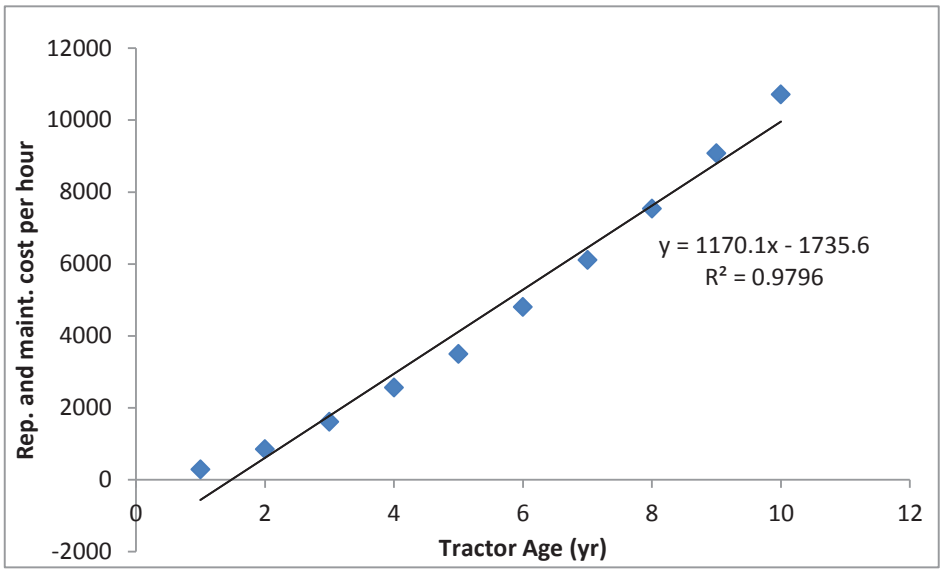

Fig. A plot of tractor age against repair and maintenance cost per hour

TABLE 6: EFFECT OF TRACTOR USE ON PROFIT

Land Area Hectare	No of Tractor	Fixed cost (FC) (N)	Total variable cost (TVC) (N)	Revenue (R) (N)	Gross Margin (GM) (N)	Profit (GM-FC) (N)	Profit per Profit per hr per(ha) ------
22	2	11 8800	156860.5	774378.86	617518.29	498718.29	22669.01	11334.51
75	4	237600	179245.72	1603620	1424374.28	1186774.22	15823.266	3955.91
148	9	445500	351079.58	3976664.5	3625585.59	3180085.59	21487.06	2387.45
22	1	59400	117637.50	77581.50	559944	500544	22752	22752
75	2	99000	231593.14	1603620	1372026.86	1273026.86	16973.69	8486.85
148	5	247500	282193.50	3497992	3215798.50	2,968,298.5	20056.07	4011.21

Source: field survey, 2013

Table 7. The effect of some selected crop alternatives on operating costs, crop yields and sales prices for lafia local and development areas of Nigeria.

Land area (ha)	Mixed cropping yield (kg/ha)				Revenue generated from sales (N/ha)				Cost benefit of cropping alternatives	
	Ma	ca	cp	me	Ma	ca	cp	me	TOC(N/ha)	RAOC(N/ha)
22	1144 (14)	1198 (5)	94877 (2)	34993 (1)	44988	20996	95982	10828	127054	45740
75	11827 (43)	68767 (20)	4877 (8)	28654 (4)	58190	100711	95982	21204	201535	74552
148	9876 (95)	125738 (31)	6828 (15)	73400 (7)	48590	148590	134375	54317	285775	102879

Source: Field survey, 2013 &2014

NOTE: Ma-maize, ca-cassava, cp-cowpea, me-melon

TOC-Total operating cost (N/ha)

RAOC-Return above operating cost (N/ha);

Figures in brackets are land allocated to each crop alternatives.