PREDICT TRACTOR DRAWBAR FORCE FOR PRIMARY TILLAGE IMPLEMENTS

Mohamed A.A.I[1] A. F. Bahnasy[2] M E. M. Morsi[3]

ABSTRACT

The effect of soil moisture content and tire inflation pressure on tractor performance was determined when linked to moldboard and chisel ploughs as primary tillage implements. The factors considered were fuel consumption, tire inflation pressure, tillage width, tillage depth, dynamic load and speed of operation and cone index of soil. By conducting the experiments in the field, relations were developed between different independent variables and one dependent variable i.e. drawbar pull for moldboard and chisel ploughs. A model for predicting drawbar pull for chisel and moldboard ploughs was developed and tested

INTRODUCTION

The amount of energy consumed during a tillage operation depends on three categories of parameters soil parameters, tool parameters and operating parameters. Although many research have been reported the effects of those parameters on tillage energy, the exact number of affecting parameters and the contribution of each parameter in total energy requirement have not been specified.

Chi and Kushwaha (1991) have described a three-dimensional Finite Element Model for simulating soil-tool interaction. The model includes both effects of soil strength and friction between soil and tool surface. They have studied the friction behavior between the soil and cutting blade and they developed a thin layer interface element

Tillage tools and implements are used to produce those favourable soil conditions. One of the criteria used to assess the suitability of a tool for soil manipulation is the force required in pulling the tool through the soil (Gill and Vanden Berg, 1967). The effects of draught on the performance of different tillage tools and implements in different countries have been investigated (Oni et al., 1992; Shirin et al., 1993; Fielke, 1996; McKyes and 1998; Manian et al., 2000; Shrestha et al., 2001; Gratton et al., 2003;

1Head of Researcher, Agr. Eng. Res. Institute
2 Senior Researcher, Agr. Eng. Res. Institute
3 Researcher, Agr. Eng. Res. Institute

McLaughlin and Campbell, 2004). All these researchers observed that draught varies with variations in soil conditions, tool design and operational parameters.

Aluko and D.A. Seig (2000) have described an experimental investigation of the failure characteristics, and conditions for brittle fracture in two-dimensional soil cutting. Most of the force prediction models developed on the basis of the classical soil mechanics theories are deficient in regard to their applications for agricultural engineering purposes, particularly because consideration is given to brittle failure only. Also, the speed effects are generally neglected. Major variations in force response to tool travel velocity have been reported by several researchers under a wide range of soil moisture contents in different soil types and for different tillage tools.

El-Banna et al (1994) concluded that increasing weight on the disk provides a means of making major change in the depth to which disks penetrate the soil. Increasing depth of harrowing due to increasing vertical load on disks required more draught, especially in primary tillage operation in heavy soil. The most important factors affected harrow draught were, disk load and its attached angle on harrow gang.

Mohammed et al. (2000) found that the dynamic weight transfer is affected by tillage depth and rear wheel slip. Weight transfer increased when tillage depth and rear wheel slip increased.

Zein El-Din and Sayedahmed (2000) developed mathematical model based on limit equilibrium analysis to predict the behavior of passive tillage tools: flat, chisel, sweep and winged chisel. They found that adding two wide wings to chisel tool increased the tool width from 7 cm to 35 cm, resulting in an increase in the draft force of approximately three times at tillage depth 15 cm, but the unit draft decreased by 18.1%.

Kazimieras and Algirdas (2005) concluded that the used of excessive ballast mass is usless particularly when working at high speed or on swampy soils (carrying one ton of ballast mass on soil prepared for sowing at the speed of 8 km/h tractor uses about 0.6 l/h.

Bukhari et. al (1988)) reported that the coefficient of traction is used for evaluation of the tractor tractive performance as effected by soil type and physical condition, moisture content and soil distribution pressure. The coefficient of traction is relatively higher in hard soil than sandy soil.

Mohamed and Clough (1989) concluded that to improve the tractive performance of a tractor is to reduce power losses at soil-wheel interaction.
Baloch et al (1991) concluded that the tractor tractive performance may be evaluated by means of a pull-slip test. The tractor must ensure to be efficiently utilized through implement draught.
Bailey et al. (1991) concluded that tractor tyre inflation pressure affected stresses in soil beneath the tyre in sandy loam soil while the same could not be concluded in clay loam soil. Wiley et al. (1992) showed that inflation pressure and dynamic load are important factors that affect the performance of tractor tyres
Al-Hamed et at (2001) studied the effect of rear tire inflation pressure (on the front wheel assist tractor performance in sandy loam soil. They found that the lower rear tire inflation pressure the better tractive performance.
El-Ashry et al (2003) carried out field experiments to evaluate the tractive performance at different levels of inflation pressure (75, 100 and 125 kPa) and ballasting conditions (0, 60 and 90 kg) in ploughed and unploughed soils. They concluded that the tractive efficiency decreased as the inflation pressure is increased from 75 to125 kPa in the tilled and untilled soils. Also, they concluded the tractive efficiency increased up to a certain value of ballast conditions (from 0 kg to 60 kg) beyond which it decreased with an increase in ballast conditions (from 60 kg to 90 kg) in tilled and untilled soil conditions.

The objectives of the present study are:

1- Measure the draught requirements of two tillage tines under varying conditions of soil moisture content and penetration resistance (cone index) and develop a model to predict drawbar pull for chisel and moldboard plows.

2- Measure and evaluate soil disturbance parameters that arose from the experiments

MATERIALS AND METHODS

The experimental work was carried at Etay El-Baroud Agricultural Research Station, Behaira Governorate Egypt in 2007. An area of about 3.1 fed. was selected for the experiment and the soil was classified as clay loam. The experimental area was divided into three main blocks (90 x 48 m), one was left dry (M.C. 7.9%) while the others were given light irrigation to maintain the required moisture content (14.8% and 21.75%). Each block was divided into three sub-blocks (90 x 16 m) representing the replicates. Each sub-block was divided into four plots giving a total of 54 plots. A factorial design was used and the treatments were randomly distributed within each replicate.

Tractors:

Two tractors were used in the experiment, namely, Naser tractor 65 (48.75 kW) hp made in Egypt and Ford 7610 (76 hp- 59.7 kW) made in U.S.A. The specifications of the used tractors are given in Table 1.

Table (1): Specifications of used tractors

Tractor	Ford	Nasr
Power	59.7 kW	48.75 kW
Tractor type	Two wheel drive	
Weight	30.93 kN	30 kN
Axel load	rear: 21 kN front: 9.93 kN	rear: 18.96 kN front: 11.04 kN
Tire size	rear: 18.4-30 front: 12.4-24	rear: 14-30 front: 5.6-20
Wheel base	2.3 m.	2.05 m.

Tillage implements:

Two primary tillage implements were used in the experiment, namely chisel plough and moldboard plough.

1- Chisel plough (RAU)

A seven blades mounted chisel plough, RAU, was used in this experiment. It was manufactured by Behera Company, Alex. and composed of three rows at 50 cm spacing between rows. The blades distribution on rows is 2, 2 and 3 from front to rear at 50 cm spacing between each two blades on the same row and 25 cm spacing between each two staggered blades. The plough weight is about 400 kg and the ploughing width is 175 cm.

2 - Moldboard plough:

A three blades mounted moldboard plough was used in this experiment. It was manufactured by Behera Company, Alex. The plough weight is about 600 kg and the ploughing width is 105 cm.

Parameters Measurements:

1 -Soil moisture content

soil moisture content was measured by taking samples from three depths 0-l0 cm, 10-20 cm and 20-30 cm at four different locations randomly selected in each of the two blocks. The moisture content was calculated using the oven method.

The soil moisture content of the area at three depths are given Table (2).

Table(2): Soil moisture content, %

Replications	Depth of soil sample, cm			Average
	0-10	10-20	20-30	
Soil moisture content (7.9%)				
1	5.22	8.18	10.24	7.88
2	5.18	7.95	10.32	7.82
3	5.28	8.21	10.36	7.95
4	5.24	8.31	10.28	7.94
Average				**7.9**
Soil moisture content (14.8%)				
1	12.9	14.5	16.7	14.7
2	11.9	14.7	17.8	14.8
3	13.5	14.2	16.9	14.8667
4	13.2	14.6	16.7	14.8333
Average				14.8
Soil moisture content (21.75%)				
1	16.68	20.34	28.13	21.72
2	16.72	20.40	28.22	21.77
3	16.60	20.44	28.18	21.74
4	16.84	20.38	28.10	21.77
Average				**21.75**

2 - The tractive force:

The tractive force of the tractor was measured by using a hydraulic dynamometer (5000 kg) and two tractors. One of the two tractors was towed by the other. The rear (towed) tractor (Naser) is used as an implement carrier whereas the front one (Ford) is, thus, used as a prime mover. A horizontal chain with the hydraulic dynamometer linked the two tractors. The rear tractor which pulled the implement is being in neutral gear but with implement in the operating position. The tractive force was recorded in the measure distance of 40 m as well as the time taken to traverse it. On the same field the implement was lifted out of the ground and the rear tractor was pulled to record the rolling resistance (R), then the drawbar pull (P) was calculated as follow:

$$\textbf{Drawbar bull, kN} = \textbf{Tractive force, kN - Rolling resistance, kN}$$

3 - The tractive power:

The tractive power was calculated by the following equation:

$$\textbf{Tractive power, kW} = \textbf{tractive force, kN} \times \textbf{speed, km/h}$$

4 - Wheel slip:

The wheel slip was computed from the following equation:

$$S = 1 - \frac{V_a}{V_t}$$

Where, s = wheel slip

V_t = Velocity, theoretical

V_a = Velocity, actual.

5 - Tractive efficiency:

Tractive efficiency is defined as:

$$TE\,(ratio) = \frac{\text{Output power}}{\text{Input power}} = \frac{NT \times Va}{\text{Axle Power}}$$

$$= \frac{NT}{GT}\frac{Va}{VT} = \frac{NT/Wd}{GT/Wd}\frac{Va}{Vt} = \frac{NTR}{GTR}\left(\frac{V_a}{V_t}\right) = \text{Pull ratio} \times \text{Velocity Ratio}$$

Where:

$$NTR = \text{Net traction ratio} = \frac{\text{Net traction (drawbar pull)}}{\text{Dynamic Reaction force}} = \frac{NT}{Wd}$$

$$GTR = \text{Grosstraction ratio} = \frac{\text{Grosstraction}}{\text{Dynamic Reaction force}} = \frac{GT}{Wd} = \frac{T}{rt \times Wd}$$

Gross traction = Net traction + rolling resistance.

6 - The coefficient of traction

The coefficient of traction was computed from the following relation (Dwyer and Pearson, 1976):

$$\textbf{Coeff. of traction} = \frac{\textbf{drawbar pull, kN}}{\textbf{dynamic load on the rear wheels, kN}}$$

7 -Dynamic load on the rear wheels:

The usual way is to calculate dynamic ratio based upon the angle and location of the line of draft. The resultant of forces on the drive wheel itself is usually considered to be at a point directly under the axle and at the soil surface when making the calculation though this is not necessarily true. Summation of vertical and horizontal forces and moments results in the following expression for the dynamic rear weight of the tractor Zoz (1970):

$$RWD = RWS + P\left[\frac{H}{WB} + \left(1 + \frac{B}{WB}\right)\tan\theta\right]$$

For horizontal pull θ = 0 then

$$R_{WD} = RWS + P\left[\frac{H}{W_B}\right]$$

Where:

H = Drawbar height, m

P = Horizontal pull, kN

R_W = Rear weight, static, kN

$_S$ = Wheelbase, m

W_B = Draft angle below horizontal.

θ

8. Tire inflation pressure

Three levels of tire inflation pressure vise 80, 100 and 120 kPa were selected for all test conditions.

Model development

Dimension analysis is used to develop the prediction model for drawbar pull requirement for different primary tillage implements. Based on the Buckingham Pi theorem (Kasprzak et al 1990). The number of dimensionless and independent quantities (namely Pi terms) required to express a relationship among the variables in any physical system can be determined as follows:

S = n-b ………………………………………………………1

Where (**S**) is the number of Pi terms: (**n**) is the total number of variables: and (**b**) is the number of basic dimensions. Basic dimensions are mass (M), Length (L) and time (T). eleven Pi term are needed since there are twelve variables and three basic dimensions in the system of the tractor moving on the soil. The basic dimensions of each variable are presented in Table (3).

The drawbar pull required to pull the implement can be expressed as a function of other twelve variables:

$P = f(FC, \delta, Z, W, Pi, V, B, D, H, CI, \gamma)$………………………………..2

To determine Pi terms, the following equation is established:

$\Pi_i = P.x_1 \times Pi.x_2 \times B.x_3 \times D.x_4 \times H.x_5 \times Z.x_6 \times d.x_7 \times W.x_8 \times Fc.x_9 \times \gamma.x_{10} \times CI.x_{11} \times V.x_{12} \times \delta.x_{13}$………………………………………………………….3

Where X_1……..X_{13} unknowns.

Because Pi terms should not have dimension, the dimensional equation corresponding to equation 4 can be written as follows:

$M^0L^0T^0 = (MLT^{-2})x_1.(ML^{-1}T^{-2})x_2.Lx_3.Lx_4.Lx_5.Lx_6.Lx_7.(MLT^{-2})\ x_8.(L^3T^{-1})x_9.(ML^{-2}T^2)x_{10}.(ML^{-1}T^{-2})\ x_{11}.(L.T^{-1})\ x_{12}.L\ x_{13}$……………………………4

Table (3) variable impact tractor pull.

Symbol	Variable	Dimension	Unit
Dependent variable			
P	Drawbar pull	MLT^{-2}	kN
FC	Fuel consumption	L^3T^{-1}	$l^3.S^{-1}$
δ	Tire deflection	L	m
Independent variable	Tillage width	L	m
d	Tillage depth	L	m
Z	Vertical wheel load	MLT^{-2}	kN
W	Tire inflation	$ML^{-1}T^{-2}$	$kN.m^{-2}$
Pi	pressure	$L.T^{-1}$	$m.s^{-1}$
V	Travel speed		
Tire properties		L	m
B	Tire width	L	m
D	Tire diameter	L	m

H	Tire section height		
Soil properties		$ML^{-1}T^{-2}$	kNm^{-2}
CI	soil cone index	$ML^{-2}T^{-2}$	$kN.m^{-3}$
γ	soil specific weight	-	-
θ	Soil moisture content		

For M: $X_1+X_2+X_8+X_{10}+X_{11}=0$……………………………………...5

For L: $X_1+X_2+X_3+X_4+X_5+X_6+X_7+X_8+3X_9-2X_{10}-X_{11}+X_{12}+X_{13}=06$

For T: $-2x_1-2x_2-2x_8-x_9-2x_{10}-2x_{11}-x_{12}=0$………………………………..7

Because three equations are available for solving the thirteen unknowns, three unknowns (X_2, X_6, and X_{12}) are kept and one of the remaining unknowns is equal 1 while the others are equaled to 0 to find out each P1 term. The determinant of coefficients of three variables kept should not be equal to zero to ensure that resulting Pi terms are independent (Langhaar 1951 and Murphy 1950). (X_2, X_6 and X_{12}) are considered of this rule as shown below:

$$\begin{array}{ccc} X_2 & X_6 & X_{12} \end{array}$$
$$\begin{vmatrix} 1 & 0 & 0 \\ -1 & 1 & 1 \\ -2 & 0 & -1 \end{vmatrix} = -1 \quad \text{…………………………8}$$

The calculation of Pi terms are found to be as follows:

$\Pi_1 = \frac{P}{Pi\,Z^2}$	$\Pi_2 = \frac{B}{Z}$	$\Pi_3 = \frac{D}{Z}$	$\Pi_4 = \frac{H}{Z}$	$\Pi_5 = \frac{d}{Z}$
$\Pi_6 = \frac{W}{PiZ^2}$	$\Pi_7 = \frac{Fc}{V\,Z^2}$	$\Pi_8 = \frac{\gamma Z}{Pi}$	$\Pi_9 = \frac{CI}{Pi}$	$\Pi_{10} = \frac{\delta}{Z}$

The soil moisture content is stand alone as Pi term because of it dimensionless variable and it is the eleventh one. A new set of Pi terms can be generated by changing X_2, X_6 and X_8 partially and totally with other unknowns by guaranteeing that the determinate of their coefficients are not equal to zero. In other way, new Pi terms can be generated by multiplying and/or dividing present Pi terms with each other. In addition, a present Pi term can be reversed to make a new Pi term. But, the independency condition of Pi terms requires that any selected ten Pi terms can not be generated from each other. Thus, if a new Pi term is selected for modeling, one of the present Pi terms involving in its calculation should be omitted. Some of Pi terms are transformed as shown in Table 4 to make them easy to work with.

Table 4 transformation among Pi terms:

Old Pi	Transformation	New Pi	Old Pi	Transformation	New Pi
$\Pi_1 = \frac{P}{Pi \times Z^2}$	$\frac{\Pi_1}{\Pi_6}$	$\Pi_1 = \frac{P}{W}$	$\Pi_6 = \frac{W}{Pi \times Z^2}$	$\frac{\Pi_6}{\Pi_9}$	$\Pi_6 = \frac{W.}{Z^2 \times CI}$
$\Pi_2 = \frac{B}{Z}$	No transformation	$\Pi_2 = \frac{B}{Z}$	$\Pi_7 = \frac{Fc}{V \times Z^2}$	No transformation	$\Pi_7 = \frac{Fc}{V \times Z^2}$
$\Pi_3 = \frac{D}{Z}$	$\frac{\Pi_2}{\Pi_3}$	$\Pi_3 = \frac{B}{D}$	$\Pi_8 = \frac{\gamma \times Z}{Pi}$	$\frac{\Pi_8}{\Pi_5}$	$\Pi_8 = \frac{\gamma \times Z^2}{Pi \times d}$
$\Pi_4 = \frac{H}{Z}$	$\frac{\Pi_4}{\Pi_5}$	$\Pi_4 = \frac{H}{d}$	$\Pi_9 = \frac{CI}{Pi}$	$\frac{\Pi_9}{\Pi_8}$	$\Pi_2 = \frac{CI}{\gamma \times Z}$
$\Pi_5 = \frac{d}{Z}$	$\frac{\Pi_{10}}{\Pi_5}$	$\Pi_5 = \frac{\delta}{d}$	$\Pi_{10} = \frac{\delta}{Z}$	No transformation	$\Pi_{10} = \frac{\delta}{Z}$

RESULTS AND DISCUSIONS

The effect of moisture content and implement type (Moldboard and chisel plow) on tire efficiency are shown in Figure (1and2). The highest tire efficiency was at the lowest soil moisture content of 7.8% and tire inflation of 80 kPa for both plows, the lowest value of tire inflation pressure is the highest moisture content and high tire inflation pressure of 120 kPa. Increasing soil moisture content from 7.9% to 21.7 % decreased the tire efficiency by 7.5 and 10% for chisel and moldboard plough respectively.

Tire efficiency of moldboard plough as compared to the chisel plough was 31% and 37.9 % in the dry soil for the lowest and highest tire inflation pressure, while in the highly moistened soil, the increase was 63.5% and 4.94% for both tire inflation pressures.

The relationship between the travel speed and wheel slippage for the different treatments is given in Figs. (3and 4).

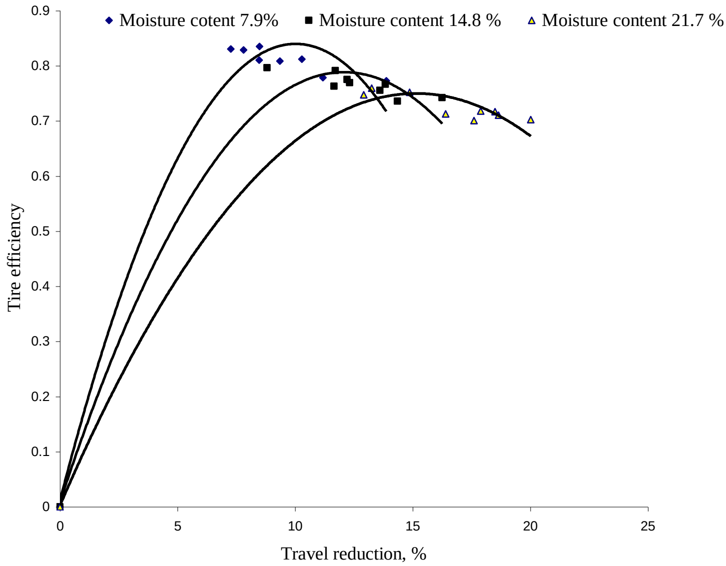

Fig 1: Effect of soil moisture content and travel reduction on tire efficiency for moldboard plow.

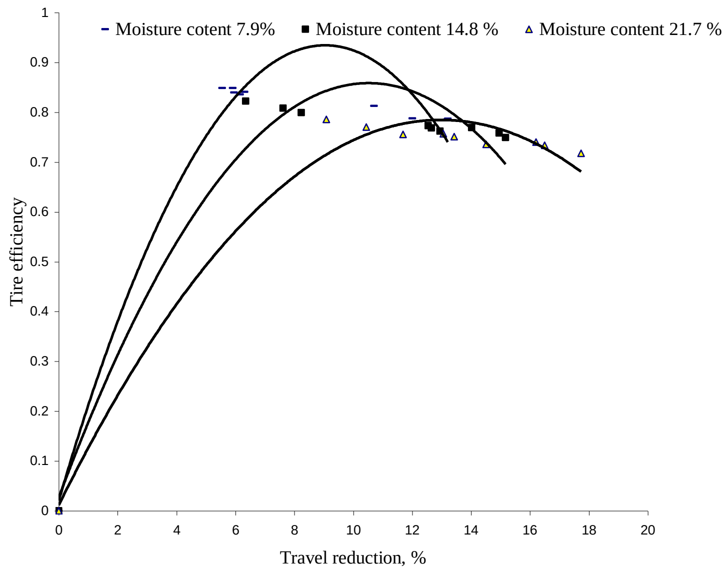

Fig. 2: Effect of soil moisture content and travel reduction on tire efficiency for chisel plow

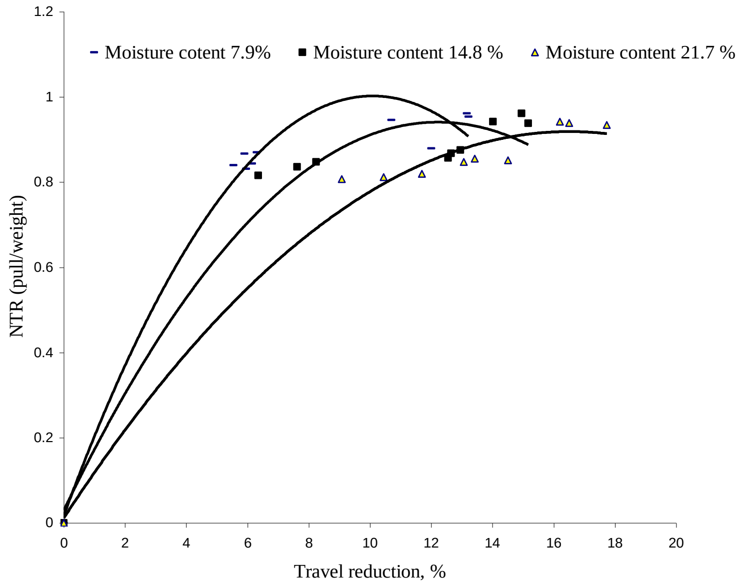

Fig.(3): Relation ship between tractor travel reduction and nettraction ratio for chisel plow.

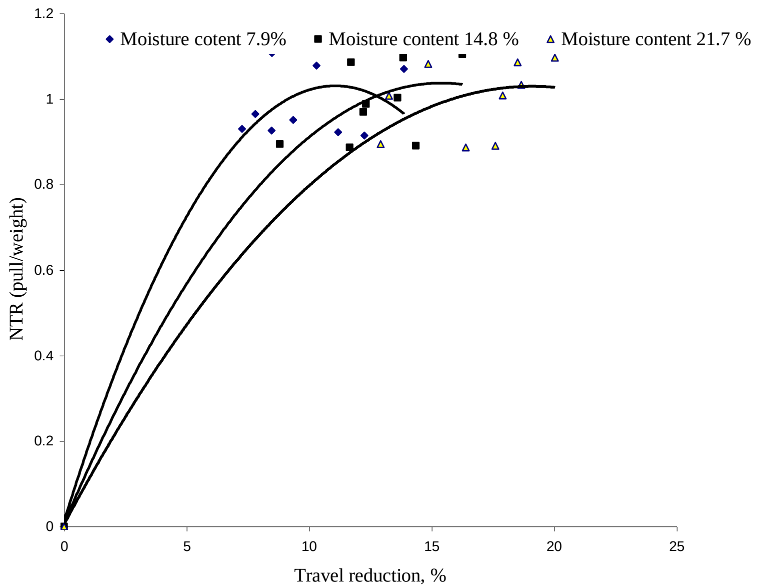

Fig.(4): Relation ship between tractor travel reduction and net traction ratio for moldboard model plow.

The final model relating all the independent factors with drawbar pull are given as follow:

$$P=\left[\beta_1\times\frac{\gamma\times Z^2}{Pi\times d}+\beta_2\times\frac{Fc}{Z^2\times V}-\beta_3\times\left(\frac{W}{Z^2\times CI}\right)+\beta_4\left(\frac{d}{\delta}\right)+\beta_5\right]*W$$

Where:

constant	Chisel plow	Moldboard plow
β1	55.198	28.61
β2	674.1	-1455.7
β3	0.004764	0.005071
β4	-0.02236	-0.01978
β5	0.52973	0.946452
R^2	0.95	0.92

Model verification:

To verify the model output, the predicated values were correlated to the measured values. A linear regression model of Y=A+BX was developed with the predicted drawbar pull as the dependent variable (Y) and the observed drawbar pull as the independent variable (X). If the regression model was a perfect predictor of the drawbar pull, the linear regression constants (A) and (B) would equal 0 and 1, respectively. Gregory and Fedler (1986) stated that values or R2 (coefficient of determination) varies between 0 and 1 and provide an index of goodness of model fit. If R2 value is 0.90 or larger, then at least 90% of the variability is explained. This would generally be considered an excellent fit. On the other hand, an R2 value of 0.80 is considered a good fit. An R2 value as low as 0.60 is sometimes considered acceptable or even good. The evaluation of linear model of different shapes is based on values of A, B, R2, R and the standard error of estimation (λ) which is defined below as:

$$\lambda = \sqrt{\frac{\sum_{i=1}^{i=n}\left(D_{Mes.} - D_{Pre.}\right)^2}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

Where:

D_{Mes} = measured drawbar pull, kN.

D_{Pre}. = predicted drawbar pull, kN, mm.

λ = standard error of estimation

n = number of observations.

The R^2 and λ (standard error of estimate linear model) indicate the scatter points about the regression equation. R (correlation coefficient) indicates the degree of association between the observed and predicted values. To assist further in this evaluation, another index called coefficient of efficient (Ce) was used. This coefficient was proposed by Nash and Sutcliffe (1970) and used by Masheshwari and McMahon (1993), Zin El-Abedin and Ismail (1999) and Sharaf (2003). If R and Ce are close to each other, the model is free from any bias all or part of the data. Ce is defined below as:

$$C_e = \frac{\sum_{i=1}^{i=n}\left(X_{oi} - \overline{X}_o\right)^2 - \sum_{i=1}^{i=n}\left(X_{oi} - X_{pi}\right)}{\sum_{i=1}^{i=n}\left(X_{oi} - \overline{X}_o\right)^2}$$

Where:

C_e = coefficient of efficient

n = number of observations

X_{oi} = ith value of observed measurements, kN.

X_{pi} = ith value of predicted measurements, kN.

$\overline{X}_o$ = average observed value, kN.

Model verification:

For different implement type:

A graphical comparison of the observed versus predicted drawbar pull for the two implement tillage is given in Figures (5) and (6).

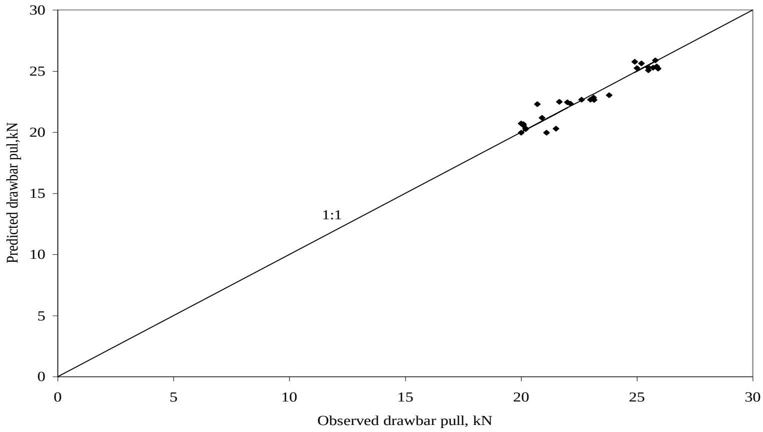

Fig. 5: The goodness of drawbar pull predicting by equation for moldboard plow.

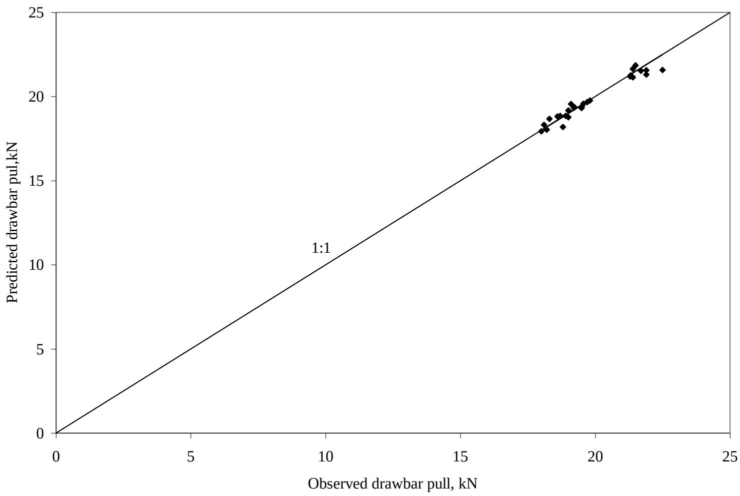

Fig. 6: Verification of drawbar pull predicting by equation for chisel plow

In general, the value of A close to 1 and B close to zero, accompanied by low standard error of estimation λ and high R2, R (correlation coefficient) and coefficient of efficient C_e values, would indicate satisfactory prediction by the model. Because the slope A and the intercept B are significantly different from 1.0 and 0, respectively, at the 99% level of confidence, a bias exists within the model estimation. This bias oscillates between over and less estimation which depends mainly on A and B values. The results of this evaluation along with the statistical parameters for drawbar pull given in Table (5).

Table (5): Indices of the different implements in predicting drawbar pull, kN diameter.

Parameter	Moldboard	Chisel
n	27	27
A	1.99	1.92
B	0.91	0.9
C_e	1	0.97
R^2	0.92	0.95
R	0.957	0.975
λ	0.0622	0.2758

Considering the value of various indices of evaluating the plow type, one can find that R^2 values for the two implements are greater than 0.90 and Ce values are closed to R^2. The value of A and B are closer to 1 and 0 respectively. Furthermore, R^2 values are high, less difference between R^2 and C_e and λ values are minimal.

In general, the correlation between the observed and predicted pull for the two implements is satisfactory. This indicates that the model output is appropriate and the bias existing within the implement can be attributed to the experimental errors and field condition variation.

CONCLUSIONS

The results of the present study led to the following conclusions:

1- The maximum tractive efficiency is obtained in the dry soil with low tire inflation pressure.

2- The correlation between the observed and predicted pull for the two implements is satisfactory. This indicates that the model output is appropriate and the bias existing within the implement can be attributed to the experimental errors and field condition variation.

3- Considering the value of various indices of evaluating the plow type, one can find that R^2 values for the two implements are greater than 0.90 and C_e values are closed to R^2. The value of A and B are closer to 1 and 0 respectively. Furthermore, R^2 values are high, less difference between R^2 and C_e and λ values are minimal.

REFERENCES

Al-Janobi, A.A. and Al-Suhaibani, A.A. (1998). Draft of primary tillage implements in sandy loam soil. Trans. of the ASAE, 14(4): 343-348.

Aluko, O.B., Seig,D.A. (2000). An experimental investigation of the characteristics of and conditions for brittle fracture in two-dimensional soil cutting. Soil & Tillage Research 57, 143-157

Al-Hamed, S. A., A. M. Aboukarima and K. A. Ahmed (2001). Effect of rear tire inflation pressure on front assist tractor performance. Misr, J. Ag. Eng., 18(3):715-725.

Bailey, A. C.; R. L. Raper, and E. C. Burt (1991). The effects of tyre inflation pressure on soil stresses. ASAE Paper No. 91-1062. St. Joseph, Mich., ASAE.

Baloch, M. J., B. A. Mirani and S. Bukhari (1991). Prediction of field performance of wheel tractor.

Bukhari, S., Bhutto, A. M., Baloch, M. J., Bhutto B. A. and B. A. Mirani (1988). Performance of selected tillage implements AMAA Japan,

19(4): 9-14

Chi, L. , Kushwaha R. L. (1991) Three-dimensional, finite element interaction between soil and simple tillage tool. . Transaction of the ASAE 34 (2), 361-366

Dwyer, M. J. and Pearson, G. 1976. A field comparison of tractive performance of 2-WD and 4-WD tractor. J. Agric. Engin. Res. 21(1): 77-85.

El-Ashry, E. R., A. I. Mohamed and A. M. Bahnasy (2003). Effect of wheel ballast, wheel slip and inflation pressure on tractive performance. Misr, J. Ag. Eng., 20(1):203-222.

Elbanna, E. B., S. A.A. E Hamad,. El-maged and A. R. Oboia (1994). Tillage tools operation affecting tractor wheels dynamic weight, soil pulverization and porosity. Misr, J. Ag. Eng., 11(1):19-35.

Fielke, J.M. (1996). Interactions of the cutting edge of tillage implements with soil. Journal of Agricultural Engineering Research, 63(1): 61-72.

Gregory, J. M. and C.B. Fedler. 1986. Model evaluation and research verification (MERV). ASAE Paper No. 86-5032.

Gill, W. R. and Vanden Berg, G. E., (1967). Soil dynamics in tillage and traction. Handbook No. 316, U. S.D.A. 511pp.

Gratton, J., Chen, Y. and Tessier, S. (2003). Design of a spring-loaded downforce system for a no-till seed opener. Canadian Biosystems Engineering, 45: 2.29-2.39

Kasprzak, W, B. Lysik and M Rybaczuk (1990). Dimenasional analysis in the identification of mathematical models. World Scientific publishing Co. Pte. Ltd. Singapore

Kazimieras, G. and Algirdas, J.(2005). Tractor ballasting in field transport work. Transport, xx(4), 146-153.

Langhaar, H.L. (1951). Dimensional anlysis and theory of models. Wiley and Sons Inc. New York.

Maheshwari, B. L. and T. A. McMahon. 1993. Performance evaluation of border irrigation models for south-east Australia: Part I, Advance and recession characteristics. J. of Ag. Eng. Research 54(1): 67-87.

Mohammed F. Wahby, Mohammed H. Kabeel and Abdulwahed M. Aboukarima (2000). Effect of tillage depth and rear wheel slip of afornt-wheel assist tractor on wheel weight transfer. Misr. J. Ag. Eng. 17 (1):185-194

Manian, R., Rao, V.R. and Kathirvel, K. (2000). Influence of operating and disk parameters on performance of disk tools. Agricultural Mechanization In Asia, Africa and Latin America, 31 (2): 19-26, 38.

Mckyes, E. and Maswaure, J. (1997). Effect of design parameters of flat tillage tools on loosening of a clay soil. Soil Tillage Research, 43: 195-204.

McLaughlin, N.B. and Campbell, A.J. (2004). Draft-speed-depth relationships for four liquid manure injectors in a fine sandy loam soil. Canadian Biosystems Engineering, 46: 2.1-2.5.

Murrphy, G. (1950). Similitude in Engineering. The Ronald press Company, New York.

Nash, J. E. and J. V. Sutcliffe. 1970. Rever flow forcasting through conceptual models. I.A. discussion of prenciples. J. of Hydrology, 10: 282-324.

Oni, K.C. Clark, S.J. and Johnson, W.H. (1992). The effects of design on the draught of undercutter-sweep tillage tools. Soil Tillage

Research, 22: 117-130.

Onwualu, A.P. and Watts R.C. 1998. Draught and vertical forces obtained from dynamic soil cutting by plane tillage tools. Soil Tillage Research, 48: 239-253.

Shari, G.A. 2003. Evaluation of pressure distribution and lateral flow rates along drip tape lateral. Misr J. Ag. Eng. ,20 (2): 542-556.

Shirin, A.K.M., Hoki, M. and Salokhe, V.M. (1993). Effects of disc and working parameters on the performance of a disc plough in a clay soil. Agricultural Mechanization In Asia, Africa and Latin America, 24(4): 9-12.

Shrestha, D.S., Singh, G. and Gebresenbet, G. (2001). Optimizing design parameters on a mouldboard plough. Journal of Agricultural Engineering Research,78(4):377-389.

Wiley, J.C.,B.E. Roming, L.V. Anderson and F.M.Zoz (1992). Optimizzing dynamicstability and performance of tractors with radial tires. ASAE Paper 92-1586. St.Joseph, Mich.:ASAE

Zein El-Din, A.M. and A.A. Sayedahmed (2000). A mathematical model for predicting draft forces for flat, chisel, sweep and winged chisel tools. Misr. J. Ag. Eng. 17 (1):208-232

Zoz, F.M (1970). Predicting tractor field performance. ASAE Paper 70-118. St.Joseph, Mich.:ASAE

Zin El-Abedin, T. K. and S. M. Ismail. 1999. Estimation and analysis of water advance in surface irrigation. Misr J. Ag. Eng., 16 (4): 720-744.

الملخص العربى

التنبؤ بقوى الشد للمحاريث الاولية

احمد على ابراهيم محمد[١] احمد محمد فوزى[٢] محى الدين محمد مرسى[٣]

الهدف من هذا البحث هو دراسة تأثير رطوبة التربة والضغط داخل العجل الخلفى على أداء الجرار وأستنباط نموذج رياضى للتنبؤ بقوة الشد عند استخدام المحراث الحفار والقلاب المطرحى وذلك فى أرض طينية بمحطة البحوث الزراعية (زرزورة) بإيتاى البارود.

ولتحقيق هذا الهدف تم أستخدام ثلاث مستويات من الضغط عجل الجرار الخلفى وهى ٨٠, ١٠٠, ١٢٠ كيلو بسكال وثلاث مستويات من الرطوبة وهى ٧,٩ %، ١٤,٨% و ٢١,٧٥ %

وتم قياس كل من قوة الشد , الأنزلاق , السرعة الأمامية , مقاومة التدحرج وكذلك تم حساب الوزن

١- رئيس بحوث بمعهد بحوث الهندسة الزراعية ٢- باحث أول بمعهد بحوث الهندسة الزراعية
٣ باحث بمعهد بحوث الهندسة الزراعية

الديناميكى على محور العجل الخلفى للجرار.
تم أستنباط وأختبار صلاحية النموزج للتنبؤ بقوة للمحراث الحفار والقلاب المطرحة كما يلى:

$$P = \left[\beta_1 \times \frac{\gamma \times Z^2}{Pi \times d} + \beta_2 \times \frac{Fc}{Z^2 \times V} - \beta_3 \times \left(\frac{W}{Z^2 \times CI} \right) + \beta_4 \left(\frac{d}{\delta} \right) + \beta_5 \right] * W$$

Where:

P:	=	Drawbar pull, kN	V	=	Travel speed, m/sec
FC	=	Fuel consumption,	B	=	Tire section, m
:	=	m^3/sec	D	=	Tire diameter, m
δ:	=	Tire deflection, m	H	=	Tire section height, m
d:	=	Tillage width, m	C	=	soil cone index, kN/m^2
Z:	=	Tillage depth, m	I	=	soil specific weight,
W:	=	Vertical wheel load, kN	γ	=	kN/m^3
p_i:		Tire inflation pressure, kN/m^2	θ		Soil moisture content, -

constant	Chisel plow	Moldboard plow
β1	55.198	28.61
β2	674.1	-1455.7
β3	0.004764	0.005071
β4	-0.02236	-0.01978
β5	0.52973	0.946452
R^2	0.95	0.92

وأظهرت النتائج أن:

١- الجرار يعطى أفضل أداء له عند الضغط المنخفض فى حالة استخدام المحراث القلاب والحفار.

٢- أعلى قوة شد تم الحصول عليها فى حالة استخدام المحراث القلاب والضغط المنخفض داخل الأطارات الخلفية للجرار وعند نسبة الرطوبة العالية للتربة.

٣- أعلى قوة وأعلى كفاءة للشد تم الحصول عليهما فى حالة الضغط المنخفض للهواء داخل الأطارات الخلفية للجرار