Study on the Mechanism of the Influence of Soil Water Content on Cold Resistance of Thermophilic Crops Based on Principal Component Analysis

Xuehong Chen*
Jiuquan Vocational Technical College, Jiuquan 735000, China
*Corresponding author: jqzycxh@163.com

Abstract. Soil water content is one of the external factors of plant life, and the cold tolerance of plants is often transferred by this factor. The purpose of this paper is to study the mechanism of soil moisture content affecting the cold resistance of thermophilic crops based on principal component analysis. This paper uses MODIS1B data to obtain the day and night surface temperature difference and albedo parameters; combined with the soil moisture data measured by meteorological stations during the same period, the thermal inertia method is used to establish an empirical model of thermal inertia-soil water content. In addition, the mechanism of the influence of soil water content on the cold resistance of temperature-loving crop rubber and citrus during the low temperature period is discussed, which provides a basis for winter irrigation and antifreeze. The experimental results of this paper show that the vegetation index has a greater impact on the model, so the thermal inertia method has a higher accuracy in monitoring bare soil moisture content. Among them, when the temperature-loving crop rubber soil moisture content is 30%, the cold resistance mechanism reaches the maximum Good, and when the citrus soil water content reaches 22%, its cold resistance mechanism is the best.

Keywords: Principal Component Analysis, Soil Moisture Content, Cold Resistance Mechanism of Temperature-Loving Crops

1. Introduction
Soil moisture is an important environmental factor and key variable in the process of soil surface transformation. It can reflect the state of the earth under the combined effects of climate, meteorology, and hydrology. It is of great significance to climate, meteorology and hydrology research [1-2]. On the other hand, the temporal and spatial distribution and changes of soil water content will have a significant impact on heat balance, soil temperature and agricultural humidity [3].

The allowable balance rate of different nutrients in the soil composition means that under local conditions, even if the nutrient balance is insufficient or excessive, it will neither affect crop yields nor cause waste [4-5]. People must consider two factors when fertilizing: One is to supplement the lack of nutrients in the soil and maintain the continuous growth of yield. The other is to minimize the waste of manure and not pollute the environment. This is the beginning of fertilization. The balance of soil organic matter and nutrients mainly depends on the relative size of material input and material...
production [6].

The purpose of Zhang Y is to drive a new robust acoustic classification scheme KPCA-ELM [7] based on kernel principal component analysis (KPCA) and extreme learning machine (ELM). The microphone samples sound signals from immature, mature and over-ripe watermelon samples through the microphone, and these samples are randomly divided into two groups of samples for training and testing [8]. First obtain a set of basic signals through KPCA of training samples. Therefore, any given signal can be expressed as a linear combination of basic signals, and the coefficients of the linear combination are extracted as the characteristics of the signal. But the practicality of this scheme is not high [9].

The innovation of this article is the use of principal component regression method for near-infrared spectroscopy analysis, and the focus on artificial neural networks. The correction effect of the network in the near-infrared spectroscopy analysis, combined with the genetic algorithm, established a network model of nitrogen and phosphorus in the soil, and optimized the network parameters as much as possible to improve the error accuracy [10].

2. Principal Component Analysis Method

2.1 Principal Component Analysis

Principal component analysis, also known as basic component analysis, is to reorganize several relevant indicators into a set of new, irrelevant content indicators to replace the original indicators. The basic element analysis transforms many indicators into some comprehensive indicators, namely the main components. Each main component may reflect most of the information of the original variable. When studying the problem of multiple index variables, because each index more or less reflects some information of the survey question, and there is a certain correlation between these indexes, therefore, the information reflected by the statistical data obtained is in a certain degree. The extent is overlapping. Therefore, some key elements come from the original variables, and the information of the original variables is retained as long as possible, and there is no correlation between them. The basic steps of the basic method of computational component analysis are as follows:

1. Select indicators and data based on research questions.
2. Calculate the eigenvalues and eigenvectors of the correlation coefficient matrix and the correlation matrix R.
3. Determine the number m of principal components and the cumulative contribution rate of the principal components, so that the cumulative contribution rate is \(>80\%\); take m as the number \(>1\) among all the eigenvalues of the correlation matrix, and these principal components can be used to replace all the original variables Without losing a lot of information.

2.2 Index Measurement and Method

This paper selects the soil from the main corn-producing area in the north-central part of our province. Due to the large range of the soil, the researchers randomly selected the central part of each farmland at a certain distance. Before fertilization, the soil of 0-30 cm cultivated layer was collected and mixed at multiple points. Sampling, a total of 55 samples were collected. Use the DG PS device (Global Satellite Differential Positioning System) to accurately locate and determine the soil sampling site. Each sampling site will sample about 0.8 kg, bagged and sealed, and then brought back to the laboratory. After natural air drying, it is ground and passed through a 1 mm sieve. For the determination of soil nutrients. Another part of the sample is taken through a 0.25 mm sieve for the determination of organic matter and total nutrient elements. Soil organic matter is measured by potassium dichromate titration; alkaline hydrolysis nitrogen is measured by alkaline hydrolysis diffusion method; quick-acting phosphorus is measured by molybdenum antimony anti-colorimetric method; quick-acting potassium is measured by ammonium acetate extraction-flame photometric method; pH is measured by Lemag-One Type 25 pH meter method (water-soil mass ratio 1:5) determination; trace elements in soil such as available iron and manganese are determined by 1.0 mol
ammonium acetate extraction-atomic absorption spectrophotometry; available copper and zinc are leached with 0.1 mol hydrochloric acid. Mention one is determined by atomic absorption spectrophotometry; molybdenum is determined by photometric method (colorimetric method).

2.3 Qualitative Analysis Methods
Qualitative analysis of NIR spectroscopy should be based on different pattern recognition methods. The near-infrared spectrum has a wide range and the characteristics are not obvious. Therefore, qualitative analysis of near-infrared spectroscopy is usually used to determine the position of the analyzed sample under a known sample concentration, and it is rarely used in the same way as other spectra (such as ultraviolet and infrared spectroscopy). Identify composite groups and structures. Commonly used identification methods should include principal component (PCA) analysis, self-organizing mapping (SOM) and cluster analysis, among which principal component analysis is the main method.

The purpose of principal component analysis is to reduce the dimensionality of the data to eliminate the overlap when multiple information coexists. The initial variables are displayed in the direction of maximum change, so that a small number of new variables (called principal components) become linear combinations of the original variables, and the new variables can maximize the data structure characteristics of the original variables. Decompose the original X table into the product of a series of components (t) and the carrying vector (P):

$$X = T_1P_1 + T_2P_2 + \ldots + T_rP_r$$ (1)

Where \( p_1, p_2, \ldots, p_r \) is orthogonal to each other. The first few score vectors contain most of the information of the original data matrix, which can be regarded as the mapping of the original high-dimensional data to the low-dimensional space.

The principle of Principal Component Regression (PCR) is to first reduce the dimensionality by PCA, and then regress the score of the sample to the reference value to establish a quantitative model. PCR will play an important role in interpreting spectral data. From the principal component weight map, it is possible to determine which component the principal component is related to, but it is still the most difficult problem to accurately and comprehensively explain what each principal component represents.

3. Experiment on Cold Resistance Mechanism of Thermophilic Crops

3.1 Experimental Materials
This experiment uses perennial thermophilic crop rubber (tropical crop) and citrus (subtropical crop) as test materials.

(1) Rubber
The seedlings came from the Guangxi Rubber Research Institute. The raw salt-planted seedlings were shipped to Beijing in September with potted soil (red clay). The height of the seedlings was 1.3-1.6 meters at the time of the test. The seedlings were at 12-16 degrees Celsius for half a month before the low temperature treatment. During the low temperature exercise period, the soil moisture content was controlled at the same time during the exercise period. The soil moisture during the test was 21%-38% (percentage of 1,000 soil weight).

(2) Sugarcane
The seedlings tested were provided by the Horticultural Research Institute of Hunan Academy of Agricultural Sciences. About two years before the experiment (The Institute of Horticulture moved the grafted seedlings to Beijing, and they were cultivated in the local (Changsha) soil (clay) in pots. The plastic shed was slightly warmed in winter to protect them from overwintering. The seedlings grew normally for two years. Before the experiment Start to control the soil moisture content in seven days (basically the same in the early period of the test), and the soil temperature during the test is between 14% and 39%.
3.2 Experimental Environment
The low temperature treatment is carried out in an artificial climate box. According to the general natural cooling law in the south, the temperature is reduced to minus 2 ℃ for 3 hours under normal temperature conditions for 36 hours. After the low temperature treatment is over, the conditions before the freezing of the room will be restored after hours, and then the performance of the seedlings after freezing will be observed every day, and the frost damage level shall be subject to when the frostbite does not continue to develop, that is, the seedlings are basically in a stable state.

After the seedlings were moved into the artificial climate box, the temperature dropped from 17°C to -11°C after 48 hours. After two hours of constant temperature, the temperature gradually increased, and then the conditions before freezing were restored after another hour. After the low temperature treatment is over, observe the performance after freezing every day. When the frost bite does not continue to develop, evaluate the seedling frost damage rating table.

4. Influence of Soil Moisture on the Cold Resistance Mechanism of Thermophilic Crops

4.1 Influence of Soil Water Content on the Cold Resistance Mechanism of Thermophilic Crops
After artificial low-temperature treatment, the surface of rubber and citrus seedlings have a common feature, that is, the frost damage is the lightest when the water content of the soil is appropriate, and the frost damage of the plants at or above the appropriate water content decreases with the water content of the soil. Or increase and increase. From the observation results in Table I, it can be seen that the freezing damage level of seedlings has obvious regularity with the soil slope moisture content during the low temperature period.

| Table 1. Artificial low temperature treatment results |
|-----------------------------------------------------|
| Numbering   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Rubber soil water content (%) | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 |
| Frostbite grade | 10 | 9 | 8 | 6 | 5 | 0 | 1 | 2 | 4 | 5 |
| Citrus soil water content (%) | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 |
| Frostbite grade | 10 | 8 | 7 | 6 | 4 | 0 | 2 | 5 | 6 | 7 |

Among them, the freezing damage level of seedlings has a low peak value with the change of soil moisture content in the low temperature period. That is, when the water content of Tucheng is suitable, the freezing damage level of seedlings reaches the minimum.

It can be seen from Figure 1 that when the soil slope humidity is within the range of one, the frost damage level of rubber seedlings is basically different, and the frost damage is very light and becomes no frost damage. Therefore, it can be considered that the soil humidity is the most suitable for the time when the test soil is inlaid with clay. At this time, it is most beneficial for the rubber to resist low temperature. With the decrease or increase of soil moisture, the freezing damage of plants will increase.
rapidly, especially when the soil slope is dry. Similarly, it can be seen that under the test soil conditions, the soil moisture is the most suitable soil slope moisture content for citrus in the low temperature period. If the soil slope has too much or too little water content, it is not conducive to the resistance of citrus to low temperature. However, it must be pointed out that due to different soil properties, the water holding capacity varies greatly, so when the soil conditions change, the optimum soil slope water content will also vary according to the changes in the soil slope properties.

4.2 Influence of Soil Water Content on Plant Cell Membrane Permeability

When plant tissue encounters a low temperature below the critical temperature, the cell membrane is damaged or destroyed, and a large amount of content penetrates from the inside to the outside, causing the cell and the entire tissue to die. This is one of the main reasons for freezing damage. Many experiments have proved that when the cell membrane is damaged, potassium ions account for more than 82% of the ions exuded. Therefore, we use an atomic absorption spectrometer to determine the potassium ion extravasation rate. The changes of potassium ion extravasation in plant tissues at different temperatures clearly show that the ion extravasation rate is very small above a certain temperature and is not affected by temperature changes. However, the extravasation of potassium ions is obvious below this temperature and the extravasation rate increases rapidly as the temperature decreases. Assuming that the temperature at which the potassium ion extravasation rate begins to increase significantly is the critical lower limit temperature at which the cell membrane is damaged, then according to the analysis, it can be seen that the critical temperature is affected by the water content of the soil slope. The soil moisture is when appropriate, the critical temperature of the citrus tissue is -8 ℃, when the soil moisture is 15% drought and 25% over humidity, the critical temperature is -4 ℃. This shows that the critical temperature of citrus when the soil moisture content is suitable for a time is 4 ℃ lower than that of drought or excessive humidity, that is, the ability of citrus to resist low temperature is stronger. On the contrary, if the soil is too dry or too wet, it will greatly weaken its ability to withstand low temperatures.

However, since the cold tolerance of plants varies depending on the variety, plant growth vigor, tree age, and pre-low temperature exercise, the critical temperature will also change. If these conditions are the same, the suitable soil slope moisture content will lower its critical temperature, thereby increasing the cold tolerance of the plant.

5. Conclusions

When the temperature-loving crops described in this article encounter harmful low temperatures, the degree of damage varies according to the amount of soil moisture during the low temperature period. Experiments show that the relationship between plant freezing warning level and soil moisture is parabolic at the same low temperature. When the soil moisture is the best, the ability to resist low temperature is the strongest, and the cold resistance ability of the soil is greatly weakened when the soil is too wet, especially when the water is lacking.

References

[1] Kumar P, Poehling H M, Borgemeister C. Principal Component Analysis-Based Block Diagonalization Precoding Algorithm for MU-MIMO System[J]. 2018, 129(9-10):489-497.
[2] Ren Y , Liao L , Maybank S J , et al. Hyperspectral Image Spectral-Spatial Feature Extraction via Tensor Principal Component Analysis[J]. IEEE Geoscience and Remote Sensing Letters, 2017, 14(9):1431-1435.
[3] Cunlin X , Jingjing W , Luhan W , et al. Numerical Taxonomy and Bayes Discriminant Analysis on 42 Fossil Species in Dicksoniaceae from China[J]. ACTA GEOLOGICA SINICA(English edition), 2019, 93(001):183-198.
[4] Zhang L , Jiefei L , Zhang Y . 2019Multi-phase degradation process modeling and prediction based on functional principal component analysis(in Chinese)[J]. Yi Qi Yi Biao Xue Bao/Chinese Journal of entific Instrument, 2019, 40(7):30-38.
[5] Liu Z, Sun X, Wang S, et al. Midterm Power Load Forecasting Model Based on Kernel Principal Component Analysis and Back Propagation Neural Network with Particle Swarm Optimization[J]. Big Data, 2019, 7(2):130-138.

[6] Wang X, Zhang Y, Liu H, et al. An Improved Robust Principal Component Analysis Model for Anomalies Detection of Subway Passenger Flow[J]. Journal of advanced transportation, 2018, 2018(PT.5):1-12.

[7] Chen S, Zhang Y. Hyperspectral Image Compression Based on Adaptive Band Clustering Principal Component Analysis and Back Propagation Neural Network [J]. Dianzi Yu Xinxi Xuebao/Journal of Electronics and Information Technology, 2018, 40(10):2478-2483.

[8] Wen F, Zhang Y, Gao Z, et al. Two-Pass Robust Component Analysis for Cloud Removal in Satellite Image Sequence[J]. IEEE Geoscience and Remote Sensing Letters, 2018, 15(7):1090-1094.

[9] Zhang Y, Deng X, Xu Z, et al. Watermelon Ripeness Detection via Extreme Learning Machine with Kernel Principal Component Analysis Based on Acoustic Signals[J]. International Journal of Pattern Recognition and Artificial Intelligence, 2019, 33(8):1951002.1-1951002.17.

[10] Wen F, Zhang Y, Gao Z, et al. Two-Pass Robust Component Analysis for Cloud Removal in Satellite Image Sequence[J]. IEEE Geoscience and Remote Sensing Letters, 2018, 15(7):1090-1094.