OPTIMISATION OF GEOTHERMAL DIRECT APPLICATION PROJECT IN AGRICULTURE IN FUJIAN, CHINA

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ABSTRACT:

The Fujian Geothermal Agricultural Institute has been researching the possibilities for optimisation the existing geothermal application in the region during the period of 1985-90. By the introduction of cascade technology of the heat use, the greenhouse and fish pond heated area has been increased by 113% (by the use of the same available geothermal water flow). The specific income increased to 15300 Yuans/Mu (area of 666.7 m^2), which is far higher than of other greenhouses and therefore proves locally the economic feasibility of geothermal direct application.

1. INTRODUCTION

The Fujian Geothermal Agricultural Institute of the Fujian Academy of Sciences took in 1985 the responsibility for optimisation of the existing geothermal agricultural project in the region. It was based on the hot water flow of two thermal wells, one 220 m deep and temperature of 63 °C, and the other of 59 °C.

The experimental project has been conducted in an area of $1.41*10^4$ m. It was divided in three parts, of which the first consists of a pool of 800 m^2; the second of three greenhouses of 936 m^2 protected surface, ten small greenhouses covered with plastic film and a fish pond of 1000 m^2; and the last one composed of a nursery, 5 plastic film covered greenhouses and an experimental project for mushroom production.

2. METHODS

Seven problems have been put under investigation:

2.1. Project Design

Based on the supposition of a cascade use of geothermal water on disposal, design heat requirements of possible users have been determined, addition of 2 heat accumulators (ponds of 20 m^2 and 30 m^2) for covering the peak heat requirements and reconstruction of the existing equipment and pipe-lines have been planned.

22. Temperatures Regulation

In order to reach a complete conditioned climate in greenhouses and fish ponds, a micro-computer based regulation system has been designed for whole the geothermal heating system.

2.3. Introduction of water thermal screens

Investigation of the influence of incorporation of side water thermal screens in greenhouses has been planned. Two greenhouse, each of 8*4 m^2, have been built - one covered with glass and the other with soft plastic film. A water screen of 4000'1200'20 mm with 4 circulating pumps has been installed on the northern wall . Southern one has been equipped with an 2*750 mm exhaust fan. Both systems are regulated by automatic inside air temperature control by twin regulators.

2.4. Evaluation of experimental results and demonstration model determination

Experimentation has been planned in three single span greenhouses (Fig.1). Temperature increase during the winter and decrease during the summer has to be measured in greenhouses and compared with the external air temperatures.

As heating equipment, a fan convector with axial air flow has been installed at one side in each greenhouse and exhaust fan at the other.

As irrigation equipment, two spray lines in each greenhouse have been installed, with the sprays at 1.5 m distance.

Tropical raining forest's cultures have been investigated, such as Chinese fan palm, deciduous trees, French parasol, pomegranate, etc. During the second phase of

experimentation also some flower and grape cultures have been investigated and a trial to promote mushroom production in controlled climate has been made.

2.6. Geothermal aquaculture

By the use of effluent heat of other geothermal water users, several experimentations with fish farming have been made, such as is breeding the famous and expensive Fuzhou golden fish, catfishes, silvery pomfret or Arfocoucian seedlignys.

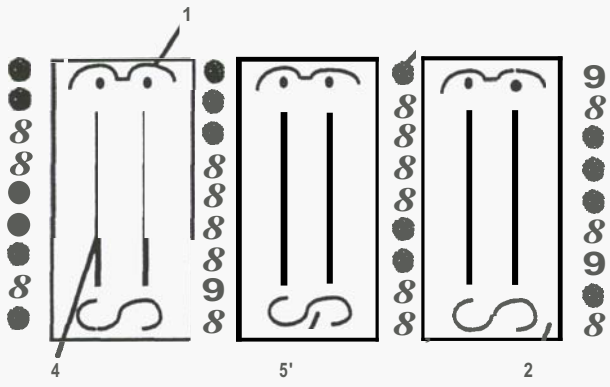

Figure 1.

2.7. Use of nutrient liquids with controlled composition in greenhouses

Technology of centrifugal fine spraying and direct spurt with spraying has been planned for investigation (Fig.2).

3. RESULTS AND DISCUSSION

3.1. Heat requirements

According to the results of the feasibility study, heating distribution system has been reconstructed, regulation of the pipe network arranged, efficiency of the heating improved and heated area increased for 113%.

3.2. Heat supply regulation

Computer supported automatic heat supply regulation has been installed in the system. It is a TP801 micro computer, equipped with a magnetic tape writer, power supply installation, 32 ways import (simulated), 16 ways export (simulated) and 48 ways switch volume. Computer is equipped also with the automatic alarm system , signalising overheating, water supply cut and power supply cut.

3.3. Inside temperature reduction with water screen use

The use of water screen in greenhouses reduced internal air temperatures mainly depending on indoor relative humidity (Table 1).

Table 1
Effect of water screen to inside/outside air temperature difference

Outdoor air temperature (°C)	Indoor air relative humidity (%)	Indoor air temperature (°C)	Effective air temperature difference (°C)
37	70	31	6
37	80	32.5	4.5
37	95	36	1

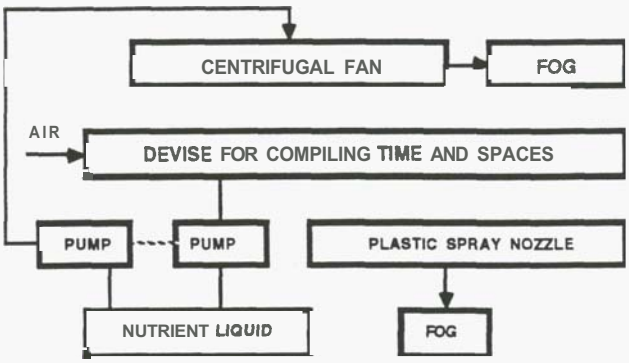

Figure 2.

3.4. Greenhouse model for South China

Table 2 shows the effect of different greenhouse construction to the temperature difference in summer climate conditions. The best is so called "ecological greenhouse" in which the temperature reduction is for about 7 °C. That could be the real solution for the conditions in South China because enabling normal plant growing even in summer.

Table 2
Comparative effects of different greenhouse constructions under summer climate conditions

Type of greenhouse	Area m^2	Number	Summer indoor temperature °C
Multispan greenhouse	2000	1	55
Single greenhouse	8X30	3	45
Small greenhouse	4X8	1	40
Plastic greenhouse	6Xdiff.lenght	8	37
Ecological greenhouse	6x20	4	30

Note: Outdoor air temperature $t_{a.o.}$ = 37 °C

3.5. Heating technology

Heating by means of forced air heaters enable temperature difference of the heating water of 30 °C and by means of radiator only 10-15 °C.

3.6. Agricultural results

Dutch seed and young plants have been experimented. Successful resutts have been confirmed by profitable sale results in Hongkong and 13 Chinese provinces. At the Second National Fair for Flowers and Plants third prize has been gained twice and one for the scientific progress.

5680 grape plants have been growed successfully on 2634 Mu (1 Mu=666,7 m^2) area, which is a significant progress for the China economic conditions.

Also heating of a mushroom farm has been experimented successfully, together with the introduction of a new breeding technology, enabling 2 months shorter breeding time (Fig.3).

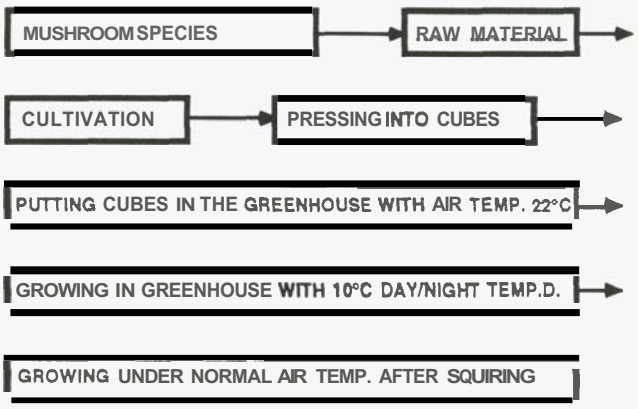

Fig.3

3.7. Aquaculture

A 550 m^2 pond has been used 4 years for breeding different fish species. Effluent water of geothermally heated greenhouses has been used for heating the pond.

The high quality of fishes has been confirmed at the Second National Fair, where the "ponda" golden fish reached first prize, one specie achieved the third prize, and one the prize for scientific progress.

Density of fishes in the pond depended on the specie in question. For example, the catfish was with density of 34000 pieces/m^2. Altogether, about 1500 thousands fish seedings have been supplied to the market over a period of 4 years. That practically resolved the market demand in Fuzhou region in China (Table 4).

Table 4
Production results of geothermally heated aquaculture pond

Item	Number (10000 Yuans)	Output 10000 Yuans)	Profit 10000 (Yuans)	Others
Golden fish	18,73	30	9.88	71100000 Yuans gain (H.K.)
Catfish	150	8.24	4.99	
Fish seedings	318.38	42.67	15.6	
Total	487.11	80.91	30.47	

3.8. Plant cultivation with controlled liquid nutrition

Several technologies have been investigated, such as are the cuttivation in foggy air, with increased oxygen in the water, etc. The technology with increased oxygen resulted with 3.8 times higher yield than the one in usual cultivation in soil and 2.4 times higher than one with cultivation in liquid. It is under patent protection in China.

Unfortunately, necessary high investment costs doesn't allow its wider commercial use in China under momental ci circumstances.

Table 5
Comparison of production results with different technologies for tomato culture

Technology	Plants piec./m^2	Cultivation days	Yield (single plant) kg/pl.	Yield kg/m^2	Yield kg/Mu
Air fog	6	210	4.81	28.86	19240
Nutrient liquid	6	210	2.63	15.78	10520
In soil	6	210	0.92	5.52	3680

4. CONCLUSIONS

Existing project optimisation proved economic feasibility of geothermal direct application in agriculture, particularly with the introduction of new cultivation and breeding technologies in greenhouses and fish ponds. Cascade use of

the geothermal water enabled better use of temperature difference on disposal and, in that way, increase of the productive surface for 113%. Very attractive gains in China economic conditions have been achieved.

5. REFERENCES

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Note by editors:

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