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DEVELOPING A MODEL USING NEURAL NETWORKS TO PREDICT WHEAT PRODUCTION IN THE KIRKUK GOVERNORATE

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ABSTRACT

Wheat is one of the most strategically essential crops in the world and one of Iraq's most important crops. The objective of the present study was to analyze energy and examine the application of a multilayer perceptron for predicting wheat yield production in the Kirkuk governorate. The research data were collected with a face-to-face inquiry made with the farmers at two fields that include the types of equipment used for the production of wheat, the number of hours worked, fuel, oil, workers, and the style of agricultural processes for the wheat crop production. The research results showed that total energy consumption in wheat was 13315.21 and 29016.27 $MJha^{-1}$, while the output energy was 24867.5 and 88641 $MJha^{-1}$ for the first and second fields, respectively. Seed and diesel fuel consumption are considered essential variables in wheat plantation operations, it's the highest input energy values being the relative values of 30.2 and 61.97 %. These variables impacted wheat operation during the 2021 to 2022 years at 4020 and 17982.44 $MJha^{-1}$ for the first and second fields, respectively. Finally, the results concluded that the neural network model is helpful for predicting wheat production—the neural network architecture 7-4-1 and 5-7-1 for the first and second field systems. The research shows that the trained models produced a minimum error, indicating that the test model can predict wheat yield production in the Kirkuk governorate.

INTRODUCTION

The Iraqi agricultural production sector is essential in raising the average living in rural areas and becoming a contributor to the Iraqi national economy. The demand for wheat production increased, leading to rapid growth in the cultivated land area in many Iraqi governorates, especially the northern region of Iraq. The Iraqi government encouraged the development and expansion of wheat farms in its five-year plans, which will contribute to the growth of the national economy (Hilal *et al.*, 2020).

Wheat cultivation in Iraq has faced many problems during the past decade. The most important of these problems is climate change and the continuation of traditional agricultural methods, which led to considerable losses in production and the farmer's reluctance to cultivate for fear of losses due to lack of rain. Therefore, climate issues have become increasingly crucial concerning. It is associated with economic and public health activities in Iraq and globally, which were ignored in the past in Iraq but have now emerged as a primary national concern in recent years (Shareef and Ahmed,2022).

Over the last decade, wheat cultivation has faced many challenges in the Kirkuk governorate. The gap in wheat yield production is one of the significant challenges, leading to decreased yield production rate with rising land usage. This issue is the prime reason for increasing the number of workers and energy consumption rate (Abdulqade, 2021). Wheat mechanization can reduce labor dependency, increase farm productivity, and hasten field operations. Field mechanization can be defined as working systems that involve the interaction between machines and operators to accomplish specific work activities (Plastina, 2016). Wheat production processes start from soil tillage, fertilizer application, irrigation, plant protection, harvesting, and threshing (Saharawat *et al.*, 2010).

In wheat mechanization, suitable tillage equipment is the main worthy agriculture operation. The soil properties and tillage equality are increased according to plow types and skilled labor (Al-Naama and Fartusy,2012). For example, Marakoglu and Carman (2012) showed that the conventional tillage system, moldboard plow, and harrowed with disc harrow under minimum tillage decrease fuel consumption, which allows energy savings. Additionally, after sowing, harrows are always used to cover the seeds.

The seeding implements are not less necessary than the tillage implements. There are two main ways of sowing wheat: broadcasting and drilling. Broadcasting is a simple, mechanized system that can broadcast seeds by fertilizer spreaders, while drilling is designed to put seedbed fertilizer and sow the seed. Broadcasting is usually quicker and less complicated on soil conditions than drilling, which leads to being appropriate at higher soil moisture contents. Harvesting and threshing are done when wheat grows. As well as, wheat production increases as essential factors like providing chemical fertilizers, pesticides, and improved seeds (Yadav and Khandelwal, 2013).

The input energy is divided to direct and indirect factors that affect energy consumption. The energy consumption study in agricultural wheat operations is critical because it shows which process is more significant for energy saving (Shahan *et al.*, 2008; Taki *et al*., 2012). Furthermore, a substantial relationship exists between output energy and technology, climate and weather, yield and price (Canakci *et al.*,2005). Wheat production consumes energy followed by numerous factors that impact the total energy. These include agricultural machinery, human factors, pesticides and fertilizers, and many others.

Regarding wheat production in Iraq's neighboring countries, several published papers are accessible on determining input energy. However, these published papers use dissimilar protocols depending on the various conditions. As the literature review pointed out, there needs to be more research on modeling energy multilayer neural networks in Iraqi wheat cultivation. The main objective of the research was to explore input and output energy in wheat yield in a multi-area of Kirkuk governorate. The second aim was to develop a neural network model to predict wheat yield production.

MATERIALS AND METHODS

Information of the Site

Kirkuk is one of the governorates of Iraq, with an area of 9,679 square kilometers. It is the region with the largest population in Iraq, with a population of 1,259,561 people, and the population is distributed between rural and urban areas, 15.1% - 84.9%, respectively. The lowest area cultivated for wheat was recorded in 2016 (89406) ha followed by 2017 (89769) ha, while the cultivated area increased in 2021 by 179385ha, with a rate of approximately 8% of the elegant area in Iraq, with an average yield of 1939.6 kg per ha.

Agricultural Inputs and Energy Coefficients

The data used in the study were collected with a face-to-face inquiry made with the farmers at two locations (35.4666° N, 44.3799° E) that include the types of equipment used for the production of wheat such as tillage and smoothing equipment, seeds, fertilizer, harvest equipment, number of hours worked, fuel, oil, workers and the style of agricultural processes for the production of wheat crop. The survey was conducted in 2021-2022. The tractor is the major machine used for all farming operations. The study was divided into three systems for tillage operation, soil preparation, planting, sowing process, smoothing, and covering the seeds. As well as broadcaster equipment is used for fertilizer operation, while sprayer equipment and knapsack sprayers are used for pesticide and weed control. So as in the whole Kirkuk region, irrigation depends on rainfall. Finally, harvested by a combine harvester after completing the operations of the wheat production. Figures (1) and (2) present these operations and input energy.

Energy estimation and equivalent in wheat production

This study estimates the energy required for the on-farm production systems prior to the harvest stages. The energy consumption for wheat production processes does not consider the energy sources derived from the environment. The input and energy consumed were calculated per total hectares basis in each location after that, converted to energy forms to evaluate the input analysis. The input and output energy equivalent are calculated by adding up the energy equivalences of all inputs in Mega Joule (MJ), shown in Table (1).

Table (1): Equivalent of inputs energy and grain yield in wheat production

A.Inputs	Unit	Energy equivalent ($MJha^{-1}$)	Reference
1-Human labor	H	1.96	Kardoni *et al.* (2013)
2-Diesel fuel	L	47.3	Kitani and Jungbluth(1999)
3- Fertilizers	Kg		
Nitrogen (N)		75.46	Mohammadi *et al.* (2008)
Phosphate (P2O2)		13.07	Mohammadi *et al.* (2008)
Potassium (K2O)		11.15	Mohammadi *et al.* (2008)
4- Pest control	kg		Hussain *et al.* (2010)
Herbicides		295	Esengun *et al*. (2007)
Fungicides		115	
Seed	Kg	25	Khan *et al.* (2010)
B. Output Grain yield	Kg	14.7	Kitani and Jungbluth(1999)

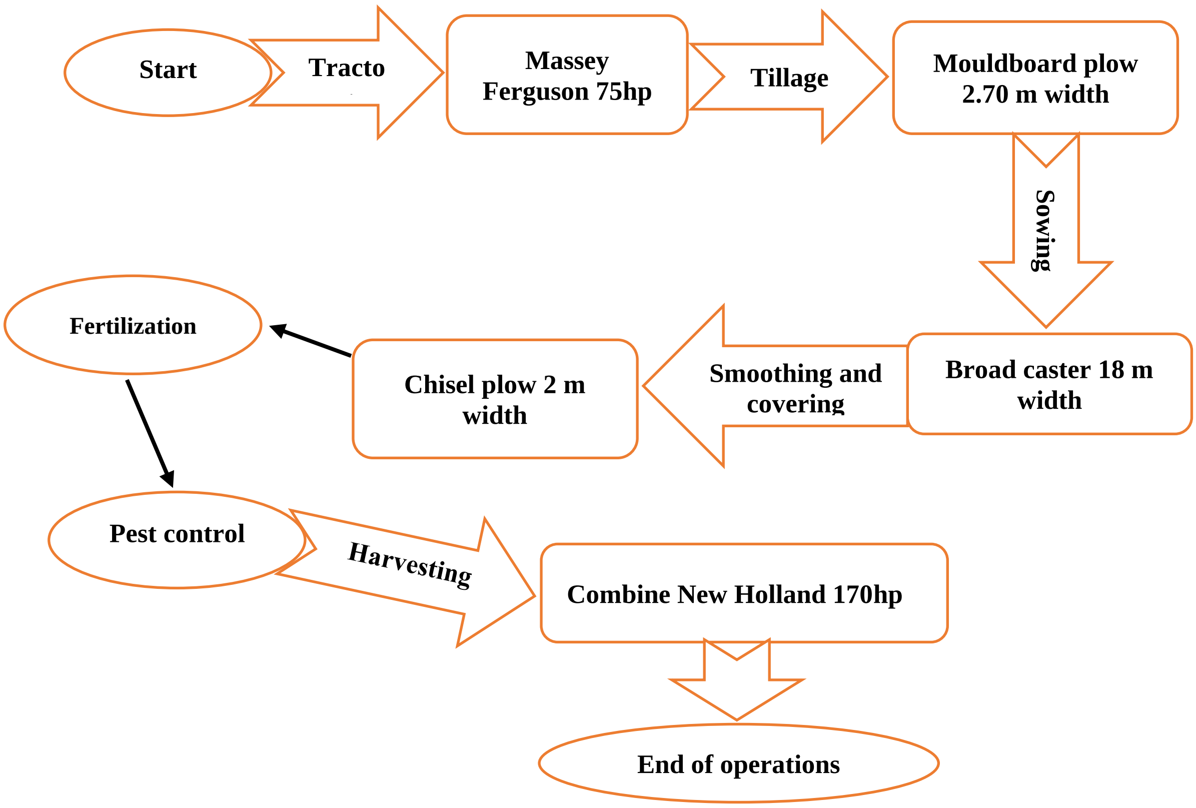

Figure (1): Field operation for the first field

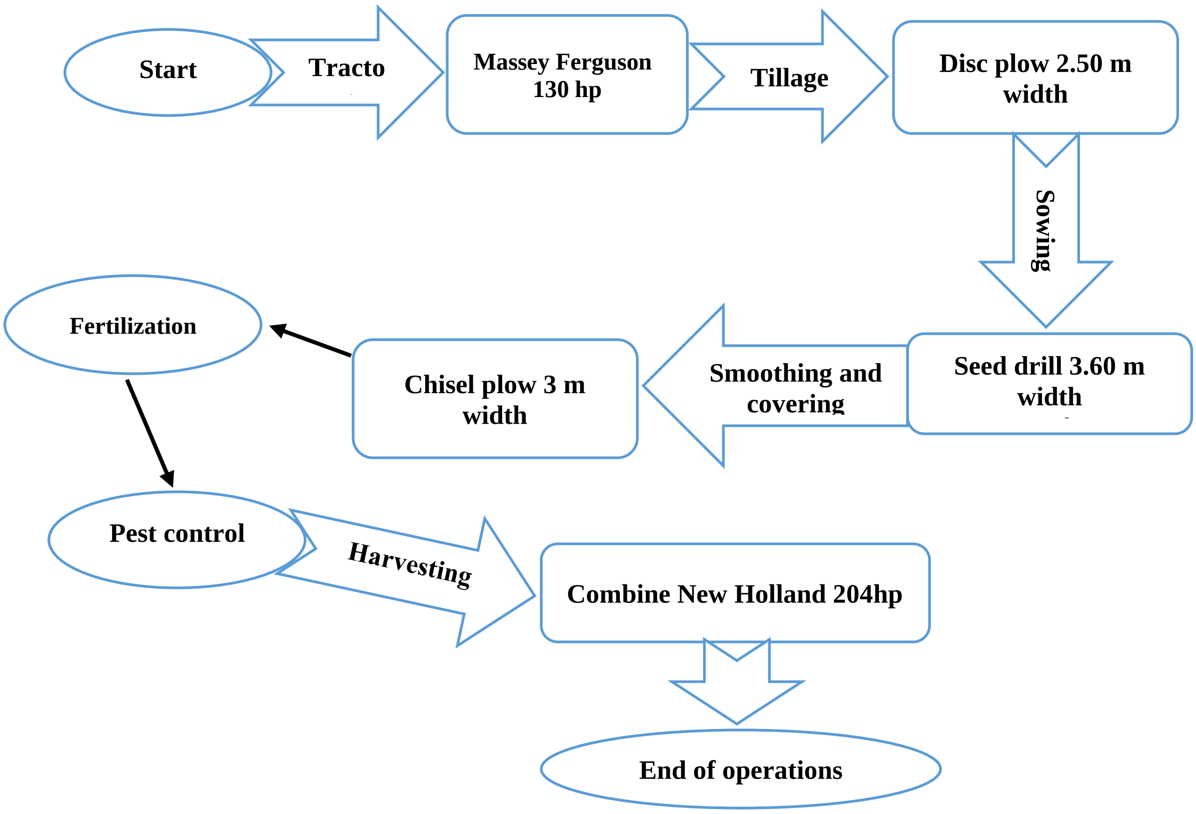

Figure (2): Field operation for the second field

Multilayer Perceptron Model Development

The developing models and steps for examining the models that included calculation error and gradient calculation error, calculation of total gradient error, correction (adjustment) weighting stop training, and final model (Build multilayer perception) are as described in Khessro *et al.* (2022). This study employed the following performance measuring functions: Coefficient correlation (R), the sum of squares error (SSE), and the relative error.

RESULTS AND DISCUSSION

Energy and sensitivity analysis

Output and input active types in wheat yield production in the first field systems are shown in Figure (3). The farming system had a susceptible effect on energy parameters. The energy amount of various inputs during the study showed an increasing trend in wheat production. Wheat production consumed energy by the first field systems was 13315.21 $MJha^{-1}$, in which the highest shares were recorded for seed and diesel fuel. The amount of seed and consumed diesel fuel per this equipment and operation were 4020 and 3895.158 $MJha^{-1}$, respectively. Other inputs, such as Herbicides, P-fertilizers, Pesticides, and Human labor, were identical Figure (3). In a study, Ziaei *et al.* (2015) reported that the total energy consumed by machinery and diesel fuel (9704.27 $MJha^{-1}$) allocated 37.82% of the total energy. After it, the total consumer chemicals were in the next place with 32.29%. The share of irrigation water, seed, and manpower was 15.27%, 13.48%, and 1.11% of the input energy.

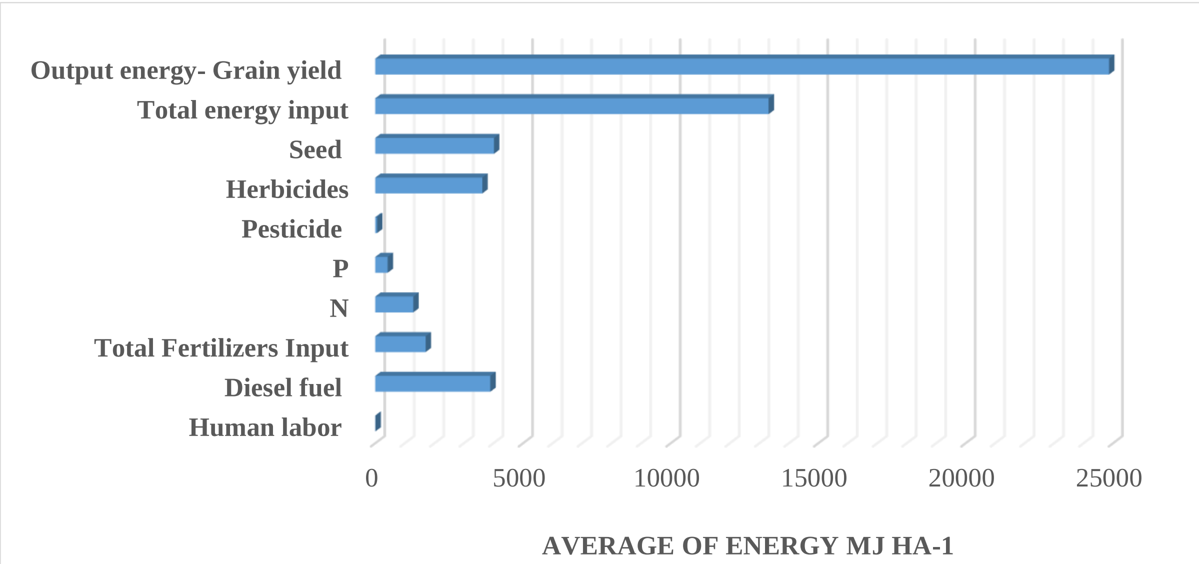

Figure (3): Energy analysis for the first field

As Figure (4) shows the percentage of total energy input among all the various inputs of energy, the seed was the highest energy-consuming input (30.2%), followed by diesel fuel (29.25%) and Herbicides (27.21%). Results showed that human labor and pesticide recorded the lowest percentage of total energy input, 0.6 and 0.5 %, respectively.

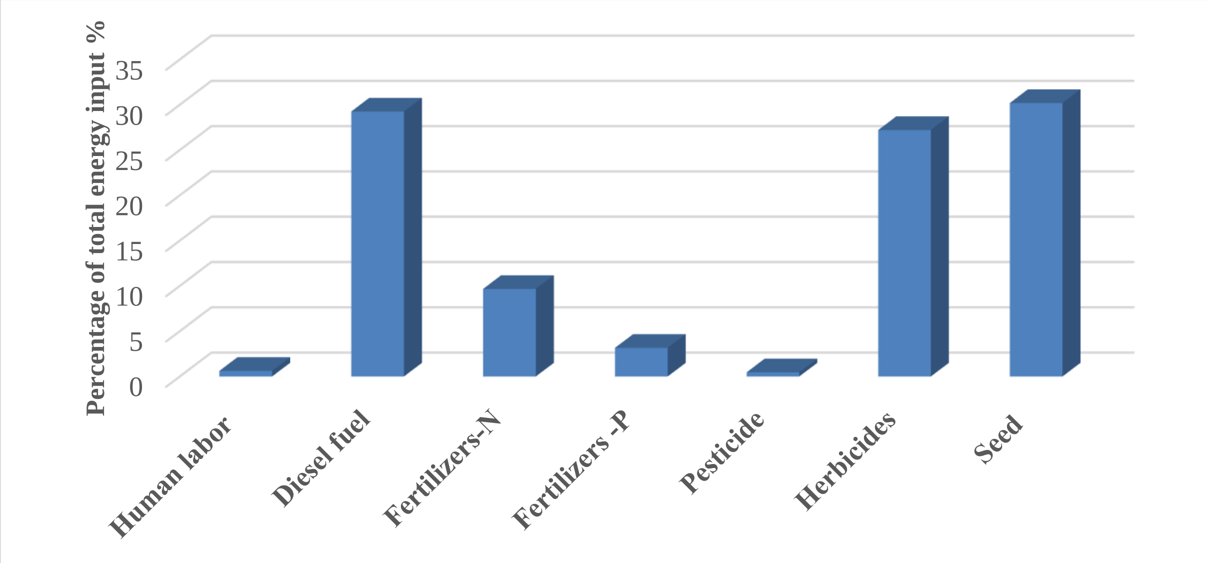

Figure (4): Percentage of total energy input for the first field

Figure (5) presents the sensitivity results, showing that the N fertilizer was recorded as the most independent variable importance with a value of about 0.273, followed by Herbicides (0.227) and P fertilizer (0.216). Seed, human labor, and pesticide were recorded as the lowest independent variable importance with values of 0.023, 0.035, and 0.031 %, respectively.

Input and output energetic types in wheat production in the second field systems and their energy equivalents are shown in Figure (6). Wheat production consumed energy by the second field systems were 29016.27 $MJha^{-1}$, in which the highest shares were recorded for diesel fuel, N fertilizer, and seed energy, respectively. The consumed diesel fuel, N fertilizer, and seed per this equipment and operation were 17982.44, 6608.576, and 3015 $MJha^{-1}$, respectively. Other inputs such as Herbicides, P-fertilizers, Pesticides, and Human labor were recorded as lowest values and identical Figure (6). At the same time, input energy for the total fertilizer is more than that consumed for Herbicides, Pesticides, and Human labor and seeds, with a value of about 7995.669 $MJha^{-1}$.

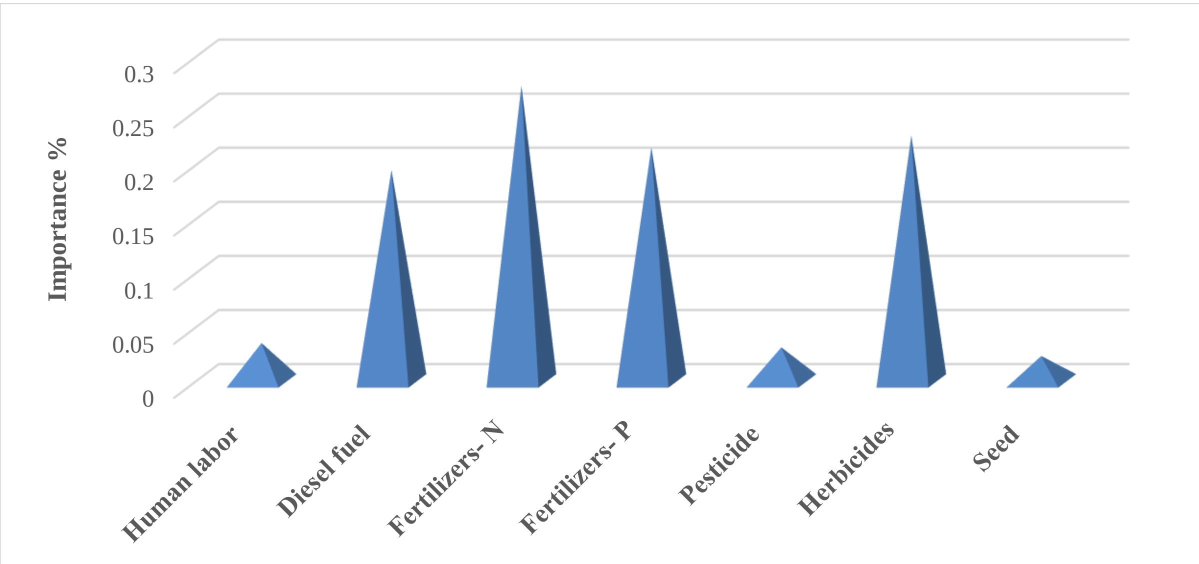

Figure (5): Importance of energy input for the first field

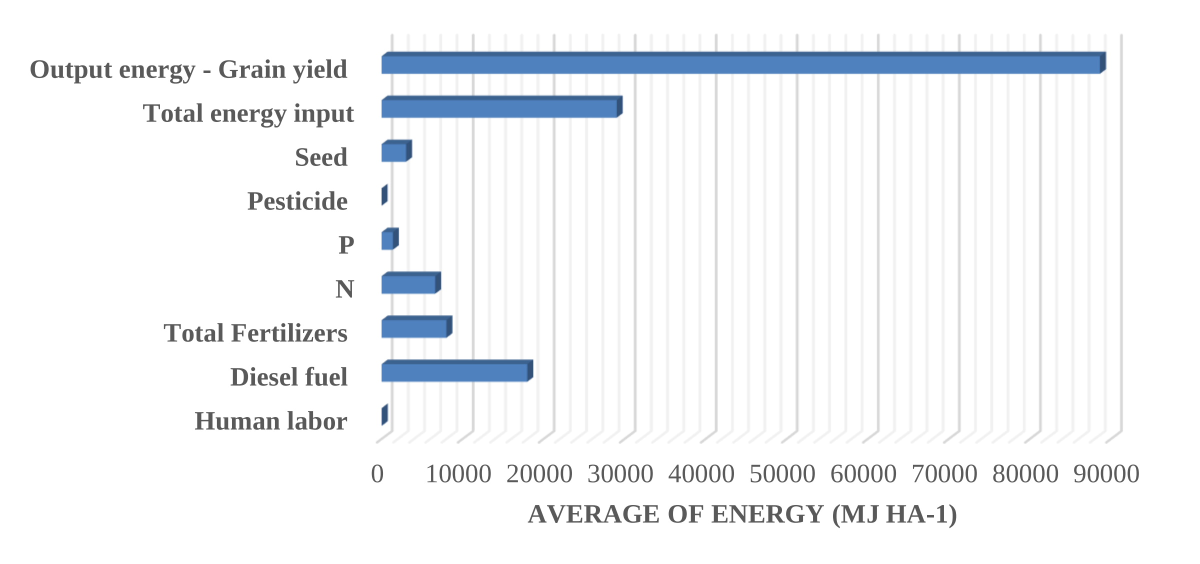

Figure (6): Energy analysis for the second field

Figure (7) shows the percentage of total energy input among all the various inputs of energy; diesel fuel (61.97%) consisted of the highest energy share of total energy input, followed by N- fertilizer (22.77%) and seed (10.39%). Results showed that human labor and pesticide recorded the lowest percentage of total energy input, respectively.

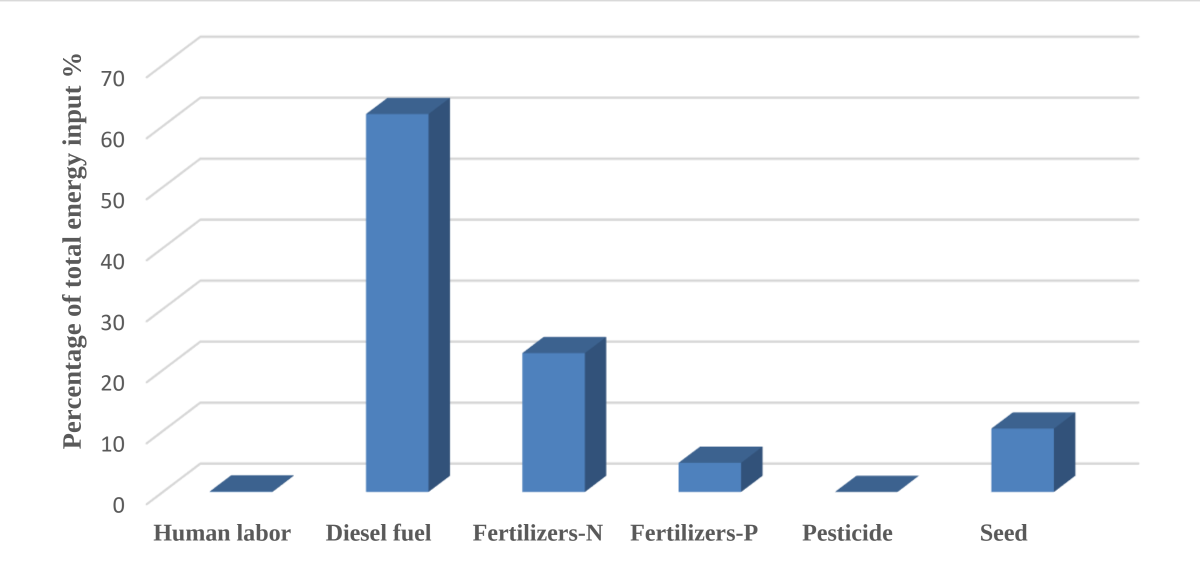

Figure (7): Percentage of total energy input for the second field

Figure (8) presents the sensitivity results, showing that the seed was recorded as the most independent variable importance with a value of about 0.32 7, followed by P-fertilizer (0.268) and human labor with a value of 0.188. Diesel fuel and N-fertilizer were recorded as the lowest independent variable importance with discounts of 0.142 and 0.073 %, respectively.

Accordingly, as in Figures 3 and 6, the total output energy in wheat production's first and second field systems were 24867.5 and 88641MJha^{-1}, respectively. The difference between the search results and a search conducted in India, Yadav and Khandelwal (2013) found that input energy consumed was 4345 MJ ha^{-1}, and output energy was 56595 MJha^{-1} in wheat production.

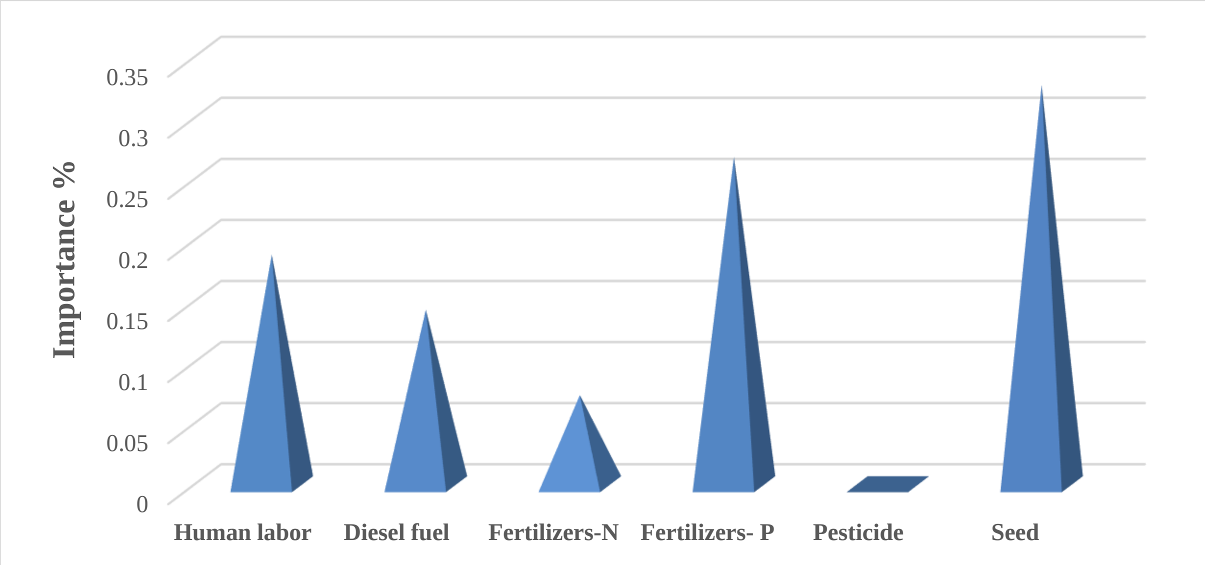

Figure (8): Importance of energy input for the second field

In comparison, the total energy consumption of hazelnut production was calculated to be 2862.62 MJha^{-1} (Tabatabaie *et al.*,2013). As well as a search conducted on Iran wheat production, total energy inputs were 42998.44 and 35604.9 MJha^{-1}, whereas total energy outputs were 62989.5 and 97935.63 MJha^{-1}, respectively (Kardoni *et al*.,2013; Moghimi *et al*.,2013).

Neural networks models

Table (2) displays the outcome of the models from field operations data in two fields in Kirkuk Governorate. The collected data is used in the network where the mechanical structure is selected. The minimization of the sum squared error during the training phase is achieved when the output layer contains scale-dependent variables. The SSE and the relative error are very low for training and testing in all areas, while R^2 is very high; for example, in the first field, the model returned the SSE was 0.008 and 0.00058 in the training and testing phases, respectively. The relative error was 0.002 and 0.0049 in the training and test phases, respectively, while the R^2 was 0.999. The SSE and the other error values in this relative error model are used to calculate the rescaled values of the yield.

Table (2): Model summary in the testing and training phase

	Training		Testing		R^2
	The sum of Squares Error	Relative Error	The sum of Squares Error	Relative Error	
Field 1	0.008	0.002	0.00058	0.0049	0.999
Field 2	0.001	0.000	0.013	0.011	0.997

Figures (9) and (10) depict three layers of neural network models that contain one output, input, and hidden layer for both fields. The program is an automatic architecture selection and identifies the identity activation functions and hyperbolic tangents suitable for these network's layers units. The number of layers, units in the hidden layers, activation function, weight, and learning rate may influence the accuracy of the multilayer perceptron network model. Figure 9 shows that the network model architecture includes seven inputs and one bias unit with four neurons in one hidden and one output layer. If the output layer does not yield the expected results, the errors go backward and distribute to the neurons. Therefore, each layer can only influence the one next to it. Then the model set weights to minimize the mistakes.

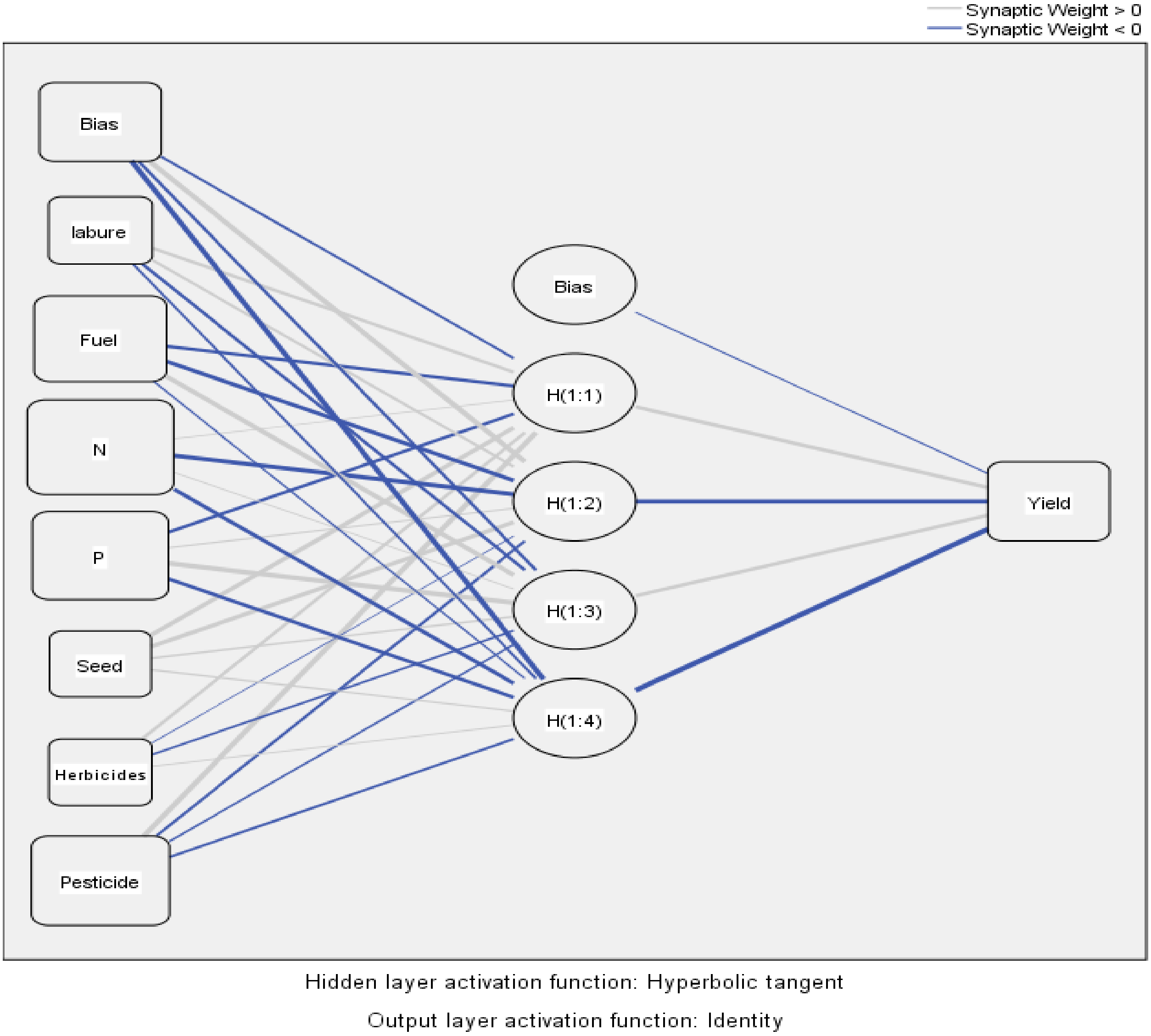

Figure (9): Neural network architecture for the first field

Figure (10) shows a multilayer perception neural network architecture; each layer consists of interconnected neurons. A network model contains five input layers, seven neurons in one hidden layer, and one output layer. The model includes nonlinear activation functions, learning from experience with an explicit mathematical model about the relationship between layers. The learning rate determines how much the weight is changed each time, and the number of units and layers may progress the prediction correctness of the network model. However, initial weight determines whether a multilayer perception neural network can reach a global minimum with increases complications and time of training.

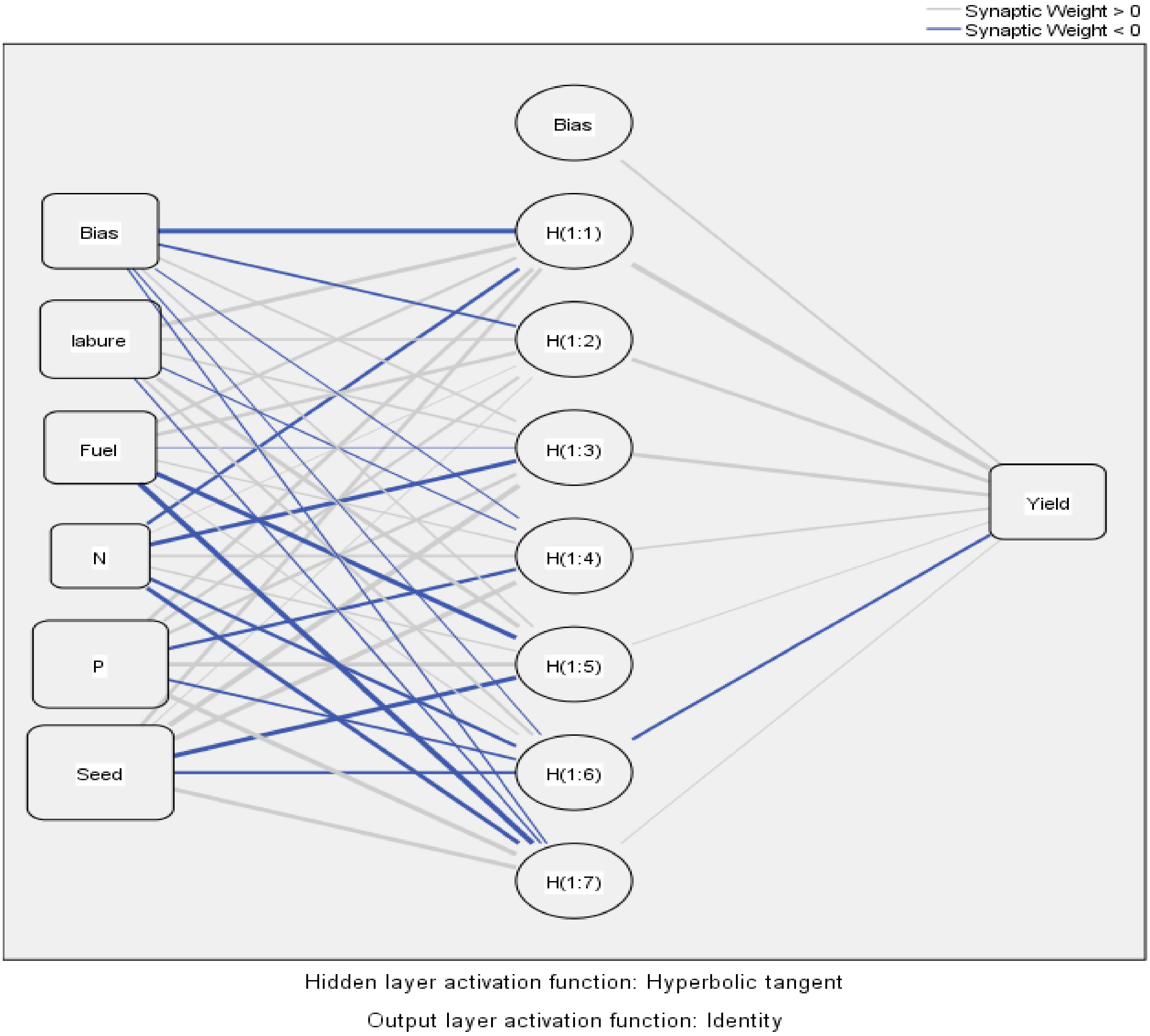

Figure (10): Neural network architecture for the second field

CONCLUSIONS

Energy analysis and modeling are vital indicators of enhanced yield production systems. The research results showed that total energy consumption in wheat production was 13315.21, and 29016.27 MJha^{-1}, while the output energy was 24867.5 and 88641 MJha^{-1} for the first and second field systems, respectively. The fertilizer energy consumption and seed are considered the most critical variable in wheat plantation operations; their importance is the relative values of 43.1%, 32.7 %, and 27.3 %. From 2021 to 2022, the impact of seed and N-fertilizer consumption on the wheat operation was 1286.744 and 3015 MJ ha^{-1} for the first and second field systems, respectively. Finally, the experiment shows that the trained neural network produced a minimum error, indicating that the test model can predict wheat yield in the Kirkuk governorate. The study recommends conducting future studies on using other neural network algorithms to predict production and the amount of energy consumed in wheat production.

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CONFLICT OF INTEREST

The authors state that there are no conflicts of interest with the publication of this work.

تطوير نموذج باستخدام الشبكات العصبية للتنبؤ بإنتاج القمح في محافظة كركوك

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الخلاصة

يعد القمح أحد أهم المحاصيل ذات الأهمية الإستراتيجية في العالم وأحد أهم المحاصيل في العراق. الهدف من هذه الدراسة هو تحليل الطاقة وفحص تطبيق شبكات العصبية الصناعية للتنبؤ بإنتاج محصول القمح في محافظة كركوك. تم جمع بيانات البحث مباشرة من الحقلين تضمنت البيانات أنواع مختلفة من المعدات الزراعية المستخدمة لإنتاج القمح وعدد ساعات العمل والوقود والزيت والعمال وأسلوب الزراعة لعمليات إنتاج محصول القمح. أظهرت نتائج البحث أن إجمالي استهلاك الطاقة في القمح كان 13315.21 و29016.27 ميكاجول لكل هكتار بينما كانت الطاقة الناتجة 24867.5 و88641 ميكاجول لكل هكتار للحقلين الأول والثاني على التوالي. يعتبر استهلاك البذور ووقود الديزل من المتغيرات الأساسية في عمليات زراعة القمح، حيث كانت أعلى قيم للطاقة المدخلة هي القيم النسبية 30.2 و61.97٪. وكان تاثير هذه المتغيرات على زراعة القمح خلال عام 2021 إلى 2022 م بمقدار 4020 و17982.44 ميكاجول لكل هكتار للحقلين الأول والثاني على التوالي. أخيرًا، خلصت النتائج إلى أن نموذج الشبكة العصبية مفيد للتنبؤ بإنتاج القمح وكانت بنية الشبكة العصبية 7-4-1 و5-7-1 لكلا الحقلين الأولى والثانية على التوالي. وأظهر البحث أن النماذج أحدثت حد أدنى من الخطأ مما يشير إلى أن نموذج الاختبار يمكن أن يتنبأ بإنتاج محصول القمح في محافظة كركوك بصورة جيدة.

الكلمات المفتاحية: المعمارية النموذج، متعدد الطبقات، القمح، الحراثة.

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