

# REGRESSION MODEL FOR PREDICTION OF FUEL CONSUMPTION AND GRAIN LOSSES OF SELF-PROPELLED PADDY REAPER R180 GD

U. Muhammad<sup>1</sup> and M. S. Abubakar<sup>2</sup>

<sup>1</sup>*Department of Agricultural and Bioenvironmental Engineering, Audu Bako College of Agriculture, Dambatta, Kano State, Nigeria.*

Email: [usmanfagge@gmail.com](mailto:usmanfagge@gmail.com)

Phone # +2348094012530

<sup>2</sup>*Department of Agricultural and Environmental Engineering, Bayero University Kano, Kano State, Nigeria.*

## ABSTRACT

Rice harvesting is normally done manually which is time consuming and highly labour intensive, hence there is need for a mechanical method of rice harvesting. Self-propelled paddy reaper is a mechanical means of harvesting rice which is more convenient than manual harvesting, yet majority of farmers around or outside the study area find it difficult to adopt the use of paddy reaper, this may be because they are not certain of the operating cost or grain losses during operation of the paddy reaper. As a result, this study aimed at creating a regression model which will assist in predicting fuel consumption and grain losses of self-propelled paddy reaper, the equation generated will suffice to minimize postharvest grain losses. Jamila and Yardass varieties of rice were used for the experiment. Multiple regression models for fuel consumption and grain loss were developed. The models were validated by plotting the predicted values against observed values. The values of the coefficient of determination,  $R^2$ ; were 0.60 and 0.66 for fuel consumption and grain loss, respectively in the Jamila variety (V1) While 0.67 and 0.78 were for fuel consumption and grain loss respectively in the Yardass variety (V2). This study shows that fuel consumption of the reaper could be reduced by reaping at lower moisture content and lower cutting speed. The developed models for predicting the fuel consumption and grain loss were in fairly close agreement with the observed values.

**Keywords:** Fuel consumption, regression model, grain losses, Paddy reaper, Rice field

## 1 INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major crops produced in the world. It is an important food crop for over half of the world's population [1], [2]. [3] reported that United Nations General Assembly (NUGA) declared the year 2004 as the International Year of Rice (IYR). This is because rice has become primary source of food for more than half of the world's population [4],[5]. Rice harvesting is the process of collecting the mature rice crop from the field. Rice harvesting operation includes cutting, laying, gathering, transporting and stacking the cut crop. Harvesting methods being used are manual harvesting and mechanical harvesting. Most farmers use manual harvesting with sickles which consumes more time and labour and then more cost requirements. Availability as well as cost of labour during harvesting is a serious problem [6].

Timely harvest of crop is important to achieve better quality of the crops. To overcome these problems, mechanical harvesting is required to minimize grain losses, quality deterioration and to maximize grain yield, field capacity, efficiency and also save total cost requirements. In small holdings,

the use of a large scale machine such as combine harvester is inappropriate because it needs high technical know-how for operation and maintenance and the large initial investment necessary. Also, field efficiency is low and losses of straw are high on irregularly furrowed soils. Hence, the use of mechanical reaper is in appropriate for small holdings.

Reaper is a crop harvesting machine which cut crops mechanically and lays down the stems, providing an alternative to using labourers to gather in crops by hand at harvest time [7]. Rice Harvesting has been and still remains a serious problem to the peasant farmers in Nigeria. The techniques for harvesting rice are still traditional based mainly on hand tools technology. This leads to the acquisition of a brand new self-propelled walking paddy reaper for teaching and research purpose in the Department of Agricultural and Environmental Engineering, Bayero University, Kano. Despite the fact that, traditional method of rice harvesting is laborious, time wasting, uneconomical and causes grain losses, commonly available rice reapers are not patronized by majority of farmers around and outside the study area. This may be because they are not certain of the operating cost or grain losses during operation of the paddy reaper. Therefore, the aim of this study is to establish a regression model for prediction of fuel consumption and grain losses of a self-propelled walking paddy reaper R 180 GD for rice harvesting.

## 2 MATERIALS AND METHODS

The materials used in this research include the following; self-propelled walking paddy reaper R 180 GD; measuring tape 50 m long; ranging pole; digital weighing balance; fuel measuring cylinder 1000ml capacity; fuel (diesel); and grain moisture meter. The rice varieties used for this study were *Jamila and Yardass*. The reaper field performance testing was carried out on Agricultural and Environmental Engineering Department Research and Demonstration field, Bayero University, Kano. The area is located about 6 km to the west of old city wall of Kano Municipal along Gwarzo road, Kano State, Nigeria. The area is between latitude 11°30' N and 8°30' E within Kano State of Nigeria with approximate boundaries consisting of the Gwarzo road to the south, the Watari River to the west. The topography is flat with slightly undulating slope in NW-SSE direction [8].

### 2.1 Description of the Self-propelled Walking Paddy Reaper R 180 GD

The machine is composed of engine, moving parts, driving system, horizontal cutting bench, traversing conveyor, reciprocating cutter, crop lifter, and divider board. Plate 1 shows the self-propelled walking paddy reaper R 180 GD.



**Plate 1:** Self-propelled walking paddy reaper R 180 GD

## 2.2 Material and Methods

Preliminary tests were conducted to determine the machine's forward speed of 2.5 km/h. The actual ground speed of the reaper was obtained by running the machine through a marked distance and timed. Crop moisture contents were monitored from time to time until appropriate rice crop harvesting moisture content obtained [9].

## 2.3 Experimental Procedure

A 25 m by 100 m rice crop field was used for the experiment. Harvesting operation was conducted using mechanical reaper by allowing the machine to enter between standing rice crops, cut the crops by the reciprocating motion of the cutter bar and finally transfer the cut crops to the side of the machine with help of chain conveyor. Operation time, total time, fuel consumption and grain losses were measured and recorded during the experiment.

## 2.4 Determination of Performance Parameters

The following parameters were determined when the reaper was operating in the field. The procedures and relationships adopted for measurement, recording and computations of various parameters are presented as follows:

### 2.4.1 Cutting speed, $C$

The knife speed of the reaper was calculated using equation provided by [7].

$$C = \frac{S \times n}{30} \quad (1)$$

Where;  $C$  = cutting speed, m/s;  $S$  = length of stroke, m;  $n$  = crank speed, rpm

### 2.4.2 Walking speed (forward speed), $S_w$

The measurement of forward speed of the self-walking paddy reaper was achieved by running the machine through a marked distance and timed. The walking speed was determined and recorded in km/h using the relationship [7].

$$S_w = \frac{3.6 D}{T} \quad (2)$$

Where;  $S_w$  = Walking speed, km/h;  $D$  = harvesting distance, m;  $T$  = harvesting time, s

### 2.4.3 Moisture content, $M$

The moisture content of the rice crop before harvest were determined by randomly taking the samples from the farm and placing them in a sealed container, it was then taken to laboratory. The samples were weighed in the laboratory and oven dried at 130°C for 24 hours and then re-weighed. The moisture content on wet basis was calculated using the formula given by [9]:

$$M = \frac{\text{weight of wet sample} - \text{weight of dry sample}}{\text{weight of wet sample}} \times 100\% \quad (3)$$

### 2.4.4 Fuel consumption, $F_c$

Fuel consumption, in liter per hour (l/h), is the amount of refueling for the evaluation test. Before the start of each test trial, the fuel tank was filled to its capacity and after each test trial; the tank was refilled using graduated cylinder. The tank was kept in a horizontal position while filling up the tank, so as not to leave empty space in the tank [7]. Fuel consumption was calculated using the relationship:

$$F_c = \frac{q}{t} \quad (4)$$

Where;  $F_c$  = Fuel consumption, l/h;  $q$  = quantity of fuel consumed, l;  $t$  = consumption time, h

**2.4.5 Effective field capacity,  $C_e$**

Effective field capacity of a machine is the actual rate of being able to reap crop in a given time. In order to determine effective field capacity, the rated width of the equipment (cutting width), speed of travel and field efficiency were measured [10]. The effective field capacity was calculated using the relationship:

$$C_e = \frac{S_o \times W \times e}{10} \tag{5}$$

Where;  $C_e$  = Effective field capacity, ha/h;  $W$  = Cutting width, m;  $S_o$  = Operating speed, km/h;  $e$  = Field efficiency, %

**2.4.6 Theoretical field capacity,  $C_t$**

Theoretical field capacity is the computed rate of being able to reap crop, it was calculated using the relationship below based on the operating speed and the width of the equipment [10].

$$C_t = \frac{W \times S_o}{10} \tag{6}$$

Where;  $C_t$  = Theoretical field capacity, ha/h;  $W$  = Cutting width, m;  $S_o$  = Operating speed, km/h

**2.4.7 Field efficiency,  $e$**

Field efficiency is the ratio of the useful time to total operating time, expressed in percent. Effective time (Useful time) was measured by stop watch and the lost time for machine adjustment, turning and refueling was taken during operation. The start and finish time of harvesting in each plot was also noted. The sum of useful time and loss time give the total operational time [10].

$$e = \frac{T_e}{T_t} \times 100\% \tag{7}$$

Where;  $e$  = Field Efficiency, %;  $T_e$  = Useful time, h;  $T_t$  = Total operating time, h

**2.4.8 Harvest losses,  $HI$**

Harvest losses were determined before and after harvesting with reaper harvester, a 1m×1m wooden frame was thrown out randomly over four spots in each plot. All the grains fallen inside the frame were gathered and weighted and the mean value were recorded [11]. But instead of using frame to mark the sample areas, ranging poles were used. Pre-harvest and post-harvest loss were determined by placing ranging poles at random on each plots to mark sample areas each measuring (1m x 1m) and collecting all the grains fail within the area enclosed by ranging poles and weighted [11]. Harvest losses were calculated using the relationship:

$$HI = \frac{W_{gt} - W_{go}}{Y} \times 100\% \tag{8}$$

Where;  $HI$  = Harvest loss, %;  $W_{gt}$  = Total harvest loss, g/m<sup>2</sup>;  $W_{go}$  = Pre-harvest loss, g/m<sup>2</sup>  
 $Y$  = Grain yield, g/m<sup>2</sup>

**2.5 Regression Model Analysis**

Regression analysis involving more than one independent variable is called multiple regression analysis. When all independent variables are assumed to affect the dependent variable in a linear fashion, and independently of one another, the procedure is called multiple linear regression analysis [12].

A multiple linear regression is said to be operating if the relationship of the dependent variable  $Y$  to the  $k$  independent variables of  $X_1, X_2, \dots, X_k$  can be expressed as:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 \tag{9}$$

Where ; $\alpha$  and  $\beta$  are coefficient

### 2.5.1 Model for predicting fuel consumption and grain losses

Multiple linear regression models to predict Fuel consumption and Grain losses with respect to moisture content and cutting speed as input parameters for each of the rice variety harvested using reaper were developed.

### 2.5.2 Fuel consumption

Multiple linear regression models to predict Fuel consumption with respect to moisture content and cutting speed as input parameters for each of the rice variety was developed. The model is shown below:

$$Fc = a + b_1M + b_2C \quad (10)$$

Where; a and b are model constants, M is moisture content, C is cutting speed, Fc is fuel consumption

### 2.5.3 Grain losses

Multiple linear regression models to predict Grain losses with respect to moisture content and cutting speed as input parameters for each of the rice variety was developed. The model is shown below:

$$Gl = a + b_1M + b_2C \quad (11)$$

Where; Gl is Grain losses, a and b are model constants

## 2.6 Data Analysis

The data collected from the experiments were subjected to analysis of variance (ANOVA) technique using statistical analysis system (SAS) software package. The developed models were analyzed using SAS (jmp software) and Microsoft excel software.

## 2.7 Model Verification

The procedure reported by [13] was adopted to modify the model. The models were verified by computing values of accuracy and precision, bias (mean difference), sum of residual (RES), absolute value of residual (ABRES), mean square prediction error (MSPE). The predicted and measured values were used to calculate various measures model quality. The mean square error (MSE) was the sum of accuracy and precision which is defined by [14] as:

$$MSE = \text{accuracy and precision} = \frac{1}{n} \sum_{i=1}^n Vi^2 \quad (12)$$

$$\text{While, RMSE} = \left[ \frac{1}{n} \sum_{i=1}^n Vi^2 \right]^{\frac{1}{2}} \quad (13)$$

Where;  $Vi$  was the difference between predicted value and observed value at locations,  $i=1, 2, \dots, n$  where  $n$  was the number of values in the check data set. Accuracy (the square of bias) was defined [14] as:

$$\text{Bias} = \frac{1}{n} \sum_{i=1}^n Vi \quad (14)$$

$$\text{Accuracy} = (\text{bias})^2 = \left( \frac{1}{n} \sum_{i=1}^n Vi \right)^2 \quad (15)$$

Where;  $V$  represents the mean of the residuals. An accurate model will have no bias.

The sum of residuals (RES) and the sum of the absolute value of the residuals (ABSRES) were used to evaluate how consistent the model was in calculating grain losses. The residual is obtained using the model below:

$$RES = \sum_{i=1}^n (Oi - Pi) \quad (16)$$

Where;  $O_i$  is measured values and  $P_i$  is calculated values and  $n$  is the number of observations.

A value of RES close to zero indicated an unbiased model and smaller values of ABRES indicate better performance. An assessment of the error of predicted related to observed values were made by

calculating the mean square prediction error (MSPE) [14], the mean square prediction error was calculated using the relationship:

$$MSPE = \sum_{i=1}^n (O_i - P_i)^2 / n \quad (17)$$

Where;  $i = 1, 2, \dots, n$ ,  $n$  is the number of experimental observation and  $O_i$  and  $P_i$  are the observed and predicted values respectively.

## 2.8 Model Validation

Validation of the model shows increase in confidence of the model in relation to solving a particular problem. If a model passes a number of tests, this only increases its credibility [15]. One of the methods that can be used for validation of a model is analysis of variance and covariance [16]. In validation of the model, the predicted values were plotted against the observed values. The coefficient of determination,  $R^2$  value was used to ascertain the agreement between predicted and observed values.

## 3 RESULTS AND DISCUSSION

### 3.1 Fuel Consumption and Grain Loss Prediction for Jamila Variety

The result for predicted and observed value for fuel consumption is shown in Table 3.1 while the value for accuracy, precision, residual, mean square error and bias for fuel consumption while harvesting *Jamila* variety (V1) is shown in Table 3.2

Table 3.1. Predicted and observed value for fuel consumption

M	C	predicted	observed	o-p	(o-p) <sup>2</sup>	(o-p) <sup>2</sup> /n
20.18	1	0.97888	0.61	-0.3679	0.1354	0.0050
20.18	1.17	1.75442	2.01	0.2586	0.0669	0.0025
20.18	1.33	2.48434	2.08	-0.4051	0.1641	0.0061
17.02	1	0.92832	0.90	-0.0306	0.0009	0.0000
17.02	1.17	1.70386	2.21	0.5067	0.2567	0.0095
17.02	1.33	2.43378	2.13	-0.3084	0.0951	0.0035
14.12	1	0.88192	0.33	-0.5497	0.3022	0.0112
14.12	1.17	1.65746	1.61	-0.0460	0.0021	0.0001
14.12	1.33	2.38738	2.10	-0.2874	0.0826	0.0031
20.18	1	0.97888	0.50	-0.4743	0.2250	0.0083
20.18	1.17	1.75442	2.85	1.0966	1.2025	0.0445
20.18	1.33	2.48434	2.50	0.0157	0.0002	0.0000
17.02	1	0.92832	0.48	-0.4520	0.2043	0.0076
17.02	1.17	1.70386	2.19	0.4904	0.2405	0.0089
17.02	1.33	2.43378	2.15	-0.2810	0.0789	0.0029
14.12	1	0.88192	0.36	-0.5187	0.2691	0.0100
14.12	1.17	1.65746	1.46	-0.2020	0.0408	0.0015
14.12	1.33	2.38738	2.67	0.2826	0.0799	0.0030
20.18	1	0.97888	0.66	-0.3182	0.1012	0.0037
20.18	1.17	1.75442	2.42	0.6614	0.4374	0.0162
20.18	1.33	2.48434	2.27	-0.2143	0.0459	0.0017
17.02	1	0.92832	0.45	-0.4776	0.2281	0.0084
17.02	1.17	1.70386	1.99	0.2842	0.0808	0.0030
17.02	1.33	2.43378	2.02	-0.4138	0.1712	0.0063
14.12	1	0.88192	2.29	1.4103	1.9890	0.0737
14.12	1.17	1.65746	2.15	0.4954	0.2454	0.0091
14.12	1.33	2.38738	2.10	-0.2828	0.0800	0.0030
Summation		45.63108	45.50308	-0.128	6.826244	0.252824

Table 3.2: Accuracy, residual, mean square error and bias for fuel consumption while harvesting *Jamila* variety (V1)

RMSE	MSE	BIAS	ACCURACY
0.502816	0.252824	-0.004741	2.24746E-05

The result for predicted and observed value for grain losses is shown in Table 3.3 while the value for accuracy, residual, mean square error and bias for grain losses while harvesting *Jamila* variety (V1) is shown in Table 3.4

Table 3.3. Prediction and observed value for grain losses

M	C	Predicted	Observed	o-p	(o-p) <sup>2</sup>	(o-p) <sup>2</sup> /n
20.18	1	2.523	2.531	0.009	0.000	0.000
20.18	1.17	3.369	2.641	-0.728	0.530	0.020
20.18	1.33	4.165	2.219	-1.945	3.784	0.140
17.02	1	8.217	5.854	-2.363	5.585	0.207
17.02	1.17	9.063	15.282	6.219	38.672	1.432
17.02	1.33	9.859	9.545	-0.314	0.099	0.004
14.12	1	13.443	11.709	-1.733	3.005	0.111
14.12	1.17	14.289	20.158	5.869	34.446	1.276
14.12	1.33	15.085	11.911	-3.174	10.073	0.373
20.18	1	2.523	2.602	0.079	0.006	0.000
20.18	1.17	3.369	2.346	-1.022	1.045	0.039
20.18	1.33	4.165	4.572	0.407	0.166	0.006
17.02	1	8.217	4.388	-3.829	14.658	0.543
17.02	1.17	9.063	4.929	-4.134	17.091	0.633
17.02	1.33	9.859	15.521	5.662	32.059	1.187
14.12	1	13.443	14.414	0.971	0.944	0.035
14.12	1.17	14.289	16.360	2.071	4.289	0.159
14.12	1.33	15.085	11.928	-3.157	9.965	0.369
20.18	1	2.523	5.633	3.111	9.676	0.358
20.18	1.17	3.369	4.214	0.845	0.714	0.026
20.18	1.33	4.165	4.523	0.359	0.129	0.005
17.02	1	8.217	5.764	-2.453	6.019	0.223
17.02	1.17	9.063	4.632	-4.431	19.631	0.727
17.02	1.33	9.859	13.069	3.210	10.304	0.382
14.12	1	13.443	14.850	1.407	1.979	0.073
14.12	1.17	14.289	19.422	5.133	26.353	0.976
14.12	1.33	15.085	8.918	-6.167	38.027	1.408
Summation		240.033	239.935	-0.098	289.246	10.713

Table 3.4. Accuracy, residual, mean square error and bias for grain losses while harvesting *Jamila* variety (V1)

RMSE	MSE	BIAS	ACCURACY
3.273042	10.71281	-0.00365	1.3297E-05

### 3.2 Fuel Consumption and Grain Loss Prediction for Yardass variety

The result for predicted and observed value for fuel consumption is shown in Table 3.5 while the value for accuracy, residual, mean square error and bias for fuel consumption while harvesting *Yardass* variety (V2) is shown in Table 3.6

Table 3.5. Prediction and observed value for fuel consumption

<b>M</b>	<b>C</b>	<b>Predicted</b>	<b>Observed</b>	<b>o-p</b>	<b>(o-p)<sup>2</sup></b>	<b>(o-p)<sup>2</sup>/n</b>
20.18	1	1.09134	0.47622	-0.61512	0.378372	0.014014
20.18	1.17	1.97415	2.292042	0.317892	0.101055	0.003743
20.18	1.33	2.80503	2.611765	-0.19327	0.037351	0.001383
17.02	1	0.89226	0.485182	-0.40708	0.165712	0.006137
17.02	1.17	1.77507	2.269795	0.494725	0.244753	0.009065
17.02	1.33	2.60595	2.013223	-0.59273	0.351325	0.013012
14.12	1	0.70956	0.509171	-0.20039	0.040156	0.001487
14.12	1.17	1.59237	1.729134	0.136764	0.018704	0.000693
14.12	1.33	2.42325	1.883444	-0.53981	0.291391	0.010792
20.18	1	1.09134	0.638034	-0.45331	0.205487	0.007611
20.18	1.17	1.97415	2.526545	0.552395	0.305141	0.011302
20.18	1.33	2.80503	3.315349	0.510319	0.260425	0.009645
17.02	1	0.89226	0.50284	-0.38942	0.151648	0.005617
17.02	1.17	1.77507	2.342466	0.567396	0.321938	0.011924
17.02	1.33	2.60595	2.12163	-0.48432	0.234566	0.008688
14.12	1	0.70956	0.445779	-0.26378	0.069581	0.002577
14.12	1.17	1.59237	1.609412	0.017042	0.00029	1.08E-05
14.12	1.33	2.42325	2.211864	-0.21139	0.044684	0.001655
20.18	1	1.09134	0.75	-0.34134	0.116513	0.004315
20.18	1.17	1.97415	2.490119	0.515969	0.266224	0.00986
20.18	1.33	2.80503	3.258947	0.453917	0.206041	0.007631
17.02	1	0.89226	0.488764	-0.4035	0.162809	0.00603
17.02	1.17	1.77507	2.225676	0.450606	0.203045	0.00752
17.02	1.33	2.60595	1.8	-0.80595	0.649555	0.024058
14.12	1	0.70956	1.965	1.25544	1.57613	0.058375
14.12	1.17	1.59237	2.259109	0.666739	0.444541	0.016464
14.12	1.33	2.42325	2.384615	-0.03863	0.001493	5.53E-05
		47.60694	47.60612	-0.00082	6.84893	0.253664

Table 3.6. Accuracy, residual, mean square error and bias for fuel consumption while harvesting *Yardass* variety (V2)

<b>RMSE</b>	<b>MSE</b>	<b>BIAS</b>	<b>ACCURACY</b>
0.503651	0.253664	-3E-05	9.13E-10

The result for predicted and observed value for grain losses is shown in Table 3.7 while the value for accuracy, residual, mean square error and bias for grain losses while harvesting *Yardass* variety (V2) is shown in Table 3.8



Table 3.7. Prediction and observed value for grain losses

M	C	predicted	observed	o-p	(o-p) <sup>2</sup>	(o-p) <sup>2</sup> /n
20.18	1	-2.362	2.597	4.960	24.597	0.911
20.18	1.17	3.224	2.673	-0.551	0.304	0.011
20.18	1.33	8.482	3.337	-5.145	26.473	0.980
17.02	1	6.950	8.326	1.376	1.894	0.070
17.02	1.17	12.537	5.212	-7.325	53.649	1.987
17.02	1.33	17.795	21.750	3.955	15.643	0.579
14.12	1	15.496	14.732	-0.765	0.585	0.022
14.12	1.17	21.083	16.872	-4.212	17.737	0.657
14.12	1.33	26.341	30.485	4.143	17.167	0.636
20.18	1	-2.362	2.143	4.506	20.302	0.752
20.18	1.17	3.224	3.111	-0.113	0.013	0.000
20.18	1.33	8.482	5.211	-3.272	10.704	0.396
17.02	1	6.950	5.452	-1.498	2.245	0.083
17.02	1.17	12.537	5.494	-7.043	49.600	1.837
17.02	1.33	17.795	20.645	2.850	8.124	0.301
14.12	1	15.496	12.595	-2.902	8.420	0.312
14.12	1.17	21.083	19.534	-1.549	2.399	0.089
14.12	1.33	26.341	28.357	2.016	4.065	0.151
20.18	1	-2.362	5.570	7.933	62.931	2.331
20.18	1.17	3.224	3.912	0.687	0.472	0.017
20.18	1.33	8.482	5.089	-3.394	11.517	0.427
17.02	1	6.950	8.772	1.822	3.318	0.123
17.02	1.17	12.537	4.806	-7.731	59.767	2.214
17.02	1.33	17.795	19.904	2.109	4.447	0.165
14.12	1	15.496	14.500	-0.996	0.992	0.037
14.12	1.17	21.083	19.380	-1.703	2.899	0.107
14.12	1.33	26.341	38.405	12.063	145.526	5.390
		328.639	328.863	0.224	555.793	20.585

Table 3.8. Accuracy, residual, mean square error and bias for grain losses while harvesting *Yardass* variety (V2)

RMSE	MSE	BIAS	ACCURACY
4.537059	20.58491	0.008292	6.88E-05

Based on the estimate parameters from the analysis, the prediction equations of fuel consumption are:

$$Y_f = -3.906 + 0.016M + 4.562C \quad \text{for Jamila variety (V1)} \quad (18)$$

and

$$Y_f = -5.373 + 0.063M + 5.193C \quad \text{for Yardass variety (V2)} \quad (19)$$

Where;  $Y_f$  = Fuel consumption, l/h;  $M$  = Moisture content, %;  $C$  = Cutting speed, m/s

While the prediction equation of grain losses are:

$$Y_g = 33.911 - 1.802M + 4.976C \quad \text{for Jamila variety (V1)} \quad (20)$$

and

$$Y_g = 24.245 - 2.947M + 32.863C \quad \text{for Yardass variety (V2)} \quad (21)$$

Where;  $Y_g$  = Grain loss, %;  $M$ = Moisture content, %;  $C$ = Cutting speed, m/s

### 3.2 Model Verification

The Mean Square Error (MSE) indicating the accuracy and precision of the models were found to be 0.2528 and 10.7128 for *Jamila* and *Yardass* variety respectively. The consistency of the model was obtained by calculating the sum of residual values (RES) and was found to be 0.00474 and 0.00365 for *Jamila* and *Yardass* variety respectively. Mean Square Predicting Error (MSPE) was used for the assessment of the error of prediction was obtained as 0.2528 and 10.7128 for *Jamila* and *Yardass* variety.

### 3.3 Model Validation

The models were validated by plotting the predicted values against observed values. The values of the coefficient of determination,  $R^2$  were 0.60 and 0.66 for fuel consumption and grain loss respectively for *Jamila* variety (V1) as presented in Figure 3.1 and Figure 3.2 while 0.67 and 0.78 for fuel consumption and grain loss respectively for *Yardass* variety (V2) as presented in Figure 3.3 and Figure 3.4. These show that there is good agreement between the models predicted values and the actual (experimental or observed) values.

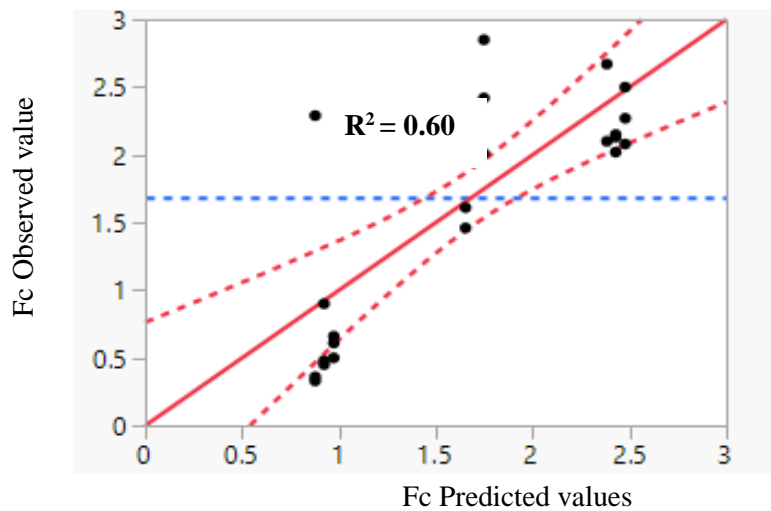


Figure 3.1. Observed against Predicted Fuel consumption for *Jamila* variety

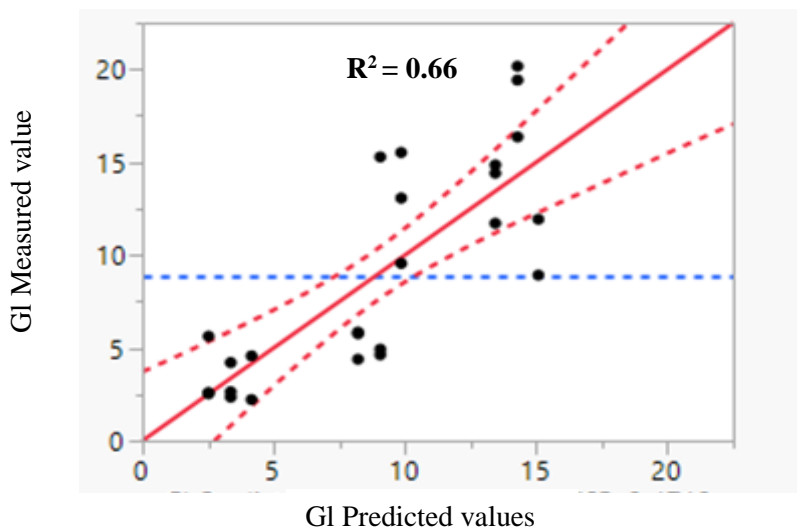


Figure 3.2. Observed against Predicted Grain loss for *Jamila* variety

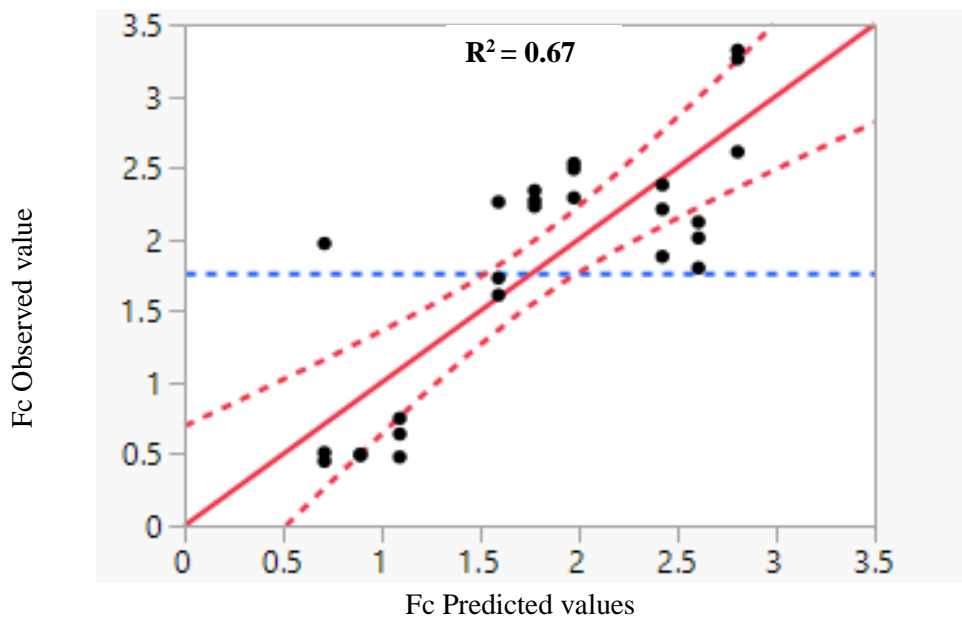


Figure 3.3. Observed against predicted Fuel consumption for *Yardass* variety

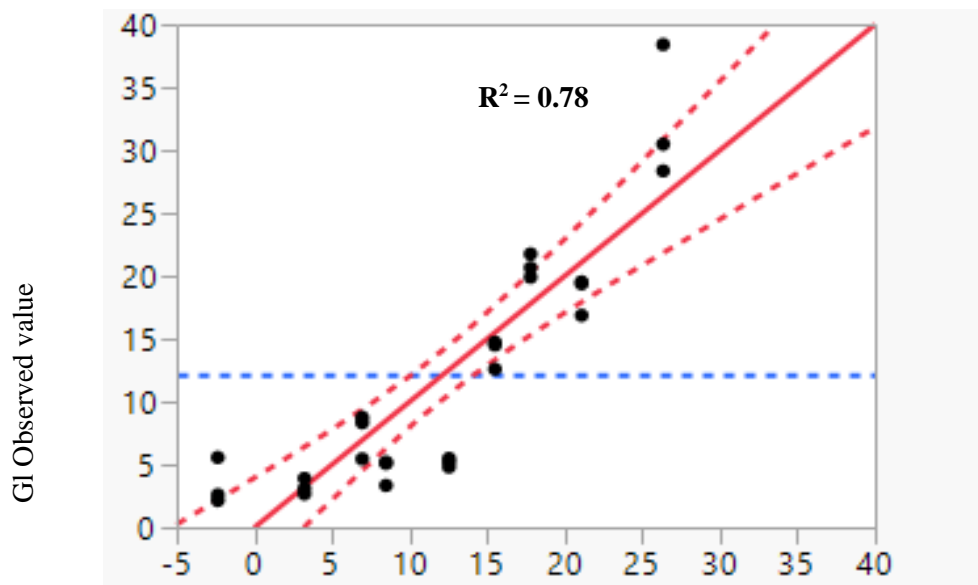


Figure 3.4. Observed against GI Predicted values variety

#### 4 CONCLUSION

Fuel consumption of the reaper could be reduced by reaping at lower moisture content and lower cutting speed. The developed models for predicting the fuel consumption and grain loss were fairly close agreement with the observed values, since the coefficient of determination ( $R^2$  values) between the predicted and observed values of fuel consumption and grain loss were 0.60 and 0.66 respectively for *Jamila* variety (V1) and 0.67 and 0.78 respectively for *Yardass* variety (V2).

**REFERENCES**

1. Li, J., Zhang, H., Wang, D., Tang, B., Chen, C., Zhang, D., Zhang, M., Duan, J., Xiong, H. and Li, Z. (2011). Rice omics and biotechnology in China. *Plant Omics*, 4: 302-317.
2. Juraimi A. S., Uddin M. K., Anwar M. P., Mohamed M. T. M., Ismail M. R. and Azmi, M. (2013). Sustainable weed management in direct seeded rice culture. *Australia Journal of Crop Science*, 7: 989-1002.
3. Oloruntoba, A., Ashimolowo, O. R., and Solomon, V. A. 2007. Rice Farmers Perceptions of Agricultural Credit in Rural Communities of a Local Government in Nigeria. *Journal of Agriculture and Rural Development*, Volume 1, Swaziland Printing and Publishing Company Limited, Swaziland.
4. Fresco, L. O. (2003). International Year of Rice 2004: Concept Paper International Year of Rice Secretariat, Food and Agriculture Organization of the United Nations, pp11.
5. FAO (2003). The International Year of Rice 2004. Concept Paper, International Year of Rice Secretariat, Food and Agriculture Organization of the United Nations, pp. 2.
6. Alizadeh, M. R. and Allameh, A. (2013). Evaluating rice losses in various harvesting practices. *International Research Journal of Applied and Basic Sciences*, Vol, 4 (4): 894-901.
7. Aung, N. N., Myo, W.P.P. and Htet, Z.M. (2014). Field Performance Evaluation of a Power Reaper for Rice Harvesting. *International journal of scientific engineering and technology research*. Vol 3 (12) 2631-2636, 2014.
8. Ibrahim, Z. (2008). Analysis of Environmental factors for establishment of field irrigation laboratory, Agricultural Engineering, Bayero University Kano.
9. FAO (1994). *Agricultural Machinery and Equipment Principles and Practices*. Pp 235-254.
10. Hunt, D. (1995). *Farm power and machinery management*. 9th ed. Iowa State University Press. Ames, Iowa, USA.
11. Pradhan, S. C., Biswajit, R.; Das D. K. and Mahapatra, M. (1998). Evaluation of various paddy harvesting methods in Orissa, India *Agricultural Mechanization Asia, Africa and Latin America*. 29; 2, 35-38; 4.
12. Gomez, K.A. and Gomez, A.A. (1984). *Statistical procedures for agricultural research*. A wiley Interscience Publication. John wiley and Sons New York pp 362-367.
13. Attanda, M.L. (2005). Effects of induced compaction by wheel traffic on soil physical properties, crop water use efficiency and yield of maize at samara, Zaria. Unpublished M.Sc Thesis submitted to Department of Agricultural Engineering, Ahmadu Bello University, Zaria. Pp35-151.
14. Willmott, C.J. (1982). Some comments on the evaluation of model performance. *Am. Meteotol Soc. Bull.*, 63(11): 1309-1313.
15. Haskett, Z.D. (1991). Nitrogen behavior and management strategies studies by simulation and experiment. Ph.D Thesis, University of Minnesota, Minneapolis, pp. 37- 45.
16. Gass, S.I. (1983). Decision Aiding Models-Validation, Assessment and Related Issues. *Operations Res.*, 31:603-631.