

Abstract

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The main objective of this study is to develop two artificial neural network (ANN) models to predict tillage implements performance under Egyptian conditions. However, the inputs for the two ANN models are the same, but the outputs are different. The predicting outputs of the first ANN model are effective field capacity (fed/h), fuel consumption per unit time and per unit area (liter/h and liter/fed), and plowing energy (kW.h/fed) based on fuel consumption (liter/h) and effective field capacity (fed/h). The predicting outputs of the second ANN model are draft (kN), unit draft (kN/m²), and energy requirements (kW.h/fed) based on draft (kN), forward speed (km/h), and theoretical field capacity (fed/h). In this study, soil texture is defined using numeric values as soil texture index given by Zein Eldin (1995).

Multilayer feedforward ANN (fully connected) was used in supervised manner and the training method was the backpropagation algorithm. The optimal configuration for the first and second ANN models consisted of 4 layers. The hidden layers had 12 and 24 nodes in the first and second hidden layers respectively for the first ANN model. However, for the second ANN model the hidden layers had 10 and 20 nodes in the first and second hidden layers respectively.

Hyperbolic tangent and Sigmoid transfer functions were employed in hidden and output layers for the first and second ANN

models respectively. The learning rate and the momentum parameter were 0.004762 and 0.8 respectively for the first ANN model. Meanwhile, they were 0.003146 and 0.8 respectively for the second ANN model. Iterations were 20000 and 60000 epochs during training process for the first and second ANN models respectively. During testing process, the results showed that the variation between observed and predicted outputs was small and the correlation coefficients were 0.933, 0.975, 0.952 and 0.975 for effective field capacity (fed/h), fuel consumption (liter/fed and liter/h), and plowing energy (kW.h/fed) respectively. Meanwhile, they were 0.947, 0.956 and 0.970 for draft (kN), unit draft (kN/m²), and energy requirements (kW.h/fed) respectively.

Results showed that the inputs affect the outputs with different percentage of contribution. Forward speed was the major input affected the effective field capacity (fed/h). Meanwhile, rated tractor power was the major input affected fuel consumption per unit area (liter/fed). Also, rated tractor power and soil texture index were the major inputs affected fuel consumption per unit time (liter/h) and the major input affected plowing energy (kW.h/fed) was rated tractor power. However, the major input affects the draft (kN), unit draft (kN/m²), and energy requirement (kW.h/fed) was rated plow width. Comparisons were made between the second ANN model and statistical equations developed using regression analysis to predict unit draft. The results showed that the second ANN model predicted unit draft with reasonable accuracy compared to statistical equations. Establishing these predictions can be considered an advantage from an economical point of view because of avoiding the need of purchasing expensive measurement instruments to collect technical data in the field of plowing or seedbed preparation process.

Key Words: Artificial neural network, ANN, Tillage implements, Prediction, Plows, Performance, regression analysis.

Table of Contents

Abstract	i
Acknowledgements	iii
List of Tables	xi
List of Figures	xvii
List of Appendices	xxiii
List of Abbreviations	xxv
1. Introduction	1
1.1 Statement of problem and objectives	3
2. Review of Literature	5
2.1 Background on tillage	5
2.1.1 Tillage definition	5
2.1.2 Tillage objectives	5
2.1.3 Tillage importance	6
2.1.4 Tillage systems	6
2.1.5 Computer applications in farm mechanization	7
2.1.6 Tillage implements performance	9
2.1.6.1 Draft	10
2.1.6.2 Fuel consumption	17
2.1.6.3 Plowing energy	19
2.1.6.4 Field capacity	23
2.1.7 Some local studies on tillage	26
2.2 Background on ANNs	30
2.2.1 Applications of ANNs	30
2.2.1.1 Different engineering fields	30
2.2.1.2 Agriculture and agricultural engineering fields	34
2.2.1.2.1 Predicting, estimating, and forecasting	34
2.2.1.2.2 Recognition, classification, and modeling	45
2.2.2 General information	47
2.3 Background on representing soil texture	48
3. Basics of Artificial Neural Networks	51

3.1	Introduction	51
3.2	Definition of ANNs	51
3.3	Biological neuron	53
3.4	ANN fundamentals	55
3.4.1	Neuron model	55
3.4.1.1	Simple neuron	55
3.4.1.2	Neuron with vector input	57
3.5	ANN architecture	58
3.5.1	Feedforward ANNs	58
3.5.1.1	Single layer feedforward ANN	58
3.5.1.2	Multilayer feedforward ANN	61
3.5.2	Recurrent ANN	61
3.6	Learning rules	61
3.6.1	Supervised learning	64
3.6.2	Unsupervised learning	64
3.7	ANN design and construction	65
3.7.1	Input and output layers	65
3.7.2	Hidden layers	65
3.7.3	Transfer functions	65
3.7.4	Data preparation	68
3.8	General procedure for building an ANN	68
3.9	ANN parameters affecting accuracy of predictions	69
3.10	Mathematical structure describing learning process	71
3.10.1	Learning modes	71
3.10.2	Performance optimization	71
3.10.3	Derivation backpropagation-algorithm	72
3.11	Summary of the backpropagation-algorithm	83
3.12	Advantages and disadvantages to using ANNs	86
4.	Materials and Methods	91
4.1	Sites of field experiments	91
4.2	Materials	91
4.2.1	Tillage implement	91

4.2.2 Tractors	92
4.2.3 Soil texture index	92
4.3 Methods	93
4.3.1 Measurements	93
4.3.1.1 Forward speed and plowing depth	93
4.3.1.2 Fuel consumption	94
4.3.1.3 Soil physical properties and soil fractions	95
4.3.1.4 Draft	96
4.4 Experiments procedures	98
4.5 Data analysis	98
4.6 Accuracy measurement	100
4.7 Simulation software	103
4.7.1 Backpropagation technical overview	103
4.7.2 Training process analysis tools	106
4.7.2.1 Root mean square error plot	106
4.7.2.2 Correlation plot	106
4.7.2.3 Targets/ANN outputs plot	107
4.7.2.4 Input interrogator	107
4.7.2.5 Statistics	107
4.8 Collected data for developing ANN models	108
4.8.1 The first ANN model	108
4.8.1.1 Source of data	108
4.8.1.2 Soils texture of data for the first ANN model	109
4.8.2 The second ANN model	111
4.8.2.1 Source of data	111
4.8.2.2 Soils texture of data for the second ANN model	111
5. Results and Discussion	113
5.1 Statistical analysis of the data used in developing the first ANN model	113
5.1.1 Statistical description	113
5.1.2 Correlation analysis	114
5.2 Training data used in developing the first ANN model	118

5.3	Developing and training the first ANN model	119
5.3.1	Optimal ANN architecture	120
5.3.2	Results of ANN training	121
5.3.3	Effect of node number in the first hidden layer	122
5.3.4	Effect of the node transfer function	125
5.3.5	Effect of number of iterations	126
5.3.6	Optimal configuration	128
5.4	Determining the effect of inputs on outputs (Inputs interrogator)	134
5.5	Comparison between multiple linear regression and the first ANN model (training phase)	139
5.6	Trend accuracy (TA) during prediction	141
5.7	Testing the first ANN model	144
5.7.1	Testing data	144
5.7.1.1	Chisel plow data	148
5.7.1.2	Moldboard plow data	150
5.7.1.3	Rotary plow data	154
5.8	Validation of the first ANN model	157
5.8.1	Nasr (1985) data	157
5.8.2	Idris (1990) data	161
5.8.3	Data from field experiments	163
5.9	Statistical analysis of the data used in developing the second ANN model	166
5.9.1	Statistical description	166
5.9.2	Correlation analysis	167
5.10	Training data used in developing the second ANN model	170
5.11	Developing and training the second ANN model	170
5.11.1	Optimal configuration	171
5.12	Determining the effect of inputs on outputs (Inputs interrogator)	175
5.13	Comparison between multiple linear regression and the second ANN model (training phase)	179

5.14	Trend accuracy (TA) during prediction	185
5.15	Testing the second ANN model	186
5.15.1	Testing data	187
5.15.1.1	Chisel plow data	190
5.15.1.2	Moldboard plow data	192
5.15.1.3	Rotary plow data	193
5.15.1.4	Disc plow data	195
5.16	Validation of the second ANN model	197
5.16.1	Idris (1990) data	197
5.16.2	Ghazy (2000) data	197
5.16.3	Data from field experiments	199
5.17	Comparison between draft predictions using regression and the second ANN model	202
6.	Summary and Conclusion	211
7.	References	215
8.	Appendices	241
9.	Arabic Summary	----

List of Abbreviations

ANN	=	Artificial Neural Network
ANNs	=	Artificial Neural Networks
fed	=	Feddan
STI	=	Soil texture index
SC	=	Statistical description
EFC	=	Effective field capacity
FC	=	Fuel consumption
EE	=	Plowing energy
Avg	=	Average value
Min	=	Minimum value
Max	=	Maximum value
SD	=	Standard deviation
C.V	=	Coefficient of variation
UD	=	Unit draft
ER	=	Energy requirements
S _a	=	Sand content in soil
S _i	=	Silt content in soil
C _a	=	Clay content in soil
C	=	Chisel plow
D	=	Disc plow
M	=	Moldboard plow
R	=	Rotary plow
RTP	=	Rated tractor power
RPW	=	Rated plow width
NSP	=	No. of plow passes over the soil
PD	=	Plowing depth
FS	=	Forward speed
ISMC	=	Initial soil moisture content
ISBD	=	Initial soil bulk density
PTO	=	Power Take-Off

- W_{if} = Weight between input and the first hidden layers
 W_{fs} = Weight between the first and the second hidden layers
 W_{so} = Weight between the second hidden and output layers