International Journal of Engineering & Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-3444

International Journal of Engineering and Technology Volume 5 No. 4,April, 2015

Performance Evaluation of Field Efficiencies of Some Tractor Drawn Implements in Ebonyi State

O.Oduma[1], J.E Igwe[2],D.I Ntunde[3]
[1]Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
[2&3]Department of Mechanical Engineering, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

ABSTRACT

The field performances of some selected tractor coupled or drawn implements which will guide the farmers in the selection of various makes and models of farm implements to optimize agricultural productivities in Ebonyi state were evaluated. The various implements studied include disc plough,3 gang tandem disc harrow,2-row ridger and 4-row combine seed planter. The capacitive performances evaluated against these implements are operation speed, operation depth, field efficiency, effective field capacity, theoretical field capacity and fuel consumption rate. The massey fagunson tractor of model MF 375E and capacity of 58.5KW with three point hitch system was used to power the implements. The experiment was conducted at EBADEP farm Ezillo at a land area of 7650m^2 (0.765ha). Results revealed that the plough operated at average speed of 5.54±0.40km/hr, harrow operated at average speed of 6.66±0.11km/hr while the ridger and seed planter operated at average speeds of 5.98±0.18km/hr and 4.68±0.33km/hr respectively. The field efficiencies of the implements were 75.73±i1.50% for the disc plough, 82.11±6.98% for the harrow, 79.94±1.75% and 77.92±1.49% for the ridger and the combine planter respectively. For the fuel consumption rate during operation, 22.87±0.63L/ha was consumed during ploughing while harrowing, ridging and planting operations respectively consumed 21.71±1.43L/ha, 18.41±0.33L/ha and 17.42±0.38L/ha of fuel. The implements operated at average depths of 0.24m, 0.22m, 0.275m and 0.025m for ploughing, harrowing, ridging and planting operations respectively. Due to variations in ecological soil conditions, it is therefore recommended that detailed time studies for each operation should be carried out to provide data of field efficiency of machines in different geographical zones; to enable farmers select the appropriate equipment for their farm works.

Key Words. *Field Efficiency, Performance Evaluation, Tractor Drawn Implement, Operation Speed, Ecological Soil Condition and Ebonyi State.*

1. INTRODUCTION

Every machine is designed to perform a given task at a specified time; if this designed objective is not met, it means that such machine and its power unit is questionable (Ojah and Michael 2012).Agriculture is very sensitive to timely operations and weather conditions, and huge amount of money is spent on investment, therefore there is the need to evaluate the capacitive performance of agricultural machines for proper machinery selection, optimization and farm scheduling (Sale et al,2013).

A successful farmer strives to make judicious use of agricultural inputs such as seeds, fertilizer, herbicides or insecticides, irrigation water and farm equipment in order to maximize production with minimum cost (Yohanna and Ifem 2000).Farm equipment acts as a device to ensure that other input give the desired results. Thus, it may be said that farm equipment and the techniques associated with its use broadly constitute the field of agricultural mechanization. Famers are very much concerned about the qualitative and quantitative field performances of the farm equipment during operation to enable them build up the expenses incurred in the purchase or hiring of such equipment.

In the light of the farmers' desire to maximize their production and/or profit, Sale et al(2013) maintained that agricultural task must be well planned and timely executed, since agriculture is essentially affected by weather and climate. In rain fed farming system, agricultural operations must be carried out within a time frame to achieve maximum yield; however, is also a limited time frame within which agricultural field works must be done at minimum cost to obtain optimum crop yield. The huge investment involved in tractors and machinery give cause for better assessment and/or evaluation of the field efficiencies of some tractor coupled or drawn implement used in farming operations.

Efficient machinery management requires accurate performance data on the capabilities of individual machines in order to meet a given work schedule and to form balanced mechanization systems by matching the performance of separate items of equipment (Whiteney, 1988). There is considerable variation in operating conditions, such as in topography, surface roughness, hardness, stoniness and soil trafficability.

Machines can be evaluated over a short period in productive work- equivalent to speed trials or they can be monitored over-time taking into account associated delays(Yohannah and Ifem,2003).Braid and Gwarzo (1985),therefore identified four types of machine performances that must be evaluated if a true knowledge of an agricultural machine is to be secured; they include functional, mechanical, capacitive and economic performances, however, field performances of agricultural machineries are affected by many factors. The major factors include those of power unit/machine condition, field and crop conditions, weather, soil type/condition and management.

According to Sale et al (2013), capacitive performance is a factor which determines how a machine completes a job within allowable constraints of time. They maintained that the capacitive performance of an agricultural machine give the answers to the question "Will the machine complete the job or task given within the allowable constraints of time under a variety of field conditions '' or is it a poor investment regardless of its costs? Tractor drawn implement should perform tasks satisfactorily with minimal damage of crops in case of seeding/planting, harvesting, prepare seed bed while conserving moisture content of the soil, create good aeration of the soil and necessary environmental condition for crop growth and conserve the soil against erosion and nutrient losses.

Energy is another important key in agricultural operations. Updhyaya et al (1984) asserts that energy plays key role in various land tillage, seeding/planting and harvesting of agricultural productivities. According to Bukhari and Baloch (1982),the speed of operation width and depth of cut, soil type and skill of machine operation affect fuel consumption. Therefore implement size and speed must also be matched to tractor size to enhance field performance efficiencies of operation (Collins et al,1981).The performance of agricultural machinery can generally be assessed by the rate of operation and the quality of output. Gbadamosi and Magaji (2003) believed that field machine performance or capacity is the rate at which it can cover a field while performing its intended function or useful work. Kuel et al (1985) stipulated that field capacity is usually measured by the rate of work in hectares per hour, and that the factors involved are the width of the useful work and the speed of travel with the allowance for the lost time in turning and servicing the machine. Efficiency of machine s shows how well they do or are made to do tasks that they are designed to perform. A good farmer will always ensure the effective and efficient operation of his farm equipment because inefficient operation or poor utilization may result to great operating expenses and reduces profit or cause total loss in productivity.

According to Anozodo et al (1983),performance data of the field efficiencies under different soil conditions is very important for tractor and implement selection as these are important parameters for measuring and evaluating performance of farm tractor implements. Unfortunately, these data are not made available to farmers here in Nigeria by the manufacturers of the machines to enable them assess and possibly make proper selection of the equipment before purchase. The data would have been a good guide for a better understanding and selection of the capabilities especially in the rural areas. The objective of this study is to evaluate the field efficiency of some selected farm tractor drawn implements and power units for seed bed preparation and planting (sowing of seed) which will guide the farmers in machine selection to reduce cost and optimize their production.

2. MATERIALS AND METHODS

2.1 Site and Machine Description

The EBADEP farm Ezillo in Ishielu L.G.A of Ebonyi state, Nigeria was used for the study. The site has an area of $7650m^2$(0.765ha) with textural class of sandy-loam. The land area was divided into four units of 21.25 X $22.5m^2$ each, for random observations. The test was conducted in may/june that coincides with the planting season and which offered the tractor and the drawn implements an exposure to wide range of soil conditions which include vegetation, soil type, topography and moisture contents.

A massey fagunson tractor of model MF 375E and capacity of 58.8kw with three point hitch system was used for the test. The drawn implements studied include disc plough, 3-gang tandem disc harrow, 2-row ridger and 4-row combine seed planter.

Apparatus used in the study include; stop watch, which was used to keep time of operation; the measuring tape, used for linear measurements of land, working distance and width of the machine; and a wooden metre rule which was used for measuring depth of cut for tillage and seed planting operations.

2.2 Performance Test

Measurement of speed of operation

The speed of operation was evaluated by noting the working or operation distance of the machine and time taken to cover such distance. The operation speed was therefore evaluated from the expression;

$$S_W = \frac{Dw}{Tt} \qquad (1)$$

where

S_W =Working speed, km/hr
D_W=Working distance, km
T_t =Total working time,hr
The average of five replications was taken as the working speed.

Measurement of Productive And Delay (Idle) Time

The total time spent on the entire row length operation and the delay or idle time encountered during operation which include, time for refilling fuel tank, time for repair of breakdown/adjustments, turning time and any other idle moment observed were noted and the actual time (productive time) used in the operation was evaluated from the relationship:

$$T_e = T_t - T_d \qquad (2)$$

Where

T_e = Actual (productive) time,hr
T_t = Total time spent on entire row length operation,hr
T_d = Delay (idle) time,hr
Measurement of turning time commences immediately the implement is raised on the completion of a row length, to initiate a turn until it turns completely to continue the

operation. The average of five replication was taken as the working time.

Measurement of Fuel Consumption

A graduated cylindrical container was used to measure the amount of fuel required to refill the fuel tank of the tractor immediately after each operation as used by Udo and Akubuo (2000). This measurement provided the quantity of fuel consumed during each experiment.

Determination of field efficiencies

Generally, the field operation was performed longitudinally at varied forward speeds as determined by noting the distance of travel and the corresponding time taken to complete the working distance and the total productive and delay time were recorded (Afzalina et al,2006).The field efficiency was determined from equation *(3) propounded by Kepner et al (1978).*

$$\mathcal{E} = \frac{100Te}{Tt} \qquad (3)$$

Where

$\mathcal{E}$ =Field Efficiency, (%)

T_e = Actual working (productive) time,hr

T_t =Total working time = ($T_e + T_d$), hr

T_d = Delay time, hr

Determination of Effective Field Capacity

The effective field capacity was determine by measuring the effective working width of the machine and speed of operation (Oduma et al, 2014). The effective field capacity was therefore evaluated from equation (4) proposed by Kepner (1978).

$$C_e = \frac{WS}{1000}\mathcal{E} \qquad (4)$$

Where

C_e =Effective Field Capacity, ha/hr

W = Effective Working Width Of Machine, m

S = Speed Of Operation, km/hr

$\mathcal{E}$ =Field Efficiency, (%)

Determination of Theoretical Field Capacity

According to Gbadamosi and Magaji (2003), the field efficiency was given by;

$$\mathcal{E} = \frac{Ce}{Ct} \qquad (5)$$

By rearrangement, the theoretical field capacity was deduced from equation (5) as:

$$C_t = \frac{Ce}{\mathcal{E}} \qquad (6)$$

Where

C_t = Theoretical field capacity, ha/hr

C_e = Effective Field Capacity, ha/hr

$\mathcal{E}$ =Field Efficiency, (decimal)

3. RESULTS AND DISCUSSION

Table 1 presents the operation time and speeds of the machines under study. From the table, it is observable that in the tillage operation, ploughing has the lowest speed of 5.54±0.40 km/hr while harrowing recorded 6.66km/hr and ridging operation took average speed of 5.98±0.1 km/hr. The low speed observed for the ploughing operation may be attributed to higher tractive force and longer time required in ploughing operation than harrowing and ridging operation which is in agreement with sale et al (2013).The average speed of planting operation according to Table1 was 4.68±0.33km/hr. The low planting speed may be as a result of careful and systematic attention required in positioning or placement of the seeds on the ridges, which work out well under moderate machine speed.

Table 2 revealed the field efficiencies of the implements. The field efficiency of plough was 75.73±1.50% while harrow, ridger and planter were 82.11±6.98%, 79.94±1.75% and 77.92±1.49% respectively. These field efficiencies are higher than the ranges obtained by Yohanna (1998) and kaul et al (1985) but were within the ranges presented by Sale et al (2013) and Alabi (2006) for tillage operations. Their differences may be as a result of differences in local field conditions, frequent breakdowns and other down times during operations as may be encountered in different ecological zones.

The highest fuel consumption was recorded for ploughing(22..87±0.63L/ha),followed by harrowing (21.71±1.43L/ha), ridging (18.41±0.33L/ha) and least was planting operation that consumed 17.42±0.38L/ha(Table 3). Ploughing requires much tractive forces of operation than other field operations and that may be the reason for highest fuel consumption in operation. Finally the average operation depth as recorded in Table 4 for the machines were 0.241m for ploughing,0.225m for harrowing,0.275m and 0.025m for ridging and seed planting respectively**.** These values are within the ranges of depth of cut obtained by Udo and Akubuo (2000) for ploughing, harrowing and ridging operation.

Table 1.Time for tillage and seed planting operation

Operation	Trials	speed,km/hr	Productive Time,min	Delay Time,min	Total Time,min
ploughing	1	5.36	45.16	16.44	60.04
	2	5.49	39.57	14.51	54.08
	3	4.92	40.11	12.32	52.43
	4	5.88	42.30	12.18	54.48
	5	6.06	42.19	13.22	55.41
	Mean/S.D	**5.54±0.40**	**41.87±2.00**	**13.73±1.59**	**55.29±2.23**
Harrowing	1	6.58	18.15	7.20	25.35
	2	6.66	18.10	3.45	21.55
	3	6.50	17.33	5.24	22.57
	4	6.83	19.08	2.01	21.09
	5	6.71	16.45	2.31	18.76
	Mean/S.D	**6.66±0.11**	**17.82±0.69**	**4.04±1.94**	**21.86±2.14**
Ridging	1	5.92	16.12	4.11	20.23
	2	5.72	14,56	3.28	17.84
	3	6.23	15.50	4.55	20.05
	4	5.88	16.21	3.54	19.75
	5	6.14	16.14	4.29	20.43
	Mean/S.D	**5.98±0.18**	**15.71±0.63**	**3.95±0.47**	**19.66±0.94**
Planting	1	4.58	14.20	5.03	18.23
	2	5.34	13.40	4.08	17.48
	3	4.45	15.15	4.00	18.15
	4	4.50	14.29	3.43	17.72
	5	4.55	13.52	4.16	17.68
	Mean/S.D	**4.68±0.33**	**13.91±0.37**	**4.14±0.51**	**17.85±0.22**

Table 2. Field performances of implements in tillage and seed planting operation.

Operations	Trials	Speed,km/hr	Theoretical field capacity,ha/hr	Effective field capacity,ha/hr	Field efficiency,%
Ploughing	1	5.36	0.804	0.605	75.22
	2	5.49	0.824	0.603	73.17
	3	4.92	0.660	0.565	76.50
	4	5.88	0.881	0.685	77.64
	5	6.06	0.909	0.692	76.14
	Mean/S.D	**5.54±0.40**	**0.816±0.09**	**0.630±0.05**	**75.73±1.50**
Harrowing	1	6.58	1.711	1.225	71.60
	2	6.66	1.731	1.454	83.99
	3	6.50	1.691	1.298	76.78
	4	6.83	1.776	1.607	90.47
	5	6.71	1.745	1.530	87.69
	Mean/S.D	**6.66±0.11**	**1.633±0.009**	**1.423±0.28**	**82.11±6.98**
Ridging	1	5.92	0.734	0.585	78.68
	2	5.72	0.946	0.772	81.61
	3	6.23	1.134	0.877	77.31
	4	5.88	1.072	0.878	82.08
	5	6.14	1.124	0.883	79.00
	Mean/S.D	**5.98±0.18**	**1.002±0.15**	**0.799±0.11**	**79.94±1.75**
Seed Planting	1	4.58	2.382	1.885	77.89
	2	5.34	2.777	2.129	76.66
	3	4.45	2.314	1.804	77.96
	4	4.50	2.340	1.887	80.64
	5	4.55	2.366	1.809	76.47
	Mean/S.D	**4.68±0.33**	**2.436±0.17**	**1.897±0.38**	**77.92±1.49**

Table 3.fuel consumption in the operation

Operation	Trials	Speed,km/hr	Fuel consumption,L/ha
Ploughing	1	5.36	21.84
	2	5.49	23.83
	3	4.92	22.83
	4	5.88	22.87
	5	6.06	22.98
	Mean/S.D	**5.54±0.40**	22.87±0.63
Harrowing	1	6.58	22.92
	2	6.66	21.94
	3	6.50	18.97
	4	6.83	21.93
	5	6.71	22.81
	Mean/S.D	**6.66±0.11**	21.71±1.43
Ridging	1	5.92	18.91
	2	5.72	17.92
	3	6.23	18.43
	4	5.88	18.54
	5	6.14	18.23
	Mean/S.D	**5.98±0.18**	18.41±0.33
planting	1	4.58	16.92
	2	5.34	17.78
	3	4.45	17.69
	4	4.50	17.71
	5	4.55	16.98
	Mean/S.D	**4.68±0.33**	17.42±0.38

Table 4. Operation depth

Implement	Average Depth Of Operation
Plough	0.241±0.13
Harrow	o.227±0.24
Ridger	0.275±0.12
Planter	0.025±0.38

4. CONCLUSION/ RECOMENDATIONS

Plough recorded the highest field efficiency and fuel consumption because of the high tractive force or effort and longer time required for its operation as compared to harrow, ridger and planter. Local field conditions, small or fragmented farm lands and machine conditions/status determine the field performances of machineries.

It is therefore recommended that detailed time studies for each operation should be carried out in every ecological zone to provide data on field efficiency of machines because of differences in soil conditions; for instance, some ecological zones have rocky/stony terrain while some have not. The stony terrain inflicts damages to machines thereby reducing there efficiencies of operation. The data will properly guide the farmers or any user of the equipment in selecting the proper machines considering the field conditions of the area.

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