Prediction Cucumber Downy Mildew Happen Date Using Different Temperature Parameters

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Predicción de la aparición de Mildiu en pepino utilizando diferentes parámetros climáticos

Resumen

La temperatura es uno de los factores que ayudan al desarrollo de enfermedades en el cultivo. Cuatro tipos diferentes de temperatura se combinan con la humedad del aire real para predecir la aparición del mildiu en cultivo de pepino: la temperatura real del aire, la temperatura real de la hoja y la predicción de la temperatura del aire y de la temperatura de la hoja. Un modelo de temperatura de la hoja basado en balances de energía y un modelo de la temperatura del aire fueron desarrollados utilizando redes neuronales BP optimizadas con Algoritmos Genéticos (red neuronal GA-BP). Los datos estimados de la aparición de enfermedades de pepino se compararon utilizando la temperatura de hoja y del aire, lo cuales se utilizan como parámetros del modelo de predicción para el desarrollo de la enfermedad en pepino. La estimación del desarrollo de la enfermedad a partir de datos reales de temperatura del aire obtuvo el mejor resultado.
Palabras clave: Modelo, Balance de energía, red neuronal GA-BP, Enfermedades fúngicas

Abstract

Temperature was one of directly factors leading to plant disease happen. Four difference temperature types combine with actual air humidity forecast the onset data of cucumber downy mildew disease, which were actual air temperature, actual leaf temperature, predicted air temperature and predicted leaf temperature. Leaf temperature model was established based on energy balance, and air temperature model was build using BP neural network was optimized by Genetic Algorithm(GA-BP neural network). Predicted data of cucumber disease occurrence were compared, using leaf and air temperature which were parameters of cucumber disease warning model. Estimated occurrence disease data was closed actual happen data using predicted air temperature, the result was better than other temperature types.
Keyword: Model, Energy balance, GA-BP neural network, Cucumber disease warning.

Introduction

Disease is a key factor of influence product with high quantity and quality. A greenhouse is an enclosure environment that allows owners to control climate to reduce disease occurrence (Rodríguez, 2014). The direct reason of disease occurrence is leaf micro-climate do not match growth demand of crop (Berdugo, 2014). But thermography is expensive to farmer, which is used to measure leaf temperature. Some simulated greenhouse environment models were established to regulated and control of greenhouse environment parameters. Usually, leaf temperature was simulated by empirical model based on energy balance. But the method needs many variables, such as air temperature, air humidity, soil surface temperature, wall temperature and so on. Recently, air temperature replace leaf temperature forecast disease occurrence, and method models were used for simulated air temperature. In this paper, the model of simulated leaf temperature was build based on mass balance and the model of simulated air temperature was established based on GA-BP neural network. Cucumber disease occurrence data was forecast using simulated air temperature and leaf temperature, meanwhile compared with actual disease occurrence data. Finally, the conclusion section will summarize the results that whether air temperature replaced leaf temperature forecast disease occurrence.

Materials and Methods

This study was conducted from March to July 2015 and a solar greenhouse at Beijing Xiao Tangshan base, in Changping district, Beijing, PR China (40°18'N, 116° 47'E) . The greenhouse (with a north-south orientation) is 350 m^2 (50m length × 7m width) . A Davis Vantage Pro & Plus meteorological station was located outside the greenhouse to measure meteorological data. The experiment material was 'Jingyan Mini 2'(Beijing Vegetable Research Center, Beijing).

*Leaf Temperature Model:*Considering the radiation heat transfer between the greenhouse crops, wall, soil and cover, plus the heat exchange caused by indoor net radiation and crop transpiration, the estimation model of canopy leaf temperature was established using the outside meteorological data and the inside greenhouse parameters based on the principle of mass balance. The model represented by a system of equation, as follow.

$$Q + E_{PI}S_P + E_{SP}S_S + E_{WP}S_W + E_{CP}S_C + \lambda E_P S_P = R_n \qquad (1)$$

*Air Temperature Model:*Air temperature inside greenhouse model was established based on GA-BP neural network. Solar radiation, temperature and wind spend of outside greenhouse were regarded as input layer neurons, and temperature inside greenhouse was regarded as output layer neurons. The structure of BP neural network was show figure 1.

*Cucumber Disease Early Warning System:*Cucumber downy mildew is regarded as warning disease in this paper. The warning method was reference by a paper(Zhao C.J., Li M., Yang et al. 2011, 76 (2): 306-315). The occurrence of cucumber downy mildew is divided into Infection condition and Incubation period. The infection condition depends on a favourable combination of leaf wetness duration (LWD) and mean temperature in LWD. The minimal threshold is 2 h×20℃=40h℃. Incubation period satisfies a relationship of hourly mean temperature (t) and temperature contribution rate (y) was fitted and expressed as:

$$y = \frac{0.0165}{1 + 10389.2 \times \exp(-0.574 \times t)} \qquad (2)$$

1)r^2, Mean Absolute Error(MAE) and Mean Bias Error(MBE) were used to evaluate accuracy between the real and the estimated leaf and air temperature.

2)Cucumber disease occurrence data was predicted using early warning model(Zhao, 2011), comparing prediction accuracy between forecast leaf and air temperature were parameters of early warning model.

Results

The predicted accuracy of leaf and air temperature models were r^2=0.88 and r^2=0.87, MAE and MBE of leaf actual temperature and estimated temperature is -0.15℃ and 2.20℃, MAE and MBE of air actual temperature and estimated temperature is MAE=1.83℃ and MBE=0.22℃. In table 2, AAH represent actual air humidity, AAT represent actual air temperature and PAT represent prediction air temperature. Combined with figure 2 and 3, we knew predicted disease occurrence data was closed using actual air temperature and actual leaf temperature, and one day earlier than using predicted leaf temperature.The result was the best using predicted air temperature, two days earlier than actual leaf temperature.

Discussion

Disease predicted is a important part of greenhouse manage, and which is a method of control and prevent disease occurrence. Temperature is a influence factor of plant growing period, meanwhile, disease happen is always relative with high temperature and high humidity environment. Collected correct temperature predicted method and predicted disease happen data is important. Due to greenhouse climate factors is non-linear with disease, Artificial neural network is suitable for nonlinear issues. BP neural network is one of artificial neural network, is uesd to predicted different plant disease, and input parameters including temperature, humidity and sunshine duration(Wang, 2012). In this paper, same environment factors were choice, but air temperatures inside greenhouse were forecast by GA-BP neural network that had the advantage of few input parameters. Combined with cucumber downy mildew warning model, disease happen data was predicted through different temperature types. Air temperature could replaced leaf temperature forecast the disease occurrence data, and prediction accuracy of prediction air temperature was better than other temperature types.

Acknowledgement

Funding provided by National Natural Science Foundation of China (31401683), Climate Change Special Founding (CCSF201521), and FP7 International Research

Staff Exchange Scheme Project (PIRSES-GA-2013-612659).

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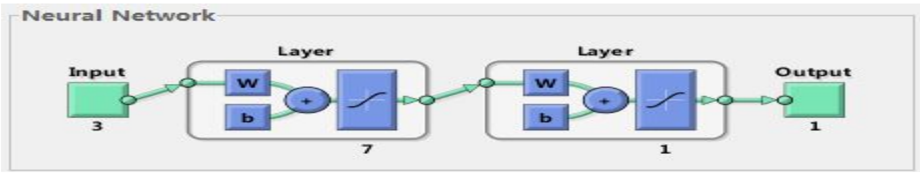

Figure 1 Structure of the BP neural network

Table 1 Verify indicators of models

Models	r^2	MAE(℃)	MBE(℃)
Leaf Temperature	0.88	0.15	2.20
Air Temperature	0.87	1.83	0.22

Table 2 Infection and disease occurrence data of different groups

Groups	AAT/AAH	ALT/AAH	PLT/AAH	PAT/AAH
Infection data	15/04/28 19:00	15/04/28 19:00	15/04/29 20:00	15/04/27 1:00
Occurrence data	15/05/01 19:00	15/05/01 21:00	15/05/02 20:00	15/04/29 20:00

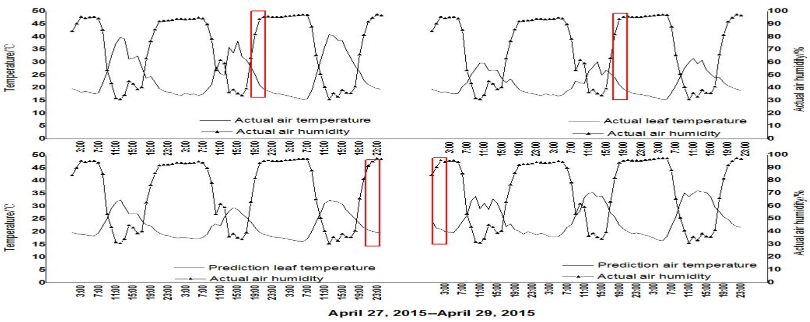

Figure 2. Prediction infection data under different groups on April 27-29, 2015

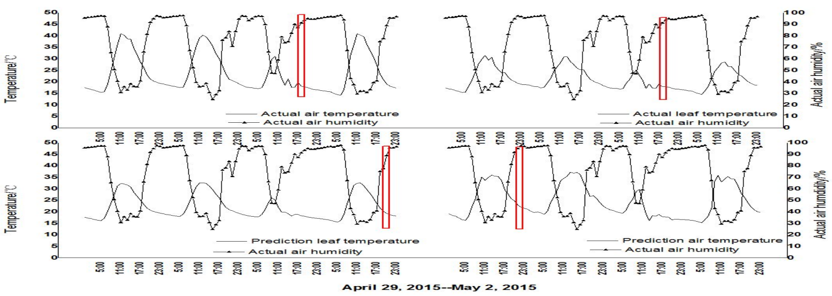

Figure 3. Prediction disease occurrence data under different groups on April 29-May 2, 2015