CONTROL ON PLANT FACTORY IN OPTICAL RADIANT CONDITION ACCORDING TO THE MARKET ECONOMICS

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ABSTRACT

There is currently no satisfactory way to optimize supplemental lighting in a greenhouse-type plant factory especially concerning plant production. In a commercial plant factory, we got outside radiation data, inside radiation data and lamp running data. They have a correlation, but have much disorder. By using regression, tendency between the outside and the inside including supplemental lighting was found. We could estimate the average transmittance of this plant factory. From this estimation, we could admit the amount of inside radiation was supplied as much supplied compared to natural radiation. Then we are trying to investigate of the production amount and the supplemental lighting. Plant factory is environmentally controlled, the temperature and humidity are not actually controlled stable. We propose a design of neural network model could be useful to estimate the profit resulting from the operation of supplemental lighting.

Keyword : Plant Factory, supplemental lighting, neural network

INTRODUCTION

Since artificial lighting is essential for production in a plant factory and constitutes more than 50% of the total production costs, energy reduction is one of the most important problems. In closed factories, lighting conditions such as light intensity, the day/night cycle, ratio of the light period to the dark period, and spectral energy distribution, can be varied widely. For instance, it is possible to shorten or lengthen the day under artificial light, while the natural cycle is constant at 24 hours. Controlling lighting is therefore much easier in a fully closed system than in a greenhouse-type plant factory, where the internal environmental control has been affected external environmental. There is currently no satisfactory way to optimize supplemental lighting in a greenhouse-type plant factory. This study therefore proposes a strategy for optimizing supplemental lighting in a greenhouse-type plant factory.

MATERIALS AND METHODS

Plant Factory to be analyzed

Kawatetsu Life Corporation is famous as a manufacture for plant factory in Japan, and which run commercial plant factory at Sanda City in Hyogo Prefecture. We started a co-operative research with the corporation in order to improve the production, increase the production efficiency and reducing the light cost. Fig. 1 shows the out line of the plant factory. The grown seedlings are set on the right side of the figure, and then move on the left side the harvest point. The seedling is installed on the cultivation trough and irrigated with NFT method. As the plant become big, the interval space of trough have been increased to provide the cultivation space to plant. The environmental control system has controlled, air and water temperature, the fertilizer concentration, pH and CO_2. Natural cooling system using latent heat in water vapor, shown on the right side on Fig. 1, is used to save the running cost. Normally cultivated plants are some species of lettuce (Mari Gold, Frill Ice, Green Rose) and the cultivating period is about 24 days to 30 days. However sometime the cultivation period of plants are changed depend on season. The cultivation area is 40m width, 42m length and the actual cultivation area is $1152m^2$.

Fig. 2 shows the location of the supplemental lamp and the inside sensor related on this report. We used 172 lamps for this cultivation place. The sensor for inside radiation intensity is located 20cm above the plant canopy (Fig. 3). The sensor for outside radiation intensity is located on outside the greenhouse at higher than roof. The light time of the lamp is captured by the accumulated lamp running time. The supplemental lamp control begins to work when the outside radiation intensity comes under $100W/m^2$ according to the custom method. At night we don't use supplemental light. High pressure sodium lamp and metal halide lamp are located in the plant factory [1](Akamine et al, 2000). The relation between supplemental light and production is not clear.

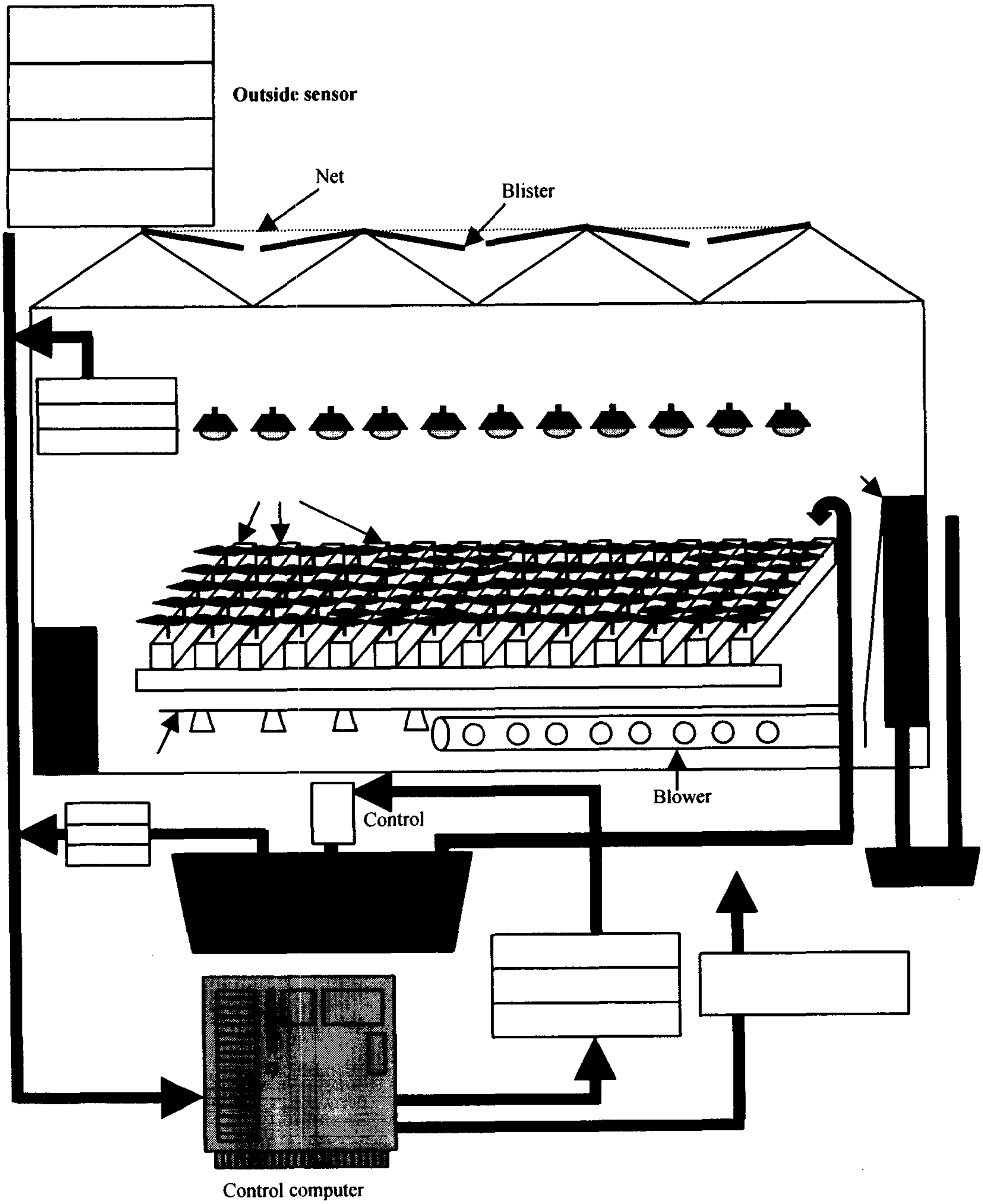


Fig. 1 The out line of plant factory in Sanda.

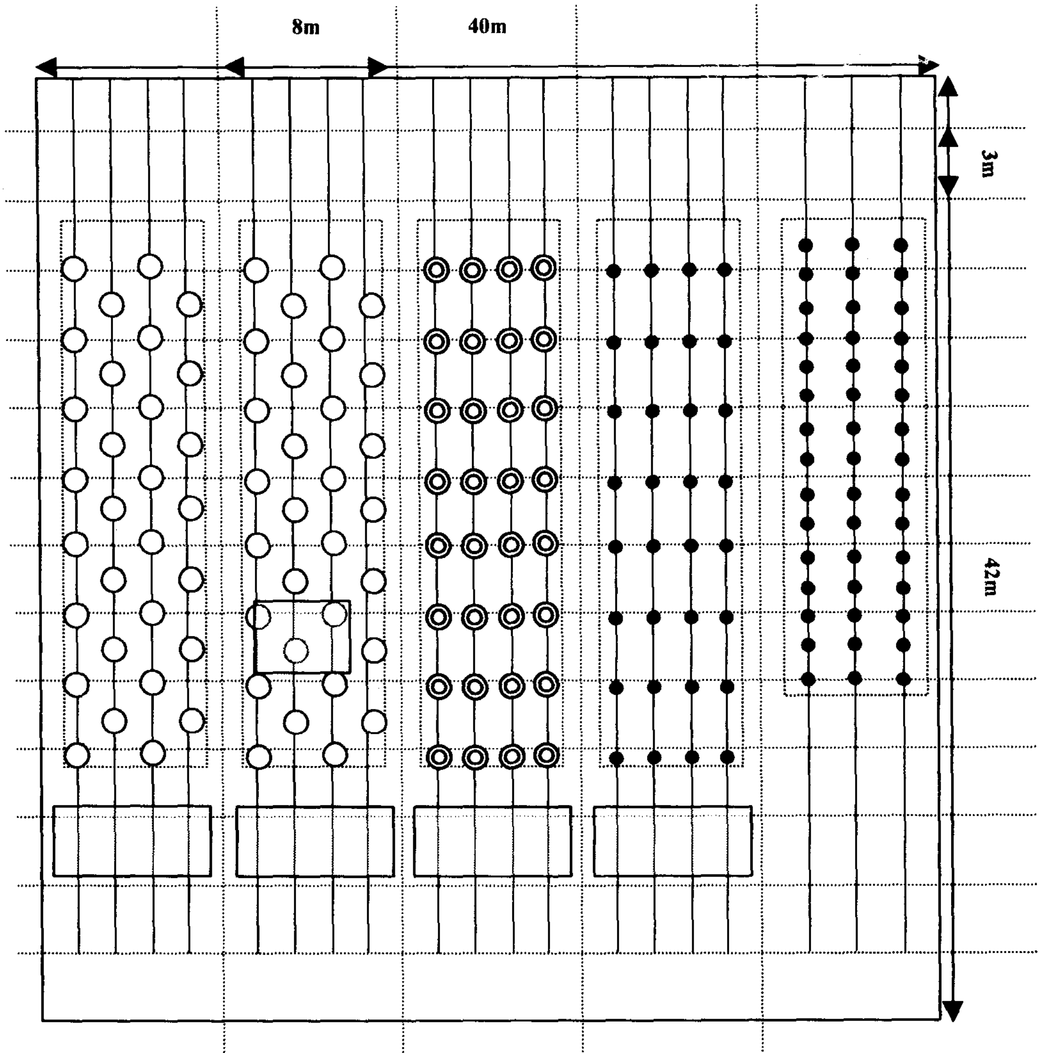


Fig. 2 The position of lamp and sensor.

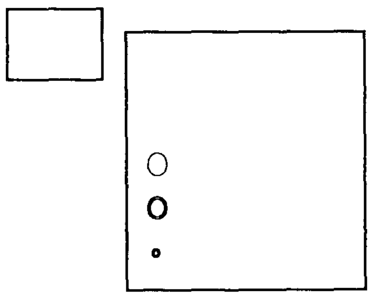
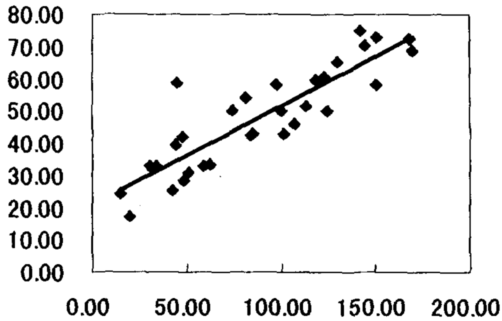
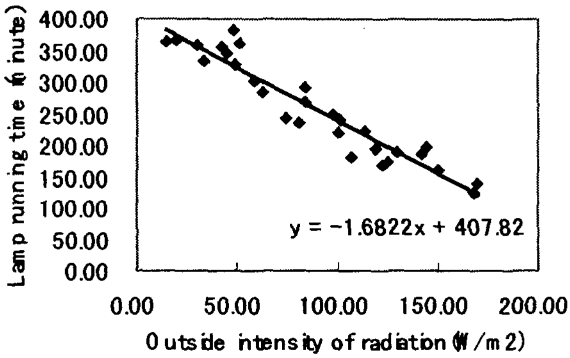


Fig. 3 The position of inside sensor.

DATA USED

Here we investigated the relationship between the data of the sensor and the daily accumulated lamp running time and the supplement light effect to the plant in the whole plant factory. Fig. 4 shows the relation between outside and inside radiation intensity in the 31days, from 1st Jan to 31th Jan. When the amount of the outside radiation intensity increase, the inside also increased. Though the relationship has a correlation, it has a disorder. The reason for this can be thought that on the one hand the sensor in outside has nothing to be interrupted, the other hand the sensor inside is located in the green house and many things like the frames or glass of the green house or the curtain in green house could affect to the sensor. Also the inside sensor was effected from the supplemental light when the lamp is running. If there is no lamp, the regression equation of this correlation will pass the zero point. However supplemental lighting is used in low radiation day, so the regression equation crossed y axis in a plus value. Fig. 5 shows the relationship of the inside radiation and lamp running time. Lighting control of lamps are turned on when the out side radiation intensity comes under intensity of 100 W/m^2. The day of lowest radiation intensity is 14.92W/m^2 and lamp running time is 363.5 minutes. On the other hand the day of highest radiation intensity is 169.75 W/m^2 and lamp running time is 140.58 minutes.





RESULT AND DISCUSSION

From the regression equation of Fig. 4 and Fig. 5, we investigated the radiation intensity in the greenhouse. The y section of the regression equation of Fig. 4 is 20.481, in that case, the calculation lamp running time shown in Fig. 5 is 407.82 minutes. On the other hand, when the outside radiation intensity was 150 W/m^2, the lamp running was 155.49 minutes, in that case, the calculation inside radiation intensity was 66.981 W/m^2 on the regression equation. As the amount of the supplemental lighting increased in proportion with lamp running time, when the radiation intensity is 150 W/m^2 we could estimate amount of the supplemental lighting is expressed 20.481/407.82 × 155.49=7.81 W/m^2, and the transmittance of the outside radiation to the inside is 59.171/150=0.3944, we can say 39% outside radiation come to the inside. By using this measured transmittance, we can calculate the natural radiation reaching inside the green house. The result is shown in Fig. 6. The difference of two parallel graphs shows the effect of supplemental lighting. The amount of supplemental lighting was high rate in the day of low natural radiation calculated. This figure shows the effect of supplemental lighting. We can conclude admit the amount of inside radiation was supplied as much supplied the natural radiation.

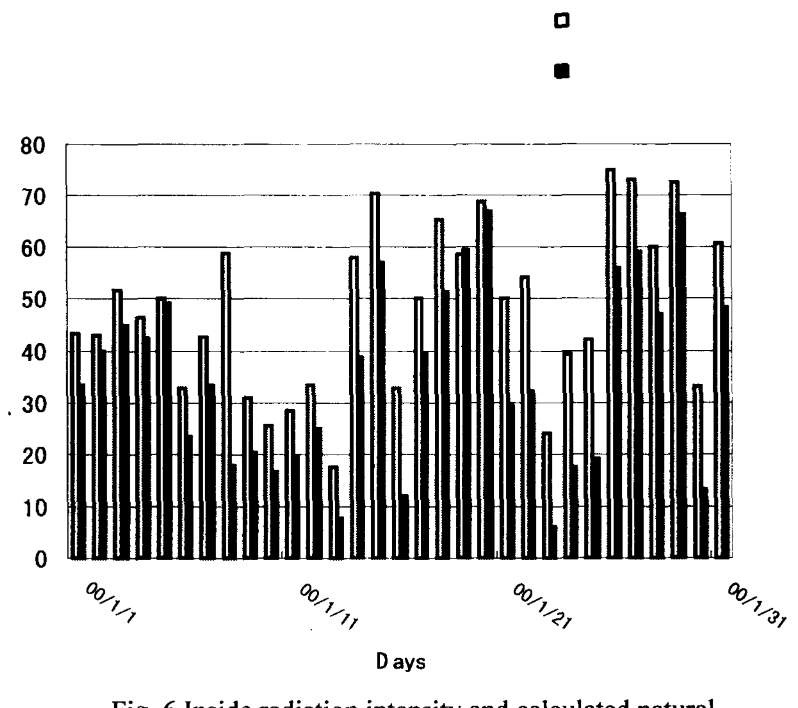


Fig. 6 Inside radiation intensity and calculated natural radiation in the greenhouse.

CONCLUDING REMAEKS AND FUTURE STUDY

This plant factory supplies the lettuce to major department and supermarket in Osaka and Kobe, where has a large consumer, and cultivations are transplanted systematically. The production as the number of pack is shown in Fig. 7. Fig. 7 shows production for

January. From 1st Jan to 3rd Jan the plant factory closed, started 4th Jan. The production of Mari Gold (MG) increased 4th 5th 6th Jan to compensate the closed date. Since then, the shipment of MG were 700-1000 pack/day, Green Rose (GR) and Frill Ice (FI) were 400 pack/day. We should investigate proper supplemental lighting to correspond these commercial products.

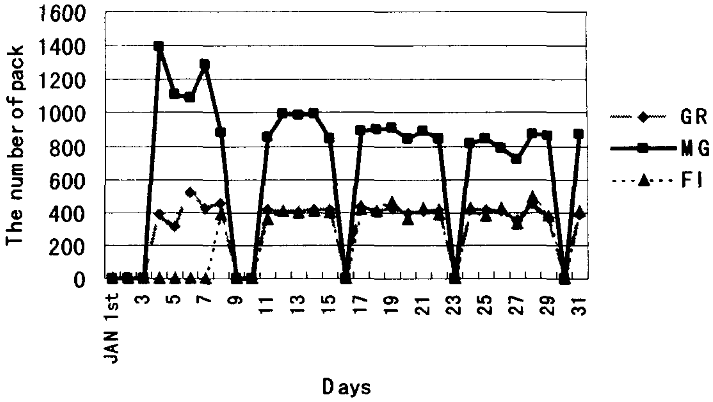


Fig. 7 Production of plant factory.

For the future, we should investigate the production amount and the supplemental lighting. The cultivation period is about 24 to 30 days and we need to investigate what kind of parameter does the radiation intensity have and how does it effect to the production amount. In addition, the plant factory is environmentally controlled, however quite different from the experimental phytotron. The temperature and humidity is not actually controlled stable. We are thinking the feasibility of neuro model to this complicated system. Fig. 8 shows an example of neuro model for this system. The plant factory used in this study was equipped with a computerized data acquisition system to gather climatic and greenhouse environment data and all environment control data, including supplemental lighting control sequence data. Some elements closely related to plant growth were selected from the logged data and used as input parameters in a neural network. This neural network model could be useful to estimate the profit resulting from the operation of supplemental lighting.

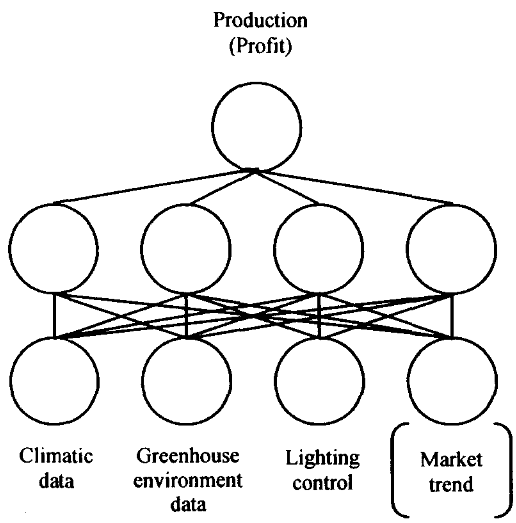


Fig. 8 Neuro model for plant factory optimization.

REFERENCE

1. T.Akamine et al.2000. Lighting Environment Control for Plant Factory Optimization.