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ENERGY MODELING USING MULTILAYER PERCEPTRON IN PRODUCTION OF POTATO CROP IN BAGHDAD PROVINCE

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Abstract

The research was conducted for the purpose of modeling energy in potato production to recognise the most influencing factors in production, as well as predicting the amount of energy output, afterwards compare it to the real value. The proceses were done through the Artificial nueral network known as Perceptron Multilayer or (M.L.P.). The model showed very high flexibility and efficiency in predicting the energy production ratios for the potato crop. The network recorded high correlation ratios, as well as very few error between actual and predictive values. The best M.L.P. model was used consisted of one hidden treatment layer that comprised of 9 neurons. The value of S.S.E. with training and testing was 0.006, 0.009, respectively. The value of the relative error, known as R.E. for training and testing, was 0.001, 0.003, respectively. As for the value of the determining factor R^2 recorded in this model, reached 0.999. The study showed that human energy in the processes of primary insect control and primary herbal control demonstrated the most important effect on the amount of energy extracted from the potato crop for the Doylebah site, as it reached 12.2% and 11.6%, respectively.

Key Words: Potato, Input Energy, Multilayer Perceptron, Energy Modeling, Hidden Layers

Introduction

The potato crop is considered one of the important crops worldwide in terms of its strategic order, the variety of its uses and its high nutritional value, as it is involved in preparing many types of food. It ranks third in the world in terms of strategic importance after wheat and rice, according to Raymundo *et al.,* (2018), potato was presented on the maize crop, as well as being an important source of national income. Potatoes (*Solanumtuberosum* L.) are grown all over the world under a wide range of lands (Mohammadi 2008). This crop is also rich in terms of many vitamins, minerals and carbohydrates. The seed breed called BURREN is distinguished by its high productivity, big volume and moderate resistance to infections. Despite the importance of this crop globally, productivity per unit area for the year (2018) in Iraq is still low at a rate of 15.69 tons/hectare compared to neighboring countries, according to the FAO report for (2020). As the cultivated area reached 2807.75 hectares and the local production for the autumn loop reached 20.9 tons/hectare, according to the report of the Central Statistical Organization (2018). It is worth noting that this statistic did not include many areas of Iraq.

This decline in productivity at the local level is due to several factors, the most important of which are the type and generation of cultivated seeds, in addition to the limited use of agricultural technologies and modern machinery specialized in work, the lack of use of renewable energy sources, lack of precision in the dates of cultivation, and the small cultivated areas and agricultural holdings, which in turn lead to An increase in energy consumption ratios compared to large areas and weak government support, which in turn led the government to compensate for the import of Arab and international markets, as the quantity of potatoes produced locally does not match the size of the local demand for this crop, according to the report of the Central Statistics and Standardization Authority (2015). Importing potato from neinoring countries in big quanteties led to Abandonment of farmers from planting moreaver their lack of interest in increasing production as a result of incomes do not cover expenses. There is no study yet that shows energy consumption and production in the cultivation of potato crops in Iraq. Potatoes offer unique benefits to plant breeders and are the most important non-cereal crop in the world, according

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to (Raymundo *et al.,* 2018). Caliskan *et al.,* (2010); Jacobs *et al.,* (2011); FAO (2013) emphasized that potatoes will be an important crop in the future in securing food resources for the world's population of an estimated 9.7 billion by 2050. Al-Bayati (2013) stressed that the potato crop is grown in Iraq during the autumn season for the purpose of selling it in the local markets and growing in Spring season for the purpose of producing tubers. The FAO report (2020) showed that the harvested area of the potato crop was 18780 hectares in 2018, while the production of Iraq of this crop reached 294778 tons. Fig. 1 shows the Iraqi productivity of the potato crop and the harvested areas for the period from 2000- 2018.

The basis of the work of artificial neural networks (ANN) is similar to the work of the neurons of the human brain, and just as a person acquires knowledge through the learning process due to past events, so is the case with the artificial networks that train and learn from the data entering them, they are able to learn from examples as is the case In the human brain, neural networks can be used to predict different levels of success, (Eskandari 2017); (Morfidis 2017) and (Yan 2017). Model development includes selecting the network topology, estimating network weights, checking the model output by comparing it with the in requist (Majumder and Saha 2016) .There are a wide range of types of artificial neural networks including the M.L.P. model. Ramchoun *et al.,* (2016); Balabanov *et al.,* (2018) believed that artificial neural networks are very popular in the field of artificialintelligence, moreaver it is highly efficient and the optimal structure of the M.L.P. model can play an important role in determining the problem to be solved. Shanmuganathan and Samarasinghe (2016) stated that in order to overcome the limitations of linear division of points the M.L.P. model was inserted. The M.L.P. neural network model consists of one or more hidden layers and one from the output layer. The individual neurons of the layers are linked either completely or partially to the neurons of the following layers depending on the type and structure of the network, the M.L.P. model consisting of a single hidden layer can approximate the results of any continuous process with any required accuracy, taking into account a sufficient number of hidden nodes. Mosa *et al.,* (2015) and Chithra *et al.,* (2016) stated that the use of the neural networks model is of great importance in predicting potato production through data entry and analysis of results and obtaining outputs that put us in front of using an ideal cultivation system with the lowest energy losses and the highest productivity. Kalogirou (2001); Kermanshahi and Iwamiya (2002); Samarasinghe (2007); Taher *et al.,* (2018) said that all ANN models show very good correlation ratios between predictive values and actual outputs with very low error values, and a high proportion of matching between predictive values and actual outputs. The M.L.P. model trains from the input and output values that are entered into the program. the amount of data entered is crucial and the more data inputs, the greater the accuracy of the results are along with the least error, provided that the number of hidden neurons is not less than the required because that results in errors increasing and the relationship between inputs and outputs is weakened. furthermore the number of the Hidden neurons are more than needed because they cause increased prediction. The network can handle data ranging from a few numbers to thousands .finding an accurate database is difficult and one of the important problems of modeling is that some of the relationships between inputs and outputs are complex and non-linear; Consequently, understanding its principles can be very difficult, so resorting to artificial neural networks is correct since it is very powerful when entering data models.

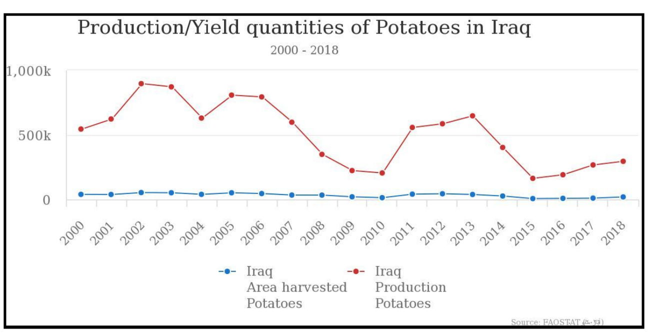

Fig. 1: Iraqi productivity of potato crops and harvested areas for the period (2000-2018).

Zangeneh *et al.,* (2010) confirmed that developed ANN models may well predict the potato production index. In this model, they rely on a hidden single-layer synthetic neural network. The expected values and the calculated values for the index were very strong according to the results after the stage of verification. They recommended choosing a suitable model using specific inputs from different agricultural systems in different regions, especially whether using machines or not in more than one agricultural system. Zare *et al.,* (2013) indicated that the purpose of using a set of data in the training phase (Traning) is to develop the model and update the network weights (bias), while testing data should be different from those used in the training phase. A higher performance was achieved for MLP-based computing models with greater durability than conventional statistical models , because there are many artificial neurons for processing. Hilal *et al.,* (2016) indicated that ANN can be used to predict palm oil production based on land and climate quality with Very good Satisfying results. Error ratios of reached a minimal level estimated of 1.1% in training and 1.9% with testing, the value of congruence between actual and predictive values R^2 was high, reaching 0.989, moraver through the ANN simulation model, one can see the impact of climate change on several elements in the same time on the land productivity. Hilal *et al.,* (2018) stated that the best oil palm yield prediction model had a value of R^2 of 0.948 and a mean error of 0.022. Mansoor *et al.,* (2018) showed that the model performance comparison is done through the R^2 coefficient and that the closer its value approaches 1 the good the model and the more R^2 approaches zero the bad the model. Livshin (2019) has emphasized that artificial intelligence is currently a set of mathematical and intelligent processing methods that allow computers to learn from the data they process and apply this knowledge to solve many important tasks , also artificial neural networks enable computers to learn from the data of Monitoring and make predictions based on that knowledge.

Expecting results for different conditions is one of the primary steps in a successful agricultural management. However, the need to use a large number of complex variables to predict the results makes them very complex which leads to large margins of errors. So choosing and using the best methods for agricultural processes and conditions would reduce agricultural production expenditures and the environmental impacts of the work, so modeling can be A valuable asset for improving agricultural operations. Artificial neural networks are widely known for their flexibility in use, their ability to map non-linear variables and the reliability of existing predictions of models developed with the help of technology according to (Majumder and Saha 2016).

Through reviewing the references, we have not yet found a specialized study that shows the amount of energy consumed and the direct factors affecting potato production.

Hence, the main objective of this research is to train the M.L.P. model for predicting energy consumption in potato production in Baghdad Governorate, which is the most potato producing location in Iraq through the use of a predictive analytical program to determine the most influencing factors on production in addition to the expected amount of production By exploring the effects of direct factors on potato production.

Materials and Methods

Research site: The research was conducted in the fall season of the year of 2019 in Baghdad governorate/ Duwailiba region located to the west of the city center by 65 km, along the Euphrates River, at a height of 49 meters above sea level, which is characterized by loam soil which is planted annually by the potato crop of two loops autm and spring. According to Site data (33.1696 - 43.9450) illustrated in the arial picture 1 during the period 10/9/2019 to 20/12/2019. The location area reached 5 acres included 20 experimental uints of 2500 m^2 per experimental unit.

Crop class: The third-generation BURREN potato seed class was used for planting in the autumn season. This class is characterized by early medium maturity to the late medium and a long to very long sedation period. Large tubers are spheral to long spheral in a consistent and uniform manner with yellow crust and yellow meat in addition to very high productivity. Resistant to diseases, they are prone to blight disease, tubercle blight, moderate resistance to leaf-wrapping disease, moderate resistance to Yn virus, and moderate resistance to combined scabies.

The equipment used: The system that was used for irrigation was by means of (pumps) and the use of machines in a small number, as it depended on the type of agricultural tractor type of (NEWHOLLAND TD 80) Turkish made, Model 2008, 4 cylinders powered by diesel fuel, with a capacity of 80 hp, four-wheel drive. And on a three-stage mouldboard plow, with an actual working width of 95 cm, Turkish made for soil preparation operations only. As for the planting, it was done based on the human effort, which was measured by smart watches that are plased on the wrist, in addition to the manual equipment Wherase control and fertilization is carried out by back-borne pumps, the extraction process was carried out by human effort and manual equipment.

Description of the analysis: The area of the

Picture 1: Research location.

experimental units was determined to be 2500 m^2 for each experimental unit. The research site consisted of several small farms with an area of two dunums that is 5000m^2 for each farm. Data was divided for each donm separately .the consumption of energy inputs in the potato production process was calculated starting from operations of (Tilling, hurrowing, seeding, planting, watering, fertilization, control, incubation or stimulation, extraction or harvesting). Then analyzing the energy outputs from the production process of the potato crop, afterwards these data were analyzed by the statistical analysis program (SPSS) produced by IBM furthermore the development of the use of ANN, which are application structures inspired by the function and how the human brain works. These networks can perform a model function estimation and deal with both linear and nonlinear functions by learning from data relationships that is considered a function of prediction variables (independent input transporters) that reduce prediction error for the target variable (dependent output variable). There are several types of ANN and one of these types M.L.P. that is a powerful modeling tool that applies training under human supervision using examples of data with known outputs. It predicts the energy outputs in the potato crop production to measure the degree of correlation and error ratios resulting from the model's working ,to determine the difference between the work results and the expected results from the best model chosen in the neural network. The artificial neural networks are distinguished by having several layers of input, processing and output, and these layers can be developed according to the number of inputs along with the ability to discover the effect of each entry on the outputs without the occurrence of interaction with the results, which may cause loss of accuracy. The results are obtained by multiplying the input matrix in the weight matrix and there is also a possibility to reduce or increase the input and output variables in the neural network, so it is an appropriate method for predicting energy. The M.L.P. structure was chosen in three layers as follows:

(Input Energy): The Doyleiba site included 19 entries according to the previously mentioned operations, as the data was divided into 70% for training purpose and 30% for testing purpose , according to the program's default classification without change.

(Hidden Layers): a copmparison was made between one layer and two using a similar number of neurons inside the layer. The number of cells inside a single hidden layer was at the site of Doyleba (7, 9, 10, 12, 15, 17 and 19), where The program was given the ability to test these numbers according to the principle of Training & Error and according to the method recommended in the catalog of the company IBM producing the program (2012), where the lowest and highest value was determined for the number of cells within one hidden layer .the program left free to choose the best number for each training. As for the two-layer network, the number of cells was determined according to the results obtained from the single hidden layer.

(Output Energy): The amount of potato yield was calculated in kilogram per donm then the amount was multiplied by the energy conversion factor of 3.6 mega joules/kg to obtain the total amount of energy output from potato production. It was divided into two parts, the first for the purpose of building models that is called training, and the second section for the purpose of comparing the accuracy of models and is called testing by studying the amount of accuracy by predicting models. The models are evaluated on the basis of square of errors for training and testing along with relative error for training and testing. The more error values approaches zero the more good the results are, in addition to the value of the determination coefficient R^2 which reflects the matching of actual results with the expected results ,and the closer it is to 1, the better the model is.

Results and Discussion

Effect of neuronal number alongwith hidden layers number on error ratio and the efficiency of model performance

Tables 1 and 2 show the statistical criterion for error ratios, its obvious from table 1 that the sum of squares of errors for training. The lowest error was recorded in the model that contains two layers hidden by 9 neurons that reached 0.002, however it cannot be considered the best model because it haven't used more than 35%, of the amount of data included in the network training process. This percentage is very low compared to the specified percentage of 70%, wherase the model that contains one

Table 1: Sum of squares of errors and the relative error of training for a one- and two-layer model.

Number of neurons in the hidden Layer in Duwailiba	S.S.E. For Traning 1 Layer	S.S.E. For Traning 2 Layers	R.E. For Traning 1 Layer	R.E. For Traning 2 Layers
7	0.009	0.132	0.001	0.018
9	0.006	0.002	0.001	0.001
10	0.01	0.005	0.001	0.001
12	0.015	0.176	0.002	0.023
15	0.005	0.046	0.001	0.008
17	0.008	0.012	0.001	0.002
19	0.003	0.17	0.001	0.026

Table 2: Sum of squares for the test errors and relative error for the test for one- and two-layer model.

Number of neurons in the hidden Layer in Duwailiba	S.S.E. For Traning 1 Layer	S.S.E. For Traning 2 Layers	R.E. For Traning 1 Layer	R.E. For Traning 2 Layers
7	0.116	0.262	0.036	0.252
9	0.009	1.96	0.003	0.322
10	0.11	0.062	0.054	0.023
12	0.288	0.068	0.118	0.044
15	1.475	0.434	0.502	0.093
17	0.045	0.032	0.044	0.014
19	0.109	1.686	0.052	0.646

layer of 9 neurons scored a 0.006 error rate which is the best model compared to the rest of the models that were trained in terms of The value of the sum of squares for the error of training, while the highest training error was recorded in the model containing two input layers with 12 neurons of 0.176.

Table 1 shows that the relative error value of the training, and the least error was recorded in the models that contain one input layer with 7, 9, 10, 15, 17, 19 neurons and two input layers with 9 and 10 neurons and these values all reached 0.001 Thus, the model with one layer and 9 cells is the best model that has been trained in terms of relative error taking into account that this model is the best in the sum of the error squares for training , because the training did not reach 70% in the rest of the models, whare as the highest error was recorded in the model that contains two hidden layers of 19 neurons that reached 0.026.

Table 2 shows the sum of the squares of the error for the test, the lowest error recorded in the model that contains one hidden layer with 9 neurons was of a value of 0.009 and the highest error recorded in the model that contains two hidden layers with 9 neurons was of 1.96. It is worth to mention that this high ratio was due to entering only 35% of data to be trained, which is supposed to reach 70%, so this was a major reason for not choosing the two-layer model with 9 cells as the best model.

Table 2 Also indicates that the relative error value of the test, and the lowest error was recorded in the model that contains one hidden layer with 9 neurons of a value of 0.003 while the highest error was recorded in the model that contains two input layers with 19 neurons of a value of 0.646, thus the model with 9 neurons along with one hidden layer is the best model recorded in this site in terms of low error rate and closeness to zero related to the four error ratios for training and testing.

The effect of the number of a single and two-layer neurons on the value of R^2

R^2 factor is calculated using a real amount of indicators in addition to the data predicted by neural networks. In other words, R^2 is a factor that shows the extent of correlation between the actual and predicted data. Neural models have been trained and tested for both sites to choose the best model in which the value of the R^2 is high, which shows the explanatory ability of the inputs, the effect of the number of neurons in the hidden layers, the number of layers in the value of the output, and the extent of convergence between the actual values taken in the field and the predictive ones of the neural network. It is worth noting that the value of the determining factor R^2 is the third criterion is considered the most important in determining the best model among all the models used. Mansoor *et al.,* (2018) indicated that the comparison of model performance is done through the determining factor R^2 and that the closer its value approaches 1 the better the model is and the more R^2 approaches zero the Bad the model is. Models with one and two hidden layer were trained and tested with a neurons of 7, 9, 10, 12, 15, 17, 19. Table 3 shows the values of the determinant factor R^2, which shows the level of correlation between the actual and predictive values obtained through conducting the training and testing process for the seven models that contain one hidden layer and the other seven models that contain two hidden layers. Thus the total of the models is 14 models, and it show That the highest R^2 was recorded by the model that contains one hidden layer with 9 neurons shown in Fig. 2, where it reached 0.999, which is a high percentage that comes very close to the value of 1, which in turn indicates that the value of R^2 represents 99.9% of the

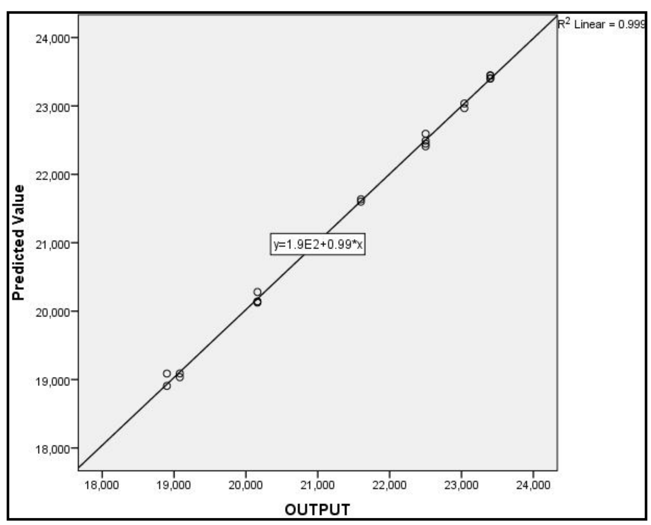

Fig. 2: The percentage of correlation between actual and predictive values.

Table 3: R^2 factor value.

Value of R^2 in Duwailiba		
No.neurons	**One Layer**	**2 Layers**
7	0.99	0.958
9	0.999	0.791
10	0.989	0.995
12	0.973	0.973
15	0.877	0.958
17	0.994	0.996
19	0.989	0.797

changes in the value of The studied trait, the reasons for which are the combination of the factors studied and selected from the mentioned model, the remaining value of R^2, which is 0.1%, represents the reasons for factors that were not within the scope of the study. Naderloo *et al.,* (2013) indicated that the value of R^2 in model tests conducted to study energy input and output in agricultural crop production reached rates above 98%.

The table also shows that the model containing two layers hidden by 9 neurons scored the lowest R^2, reaching 0.791, which shows us that the model with one hidden layer is able to predict the best energy outputs, which in turn confirms that the neural networks are able to deal with these entries of our study With high efficiency and accuracy without requiring a two-layer model.

The outputs of the neural network training (network structure)

Fig. 3 shows the structure of the neural network for the best model chosen from among 14 models, which consisted of an input layer that included 19 input nuerons, the input nuerons are not connected with each other, but they are connected by neurotransmitters, which represent weights with the hidden layer specialized in treatment and analysis, which consists of 9 Neurons and we notice the difference in thickness and color of the neurotransmitter lines, which ranges from light gray to dark blue, which means that the effect of this input on the outputs increases with the increasing in thickness and color of the transmitter. From the above mentioned, it can be said that the number of input neurons in the model consists of 9 operations, and this is the interpretation of the program's choice of this model that contains 9 neurons. In other words, the more complex the processes involved, the more the program chooses more hidden nuerons and more layers, (Shah *et al.,* 2019), they showed that the number of layers and neurons may change with the extent of the problem being measured and increases with the increase in the complexity of the data presented by the system , also they indicate that the neurons in each layer are linked The other that is located in the next layer, with the goal of flowing data of information into the output layer. Thus, neurons can deal with a huge number of data and analyze them without any loss in the accuracy

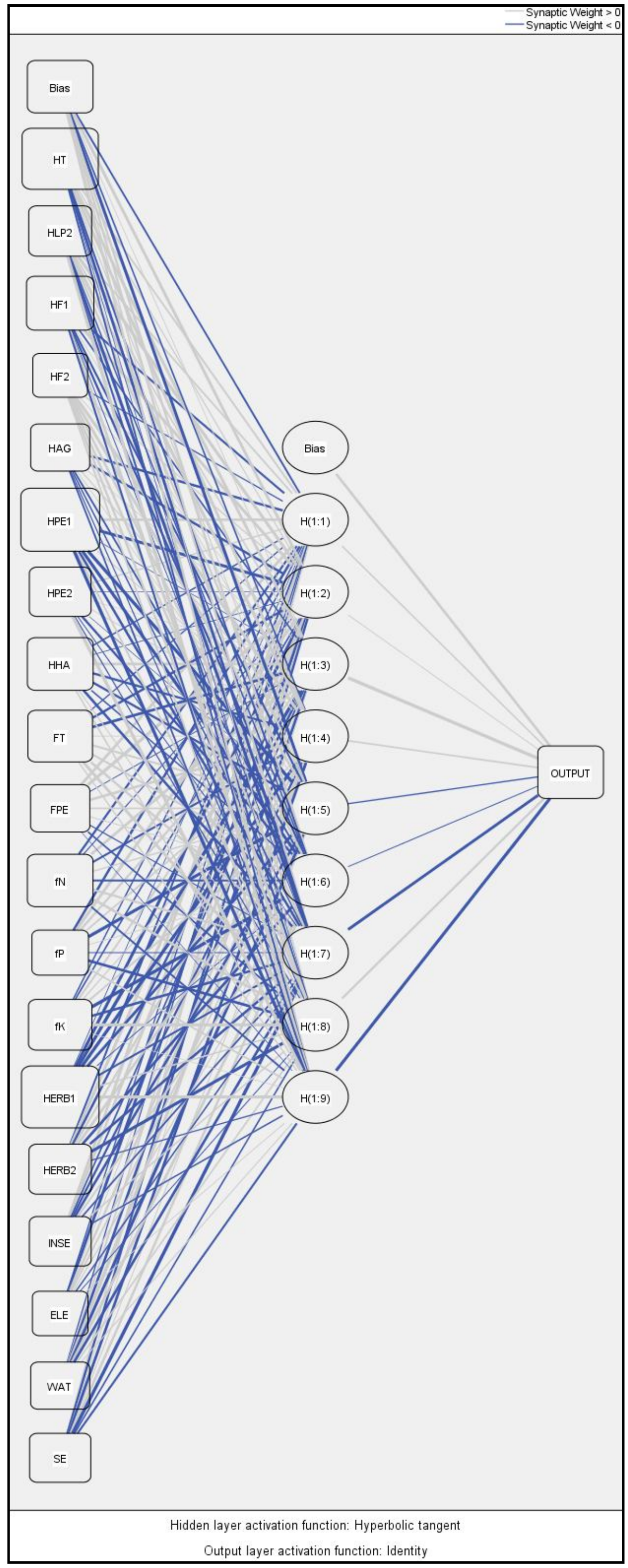

Fig. 3: The neural network structure of a model with (9) neurons and a single layer.

of the results. On the contrary, they increase with increasing inputs.

Sensitivity test of variables for the best model

The most meaningful explanatory parameters for M.L.P. models were insect control, herbal control and human energy performed in the operations of tillage and fertilization. The results showed that humans have a significant role in increasing energy outputs in agricultural systems that depend mainly on humans nevertheless complained with a decrease in the use of agricultural mechanization .The increase in output was a result of the increase in human energy in the insect and herbal chemical control that the causes of which are due to insect injuries in the fields of the study, as well as the increase in the rates of bushes due to excessive irrigation. moreaver human energy had a significant impact on tillage, which could be due to the accuracy of using the tractor by the driver and the small agricultural holdings that require the driver's skill and accuracy in the tillage process, in addition to the role of human energy in the fertilization process, which is due to the experience and accuracy of the workers in this site observing the plants planted during the fertilization process, in which they gained through the repetition of agricultural seasons and the passing of experiences From parents and grandparents.

Hence it can be said that there is a direct relationship between the inputs in the chemical control process and the energy outputs resulting from the yield. This interpretation can only be generalized in the event of an insect or herbal injury to the crop. Likewise, with the increase in the vegetative density of the plant, the need to increase human labor in the control and fertilization process is greater, thus increasing the energy output versus an increase in the inputs of insect and herbal chemical control in site within the scope of the study. In other words, it can be said that the insect and herb control inputs and human energy inputs in the processes of tillage and fertilization have a high correlation between the actual and predictive values of the best model.

Table 4:

Inputs	Importance	Normalized Importance
HT	.110	90.4%
HLP2	.048	39.3%
HF1	.069	56.6%
HF2	.011	8.8%
HAG	.030	24.6%
HPE1	.122	100.0%
HPE2	.043	35.1%
HHA	.061	50.4%
FT	.056	46.0%
FPE	.031	25.2%
Fn	.061	49.7%
Fp	.018	15.0%
Fk	.050	41.3%
HERB1	.116	95.2%
HERB2	.046	37.8%
INSE	.043	35.2%
ELE	.014	11.6%
WAT	.030	24.5%
SE	.040	33.2%

Table 4 shows the values of Importance and Normalized Importance through which we can test the sensitivity of the variables to the best model chosen from among the 14 M.L.P. models for this region , according to that, The model was chosen which contains one hidden layer with 9 neurons as the best model.

The importance of the impact of energy inputs on its outputs were 12.2%, 11.6%, 11%, 6.9% for human energy in (insect control, herbal control, tillage, fertilization) operations, respectively, Seddik and Tawfik (2018) in their study agrred that determining Most of the costs in production, reflects the need to develop this type of neural network.

It is worth to mention that the main reason for choosing models with one hidden processing layer instead of two hidden layers as the best models that are relied upon because they achieve the lowest error rate and the highest coefficient of determination of R^2 among all models, moreaver choosing models with two layers may increase the complexity and increase the prediction rates And thus give results far from reality. Therefore, although the model with a single layer with 8 neurons at the Rashidiya site had achieved the lowest S.S.E. and R.E. ratio in the test, never the less it was not approved because the test had stopped at 25% while the percentage that was determined for the test was 30%.

Conclusions

1. M.L.P. models composed a of Single- hidden layer proved superior to two-layer models when predicting results, and the best M.L.P. model was selected with a single hidden layer consisting of 9 neurons. Therefore, the adoption of the artificial neural network M.L.P. in predicting energy production ratios for the potato crop gives positive results in future studies.
2. The S.S.E. value for the best model of 9 neurons with a single hidden layer of training and testing was 0.006 and 0.009, respectively. While the value of R.E. for training and testing was 0.001 and 0.003 respectively.

The value of R^2 in this model was 0.999. In order to give a clear and full-scale idea of the real energy expenditures in both input and output alike in agricultural production in subsequent studies conducted in different regions of the country, it is necessary to investigate the latest and best neural networks programs that give high accuracy.

3. The human energy in the processes of pest and herbal control had the most important effect on the amount of energy extracted from the potato crop, as it reached 12.2% and 11.6%, respectively. Therefore, we recommend the use of controlling and fertilization programs along with equipment specialized in these two processes in the future work, because of its role in reducing the inputs of human energy consumed which leads to shortening the time, effort and material expenses while increasing the marketing quality.

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