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THE SIMPLE & EASY ENVIRONMENTAL CONTROL FOR THE MEMBRANE GREENSHED OF VEGETABLES IN CHINA

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ABSTRACT

In China, the membrane greensheds are chiefly for yielding vegetables, using simple & easy methods to control the micrnclimate. The yield of the vegetable is raised & the lack of variety of vegetable in the slack season is overcome. This paper presents the general planning, the environmental control and the reformed designs of such greenshed in China.

Key Words: Membrane greenshed, Microclimate, Reformed designs

INTRODUCTION

The first membrane greenshed with sorghum stalk for its skeleton was set up in 60's in China, thereafter greensheds of bamboo & wood or reinforced concrete skeleton were widecly erected. The fabricated steel pipe greenshed began to be studied and manufactured until 1980. Thus led it towards standardization and reduction of self weigat.

Most of them are now set up to yield vegetables, spreading in a vast area from about 40 ° north latitude to the Yangtze river basin & its south. They are mostly of sunlight greenhouse type and using simple & easy methods and facilities, such as simple covering for retaining heat, non–mechanical ventilation etc. to control the microclimate. The aim of cold protection in winter & lowering the temperature in summer can be avhieved. The conditions for early spring advanced plantation & early winter prolonged cultivation can then be created so as to prolong the growth period and the time of supplying varied vegetables. Therefor the greenshed has achieved remarkable effests of increasing the yield & adding variety to the vegetables in the slack season.

There are a few higher level Mechanized & automatized greenhouses or greensheds in China, they can yield flowers & vegetables all the year round

for particular consumption, which are not capable to grow in common conditions in the severe winter or hot summer. Nevertheless, it is not possible and yet unneccessary to develop them widely at present because of the reguirement of huge initial investment and high running cost. This is compatible with the present level of economic development in China, and might be used by other developing countries for reference.

A BRIEF EXPOSITION OF THE CONSTRUCTION OF GREENSHED & THE GENERAL PLANNING

1. The Categories & Construction of the Greenshed

2 kinds of greenshed are often used: ① Arched roof pattern: The top of it is a curved surface of a barrel vault. The whole external surface is covered with a transparent plastic membrane. Door is put upon each of the mitre end walls. ② Single–pitch roof pattern: The fore part of it has a transparent membrane surface. The rear part is a passage with a straw or clay tile roof, the back & side wall of this part are built of earth or brick. Door is put upon the side wall. This shed has better wind proctection & heat retaining properties than the arched roof shed and is suitable for vegetable yielding in winter in north China. The general dimensions is as shown in Fig. 1 & Fig. 2.

Now these 2 kinds of greenshend are usually using thin wall galvanized steel pipe for their skeleton of which the main member is arch bent. The Posts which are often used in the skeleton of bamboo or wood shed is not needed here except for shed of large span (10m or more). The arch bent can bear wind & snow load stably without post. The longitudinal ties of the shed with a span below 8m can also be taken away. The longitudinal stability can be ensured so long as the footings of the bent are firmly buried into the earth and the surface membrane is stretched tight by guy ropes. The Chinese technical personnels realized that longitudinal ties generally obstruct the guy rope from stretching tight the surface membrane and result in local depressions of the membrane to accumulate snow & rain water.

For protection of the plants from frost injury, small arched shelters with a span of 1.5m & height of 1m are often put up in the greenshed in China. Bamboo laths of 3～4cm in width & 0.6～0.7cm in thickness are often used for skeleton of the small shelter. The lath is bent into a semi–circle of which the 2 foots are firmly inserted into earth, the distance center to center of the bent laths is about 0.4～0.5cm.

2. Covering Materials

The kinds of membrane generally used for greenshed in China are the same as at abroad. They are polyethylene (PE) & polyvinyl chloride (PVC). The thickness is commonly about 0.08～0.12mm. To overcome the defects of PE, i.e, easy of ageing & low strength. The improved PE membrane which has a tensile strength of'18.5～24.0 Mpa and is ageing resistant has been produced in China. Its life of utility reaches to 2 years. The PVC membrane is easy to bear condensed moisture drips, so that a product of non–drip PVC membrane has also been manufactured in our country.

When spreading membrane on the shed skeleton, the locations of the vent–gap need be considered. There should be 3 longitudinal vent–gaps on the arched roof shed, i.e. one on the centre of the top, 2 on the bilateral shouldrs, so the membrane should be cut out & pieced together into 4 pieces. For single pitch roof shed, there should be 2 longitudinal vent–gaps on the transparent part: one at a slightly backwards place from the longitudinal center line and another at the shoulder line infront of the center line, thereby the membrane must be cut out & pieced together into 3 pieces.

In order to protect from cold in winter and from heat in summer, the shed surface usually needs to be covered by straw mats or multi–layers of plastic textile–membrane which is weak in transparence.

3. General Planning

For the simple & easy control of environment in the greenshed, the general planning must be well done at first. The arched roof shed has a bilateral symmetrical cross–section, and the sun light can be transmitted into it from both sides. Thereby the longitinal axis of it can be oriented north & south direction so as to let in more sunlight from east in the forenoon as well as from west in afternoon, and the plants at different parts in the shed will receive light uniformly. While at noon, there is less sunlight entering into it, Because that only a narrow surface of the shed's end is normal to the sunlight and the angle of incidence of the sunlight upon the broad side surface of the shed is much larger.

The single pitch roof shed receives sunlight chiefly in the fore part. While the thick earth or brick wall of its back part can protect it from the cold spell & north west wind in the severe winter, therefore the longitudinal axis of it is usually oriented in the east & west direction. At noon, the broad front surface is in the normal direction facing the sun, the intensity of sunlight transmitted into the shed is high and the temperature rises rapidly, but in the forenoon or afternoon, the sunlight inclines remarkably onto it and is weak. Thus the temperature in it varies considerably through the day and the light spreads in the shed area unevenly. Nerertheless, its heat retaining effect is

better than that of a arched roof shed. In the north region of China, therefore, a great number of single pitch roof shed are erected. Yet there are some arched roof sheds which have to be covered with multi–layer membrane for cold protection in winter. In the YangTze river basin & the south, the air temperature in winter is higher and the angle of altitude of the sun is lager, which results in comparatively small angle of incidence of the sunlight, so that the arched roof sheds are widely used.

The appropriate dimensions of an independent greenshed are as follows: the arched roof shed in the north region usually has a span (or Width) of 8～10m with a longitudinal length of 42～60m and covers an area of 335～ 600m^2. Shed with such dimensions is easy for heat retaining & management. The shed in the Yangtze river basin is usually of smaller area and simple construction which has a span about 5m and an area about 165m^2.

The distance between sheds must be propevly arranged, otherwise may cause ineffective ventilation, intercepting sunlight each other and obstruction of the moving of farming facilities. The experiences in China are that: The east–west distance between arched roof sheds is 2～ 3m, the north–south distance is 3～ 4m. The north–south distance between single pitch roof sheds is 4～4.5m (according to the result of computation which will not cause the fore shed casting shadow on the rear shed in the noon of the winter solstice at 40 ° north latitude), and the east–west distance is 5～ 6m.

SIMPLE & EASY CONTROL OF THE MICROCLIMATE IN THE GREENSHED

1. The light regulation

Except in the high temperature season, more sunlight is expected to enter the shed, thus the first thing is to consider the orientation & the angle of inclination of the shed surface.

For the arched roof shed which is usually oriented north and south as mentioned above, the direction & inclination of the sunlight relative to the surface of the shed varies in 3 dimensions continuously day and seasons. It is very difficult to determine an optimum angle of inclination for the stationary surface. In addition, the intensity & quality of the light in the shed is influenced largely by the surface materials, the growing conditions of plants and the surroundings etc., to precisely calculate the angle of inclination for such shed is yet of no practical significance. The selection of the type of curve for

the arched roof is generally aimed at high strength of the arch bent and better surface conditions to drain the rain water & snow.

In the past, for the single pitch roof greenhouse in the higher latitude, the front roof is often of an inclined plane. In order to transmit more light at noon to raise the temperature in it, the optimum angle of inclination of the plane has been calculated by using the angle of altitude of the sun at 12 o'clock at winter solstice in accordance with the principles of optics. But at present, the front roof of the shed is mostly put up with a curved surface, so the empirical method is generally used to determine the pattern of curve, to avoid the theoretical calculations.

The plastic membrane has better light transmission properties of quality and intensity, but it is easy of ageing and easy to be soiled. The transmittancy of commonly used PVC or PE membrane is about 85%～90%, the Chinese technical personnels have tested & found that the transmittancy has decreased to 50% or more after being used one year. For getting better lighting condition, the membrane has to be replaced by a new one after using 1 year. In some districts, the membrane is washed with detergent for use in another year to save the expenses. To develop the full function of light transmission, the membrane must be stretched tight and the creases be smoothed away when putting up the shed. As there is drip from condensed moisture on it, it must be eliminated by ventilation timely.

The rational arrangement of planting is another important measure to distribute the sunlight uniformly. Keeping proper spacing as well as employing intercropping of high stem plants with short ones or of light–loving vegetables with shade–enduring ones is a better choice to avoid intercepting light. To improve the light & vantilating conditions in the lower space in the shed, training & gartering of vine and taking off the old leaves in time may achieve good effect.

When light is insufficient, artificial illumination in a vast area is not possible to use in our country for the cost is too high. But during the centralized cultivation of seedling in winter, the fluorescent lamp or high voltage mercury lamp etc. is often used for artificial illumination. The time of cultivation can be reduced and the seedling can grow strongly by the supplement with lamp light 2～4 hours, as the sunshine at that time is only 8 hours or so.

2. The simple & easy facilities of heat retaining & cold protection

The most simple measures of protection from cold is to cover straw mats or multi–layer membrane–textile. But the effect of the covering is much limited, For example, in the region near 40 ° north latitude in our country, from the last 10 days of Nov. to the last 10 days of Jan. next year, the tem-

perature in the single–layer membrane shed is generally below 0℃, while in the straw covered single pitch roof shed or in the multi–layer covering arched roof shed, the lowest temperatare can be 10℃ or more higher than that in open ground. If the temperature in the open ground decreases to –10℃ or below, the temperature in the shed can yet be 2 ° ~ 6℃ at night and reaches to 15℃ at noon, even so, the shed can merely keep the cold resistant greens to live through winter. Therefore, there have been some additional simple & easy facilities developed in China for cold protection, as stated in the following:

(1) Bioheating hotbed In severe winter, no thermophilous vegetable can be cultivated in the simple geenshed, but the hotbed cultivation of seedling of cucumber or tomato etc. can be carried on in it. The hotbeds usually set up in our country are electrical hothed, bioheating bed etc. The latter is a comparative simple & easy type. It is easy to work, can use local materials and the cost of it is low. The defect is that the temperature can not be regulated, and yet its effects are remarkable through the handling of an experienced farmer. The biofuel usually used is a blend of 70% fresh horse feces & 30% wheat straw. When mixing, proper amount of feces & urine of man are to be added. At the bottom of the hotbed, a 5 cm heat insulating layer of stalk chaffs is placed & compacted, then the biofuel is placed by layers and compacted, above which is a layer of culture soil. By testing, if the the layer thickness of biofuel is 30 cm, the soil temperature can be 4 ° ~ 6℃ higher than in the cold bed within 20~ 30 days after seedling. The soil temperature lowers gradually thereafter and the biofuel can yield heat continuously up to 40 days.

(2) The cold protecting covering for the small arch shelter In the Yangtze river basin, the temperature in winter is higher than in north China. Yet the lowest temperature can reach to –10℃ or below, but the duration is short. So that the seedling cultivation can usually be carried out in the small membrane arch shelters which are put up in the arched roof greenshed. The shelter is often corvered with cold protection materials such as straw mats or vacant straw bags etc. at night or in the rainy, cloudy days. The temperature in the shelter can be maintained at 4 ° ~ 6℃ or above. In north China, when carrying out early spring advance plantation or early winter prolonged cultivation, the weather is still very cold, the small arch shelters have to be put up also in the single pitch roof greenshed and covered with straw mats at suitable time.

The straw mat or vacant straw bag are widely used for cold protection in China. It is available locally, the effects of cold resisting is better, and the cost is low. Through many years of use in greenshed, it is found that the life

of utility of such material is only 2～3 years, it must be replaced by new one when the time limit is exceeded. So the actual cost will be higher, owing to the fact that the straw mat or bag is comparatively crude & bulky, especially when it gets moisture from the drip of the surface membrane, the weight will increase greatly, thus it will cost more time and labour to cover or uncover the shelter with it. In addition, the wetted staw mats or bags must be moved out of the shed 1～2 times a year to be dried by sunlight, this also needs a lot of labour. Some agricultural engineers in our country have, therefore, carried out a researching subject of using 2 layers of membrane sandwiched with a piece of plastic textile to replace the straw materials, and at the same time have designed a simple device for rolling up & unrolling the membrane–textile to raise the efficiency of operation and save the labour. Through test & inspection, the effect of cold protection of such membrane–textile is similar to the straw materials, but has other striking properties such as light in weight, high tensile strength, easy to be rolled up & unrolled and at low cost. So it can be expected to be widely used in our country in the near future.

(3) The cold protection ditch In north China, to keep the ground temperature in winter in the greenshed at an opotimum value (e.i. about 12°～14℃), the cold protection ditch must be excavated in the greenshed besides the use of small shelters. The ditch is laid along the 4 sides of the shed to forrm a closed loop to intercept the outside frozed layer of earth. In the past, only one line of ditch is set up at the south toe outside of the shed, the bran & stable manure etc. are filled in the ditch to yield and preserve heat. But the rapid development of greenshed causes the difficulty of getting such materials, so the ditch is now kept unfilled and the upper opening of it is covered with a flat layer of brick to form a belt of air insulator. The width of the ditch is 18～ 20cm, and both sides of it are retained by a half–brick wall. The depth is 0.5～ 1.0m according to the frozen depth of earth in the open ground. Setting up the ditch inside the shed can avoid the seepage of rain or snow water into it, thus prevent it from losing the property of heat insulation.

3. The Environmental Control in the Greenshed During the Growth Period of Vegetable

Besides the lighting regulation as mentioned above, the chief measure of the environmental control in the growth period of vegetable is the regulation of the temperature & humidity to meet the reguirements of varied vegetables. The high humidity in the greenshed is caused by the evaporation of the soil and transpiration of the plants. Espectially in the night, owing to the lowering of temperature, the relative humidity usually rises up to 100%. This

condition is probable to breed diseases of vegetable, such as cucurbits downy mildew or tomato leaf mould. The most easy & simple regulation of humidity is to arrange natural ventilation.

Nevertheless, the non–mechanical ventilation generally results in contradiction between heat keeping and lowering of the humidity. To resolve this difficulty, the chief measure is to control the vent–time (early or late); the vent–duration (long or short) and the vent–opening (wide or only of a fraction) etc.

Take an example about early spring plantation of the cucumber in north China. The planting can be carried out in the small arch shelter in the last 10 days of Feb. or the first 10 days of march. The environmental control should lay emphasis on raising the air and ground temperature as the weather is still very cold. In the first 1～2 weeks, all the vent–openings should be closed tightly and the shelter has to be covered with straw mats. As the ground temperature has rised in the latter days of the 2nd. week, the soil is to be cultivated and loosened while the ventilation may be properly carried out to lower the temperature in the shed. Usually the south and north doors can be opened at noon to make the air flowing and to get out the dampness.

In the cucumber fruit–yielding period, frequent ventilation at specified time is carried on to regulate temperature, humidity & the concentration of CO_2etc. In the Yangtze river basin (or in the north region), begin at the 2nd. 10 days (or at the last 10 days) of april, the vent–gaps on the shoulders can be opened, it is opened & closed at proper time in the day and remaining a fraction in the night to control the humidity, this is advantageous for preventing plant diseases. Generally, the temperature in the shed kept at 28°～32℃ in forenoon, lowered to 25℃ or so in the afternoon and more low at night. The relative humidity is kept at 30～60% in the day and 80～85% at night. The daily sequence of opening of the vent–openings is as follows: open the south door at first, open the north door second, then open the vent–gap at top, and then open the vent–gaps on shoulders (east gap at first and west gap follows), and the seqence of closing vice versa.

Beginning at May, the temperature in the open ground is rising gradually, when the ground temperature of the open ground has kept above 15℃, the membrane at the 4 sides of the shed can be rolled up to form an awning, the ventilation is carried on day & night to prevent the plants from high temperature injury.

SOME CATEGORIES OF THE REFORMED DESIGN & EXPERIMENT FOR THE SIMPLE & EASY FACILITIES

1. Double–Layer covering greenshed

In some districts in our country, there have been a kind of 2 layers membrane shed in use. The construction is very simple, that is at a level 30cm below the surfac membrane in the shed a curved net work of 2# galvanized iron wire is hanged down and fixed on the arch bent. Upon the network, a sheet of plastic textile & membrane composite of low transmittancy or a sheet of polyester long fibre unwoven textile is spreaded. Such desigh can achieve the effect of heat–keeping in cold season and intercepting sun rays in hot season. For example, when carry on prolonged cultivation of tomato in late Autumn. The early stage of plantation is in summer, the textile–membrane composite has to be spread to protect the plants against sunrays. During the mild season or when light is needed,the composite can be rolled up and stationed at the shoulder parts in the shed to let the sunlight in. In late autumn, the composite can be easily unrolled again to protect the tomato from cold in the night.

2. Greenshed for the Combination of Vegetable Planting and Stock Breeding

Some agricultural engineers in our country have designed a particular greenshed, the construction is similar to the single pitch roof shed. The fore part of it uses a 2 layers of membrane covering to protect against cold, the rear part has a straw or tile roof as mentioned above. A 200m^2shed has a fore area of 140$m^2$for planting vegetbles, and a rear area of 60$m^2$for breeding 20 cows or 1000 hens etc. In winter, the CO_2 exhaled by animals and the heat diffused from the body & muscle of animals can be used by the plants, while the growth of vegetables can as well improve the environ–conditions of animals. Thus making the growth period of vegetable prolonging about 30 days and making the poultry & animal capable to live safely through the winter. The yields of milk or egg will increase too. Such greenshed will be worthy of extexsion in the north cold region of China. Further research and experiments may be necessary to eliminate or reduce the harmfiul gas from the excrements of the animal.

3. CO_2 Producer

In winter or in early spring, the greenshed is always closed tightly, it is necessary to replenish it with CO_2. The very simple method has been used

such as to burn coal in a stove which can prodduce plenty of CO_2 but a large amount of harmflul gas is also produced. At present, several types of CO_2 producer have been manufacturing in our country, and the experiments & modifications are follwoing. The effective & economical fuel of it in China is realized to be the bio–gas or liquefied petro–gas.

CONCLUSIONS

In the past, only some cold resistant greens can be yielded in the severe winter, especially in north China. While the membrane greenshed being developed, conditions of early spring advanced plantation and early winter prolonged cultivation are created for the warm required vegetables by the simple & easy environmental control. The period of slack & monotonous vegetable supply is reduced and varieties of vegetable are given. Thus the food supply of people in China is much improved. Owing to the high cost of the greenhouse of high level which will produce fresh fruits & vegetables in all seasons, it is impossible and yet unnecessary to develop such ones widely at present in China.

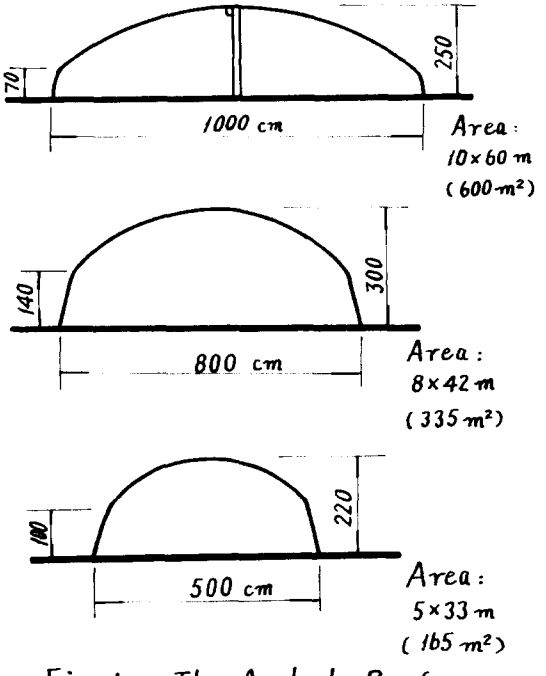

Fig.1 The Arched Roof Greenshed

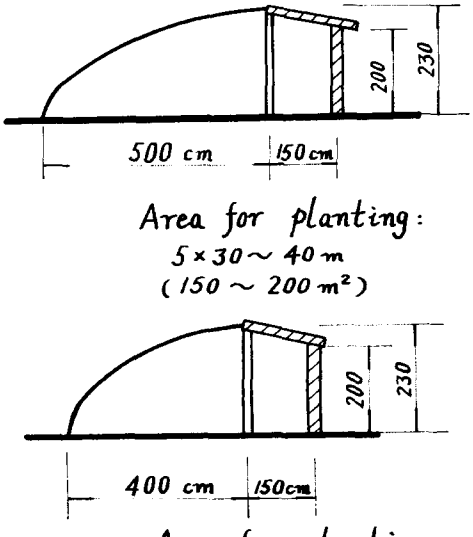

Fig.2 The Single Pitch Roof Greenshed