



MATHEMATICAL MODELING OF FIELD RECITAL OF HARROW IN CLAY – LOAM SOIL IN SOUTH EASTERN NIGERIA

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ABSTRACT

This research was carried out to model and optimize the efficiency of disc harrow on clay-loam soil in South – East Nigeria to assist farmers scrutinize and select appropriate harrowing implement reliant on soil type for efficacious and magnificent production. The harrowing operation was conducted at selected effective working widths, operational speeds and cutting depths using 2-gangs tandem disc harrow. The experimental design adopted in the research was a three level – three factor full factorial design. The experiment consists of three factors which were varied at three levels of harrowing depths which include 10, 20, 30 cm; three levels of effective working widths of 60, 120 and 180 cm and three levels of operational speeds (6, 7 and 8 km/hr). Central Composite Response Design which gives 17 test runs was performed for each sample. The results found that the highest field efficiency of 98.50% was obtained when the harrow was operated at the pulverizing depth of 20cm under operational speed of 7 kmh⁻¹ and working width of 120 cm. The quadratic model equation was statistically significant ($P < 0.05$) for the prediction of the field efficiency. Additionally, the results show that the coefficient of determination; R^2 for the field efficiency was 0.9139, which indicated adequate correlations among the factors. The Predicted R^2 of 0.7695 was reliable with the Adjusted R^2 of 0.8031 which identified excellent interactions between the factors (effective working width, operational speeds and harrowing depths). The adequacy Precision (10.3749) obtained indicated seemly indicator and that the model could navigate the design space. The optimum field efficiency and the desirability of 96.66% and 0.697 were respectively attained at optimum depth of 30 cm, working width of 180 cm and speed of 6.16 kmh⁻¹. Therefore, farm operators can henceforth, evaluate and select the harrow implements using the developed model

1.0 Introduction

Tillage is the preparative phase of seedbed (crop planting environments) which is the crucial period in plant growth, development and yield. It is the paramount and utmost essential farming operation in most agricultural areas that oversees the success of the agricultural period. The success of plant growth and yield production hinge on quality of mechanical manipulation of the soil in piercing and pulverizing the soil to produce proper environment for plant development; to guarantee regular growth of plant, in a manner that will permit roots access to air, nutrients and moisture. It is therefore imperative to scrutinize the effect of tillage depth, operational speed and working width of the various tillage implements and to relate it with the performance capabilities of farm implements during execution of task for proper

selection of the suitable tillage apparatus based on soil type or situation for better agricultural production at reduced cost (Boydas and Turgut, 2017). Selecting the appropriate tools to match certain soil types or condition is an essential guide in lessening the energy loss, cost of work, mechanical breakdown, and to maintain the soil fertility as well as decreasing the detrimental effect of soil structure like compaction (Coates and Thacker, 2001).

Accordingly, cost of using machineries has to be rationally economical, consistent and should have least energy requirements (Udo and Akubuo, 2000). Additionally, tillage depth, working width, soil type, speed, soil conditions and operator's skillfulness affect performance and energy consumption rate (Bukhari and Balock, 1982). Therefore, contrivance size and working depth and/or speed ought to suit the machine size to upsurge its working proficiencies (Collins *et al.*, 1998). It is noteworthy that the best agricultural processes can be attained by sufficient knowledge of performance characteristics, dynamic utilization and management of tractors and the coupled tools (Oduma and Oluka, 2019). Skillful machine applications and management needs accurate performance records as well as general energy demands of diverse equipment to undertake an indicated job and to attain a steady mechanization arrangement by matching the capabilities of different agronomic devices. Again, discrepancy in environmental soil states desires the accounts of the energy and performance features of the tractor coupled tools. For that reason, Anazodo *et al.* (1983) upheld that due to divergences within ecological soil locations, records of performance of equipment under different soil kinds are very vital for choice of the contrivances.

The current costly agronomic tools necessitate upgraded process alongside with appropriate utilization of resources and reduction of effective costs so as to increase production and to upsurge revenues. The foremost expenses of each agribusiness system are contrivance/equipment cost. Increasing the proficiencies at minimized energy intake rate of machines may cause a significant drop in production expenditures. A good farmer goes to appositely exploit every single farm input with the intention of curtailing cost (Yohanna *et al.*, 2010). Agricultural mechanization tools are recurrently imported to Nigeria to help varied farm mechanization resolutions of the government (Oluka, 2000). Right now, importation cost of farm machineries is excessive owing to the depression in value of Nigerian currency, and to muddle through within such poor fiscal status quo, farm operators ought to be farsighted in selecting and acquiring farm equipment. As a result, it is imperative that operators and owners of agricultural machines should be conversant with the technique with which their equipment handle any given task, as well as the easiness in which it does the job to ensure minimum wastage of time and energy. Substantial amount of cash is expended by agriculturalists annually in energy supply, operation charge, maintenance and management of farming equipment. Indecorous selection or unsuitable matching of machines most times causes great energy and power loss. Statistics on the performance of harrow will effortlessly resolve the strain of farmers, and assist in enhancing and increasing their outputs as they make proper selection of tools that would match their soil situations.

Development of mathematical model (through studying the effect of tillage depth, operational speed and effective working width on the field efficiency of harrow) is vital and stress-free means of assisting farmers at all levels in appraising, envisaging and/or predicting the credible performance capabilities of harrowing equipment for apposite selection of the implement in view of the soil type and/ or situations before acquiring and engaging the mechanism to work. Therefore, the aim of this study is to develop a mathematical model by examining the effect of tillage depth, speed of operation and effective working width on the field efficiency of disc harrow in clay-loam soil, which will help farmers in South- East Nigeria and other areas with similar soil type/conditions in assessing/predicting the performance and selecting the tillage implement to reduce cost, lessen energy loss, and improve agricultural productivity.

2. Materials and Methods

2.1 Research Farm

The research was conducted at the experimental farm of Michael Okpara University of Agriculture, Umudike (05° 25'N/ 7° 34'E), Abia State, Nigeria, Figure 1. The climatic state in the farm is characterized by an average temperature of 27°C, annual rainfall varying from 2250 to 2500mm and average relative humidity of 75%, distinctive of tropical rain forest areas (Amanze et al., 2020). Clay-Loam is appropriate for arable farming.

The research area has average soil bulk density of 1.68 g/cm³, porosity of 37.40%, moisture content varying from 12.35% to 18.90% (w.b) and granular in structure (Oduma et al., 2021).

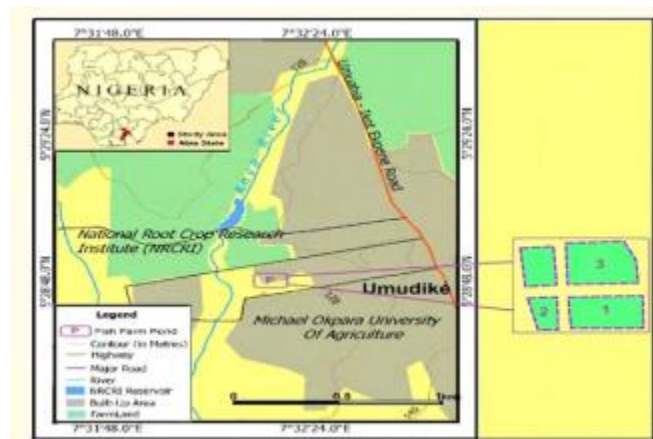


Figure 1: Map of the Study area (source: Kelechi et al., 2019)

2.2 Tractor and harrow used for the research

The tractor (Massey Ferguson) of model MF430E with capacity of 55.2kw and 3- point hitch mechanism and a disc harrow with operating units of 2-gang tandem discs was obtained from Works Department, Michael Okpara University of Agriculture and used for the study.

2.3 Field Test procedure

The harrowing operation was conducted at selected effective working widths of 60, 120 and 180 cm and cutting depths of 10, 20 and 30 cm using 2-gangs tandem disc harrow. The area harrowed and the equivalent time taken to till the area was recorded according to Oduma and Oluka (2019).

2.4 Experimental design

The experimental design adopted in the research work was a three level – three factor full factorial design. The experiment consists of three factors which were varied at three levels, namely: the harrowing depths which include 10, 20, 30 cm; the effective working widths of 60, 120 and 180 cm and three levels of operational speeds (6, 7 and 8 km/hr). Central Composite Response Design which gives 17 test runs was performed for each sample using Equation 3 according to Umani et al. (2019) and Oduma et al. (2022)

$$N = 2^k + 2k + n_c \quad (1)$$

Where, N = number of test runs, k = experimental factors and n_c = centre point

In order to obtain the desired data, the range of values of every one of the three factors (k) was evaluated (Table 1). Effective working width, operational speed and harrowing depth were adopted as independent factors for the energy requirement assessment of the harrow. The response selected was the fuel consumption rate (L/ha) of the harrow. Four repetitions of the

center points were adopted in order to predict a well and concise approximation of errors; and the field experiments were conducted in randomized form (Oduma et al., 2021).

Table 1: Actual values, codes and levels of the test variables for design of experiments

Factors	Symbols	Codes and levels		
		-1	0	1
Effective harrowing width (cm)	A	60	120	180
	B	10	20	30
Depth of cut (cm)	C	6	7	8
Operational speed (km/hr)				

2.5 Calculation of Actual Field Efficiency

The actual field efficiency was evaluated using Equation 1 proposed by Kepner, (1982) as adopted by Oduma et al. (2022).

$$\varepsilon_f = \frac{100T_p}{T_t} \quad (2)$$

Where: ε_f = field efficiency, %; T_p = productive time, h; T_t = total working time, h.

$$T_t = T_p + T_i \quad (3)$$

T_d = idle or delay time, h

2.6 Statistical Analysis

The Design Expert of version 11.0 was used in the experimental design, analyzing the data obtained, optimizing the functional parameters and to generate model equations for the estimation of the energy requirement (fuel intake rate) of the disc harrow. The quadratic, cubic, linear and two factorial interaction (2FI) models were selected and used to analyze the fuel consumption rate of the implement; and the models were fitted to the generated experimental data.

Data generated was analyzed applying the Response Surface Methodology to fit the quadratic polynomial equation obtained from the Design Expert Software version 11.0 expressed in Equation (4) according to Chih et al. (2012).

$$Y = \beta_0 + \sum_{i=1}^2 \beta_i X_i + \sum_{i=1}^2 \beta_{ii} X_i^2 + \sum_{i=1}^2 \sum_{j=i+1}^2 \beta_{ij} X_i X_j \quad (4)$$

where, Y = Response; β_0 = constant term; $\sum_{i=1}^2 \beta_i$ = Summation of coefficient of linear terms; $\sum_{i=1}^2 \beta_{ii}$ = Summation of quadratic terms; $\sum_{i=1}^2 \sum_{j=i+1}^2 \beta_{ij}$ = summation of coefficient of interaction terms; $X_i X_j$ = independent variables.

Furthermore, the multiple regressions were equally employed in fitting the coefficient of the polynomial model so that the response variable may be correlated with the independent variables. The consistency of fit of the model, the individual and interaction effect of the tillage parameters (harrowing width, operational speed and depth of cut) on the response (fuel consumption rate) of the implement were calculated by means of ANOVA. Again, the results were also analyzed statistically to ascertain the effects of the factors and their interactions on the total fuel consumption rate at $\alpha = 0.05$ via Minitab 17.0.

2.8 Model Validation and Optimization Procedure

The model equations developed from the study were validated by comparing the results obtained from the experiment (**actual values**) with the results of the model equation developed (predicted values) by simple simulation. The coefficient of determination, R^2 was also used to indicate the adequacy of the model. The value of R^2 nearer to +1 indicates high

degree of correlation between the dependent and independent variables (Kothari, 2013). Optimization of the practical factors of disc harrow on clay - loam soil was done by means of design expert in response surface methodology (RSM) to determine the optimum field efficiency.

3. Results and Discussion

3.1 Harrow Operation

The process of harrowing operation was conducted at selected working width, operational speeds and harrowing depths, at soil moisture content varying from 12.5 – 18.90 % and the results of the field efficiency of the disc harrow were presented in Table 2. This table presents the relations between the trial factors (working width, operational speeds and harrowing depths) with the field efficiency of the harrow. The values of actual field efficiencies achieved in the course of the tillage operation vary from 91.70 – 98.50% for the range of operational speed (6 – 8 kmh⁻¹), harrowing depth between 10 – 30cm and working width range from 60 – 180 cm. The results found that the highest field efficiency of 98.50% was obtained when the harrow was operated at the cutting depth of 20cm under operational speed of 7 kmh⁻¹ and working width of 120 cm; while the least field efficiency of 91.70 % was achieved at cutting depth of 30cm under working width of 180 cm and operational speed of 7 kmh⁻¹. It was frequently discovered that at different operational speeds and effective working width, the field efficiencies increase with the increase in harrowing depth and increases to peak point of 98.50% at operational speed of 7 kmh⁻¹ and at depth of 20cm under effective working width of 120 cm. The field efficiency of the implement decreases by 6.15% when harrowing at depth of 10 cm and 3.05% at depth of 30 cm irrespective of the effective width of cut and operational speed. This is in line with the observations of Oduma *et al.* (2022) and Sale *et al.* (2013).

Table 2: Randomized design layout of three levels –three factors full factorial composite design of experiment with actual and predicted values of energy requirements of disc harrow

Run order	Coded factors			Actual factors Harrowing depth (cm)	Actual factors		Field efficiency, %	
	A	B	C		Effective working Width (cm)	Operational speed (km/hr)	Actual values of Field efficiency	Predicted values of Field efficiency
1	-1	0	-1	20	60	6	97.83	91.51
2	1	1	0	30	180	7	91.70	86.47
3	-1	1	0	30	60	7	92.20	86.40
4	0	-1	1	10	120	8	95.90	81.29
5	0	0	0	20	120	7	95.90	86.51
6	0	0	0	20	120	7	98.50	86.51
7	0	1	1	30	120	8	97.10	81.43
8	1	1	0	30	180	7	95.90	86.47
9	0	0	0	20	120	7	95.80	86.51
10	1	0	-1	20	180	6	96.90	91.59
11	0	-1	-1	10	120	6	97.80	91.64
12	1	0	1	20	180	8	95.50	81.54
13	0	1	-1	30	120	6	98.11	91.50
14	-1	-1	0	10	60	7	97.50	86.55
15	-1	0	1	20	60	8	97.50	81.45
16	0	0	0	20	120	7	95.60	86.51
17	0	0	0	20	120	7	97.88	86.51

Figure 2 is the response surface plot of harrowing depth, effective working width and operational speed against field efficiency of disc harrow showing the relationship between the factors and the response. It was observed that the highest field efficiency of 98.50% was noticed

at speed of 7 kmh^{-1} at harrowing depth of 20 cm and effective working width of 120 cm. The highest field efficiency achieved at operational speed of 7 kmh^{-1} is slightly higher than the operational speed of plough and was attributed to the lower tractive and draft force associated with secondary tillage operation after the soil has been acted upon by the plough (primary tillage implement) which is related with low working speed enabling the implement to pierce deep and collapse the resistance force offered by the soil to implement penetration thereby creating an adequate environmental condition for plant root to penetrate deep into the soil as observed by Sale et al. (2013).

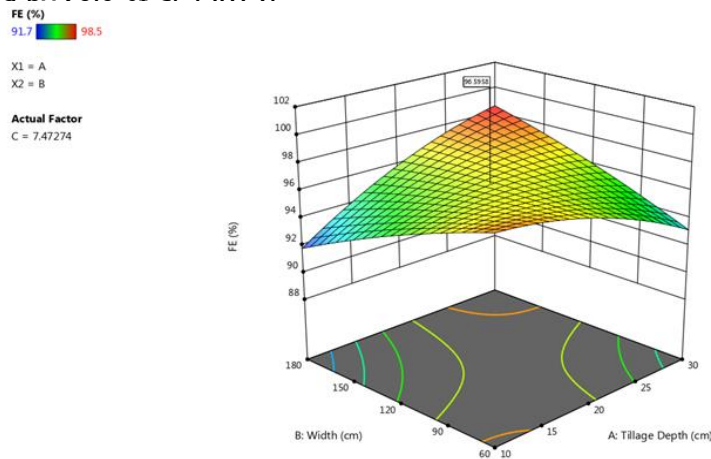


Figure 2: Response surface plot of harrowing depth, effective working width and operational speed against field efficiency of disc harrow.

3.2 Effects of tillage factors (speed, effective working width and tillage depth) on field efficiency of disc harrow

The values of actual field efficiency attained during the harrowing operation ranged from 91.70 to 98.50% for the range of operational speed, effective working width and tillage depth of the discs harrow. These field efficiencies are within the range of efficiency of 90 – 77% as recommended by Hunt (2013) for harrowing at speed range of 6 – 10 kmh^{-1} . It was commonly practical that at different operational speeds and effective working width, the actual field efficiency increases with the increase in tillage depth and increases to a maximum point of 98.50% at operational speed of 7 kmh^{-1} and tillage depth of 20cm under effective working width of 120 cm. The actual field efficiency of the implement decreases by 6.15% when harrowing at depth of 10 cm and 3.05% at depth of 30 cm irrespective of the effective width of cut and operational speed. The maximum field efficiency (98.50%) was achieved at a slightly higher forward speed (7 kmh^{-1}) as compared to ploughing operation, and is in line with the observation of Chandrashekar and Jayant (2018) in their studies on performance evaluation of vertical rotary plough wherein the maximum field efficiency of the plough (88.09 %) was noted at a very low operating speed of 2 km h^{-1} . The highest field efficiency attained at higher working speed of 7 kmh^{-1} might be due to somewhat lower tractive and draft force associated with higher working speed of harrow as compared to plough, enabling the implement to shatter and break the lump/clod of the soil after ploughing, thus creating a suitable environmental condition/seedbed for plant root to penetrate deep into the soil as detected by Sale et al. (2013). Additionally, the range of predicted field efficiency (81.29 – 91.64%) obtained (Table 2) is within the experimental range and somewhat higher than the range of field efficiency of 72.90 – 78.80% gotten by Sale et al. (2013) in their study of performance of selected tillage implements and may be ascribed to variation in soil conditions. The results obtained from this study postulate that the tillage depth and operational speed have boundless effect on the field efficiency of tillage implement than the effective working width. Hence, the depth of tillage ought to be determined depending on the root length of crop in other to enhance the field efficiency of disc harrow as indicated by Oduma et al. (2022) and Chandrashekar and Jayant (2018).

3.3 Statistical analysis of results

The analysis of the effects of tillage factors (operational speed, effective working widths and harrowing depth) on the field efficiency of the harrow is presented in the ANOVA results for field efficiency in Table 3. The results showed that the field efficiency was significantly ($P \leq 0.05$) affected by the interaction of tillage depth and operational speed and increases with the increase in cutting depth as noted by Ajav and Adewoyin (2012) in their study of the influence of forward speed and tillage depth on draft of tillage implements in sandy loam soil. The field efficiency was also significantly ($P \leq 0.05$) affected by the interaction of tillage depth and effective working width of the harrow. The field efficiency decreases with the increase in speed of operation which may be ascribed to high drawbar pull associated with high working speed (Sachin *et al.*, 2013). Thus, the p-value for interaction of the operational speed and tillage depth; and interaction of tillage depth and working width are 0.0515 and 0.0003 respectively. It then infers that the mean field efficiency differs for the different interactions of tillage depths, effective working widths and operational speeds.

Table 3: Analysis of variance for field efficiency

Source	Sum Squares	of df	Mean Square	F-value	p-value
A-Tillage Depth	0.0595	1	0.0595	0.0818	0.7831
B-Width	1.35	1	1.35	1.86	0.2148
C-Speed	1.64	1	1.64	2.25	0.1771
AB	31.98	1	31.98	43.97	0.0003
AC	4.00	1	4.00	5.50	0.0515
BC	1.42	1	1.42	1.95	0.2056
Pure Error	4.70	4	1.17		
Total	59.10	16			

3.4 Model assessment of disc harrow efficiency

The field efficiency of the disc harrow in clay -loam soil depends on the results illuminating the significant difference for combination of the speed, effective working width and cutting depth of the harrow. The model coefficient, effect, contribution, test of lack of-fit and the significance of the factors and their interactions on the field efficiency were evaluated according to Umani *et al.* (2019), Oduma *et al.* (2022) and Hensh *et al.* (2022). A quadratic model was significant for the response (Table 4), thus, $P < 0.05$; indicating that the significant model term was achieved at 95% significance level. The quadratic model equation obtained to predict the field efficiency in regard to the independent variables or operating factors (speed, effective working width and harrowing depth) is as stated in Equation 5.

$$FE = 128.30 - 0.89A - 0.15B - 24.52C + 0.005AB + 0.1AC + 0.10BC - 0.01A^2 - 0.0001B^2 + 1.56C^2 \quad (5)$$

Where FE = field efficiency, %; A = harrowing depth of the disc harrow, cm; B = effective working width of the disc harrow, cm; C = operational speed, kmh^{-1}

The quadratic model as acquired in this research work is in accordance with the findings of Oduma *et al.* (2019) in the study of the development of empirical regression equations for predicting the performances of disc plough and harrow in clay-loam soil. The p-value (0.0055) of the model as presented in Table 5 is less than the designated α - level of 0.05 indicating that the model is significant. Thus, the interactions of the operating factors (speed, effective working width and harrowing depth) have significant effects on the field efficiency of the implement. Hence, the model term p-values of 0.0003, 0.0515 and 0.0072 which are less than

the selected α - level of 0.05 stipulate that the model terms are significant. Thus, AB (interaction of A-harrowing depth and B-effective working width), AC (interaction of A-harrowing depth and C-operational speed) and C^2 are significant model terms as displayed in Table 5. This result agrees with the report indicated by Chandrashekar and Jayant (2018). Nevertheless, it is not statistically consistent with the results of (Oduma *et al.* (2022) in the research of performance of tractor and tillage implements in clay Soil wherein the p-value of the field efficiency attained is 0.00 at $p \leq 0.05$ and could be credited to the variances in the soil and/or ecological/environmental conditions of diverse study regions as indicated by Saeed *et al.* (2017). Finally, The Lack of Fit F-value of 0.1114 (Table 5) implies that the Lack of Fit is not significant relative to the pure error. However, there is a 94.89% chance that a Lack of Fit F-value this large could occur due to noise. Non-significant lack of fit according to Oduma *et al.* (2022) is good since the model is required to fit.

Table 4: ANOVA of model summery statistics

Source	Sequential p-value	Lack of Fit p-value	Adjusted R ²	Predicted R ²	
Linear	0.8698	0.0712	-0.1672	-0.9071	
2FI	0.0094	0.2649	0.4950	-0.2972	
Quadratic	0.0219	0.9489	0.8031	0.7695	Suggested
Cubic	0.9489		0.6820		Aliased

Table 5: ANOVA of response surface quadratic model for field efficiency of disc harrow

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	54.01	9	6.00	8.25	0.0055*
A-Tillage Depth	0.0595	1	0.0595	0.0818	0.7831 ^{NS}
B-Width	1.35	1	1.35	1.86	0.2148 ^{NS}
C-Speed	1.64	1	1.64	2.25	0.1771 ^{NS}
AB	31.98	1	31.98	43.97	0.0003*
AC	4.00	1	4.00	5.50	0.0515*
BC	1.42	1	1.42	1.95	0.2056 ^{NS}
A ²	3.50	1	3.50	4.81	0.0643
B ²	0.5663	1	0.5663	0.7786	0.4068 ^{NS}
C ²	10.19	1	10.19	14.01	0.0072*
Residual	5.09	7	0.7273		
Lack of Fit	0.3927	3	0.1309	0.1114	0.9489 ^{NS}
Pure Error	4.70	4	1.17		
Cor Total	59.10	16			

*Significant; NS= Not Significant

3.5 Validation of the Model

Results of the validation of the model equation are shown in Table 6. The results show that the model is significant. The coefficient of determination, R² (0.9139) shows good alliances amid the independent variables, which means that the response model can elucidate 91.39 % of the full changeability in the response (Fakayode *et al.*, 2016; Oduma *et al.*, 2022)].

Table 2 shows the simulation results of the quadratic model achieved in the study which indicated that the field efficiency falls within the experimental array. The Predicted R² (0.7695) is reliable with the Adjusted R² of 0.8031 (Table 6); thus, the difference is less than 0.2 indicating that the trial data fitted very well, as posited by Bako *et al.* (2021). The adjusted R²

obtained is compatible with the R^2 (0.9615) as obtained by Kothari (2014). The adequacy Precision (10.375) ratio obtained is greater than 4 is appropriate, indicating an acceptable signal and that the model equation might be espoused to navigate the design space.

Table 6: Coefficient of determination, R^2 for validation of model term

Std. Dev.	0.8528	R^2	0.9139
Mean	96.19	Adjusted R^2	0.8031
C.V. %	0.8867	Predicted R^2	0.7695
		Adeq Precision	10.3749

3.6 Optimum field efficiency of disc plough:

Optimization of the practical factors (harrowing depth, effective working width and operational speed) of disc harrow on clay - loam soil was done by means of design expert in RSM to determine the optimum field efficiency. The curve (Figure 3) presents the optimization process with the optimal operational factors of harrowing depth of 30 cm, effective working width of 180 cm (which is the full width of disc harrow) and operational speed of 6.16 kmh^{-1} . Thus, the optimum field efficiency and the desirability of 96.66% and 0.697 were respectively attained. The optimum harrowing depth as shown in the result of the optimization is in accordance with the findings of Chandrashekar and Jayant (2018) which vary from 20 – 30 cm due to the disparity in the length of roots of crop penetration for improved yield as pertinent in different crops. However, the optimum speed (1.94 ms^{-1}) obtained by Oduma *et al.* (2020) is lower than the optimum speed obtained in this study. This could be as a result of dissimilarities in the soil environments exclusively the moisture contents of the diverse study regions as indicated by Anazodo (1983) and Olatunji (2011).

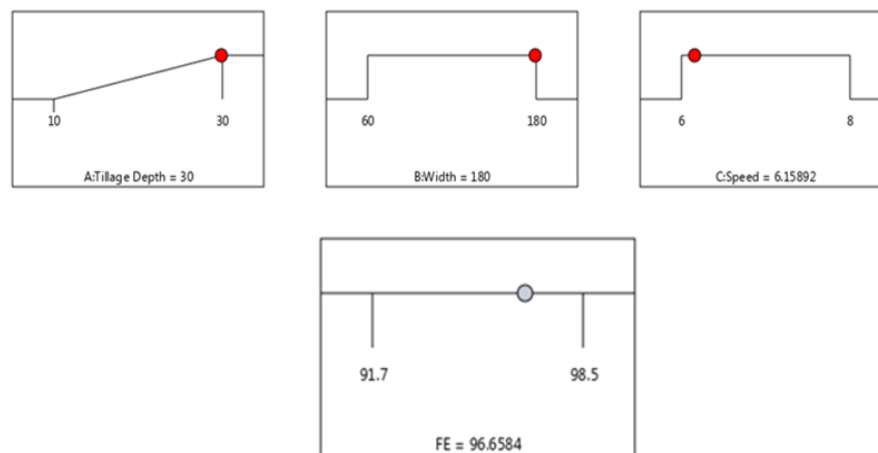


Figure 3: Optimization curve of field efficiency of disc harrow in clay – loam soil

4. Conclusions

The modeling of the field performance of disc harrow on clay-loam soil in South-East Nigeria was conducted. In the course of the harrowing process, it was detected that the peak field efficiency was noted when the harrow was engaged at depth of 20cm with the working width of 120 cm and speed of 7 kmh^{-1} while the lowest field efficiency of 91.70 % was recorded at depth of 30cm, working width of 180 cm and operational speed of 7 kmh^{-1} .

The statistical analyses carried out, showed that the quadratic model was recommended for the prediction of the field efficiency of the disc harrow. The developed model and the coefficients were statistically significant. The predicted and the adjusted R^2 values were resolutely reliable. Hence, the experimental values were appropriate with the coefficient of

determination ($R^2 = 0.9139$) postulating exceptional correlations amid the independent variables. The generated model will aid the farmers in assessing the performance of the contrivance for appropriate selection and assignation to task. The optimum efficiency and the desirability of 96.66% and 0.697 were respectively attained at optimal tillage depth of 30 cm, operational speed of 6.16 kmh⁻¹ and effective working width of 180 cm.

Due to dissimilarities in agro-ecological field situations and soil types in different regions, it is therefore recommended that research of this kind should be conducted in every agricultural zone to obtain models for assessing the performance of tillage implements for decision on machine selection based on soil characteristics for increased production, to minimize production costs, reduce loss/wastage of energy, time and waste of agricultural products

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