The Design And Application Of Efficient Heating Device For Floating Nursery

XuJichao[1,2]
[1]Faculty of Environmental Science and Engineering, Kunming University of Science and Technology, Kunming, China
[2]Xuanwei Branch Office, Qujing Tobacco Company, Qujing,China
593983131@qq.com

ChenLiang*
Faculty of Environmental Science and Engineering, Kunming University of Science and Technology, Kunming, China
e-mail: 448191722@qq.com

Abstract—Considering the relative large heat capacity of water, this study intends to assess the application of heating blanket as a homoiothermal heating source to heat water in the floating nursery pond. In order to minimize the unfavorable effects of low temperature on the growth of seeds, this study tries to develop a comprehensive set of float breeding technology that consumes less energy. The results indicate that an improved high-efficiency heating blanket has a higher heating ability and heat-insulating property. With proper supporting technology，the system is expected to reduce the relative temperature difference between day and night, and the influence of low temperature on the relative temperature in greenhouse, shorten the time for float breeding by about 10 to 15 days, improve the quality of tobacco seeds, increase the strong seedling rate by 3%and ultimately save energy and cost.

Keywords-Float breeding; Warming system; Adiabatic reflecting film; Heat energy utilization

I. INTRODUCTION

Greenhouse floating nursery currently is the major way of seeding flue-cured tobacco. [1] Yunnan, Guizhou, the south of Sichuan, the west of Hunan, the southwest of Hubei and the southwest of Guangxi are the southwest tobacco-growing areas. These areas are located in the Yunnan-Guizhou Plateau including the slope zone of it whose elevation is almost in 1000~2000m with the rich calorie and the abundant rainfull. The tobacco acreage and production of these areas are both accounted for about half of the whole country. And both the flue-cured tobacco and the sun-cured tobacco growing in the areas have a higher quality. For example, the average annual temperature in Liangshan Sichuan is 16 ℃ ~ 17 ℃, while the tobacco seedling usually starts from February 5 to February 25.Low temperature, irregular rain, great temperature fluctuations and nutrient solution freezing often happen during that time which has an adverse influence on the temperature inside the greenhouse. A low temperature inside the greenhouse has negative influence on the emergence and growth of tobacco seeds. Even if the average temperature is maintained at about 10 - 15 ℃ from sowing to emergence, there will be a certain gap between the average temperature and the optimum temperature required for the nursery. [2]It makes the breeding cycle becomes longer, increases the cost of labor, and also increases the risk of infection during the nursery Tobacco. [3] These issues have an adversary effect on seed germination, seedling and tobacco growth, and also result in a decline in the quality of tobacco. Therefore, the development of heating technology to ensure the temperature of the water in the floating nursery pool and the ambient temperature in the nursery is urgent. This technology has important practical significance to the improvement of tobacco and tobacco seedling quality.

Existing heating technology suggests to blow hot air into the greenhouse in order to increase the local temperature. [4]However, because of the low heat capacity of air, it is difficult to maintain the temperature inside the greenhouse, and usually it will result in high energy consumption. [5] Considering the large heat capacity of water, this study uses heating blanket as a constant temperature heat source to heat water in the floating nursery pond and keep the greenhouse warm and humid . This is a safe, stable and energy-efficient system, and is able to adjust the inner temperature according to outside temperature, thus, enables the control of the overall greenhouse temperature. At the same time, this paper will also discuss the new thermostat technology's effects on shortening breeding time, promoting the development of tobacco seedlings and improving the quality of the tobacco seedlings. The aim is to look for the most suitable floating nursery warming measure and to assess its effect on seedling growth, to develop low-power floating nursery water warming supporting technologies and to address and overcome the adverse factors on seedling growth in low temperature tobacco-growing areas.

II. EXPERIMENTAL MATERIALS, DEVICES AND METHODS

With the continuous improvement of plant cultivation technology, artificial heating technology emerges as a way to improve the speed of plant growth and development. At present the most widely used plastic green house is one of the representatives. Although plastic greenhouse is easy to make and convenient to use, it is easily affected by the weather and cannot process heating cultivation on plants timely[7]. In order to solve this problem, plant heating pad appeared on the market and through which, the plant can be heated for heat preservation. The existing heating pad is provided with heat by heating wire since the thermal energy of heating wire is conducted via the two directions of up and down of the heating pad. Thus the heat received by plant is merely from the upward heat of heating pad and the downward heat of heating pad can not be efficiently used. This leads to losses, low energy

utilization of heating pad and severe electrical power consumption. Moreover, the heating effect is poorer. Therefore, the development of a highly efficient heating pad is necessary to solve problems such as the existing heating pad can only use the upward transferred heat energy while heating and cannot make use of the downward transferred heat energy, leading to energy waste and poor heating effect, etc.

A. Materials

Computer temperature recorder, power out putter, stabilized voltage supply, regular heating pad, adiabatic pad, temperature keeping pad & reflecting pad, seedling nursery pond film, nursery greenhouse film, methyl bromide arch, seedling nursery pond, reflecting film, thermocouple, etc.

B. The Design of Adiabatic Heating Pad

Basic specification: the overall size is 1.1m*3.3m and the shape is rectangle to adapt to the size of seedling nursery pond so as the water in nursery pond can be heated evenly. Basic structure: it is divided into four layers. The first layer is non-woven cloth, the second layer is heating layer, the third layer is non-woven cloth and the fourth layer is reflective materials. These four materials are manufactured according to the form of agglutination to make them tightly attached to each other. Fig .1 shows the selected structure of high-efficiency waterproof heating pad that is used in the experiment. The upper layer and lower layer are insulating layers, the second layer is heating layer, and the third one is the insulation reflecting layer. The function of the reflecting layer is to transfer the downward passed heat energy in heating layer upwardly through the reflecting layer, thus improving the heat energy utilization.

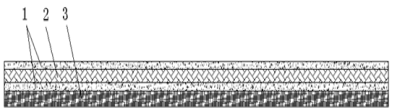

Figure 1. The section structure of high-efficiency waterproof heating insulating layers, 2- heating layer, 3- insulation reflecting layer.

Figure 2. Normal materials and reflecting layer The specification for each layer's material:

1) *Normal materials and reflecting layer:* The first and the third layers are made up by 200g non-woven material respectively, the second layer is the heating wire and the fourth layer is the reflecting layer, as shown in Fig .2;
2) *Thin materials and reflecting layer for the top layer:* the first layer is 50g blanket-core non-woven cloth, the second layer is the heating wire, the third layer is 200g non-woven cloth and the fourth layer is reflecting layer, as shown in Fig .3.

Figure 3. Thin materials and reflecting layer for the top layer

Property Parameters: for the heating pad, the designed power is 140W, the normally used voltage is 220V and the safety standard is in accordance with the domestic 3C standard requirement for design and subsequent production. It has characteristics like uniform heating, low power, safe & convenient to use, long service life, consecutive heating while working and the heat transmitted towards one direction as far as possible, etc.
The reflecting layer: it is made of aluminum foil and a thin PVC layer. The material for this product is non-woven cloth and the temperature-resistance of non-woven cloth is kept at 180℃. And the highest temperature-resistance temperature of aluminum foil is determined by the processing technique of aluminum foil and it is kept at around 300℃, while the highest temperature-resistance temperature of PVC is 140-160℃; The highest temperature of heating wire of this product is around 60℃in the heating process. Therefore, according to the product features of these materials, this improved heating pad meets the working requirements of long-time water heating. The reason for putting the reflecting layer at the bottom is that if it is placed in the third layer and clings to the heating wire, it is very difficult for agglutination because both sides of reflecting layer are smooth. Thus, in the subsequent use process, it is easy to come away and causes damages to product. In addition, the heating wire should not be connected to each other. They must be placed according to certain rules and in this way the evenly heating effect can be obtained. This is the reason that the reflecting layer can only be placed in the fourth layer.

C. Experimental Methods

1) Heating Efficiency Experiment

Three schemes are used for comparative test:
T1: The heating blanket is directly placed under the sink for direct heating;

T2: Add a reflecting layer on the back of the heating blanket to concentrate the heat;
T3: The thin layer is used for directing heat to textiles on the upper part of heating blanket;
T4：Regarding the above-mentioned improved heating blanket, the material of first layer is thin insulation material, the second layer is the heating layer, the third layer is the insulation layer and the bottom is the reflecting layer.

Experimental environmental conditions: this experiment is carried out at a homoiothermal air conditioning room, the temperature is set at 23℃ and the initial temperature of water is 19.6 ℃. The water temperature in the three parts of the seeding nursery pond including the front part, the middle part and the rear part is recorded every ten seconds by using combinations of computer temperature recorder and thermocouple and the average value of each measurement is recorded and processed. The results are shown in Tab .1.

2) Test for Impact on Growth of Tobacco Seedling

TABLE 1 .THE EXPERIMENTAL RESULTS OF FOUR HEATING TREATMENTS

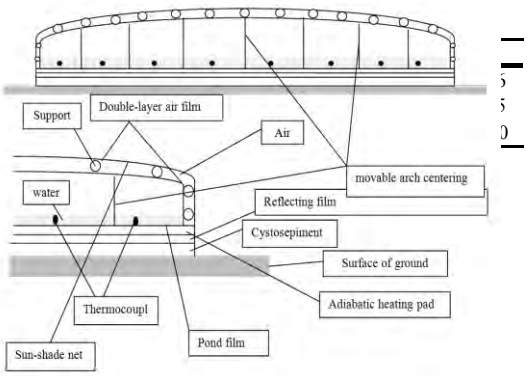

Figure 4. The adiabatic heating system

As shown in Fig .4, place the improved adiabatic heating pad (T_4) under the pond film for use of seedling nursery, then lay 1cm adiabatic cystosepiment under the heating pad and then process operations like draining and seeding according to the conventional seedling nursery. The upper part is covered with double-layer air film which is covered by sun-shade net.

The water temperature can be controlled via a self-made thermocouple, relay and temperature combination controller. The specific process is as follows: the upper limit and the lower limit of water temperature can be set and water can be electrically heated when the water temperature is lower than the lower limit. Heat the water until the temperature reaches the ceiling and the electricity power will automatically be cut off. Wait till the water temperature falls below the lower limit of temperature and then do automatic heating again by connecting electricity and this can effectively save energy.

The experiment is carried out with a group of untreated adjacent seedling nursery greenhouse serving as the control group, these two groups of seedling nursery greenhouse use No.87 tobacco seedling. The water temperature, substrate temperature, temperature inside the greenhouse, the outside temperature and the growing conditions of tobacco seedling are tested at 19:00 8:00, 15:00 respectively everyday.

III. RESULT &DISCUSSION

The results for application of three heating methods for Warming Velocity are processed according to formula 1) and 2), as shown in Tab .2.

TABLE 2 . THE CALCULATING RESULTS FOR WARMING VELOCITY & HEAT UTILIZATION RATIO

	T1	T2	T3	T4
Warming Velocity（min/℃）	25.69	20.56	36.01	30.9
Thermal efficiency increase	0.00%	25.00%	33.33%	58.33%

T1- Untreated,
T2- Add Reflecting Film,
T3- Thin Film Treatment,
T4- Thin Layer & Reflecting Film
Warming Velocity(min/ ℃)=t/(Tt-T0),t=1850s,Tt-Final Temperature,T0-Final Temperature.
Absorbed heat: r=cm△T
Thermal efficiency increase=(rT-rT1)/rT1=(cm△Tt-cm△T1)/cm△T1=(Tt-T1),T1-Final Temperature of T1.

A. The Impact of Reflecting Film

As shown in Fig .5, the conventional heating pad with sole heating function and heating pad with the addition of reflecting film are compared and the results show that these two groups of curves both have nonlinear changes and the curve with reflecting film is always slightly higher than the curve of untreated group. Relatively bigger wave peak and wave trough appear in the untreated group, however, the rise of the temperature of reflecting film is relatively uniform and there are no big fluctuations in the full process. (The relatively bigger wave peaks that occur in the later period is within the allowed value of error range and can be negligible) can demonstrate that the reflecting film can have good adiabatic and reflecting effect in the whole heating process. The rising velocity of the average temperature rises to 20.56min/℃. When the water temperature rises for 1℃, the time can be saved by 5.13min. The heat utilization ratio is enhanced by 25.00% compared with the conventional heating pad, and the heating effect is especially in the earlier period.

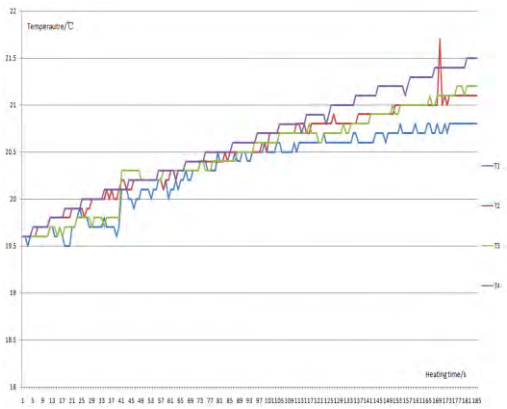

Figure 5. Time-Water Temperature Curve

B. *Impact of Thin Layer*

The earlier period of T_2 is a bit higher than that of T_1 in warming trend but when the trends are similar to each other, the trend curve of the later period begins to obviously rise, which shows that the upper insulation layer afterwards in the middle and later period of heating greatly affects the effective conduction of heat energy from heating layer to water. After the treatment on thin layer, the heat energy utilization can be effectively improved. The specific process is that when the water temperature rises by 1℃, time can be saved by 6.42min in contrast with that of T_1 and the heat energy utilization can rise by 33.33% in contrast with that of T_1.

In addition, the trend curve of T_3 is slightly lower than that of T_2 in the early heating stage and the average heat utilization ratio and the average warming velocity of T_3 are both lower than those of T_2. This shows that after the treatment on thin layer, the heat-preservation & adiabatic effect of heating pad may both decline. But the temperature curve and trend curve of T_4 group during the full process are both higher than those of other three groups. This shows that the joint function of treatment on thin layer and adding reflecting film can together make up for this defect and the heat utilization ratio as well as the warming velocity have been improved significantly on the basis of T_2 and T_3.

Totally, T4(Thin Layer & Reflecting Film) is that when the water temperature rises by 1℃, time can be saved by 9.46min in contrast with that of T_1 and the heat energy utilization can even rise by 58.33% in contrast with that of T_1.And it also got a decent result in contrast with T2 or T3.

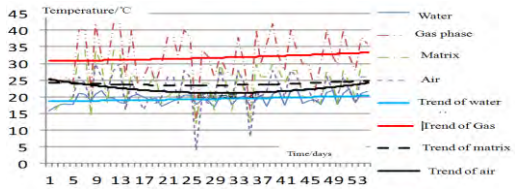

Figure 6. Figure for the Changes of Water Temperature Inside Greenhouse, Gas Temperature, Substrate Temperature & Outside Temperature with Time

C. *The Improvement of Heat Utilization in Actual Application*

As shown in Fig .6, the outside temperature has larger fluctuations in the morning and evening every day. After installing this device, the fluctuation amplitude of water temperature, substrate temperature and gas temperature are all obviously decreased, especially for that the water temperature and substrate temperature are basically maintained at a stable level. This shows that this device plays an obvious role in reducing temperature differences between day and night. From the trend curve, it can be seen that the outside temperature has depressions with apparent amplitude in the middle stage of experiment and it indicates that in the middle experimental stage, there is an obvious drop in temperature in 15-25 days and it is extremely adverse to the seedling nursery work. But through the installation of this device, the trend curves of water temperature, gas temperature and substrate temperature all keep stable and this demonstrates that this device can play a significant adiabatic and warming effect in the fight against bad weather changes, especially in the aspect of springtime temperature fall (cold spell in later spring).

D. *Impact on Growth of Tobacco Seedling*

TABLE 3 THE RESULT OF TWO GROUPS OF EXPERIMENT

	Sowing	Emergence	Small Cross	Large Cross	Cat Ears	Standard
Experimental	4th,February	18th, February	22nd,February	28th,Feb ruay	7th, March	14th, March
Contrast	5th, February	18th, February	26th,February	10th, March	18th, March	25th, March

1) Shorten the seedling nursery time: by using this device the small cross period of tobacco seedling can be shortened from the original 8 days to the half of it as about 4 days; the large cross period can be shortened from the original 12 days to the half of it as about 6 days. Because in the cross stage, the synthetic ability of leaves and the absorption capacity of roots are both weak, the photosynthate is less and the seedling growth is very slow with poor stress tolerance and relatively sensibility to external environment, if the seedlings encounter abrupt weather changes, it is easy to cause dead seedlings. Via the use of this system, the tobacco seedling can enter the rooting period in advance by about 10 days so as to avoid the cold and changeable weather in early spring.

In addition, if the cross period for the growth of tobacco seedlings is shortened by 10 days or so, the stage for small seedling with 595 holes from emergence to reaching the transplanting standard is shortened by 10-12 days and the stage for large seedlings with 162 holes from emergence to reaching the transplanting standard is shortened by 10-15 days, thus the choice of seedling nursery time and transplanting time will become more flexible.

2) Improve the internal and external quality of tobacco seedling: by using this device, the height of tobacco seedling in seeding period can be increased by about 14.16% compared with that of tobacco seedling that

is in the same growth period and does not use this system; and the stem girth can be increased by 15.69%；The wet weight of tobacco seedling will increase by about 34.20%, the wet weight of the aboveground part increases by about 40.33% and the wet weight of root increases by about 14.37%；the dry weight of tobacco seedling will increase by about 77.67%, the aboveground part increases by about 78.98% and the dry weight of root increases by about 70.83%；And the strong seedling rate will be increased by 3%.

IV. CONCLUSION & PROSPECT

Taking the existing electrical heating blanket as the model, adjustments can be made by adding an insulation layer between two heating layers, adding a reflecting layer under the insulation layer and replacing the material of heating pad to thin material, in order to reflect upwards the heat that transferred downwards by heating layer so as to enhance the efficiency of heating plants and avoid the problem causing by increased electrical power consumption.

The conventional flue-cured tobacco seedling nursery greenhouse contributes as a platform for innovating and establishing a set of water warming & adiabatic systems. Compared with the current single water heating method, the additional modules of adiabatic & temperature control contribute to efficient use of heat and to innovatively solve the problem of high cost and energy consumption that undermine the conventional heating method from an adiabatic perspective. In addition, electrical power of heating blanket can be automatically connected or cut off according to the required temperature so that the energy waste can be effectively controlled.

After applying the device, the temperature difference between day and night was obviously reduced and the impact of low-temperature climate on temperature inside the greenhouse was significantly weakened. Furthermore, the intrinsic quality of tobacco seedling was remarkably improved, the strong seedling rate was increased by 3%. The market price for each tobacco seedling is 0.065 Yuan. One middle-sized greenhouse can cultivate 470 seedling nursery plates. For each plate, there are 162 holes. The strong seedling rate of contrast group is 89.9% and the income for one seedling nursery pond is around 4449.24 Yuan; the strong seedling rate of experimental group is 92.9% and the income for one seedling nursery pond is about 4597.71 Yuan, with an increase of about 148.47 Yuan. As a result, by using the 595 floating plate, the income is calculated to be increased by 545.32 Yuan per seedling nursery pond. Combined with the use of measures such as double-layer air film and adiabatic cystosepiment, the nursery time for tobacco seedling can be shortened by about 10-15 days, the labor cost and the management fees can be further reduced. The application of efficient heating device is highly recommended.

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Thanks to Liang Chen as corresponding Auther to help for me.

*Corresponding Author:LiangChen,E-mail:kmchenliang@hotmail.com.

Author introduction: Xu Jichao, male, master degree, was born in the year 1990. Research direction: the high-efficient seedling nursery & cultivation technology of plants. Correspondence Address: Faculty of Environmental Science and Engineering, Kunming University of Science and Technology, Kunming, China ; Postal Code: 655415，Telephone: 13508741539，E-mail：593983131@qq.com.

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