Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina L
Broj 4, 2025.
Strane: 73 – 85

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year L
No. 4, 2025.
pp. 73 – 85

Original Scientific paper
Originalni naučni rad
DOI: 10.5937/POLJTEH2504073O

EVALUATION AND MODELLING THE EFFECT OF TILT ANGLE, PENETRATION CHARACTERISTICS AND MOISTURE CONTENT ON DRAWBAR POWER REQUIREMENT OF RIDGER ON LOAMY SANDY SOIL

Okechukwu Oduma*[1], Muofunanya F. Umunna[2], Daniel C. Nnadi[3], Stella N. Eni-Ikeh[3]., Chineze G. Okeke[4], James C. Ehiem[1], Aviara N. Aviara[1]

[1] *Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria*
[2]*Department of Agricultural and Biosystems Engineering, Southern Delta University Ozoro, Delta State, Nigeria*
[3]*Department of Mechanical Engineering, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria*
[4]*Department of Agricultural and Bioresources Engineering, Enugu State University of Science and Technology, Enugu, Nigeria*

Abstract: The evaluation and modeling of the effect of tilt angle, penetration characteristics and moisture content on drawbar power requirement of ridger on loamy sandy soil was carried out for apposite choice of ridgers for tillage operations. Results showed that, the ridger operation requires drawbar power range from 10.43 – 11.38 kW to operate under tilt angle between 15 – 25° while operating at depth varying from 14 – 28 cm.

The highest drawbar power of 11.38 kW was attained when the ridger was operated at a tilt angle of 20°, cutting depth of 14 cm and at average moisture content of 20.5% while the least drawbar power of 10.43 kW was obtained at tilt angle of 25°, cutting depth of 28 cm and average moisture content of 15.5%. Results of statistical analysis indicated that, the interaction of the tilt angle and depth of cut, and the moisture content of the soil were statistically significant ($p < 0.05$). The coefficient of determination, R^2 and adjusted R^2 values were resolutely reliable.

*Corresponding Author. Email address: odumaoke@gmail.com
ORCID NUMBER: 0000-0002-5165-2397

Thus, the experimental values were appropriate with the coefficient of determination of $R^2 = 0.9983$, suggesting exceptional correlations among the independent variables.
The optimum drawbar power of 10.90kW was attained with the desirability of 1.000 at optimal tilt angle of 16.24°, cutting depth of 19.31cm and average moisture content of 14.44%.

Key words: *Depth, drawbar-power, farmers, loamy-sandy, moisture, tilt-angle, ridger.*

INTRODUCTION

The environment for crop production needs a number of field operations, such as preparation of seed bed, seeding, fertilizer application, spraying of pesticides or herbicides, dusting, irrigation, harvesting and threshing [1]. The first operation in production of crop after land clearing is tillage. Tillage is a mechanical manipulation of soil to provide favourable conditions for crop production. Soil tillage consists of breaking the compact surface of earth to a certain depth and to loosen the soil mass, so as to enable the roots of the crops to penetrate and spread into the soil. Soil tillage is a cultural practice that effects the soil's physico-chemical characteristics, and, henceforth, produces variations in the crop growth and/or development, the aerial cover, the growth of roots, and the overall yield performance of the crop [2]. Tillage may be called the practice of adjusting the condition of soil to offer favorable environments for plant growth and development. It is the most labor intense and difficult operation compared to all subsequent operations in the field. The main objectives of tillage are the production of a suitable tilt, the destruction of weeds, the destruction of pests and burying the rubbish and the incorporation of fertilizers into the soil.

The main source of power in agriculture is the tractor, which is now available in different sizes. Tractor power utilization is achieved through the driving wheels as traction to provide the drawbar power required for draft implements and to provide mobile support for attached machine. Draft, energy and fuel requirements for agricultural implements have been recognized as essential factors when attempting to correctly match an agricultural implement with tractor power. Soil condition and speed of operation to carry out tillage operation in soil were found to be important and should be given proper attention. The use of machines for agricultural production has been one of the outstanding developments in the global agriculture during the last century. The benefits of the application of the farm machinery can be seen in many aspects of human life.

The dynamic variations of soils in response to tillage devices are main concern in evaluating their enactment [3]. The alliance amid tillage tools and soil is of a major consideration to scheming and applying the tools intended for soil pulverization [4].
Tillage task encompasses the utmost energy and power expended on farms. Hence, drawbar power requirements are imperious for apt choice of size of tractor for a specific implement. Naderloo et al. [5] propounded that soil type/conditions also influence the draft needed for a specified device. A good measure used to consider the fitness of an implement for tillage operation is the power required in drawing the machine to pulverize through the soil [6]. Drawbar power is the power transmitted through the drive wheels or tracks to move the tractor and implement during the field operation [7].

Ridgers requires drawbar power for its operation. The dynamic differences of ecological soils in response to tillage devices are key concern in evaluating the enactment of the ridging implements for apposite selection and engagement to task.

According to Abu [8], it is important to select the suitable machine or machines to carry out a specific operation with minimum cost of energy and in the required time under suitable field condition. Disk plows, which are primarily suitable for the tillage of virgin, stony and wet soils, cut through crop residues and roll over the roots. Blades on disk plows are concave, usually representing sections of hollow spheres. The action of a concave disk blade is such that the soil is lifted, pulverized, partially inverted, and displaced to one side. The disk blades are set at an angle, known as disk angle from the forward line of travel and also at a tilt angle from the vertical; the disk angles vary from 42° to 45°, whereas tilt angles vary from 15° to 25°. Al-Hashimy [9] concluded that the increase of tilt angle decreased discs penetration in the soil which led to an increase in the effective field capacity due to the increase of the actual cutting width. Osman, *et al*. [10] found that as disc and tilt angles increased, the field capacity and fuel consumption rate increased. The increase of tilt angle increases rear wheel slippage. Abu-Hamdeh and Reeder [11] stated that the reason of increasing slippage when tilt angle increased may be attributed to the increase of the tensile force.

Effectual equipment application and/ or utilization desires correct performance data on the proficiencies of the specific machineries to accomplish a specified work plan and to acquire a stable mechanization scheme by matching the performance of diverse farm equipment. The differences in agro-ecological soil state also necessitates the information of the field proficiencies or capabilities of the coupled implements. Nevertheless, manufacturers of those tools do not make the data available for the users in Nigeria, which would have been a better guide in the selection of the implements based on the soil variances applicable in various agricultural areas in Nigeria [12].

According to Oduma et al. [13], farmers are practical and greatly concerned about the quality and extent of the recitals of their machineries during operation to be able to recuperate the costs of either hiring/purchase or maintenance of such apparatus. Sale et al. [14] upheld that agricultural operation is exceedingly sensitive to time and weather situations, and much expenses are involved in the venture, therefore, it remained prudent to assess the capacitive recital of farm machineries for apposite selection, optimization of production and appropriate farm planning.

Evaluation and modelling the effect of operation angle, penetration characteristics and moisture content on drawbar power requirement of ridger on loamy sandy soil is a simple means of assisting the farmers/users of the implements in evaluating and envisaging the possible performance capabilities of the equipment in order to make proper selection based on soil type/conditions before purchasing and/or engagement to task.
This will go a long way to reduce failures, unnecessary break down, mismatching of implement to prime movers, minimize fuel consumption (energy loss), reduce cost and largely maximize production and profit [15].

The objective of this research is to evaluate and model the effect of operation angle, penetration characteristics and moisture content on drawbar power requirement of ridger on loamy sandy soil that will help farmers to predict the field recitals of tractor hitched ridger for improved field operation.

MATERIAL AND METHODS

3.1 The experimental area

The study was conducted at the experimental farm of Michael Okpara University of Agriculture, Umudike (05◦ 25′N/ 7◦ 34′E), Abia State, Nigeria located at Olokoro. The climatic nature of the farm is characterized by an average temperature of 27 ◦C, rainfall between 2250 to 2500 mm annually and average relative humidity of 75%, distinctive of humid rain forest zones [16]. Loamy-sand is suitable for arable agrobusiness/farming. The research farm has mean soil bulk density of 1.68 g/cm^3, porosity of 37.40%, moisture content ranging from 12.35% to 18.90% and structurally granular [17].

3.2 Machine and implement used for the experiment

A Massey Ferguson tractor of model MF430E, with capacity of 55.2 kW which has average field efficiency of 74.05% and mean fuel consumption rate of 31.25l/ha; and a disc ridger with different tilt angles and coupled by means of 3-point hitch system was used for the research. This tractor and the coupled implement were obtained from Works Department, Michael Okpara University of Agriculture was used for the research.

3.3 Field experiment procedure and Evaluation of drawbar power requirement of the ridger

The ridging process which proceeded after ploughing and harrowing the farm site was carried out at selected tillage angles of 15, 20 and 25 degrees; cutting depths of 14, 21 and 28cm and selected moisture contents of 10.5, 15.5 and 20.5%. The area ridged and time taken to make the ridges were recorded according to [17]. Then, the drawbar power which is the power transmitted through the drive wheels or tracks to move the tractor and implement during the field operation was determined from Equation (1) according to Rangapara et al [7]

$$\text{DBP} = \frac{DT \times S}{3.6} \tag{1}$$

Where,

DBP = drawbar power, kW; DT = total draft force, kN; S = operational speed, hr

Note: The total draft force of the ridger was assessed from Equation (2) suggested by Hunt [27] as

$$\text{Total Draft = implement working width, m X draft per unit width, kN/m} \tag{2}$$

The draft per unit width of the ridger was gotten from the standard draft per unit width of tractor drawn tillage implements according to Williams [18].

3.4 Design of Experiment

The investigational design applied in the study was a three level – three factor full factorial design. The test comprises of three factors varied at three levels of tilt angles (15, 20 and 25 degrees), three levels of cutting depths (14, 21 and 28cm) and three levels of moisture contents (10.5, 15.5 and 20.5%). The Central Composite Response Design which gave 16 test runs were made using Eq. (3), [19].

$$N = 2^K + 2\text{k} + nc \tag{3}$$

Where,
N = number of test runs,
k = experimental factors and
nc = Centre point

To attain the anticipated data, the range of each one of the 3 factors (k) was assessed (Table 1). Tilt angles, cutting depths and moisture contents were adopted as independent factors for the drawbar power requirement (response) of the ridger. Four (4) replications of the centre points were espoused so as to envisage a well and succinct calculation of errors; and the experiments were carried out in randomized form.

Table 1. Actual values, codes and levels of the test variables for design of experiment

Factors	Symbols	Codes and Levels		
		-1	0	1
Tilt angles, degrees	T_a	15	20	25
cutting depths, cm	Dc	14	21	28
moisture contents, %	Mc	10.5	15.5	20.5

3.4.1 Statistical Analysis Using Response surface methodology (RSM)

The Design Expert of version 11.0 was used to design the experiment, analyze data obtained, optimize the investigational factors and obtain model expression for the prediction of the drawbar power of the ridger. The quadratic, cubic, linear and two factorial interaction (2F1) models were designated to analyze the drawbar power of the device; and the models were fixed to the generated experimental data. Data attained were analyzed using the Response Surface Methodology (RSM) to fit the quadratic polynomial equation obtained from the Design Expert Software as stated in Equation (4) conferring to Chih et al. [20] as adopted by Oduma et al. [17].

$$Y = \beta_0 + \sum_{i=1}^{2} \beta i X i + \sum_{i=1}^{2} \beta ii X i^2 + \sum_{i=1}^{2} \sum_{j=i+1}^{2} \beta ij X i X j \quad (4)$$

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;
$XiXj$ = independent variables.

RESULTS AND DISCUSSION

Ridger operation

The ridging process was achieved at designated tilt angles (15, 20 and 25 degrees) with selected cutting depths (14, 21 and 28 cm) and at soil moisture content ranging from 10.5 to 20.5%; and the results of the drawbar power necessities of the ridger was presented in Table 2. Results obtained showed that, the ridger operation requires drawbar power range from 10.43 – 11.38 kW to operate under tilt angle between 15 – 25^o while operating at depth varying from 14 – 28 cm.

The highest drawbar power of 11.38 kW was attained when the ridger was run at tilt angle of 20°, cutting depth of 14 cm and at average moisture content of 20.5% while the least drawbar power of 10.43 kW was obtained at tilt angle of 25°, cutting depth of 28 cm and average moisture content of 15.5%. It may therefore be inferred that the ridger exert the highest drawbar power when operated at a lower tilt angle, cutting depth and at a higher soil moisture content. The drawbar power obtained in this research work is slightly lower than the drawbar power estimated by Williams [18] and was accredited to variations in soil conditions (such as bulk density, moisture content and/or structural disposition of the soil) due to differences in geographical areas as detected by Arvidsson et al. [21] and Naderloo et al. [5]. The results is broadly in line with the observation of Oduma et a l[15] in their study of the effect of soil type and operational speed on performance of some selected agricultural field machinery in south east Nigeria.

Table 2. Observed/Actual values and predicted values of drawbar power of ridger in loamy sand soil

Trial Runs	Coded factors			Actual Tilt Angle (Ta), degrees	Actual Depth of cut (Dc), (cm)	Actual Moisture content (Mc), (%)	Draw bar power (kW)	
	Ta	Dc	Mc				Actual/ observed values	Predicted values
1	0	-1	1	20	14	20.5	11.375	11.350
2	0	0	0	20	21	15.5	11.313	11.280
3	0	0	0	20	21	15.5	11.249	11.280
4	0	1	-1	20	28	10.5	11.186	11.190
5	0	0	0	20	21	15.5	11.122	11.280
6	0	0	0	20	21	15.5	11.060	11.280
7	0	0	0	20	21	15.5	10.996	11.280
8	0	0	0	20	21	15.5	10.934	11.280
9	-1	0	0	15	21	15.5	10.896	10.902
10	0	0	0	20	21	20.5	10.807	11.393
11	0	0	1	20	21	15.5	10.733	11.280
12	9	0	0	20	21	15.5	10.681	11.280
13	0	0	0	20	21	15.5	10.617	11.280
14	-1	-1	-1	15	14	10.5	10.554	10.550
15	1	0	-1	25	21	10.5	10.490	10.490
16	1	1	0	25	28	15.5	10.428	10.406

Figure 1presents the response surface plot of tilt angles, cutting depths and moisture contents against the drawbar power requirement of the ridger demonstrating the correlation amid the factors and the response.

Results of figure 1 specified that the topmost drawbar power of 11.38 kW was accomplished when the ridger was betrothed at tilt angle of 20°, at cutting depth of 14 cm average moisture content of and 20.5%. The highest drawbar power attained at lower tilt angle and is in agreement with the observations of Olatunji [23] and was accredited to the high traction and draft strength related to low operational angle enabling the implement to cut practically deep, thus breaking down the resisting force and /or strength of the firmed soil thereby creating an apposite ecological environment for root penetration, growth and proper development as acknowledged by Sale *et al*. [14] and Oduma et al. [22]

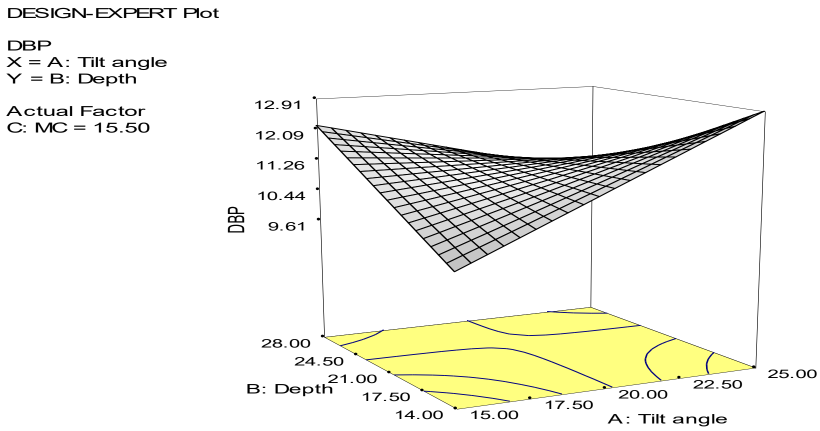

Figure 1. Response surface plot of tilt angle, cutting depth and moisture content against power requirement of the ridger in loamy-sand soil.

Model equation of drawbar power requirements of ridger in loamy-sand soil

The drawbar power necessities of the ridger in loamy-sand soil is dependent on the results illuminating the significant variation for combination of experimental factors (the tilt angle, cutting depth and moisture content). The model coefficient, effect, contribution, test of lack of-fit and the significance of the factors and their interactions on the drawbar power were evaluated according to Fakayode *et al*. [24] and Umani *et al*. [19]. Both mean and 2F1 models were statistically significant for the response ($P < 0.05$) and therefore were suggested (Table 3). This implies that the significant model term was identified at 95% significance level. The 2F1 model with the highest order polynomial, $R^2 = 0.9983$ (Table 4) and with significant additional terms as revealed in Table 3 is designated. The 2F1 model equation produced to estimate the drawbar power requirement relating to the independent variables (working width, operational speed and tillage depth) is as presented in Eq. (5).

Table 3. Sequential Model Sum of Squares

Source	SS	DF	MS	F Value	Prob F	
Mean	959.22	1	959.22			Suggested
Linear	0.43	3	0.14	0.95	0.4956	
2FI	0.60	3	0.20	111.62	0.0694	Suggested
Cubic	0.000	0				Aliased
Quadratic	0.000	0				Aliased
Residual	1.800E-003	1	1.800E-003			
Total	960.26	8	120.03			

Table 4. Model Summary Statistics

Source	Std. Dev.	R-square	Adjusted R-Square	Predicted R-Square	Press	
linear	0.39	0.4168	-0.0206	-1.9766	3.09	
2F1	0.042	0.9983			±	Suggested
Quadratic					+	Aliased
Cubic					+	Aliased

$$DBP=7.16269+0.18335T_a+0.73119D_c-0.82008Mc-0.036321T_aD_c+0.042283T_aM_c-1.42857e^{-4}D_cM_c \quad (5)$$

Where,
DBP = drawbar power, (kW);
T_a = tilt angle, degree, (cm);
D_c = depth of cut;
M_c = moisture content, (%)

The moisture content and the interaction of tilt angle and depth of cut with p-values of 0.0428 and 0.0509 respectively have significant effects on the drawbar power of the ridger. Thus, these p-values which are less than the selected α- level of 0.05 stipulate that the model expressions are statistically significant (Table 5). This is in line with the discoveries of Oduma *et al*. [15] and Ajav and Adewoyin [25].

Table 5. Analysis of variance for drawbar power requirement of ridger

source	ss	df	ms	F-value	F-value
T_a	0.096	1	0.096	54.48	0.06365
D_c	7.426E-004	1	7.426E-004	0.41	0.1542
M_c	0.029	1	0.029	16.37	0.0428
T_aD_c	0.40	1	0.40	220.37	0.0509
T_aM_c	0.28	1	0.28	155.87	0.9253
D_cM_c	2.500E-005	1	2.500E-005	0.014	
Pure Error	1.800E-003	1	1.800E-003		
Cor Total	1.11	7			

Validation of the model for drawbar power requirement of ridger in loamy-sand soil

Figure 2 show the validation of the suitability of the order 2F1 model using the normal % probability plot of the draft force requirement residuals as well as the plot of the predicted versus experimental draft force demand. The plotted points tailored adequately on the line of best fit which postulates that the predicted drawbar power and experimental drawbar power are within acceptable array. The model equations generally did not over or under-predict the experimental results, thus, the estimates are within appropriate range, a signal of good relations and adequate correlation amid the independent variables and a sign showing that the response model of the drawbar power might define the general variableness in the response.

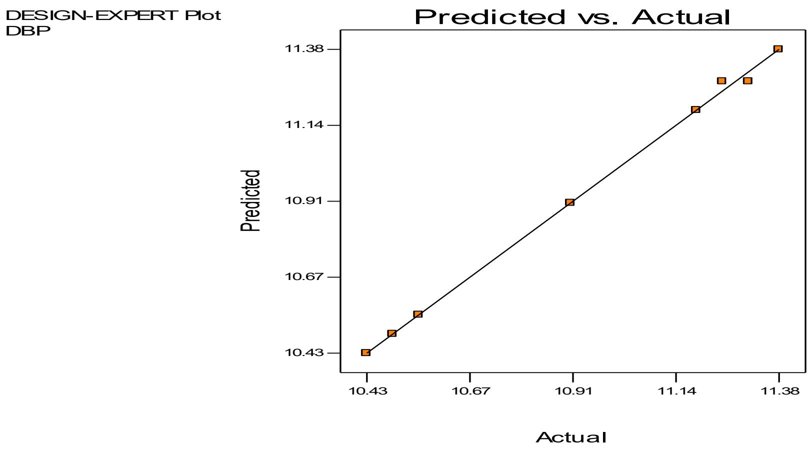

Figure 2. Normal % probability plot of the draft force requirement residuals as well as the plot of the predicted versus experimental draft force demand of the ridger

Similarly, the validation of the generated model for the drawbar power of the ridger is also shown in Table 6. According to this result, the model has coefficient of determination, R^2 of 0.9984 which demonstrates a notable relationship within the independent variables and it postulates that, the response model could clarify 99.84% of the whole changeability in the response. The model equation simulation indicated that the ridger's drawbar power requirements fall within the experimental range according to Kothari [26]. The adjusted R^2 attained is also compatible with the R^2 of 0.9615 obtained by Almaliki *et al.* [4]. The adequacy precision of 23.938 ratio attained is greater than 4 is apposite to establish a tolerable signal, indicating that the model might be adopted to navigate the design space.

Table 6. ANOVA of validation of model term for drawbar power of the ridger

Std. Dev. Mean	0.042 10.94	R-Squared Adj R-Squared	0.9984 0.9886
C.V.	0.39	Pred R-Squared	N/A
PRESS	N/A	Adeq Precision	23.938

Optimization of the drawbar power requirement of disc plough

Optimization of the drawbar power requirement of the ridger was carried out using a design expert in response surface methodology. Figure 2 presents the response plot of the optimization process with the optimum practical factors of tilt angle of 16.24°, cutting depth of 19.31cm and average moisture content of 14.44%. Congruently, the optimum drawbar power requirement of 10.90kW and the desirability of 1.000 was obtained. The optimum value of drawbar power in this study falls within the range obtained by Kareem and Sven [3] but slightly higher than the observations of Oduma et al. [22]. However, the trivial variance may be attributed to the disparity in ecological soil conditions.

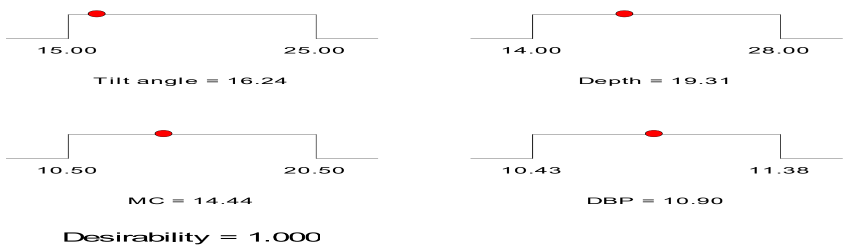

Figure 2. Optimization plot of tilt angle, cutting depth, moisture content and drawbar power requirement of ridger

CONCLUSIONS

The evaluation and modeling of the effect of operation angle, penetration characteristics and moisture content on drawbar power requirement of ridger on loamy sandy soil was efficaciously carried out. During the ridging process, it was observed that, the ridger operation requires drawbar power range from 10.43 – 11.38 kW to operate under tilt angle between 15 – 25° while operating at depth varying from 14 – 28 cm.

The highest drawbar power of 11.38 kW was attained when the ridger was run at tilt angle of 20°, cutting depth of 14 cm and at average moisture content of 20.5% while the least drawbar power of 10.43 kW was obtained at tilt angle of 25°, cutting depth of 28 cm and average moisture content of 15.5%.

The interaction of the tilt angle and depth cut, and the moisture content of the soil were statistically significant ($p < 0.05$). The coefficient of determination, R^2 and adjusted R^2 values were resolutely reliable.

Thus, the experimental values were appropriate with the coefficient of determination ($R^2 = 0.9983$), suggesting exceptional correlations among the independent variables.

The model equation simulation indicated that the ridger's drawbar power requirements fall within the experimental range.

The model obtained will help farmers/agronomist in assessing the enactment of the ridger for suitable choice and engagement to task. The optimum drawbar power of 10.90kW was attained with the desirability of 1.000 at optimal tilt angle of 16.24°, cutting depth of 19.31cm and average moisture content of 14.44%.

BIBLIOGRAPHY

[1] Ojha T.P., Michael A.M. 2012. Principles of Agricultural Engineering. Volume 1. New Delhi, Jain Brothers. pp.1-166.

[2] Bako, T., Mamai, E.A., Istifanus, A.B. 2021. Determination of the effects of tillage on the productivity of a sandy loam soil using soil productivity models, Res. Agric. Eng. 67 (2021) pp.108–115.

[3] Kareem, K.I., Sven, P. 2019. Effect of ploughing depth, tractor forward speed, and plough types on the fuel consumption and tractor performance, Polytechn. Journal, 9 (1), pp. 43–49.

[4] Almaliki, S., R. Alimardani, and M. Omid.2016. Fuel consumption models of MF285 tractor under various field conditions. Agricultural Engineering Int. CIGR Journal, 18(3), pp.147-158.

[5] Naderloo, L., Alimadani, R., Akram, A., Javadikia P, Khanghah, H.Z. 2009. Tillage depth and forward speed effects on draft of three primary tillage implements in clay loam soil, J. Food Agric. Environ. 7 (2009), pp. 382–385.

[6] Olatunji, O.M., Davies, R.M. 2009. Effect of Weight and Draught on the Performance of Disc Plough on Sandy-loam Soil. J. Applied Sciences, Engineering Technology, 1(1), pp.22-26.

[7] Rangapara D. K., Dabhi K.L. and Makwana A.D. 2017. Comparative performance of tractor drawn implements tillage system with rotavator tillage system.I nternational Journal of Agriculture Sciences. Volume 9, Issue 5, pp.3742-3748.

[8] Abu Z.F.S. 2011. Principle of agricultural mechanization management, Faculty of Agriculture. Egypt (In Arabic): University of Alexandria.

[9] Al-Hashimy, L. A. Z. 2003. Study of some technical and economical indicators and physical soil characteristics under different tillage systems, Faculty of Agriculture, M.Sc.Thesis, Department of Agricultural Machinery, University of Baghdad, Iraq.

[10] Osman, A. N., Xia, L. and Dongxing, L. 2011. Effect of tilt angle of disk plough on some soil physical properties, work rate and wheel slippage under light clay soil. Int. J. Agric. Biol. Eng., Vol. 4, pp. 1-7.

[11] Abu-Hamdeh, N. and Reeder, R. C. 2003.A nonlinear 3D finite element analysis of the soil forces acting on a disk plough/Ridger," Soil and Tillage Research, vol. 74, pp. 115-124.

[12] Oduma, O., S.I. Oluka.2019. Effects of soil type on power and energy requirements of some selected agricultural field machinery in South – East Nigeria, Scientific J. Agricultural Engineering, Year XLIV, No3, pp.69–77. University of Belgrade, Republic of Sebia.

[13] Oduma, O., Igwe, J E. and Ntunde, D. I. 2015. Performance Evaluation of Field Efficiencies of Some Tractor Drawn Implement in Ebonyi State. *IJET, UK. Centre of Professional Research Publications.* 5(4): pp.199 – 204.

[14] Sale S. N., Gwarzor M.A., Felix O.G., Idris S. I. 2013. Performance evaluation of Some selected tillage implements. Proceeding of NIAE.Vol.34. pp 71-77.

[15] Amanze N.N., Oduma, O., Orji F.N. 2020. Physical Characteristics of Soils at Demonstration Farm of Michael Okpara University of Agriculture, Umudike. Umudike, Journal Eng. Technol. (UJET) 6 (2), pp. 97–103.

[16] Oduma, O., Okeke, C.G, Onyeka F.C., Edu, C.N. 2021. Penetration characteristics of some selected tractor-hitched tillage implements in agro-ecological soils of South- East Nigeria, Futo J. Ser. (FUTOJNLS) Vol. 7 (Issue 1) (2021), pp. 37–46.

[17] Oduma, O., Ehiomogue, P., Okeke, C.G., Orji N.F. 2022. Modeling and Optimization of Energy Requirements of Disc Plough operation on loamy-sand soil in South-East Nigeria using response surface methodology. *Scientific African* 7(3): pp.1-8. DOI: 10.1016/j.sciaf.2022.e01325
[18] William, E. 2015. Crop – Machinery Management, Lower State University Extension and Outreach. Dept. of Economics, 2015 agdm@iastste.edu641-732-5574.
[19] Umani, K.C., Ituen, E.U.U., Fakayode, O.A., 2020. Development and testing of a double-action cassava grater with an automated contact plate. Journal of Food Process Engineering, Vol. 43, Issue 4, https://doi.org/10.1111/jfpe.13372.
[20] Chih, W.T., Lee, I.T., Chung, H.W.2012. Optimization of multiple responses using data development analysis and response methodology, Tamkang, J. Sci. Eng. 13 (2), pp. 197–203.
[21] Arvidsson, J, Keller, T., Gustafsson K. 2004. Specific draft for moldboard plow, chisel plow and disk harrow at different water contents, Soil Tillage Research. Vol. 79, pp.221 231. DOI: https://doi.org/10.1016/j.still.2004.07.010
[22] Oduma, O., Okeke, C. G, Ehiomogue, P., Ugwu, E.C. and Agu, C. S. 2023. Assessment and Modeling of Drawbar Power Necessities of Disc Plough in Sandy-clay Soil in South-East Nigeria. Covenant Journal of Engineering Technology (CJET), Vol. 7, No.1, pp. 30-36.
[23] Olatunji O.M. 2011. Evaluation of Plough Disc Performance on Sandy Loam Soil at Different Soil Moisture Levels. Research Journal of Applied Sciences, Engineering and Technology 3(3): pp.179-184.
[24] Fakayode O.A., Ajav E.A., Akinso R. 2016. Effect of processing factors on the quality of mechanically expressed Moringa (*Moringa Oliefera*) oil: A response surface approach. Journal of Food process Engineering. 40 (4). 1-12. DOI:10.1111/jfpe.12518.
[25] Ajav E. A., Adewoyin A. O. 2012. Effect of ploughing depth and speed on tractor fuel Consumption in a sandy-loam soil of Oyo State-Nigeria. Journal of Agricultural Engineering and Technology, Vol. 20, No.2, pp. 1 – 10.
[26] Kothari C.R. 2014. Research Methodology. Methods and Techniques. Second Revised Edition. New Age International Publishers. New Delhi. pp. 140 – 145.
[27] Okechukwu Oduma; Precious Ehiomogue; Chineze G.Okeke; Nkemdirim F.Orji; Elijah C.Ugwu; Muofunanya F. Umunna; Kenechi Nwosu-Obieogu. 2022. Modeling and optimization of energy requirements of disc plough operation on loamy-sand soil in South-East Nigeria using response surface methodology. Scientific Africa, Vol. 17, pp. 1–8, https://doi.org/ 10.1016/j. sciaf. 2022. e01325.
[28] Hunt, D. 2013. Farm Power and Machinery Management, 10th Edition, 3, Scientific International Congress on Agricultural Engineering, pp. 1703–1709.

PROCENA I MODELIRANJE UTICAJA UGLA NAGIBA, KARAKTERISTIKA PRODIRANJA I SADRŽAJA VLAGE NA POTREBNU SNAGU VUČE KOD RAONIKA ZA ILOVASTO-PESKOVITO ZEMLJIŠTE

Okechukwu Oduma[1*], Muofunanya F. Umunna[2], Daniel C. Nnadi[3], Stella N. Eni-Ikeh[3]., Chineze G. Okeke[4], James C. Ehiem[1], Aviara N. Aviara[1]

[1] Department of Agricultural and Bioresources Engineering, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria
[2]Department of Agricultural and Biosystems Engineering, Southern Delta University Ozoro, Delta State, Nigeria
[3]Department of Mechanical Engineering, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria
[4]Department of Agricultural and Bioresources Engineering, Enugu State University of Science and Technology, Enugu, Nigeria

Apstrakt: Istraživanje i modeliranje uticaja ugla nagiba, karakteristika prodiranja i sadržaja vlage na potrebnu snagu vuče za ronik koji formira bankove na peskovito-glinovitom zemljištu, sprovedeno je u cilju pravilnog izbora odgovarajućeg oblika raonika za operacije obrade zemljišta.

Rezultati su pokazali da rad raonika zahteva snagu vuče u rasponu od 10,43 do 11,38 kW za rad pri uglu nagiba između 15° i 25°, uz dubinu rada koja varira od 14 do 28 cm. Najveća potrebna snaga vuče od 11,38 kW dobijena je pri uglu nagiba od 20°, dubini rezanja od 14 cm i prosečnom sadržaju vlage od 20,5%.
Najmanja vrednost od 10,43 kW zabeležena pri uglu nagiba od 25°, dubini rada od 28 cm i prosečnom sadržaju vlage od 15,5%.

Rezultati statističke analize pokazali su da je interakcija između ugla nagiba i dubine rezanja, kao i sadržaja vlage u zemljištu, statistički značajna ($p< 0,05$). Koeficijenti determinacije R^2 i prilagođeni R^2 bili su veoma visoki, što ukazuje na pouzdanost modela. Naime, eksperimentalne vrednosti su bile odgovarajuće uz koeficijent determinacije R^2=0,9983, što ukazuje na izuzetnu korelaciju između nezavisnih promenljivih.

Optimalna snaga vuče od 10,90 kW postignuta je sa poželjnošću (stepen pogodnosti) od 1,000 na optimalnom uglu nagiba od 16,24°, dubini rezanja od 19,31 cm i prosečnom sadržaju vlage od 14,44%.

Ključne reči: *Dubina, snaga vuče, poljoprivrednici, peskovito-glinovito zemljište, vlaga, ugao nagiba, raonik za bankove.*

Prijavljen:
***Submitted*: 05.09.2025.**
Ispravljen:
***Revised*: 20.10.2025.**
Prihvaćen:
***Accepted*:25.11.2025.**