15A.2 PREDICTION OF WHEAT YIELD USING ARTIFICIAL NEURAL NETWORKS

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1. INTRODUCTION

Prediction of crop yield mainly strategic plants such as wheat, corn, rice has always been an interesting research area to agrometeorologists, as it is important in national and international economic programming. Dry farming crop production, apart from relationship to the genetic of cultivator, adaphic terms, effect of pests and pathology and weeds, the management and control quality during the growing season and etc. is severely depend to climatic events. Therefore it is not beyond the possibility to acquire relations or systems which can predict the more accuracy using meteorological data. Nowadays, there are a lot of yield prediction models, that more of them have been generally classified in two group : a) Statistical Models, b)Crop Simulation Models (e.g. CERES). Recently, application of Artificial Intelligence (AI), such as Artificial Neural Networks (ANNs), Fuzzy Systems and Genetic Algorithm has shown more efficiency in dissolving the problem. Application of them can make models easier and more accuracy from complex natural systems with many inputs.

In this research it has been tried to develop a wheat yield prediction model using ANNs. If we design a network which correctly learn relations of effective climatic factors on crop yield, it can be used to estimate crop production in long or short term and also with enough and useful data can get a ANNs model for each area. Furthermore using ANNs can find the most effective factors on crop yield. Therefore some factors that their measurements are difficult and cost effective can be ignored. In this the effect of climatic factors on wheat yield has only been applied.

2. METHODOLOGY

ANNs is a free-model intelligent dynamic system, which can compute on empirical data and find out the hidden rule through them, and then make the network structure. And also it learns relations or rules through them or the other examples. These systems endeavor to make a model which is similar to neuro-synaptic structure of brain (Menhaj, 1998). A neuron is the smallest computation unit of data and also is the basis of ANNs work. Figure (1) shows a neuron which has one input. P, a, are the scalar input and output of the network. The degree of effect (p) on (a) is appointed by scalar (w). The other input is constant (1). It is multiplied by term of bias (b) and then is added to (wp), that in result will be the net input for transfer function (f); So the output of neuron is explained by the equation :

a = f (wp + b)

The term of bias (b) is respected such as weight (w). Since the quantity of constant (1) is reflect by input of neuron. The parameters (w, b, f) are regulated by designer. The transfer function can be used as linear or non-linear. Transfer function must also be differentiable. The parameters (w, b) are regulated on the basis of selection of transfer function (f) and the type of learning rule (Algorithm). Learning rule is generally explained by differentiable functions. The goal of learning rule is to train ANNs to perform specified work. This research was accomplished using Sararood station data in Kermanshah Province in Iran. The climatic observation data used in this study were mean of daily minimum temperature, extreme of daily minimum temperature, mean of daily maximum temperature, extreme of daily maximum temperature, sum of daily rainfall, number of rainfall days, sum of sun hours, mean of daily wind speed, extreme of daily wind speed, mean of daily relative humidity and sum of water requirement that were collected during 1990-1999 for wheat (winter wheat) at different phenological stages (11stages)consisting: sowing, germination, emergence, third leaves, tillering, stem formation, heading, flowering, milk maturity, wax maturity

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full maturity. These data arranged in two matrix forms:

1- A matrix which its rows are repetition of the statistical years (i) at each phenological stages (j) and its columns are meteorological factors (k).

2- A matrix which its rows are each of the statistical years (i) and its columns are meteorological factors (k) at each phenological stage (j).

In fact, statistical years (i), phenological stage (j), and meteorological factors (k) are the basic elements of 3-D matrix (M ijk) and the best answer was only derived from the second matrix.

Finally, different networks were made for each stage and the optimum values of network parameters were obtained through try and error procedure, It should be noticed that two years of the eight years data were randomly put away and were not used for network training in order to test the accuracy of the developed model .

3. RESULTS AND DISCUSSION

Figure 2. shows the difference between actual and estimate yield is regularly increasing. The main reason of this matter can be due to data disband. Because, with omission of each stage, the noise is increasing this problem can be solved, by decreasing learning rate, diminishes length of scales during movement on function curve.

Figure 3. shows the most important effective meteorological factors on crop yield, is quantity and quality of rainfall, but the most sensitivity stages relative to rainfall are flowering and heading. After them are primary stages of growth. So rainfall quantity after sowing and also the first two months of spring are very important to the crop production.

4. CONCLUSIONS

Results of this study is summarized as follows :

1. Presentation of new method for wheat yield prediction.
2. Prediction of wheat yield with maximum error of (45-60 kg/ha) at least two months before crop ripening (end of stem formation stage).
3. Determination of sensitivity of each phenological stage with respect to meteorological factors that it can help to understand effect of increase and decrease factors at each stage, and with in possible limit controls prejudicial effects of each factor at different stages.
4. Determination of priority order and importance of each meteorological factors, effective to plant growth and crop yield.

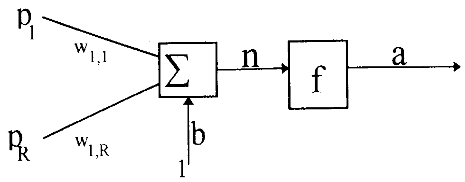


Figure (1) : Model of single - input neuron

Figure (2) : Comparison of Estimate of Yield & Actual Yield

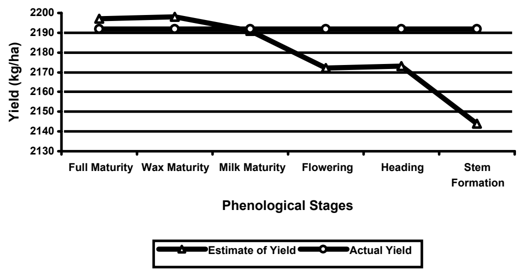
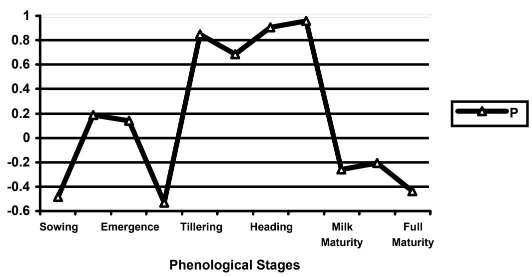


Figure (3) : Sensitivity Analysis for Precipitation



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