# Growth Chamber and Cabinets at the Institute For Agricultural Research, Tohoku University

By YOSHIHARU ODA* and SHOICHI MUSASHI**

Head,* and Research Assistant,** Plant Physiology Division,
Institute for Agricultural Research, Tohoku University

The control of various factors in the plant environment offers a powerful tool for the study of growth and yield. This approach gives attractive opportunities in the fields of research ranging from the fundamental aspects of plant physiologiy, ecology and genetics to applications of immediate importance in plant breeding and production.

Environment in its broadest sense includes both soil and climatic factors. Since the time of *Justus von Liebig* our knowledge about the effects of soil has greatly increased. Apart from the soil condition the present approach is primarily devoted to climatic factors in the air.

Studies on plant environment cover an immense field, not only because there are so many factors, but because each separate factor is subjected to an almost infinitive number of quantitative variations, there being a constant interaction between all factors.

A change in one factor influences the action of most of the others and in many cases it is almost impossible to ascribe certain definite effects to an isolated factor without considering the others. The most important factor at any given moment is the limiting one, and any factor can sooner or later become limiting.

Therefore, studies on the quantitative character of plant growth and development demand the use of a controlled environment. The first systematic plan of controlling environment was made in California by Went in 1943,[1] who constructed airconditioned greenhouses in which higher plants could grow under given temperature and humidity. These greenhouses were evolved in the well-known "Phytotron" in which practically all environmental factors were under control.

In Japan, though a little too late, some have been established in the universities, research institutes and national agricultural experiment stations.[2]

To advance the studies on growth and development of rice and other plants in the districts of cool summer in Japan, which have been one of the main approaches in our institute, we began to construct in 1954 an air-conditioned dark room with special caution laid upon artificial light, being not an air-conditioned greenhouse that has ever been used.

From 1955 to 1960 the greatest part of the laboratory was installed, and preliminary experiments were made in it, with satisfactory results to some degree.[3] That is, the attempt promised that rice plants could be grown normally throughout their whole life cycle under the artificial conditions.

However, there were still some unsatisfactory points left in obtaining higher light intensity with precaution focused on spectral regions. Various types of high pressure mercury-vapour and iodine lamps were added to florescent and reflector ones to increase intensity of light with effective spectral regions for plant growth and development. Thus, the installation was completed in 1962, though not entirely satisfactory, for the purpose of studying the growth and development of rice and other plants.

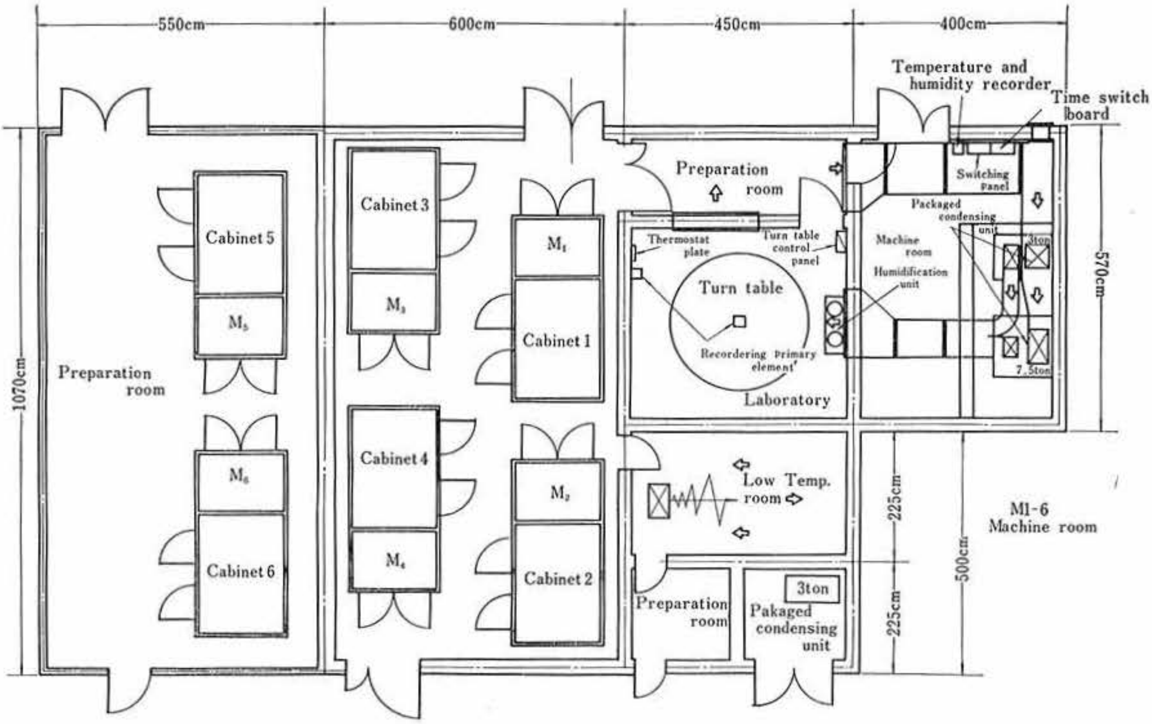


Fig. 1. Plan of the Laboratory.

In the present paper, the outline of the installation will be mentioned with special reference to the illumination of artificial light.

The laboratory of Growth Chamber, one stored, measures about 43 m² in area, including a machine room (24.5 m²), an experiment room (13.2 m²) and a preparation room (5 m²). The experiment room including six Growth Cabinets is attached. The plan of the laboratory is shown in Fig. 1.

In the experiment room of Growth Chamber, temperature and humidity—there still remain some unsatisfactory points even at present as to the latter—, are, needless to say, controlled, but special caution is laid upon the regulation of light conditions, only artificial light being adopted for illumination.

Furthermore, as night temperature is a very important factor for the growth and development of plants, an automatic controlling apparatus is used for the exchange of both the temperature and humidity corresponding to the illumination or dark period. Thus, it is characteristics of the installation that three conditions such as light, temperature and humidity can be controlled at will, though confined within narrow limits.

As to the day-length, an astrodial time switch is used for reproducing the natural day-length condition throughout a year, and a time switch for producing the illumination or dark period as required. The regulators to control automatically temperature and humidity in the illumination or dark period are independent and they are made to be operated with the time switches.

The range of temperature under control is 10 ±1.5°C∼35 ±1.5°C and that of humidity is 40 ±10%∼80 ±10%.

For the illumination with artificial light, a lamphouse is equipped on the top of the room and a paired glass is inserted under it to remove heat rays. The room is planned to be illuminated intensively by such lamps as florescent, high pressure mercury-vapour, iodine and reflector ones with reflecting screens which

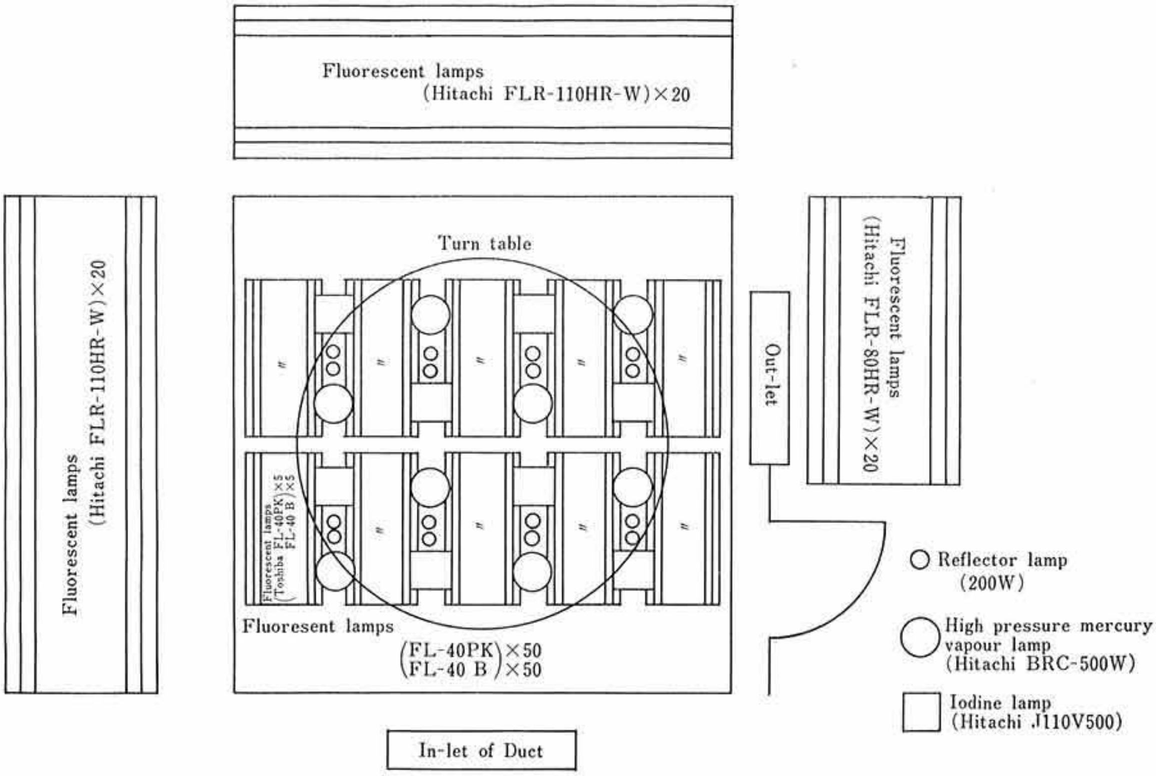


Fig. 2. Arrangement diagram of illumination lamps in Growth Chamber.

are fixed on the lamphouse and side walls. The arrangement of the lamps is briefly shown in Figs. 2, 3 and 4.

A turntable is set at the center of the experiment room. It is made to rotate once per five minutes, so that the plants under experi-

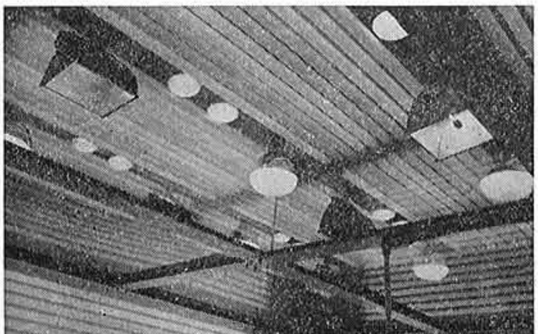

Fig. 3. Arrangement of illumination lamps on the ceilling of Growth Chamber.

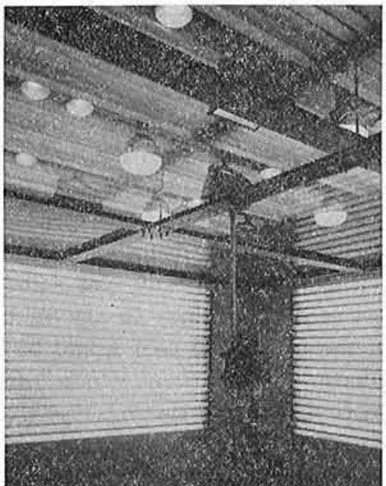

Fig. 4. Arrangement of illumination lamps on the ceilling and sidewalls in Growth Chamber.

ment may be placed uniformly as to light and temperature. In addition, a heater with thermostat is attached to control the soil and water temperature in the pots.

The light intensity is about 25,000 lux at full illumination at the surface of the turntable and can be regulated at six grades ranging from 6,000 to 25,000 lux. The distribution of light intensity on the surface of the turntable (52 cm above the floor) was measured by using Toshiba Co.'s illuminometer Type SPI-1, the surface of the photoelectric cell being always kept horizontal. The result shown in Fig. 5

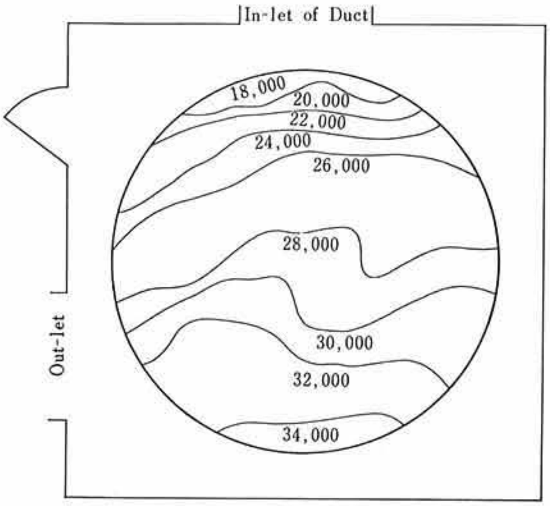


Fig. 5. Equiluminous curves on the surface of turntable in Growth Chamber (Lux).

indicates that the light intensity which plants receive varies according to their place on the turntable.

Although the rotation of the turntable is of great service without doubt in order to distribute intensity uniformly, yet some differences between the values in the middle and those in the peripheral part would be difficult to eliminate.

In addition, by using Iio Co.'s Spectro Photometer Type SRP-1460 the spectral energy distribution was measured, ranging from 400 to 700 mu of artificial light which consisted of several kinds of sources mentioned above. Measurement was made at the center of the surface of turntable. As shown in Fig. 6, the

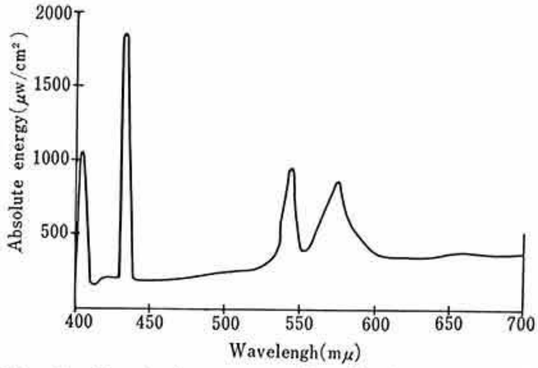


Fig. 6. Spectral energy distribution curve in Growth Chamber.

bright line spectra from the mercury discharge are clearly found in the spectral curve, and their relative energies are, for the most part, much more intense than those of continuous part of the spectrum.

The line spectra from 500 to 600 mμ seem to be not so useful for light reactions such as photosynthesis and photomorphogenesis. The arrangement of light sources such as special lamps having much higher peaks in effective regions (blue, red and far-red portions) is expected in the near future.

Thus, though small in scale, the present installation was constructed with an effective combination of apparatuses obtainable which could reproduce various climatic factors, including special light conditions. It has also proved to meet the requirements satisfactorily, through the operation for several years.

As was already shown in Fig. 1, right, the laboratory including six Growth Cabinets is attached to the Growth Chamber. The experiment room of each Growth Cabinet measures about $3.75\ m^2$ $(2.27 \times 1.65\ m)$ in area and 2.27 m in height.

The ranges of temperature and humidity under control are almost same as those in the Growth Chamber. A lamphouse is equipped on the top of the room and a paired glass or a coloured plastic filter (Nagahama Jushi Co.) is inserted under it to remove heat rays or to get a narrow range of wave length, as shown in Fig. 7.

The arrangements of the light sources and

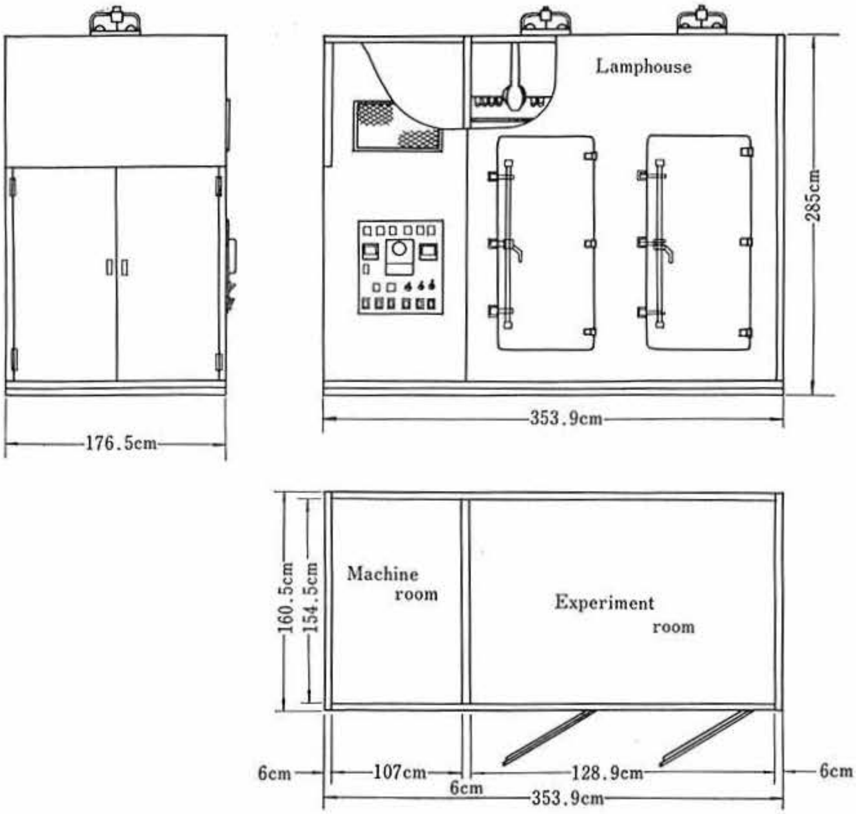


Fig. 7. Diagram of the Growth Cabinet.

the spectral energy distribution curves at the center of the experiment rooms in Growth Cabinet Type 1 and 2 are shown in Figs. 8, 9 and Figs. 11, 12 and 13, respectively.

These installations are now used to advance studies on the spectral dependence of photomorphogenesis in higher plants.

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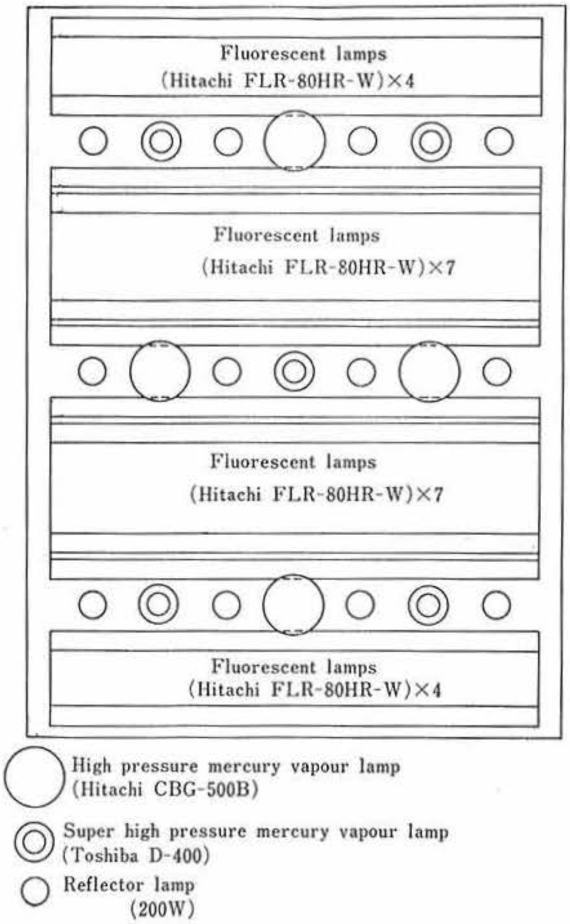


Fig. 8. Arrangement diagram of illumation lamps in Growth Cabinet Type 1.

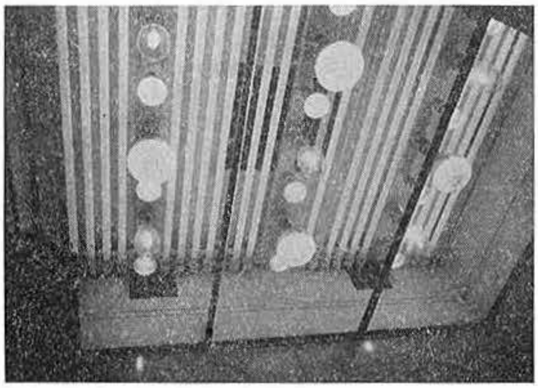

Fig. 9. Arrangement of illumination lamps in the lamphouse in Growth Cabinet Type 1.

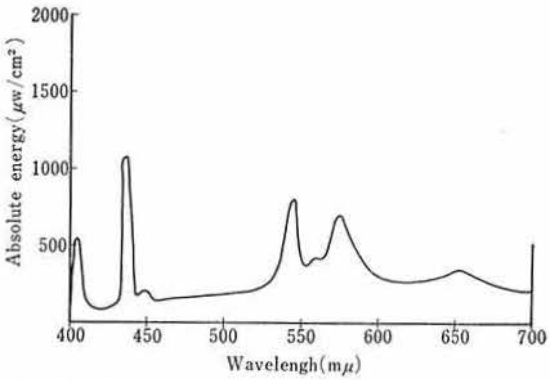


Fig. 10. Spectral energy distribution curve in Growth Cabinet Type 1.

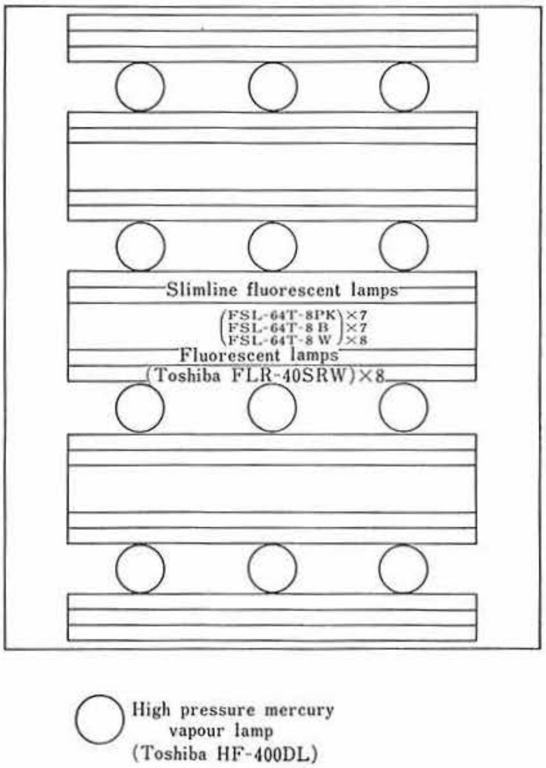


Fig. 11. Arrangement diagram of illumination lamps in Growth Cabinet Type 2.

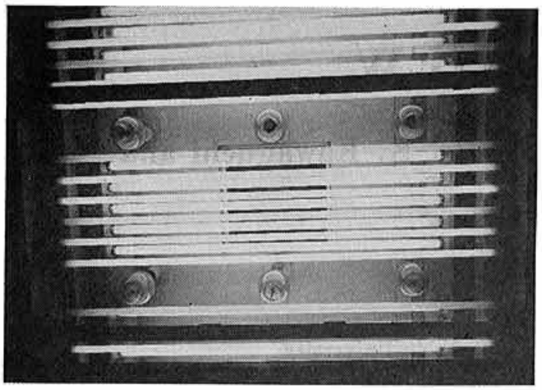

Fig. 12. Arrangement of illumination lamps in the lamphouse in Growth Cabinet type 2.

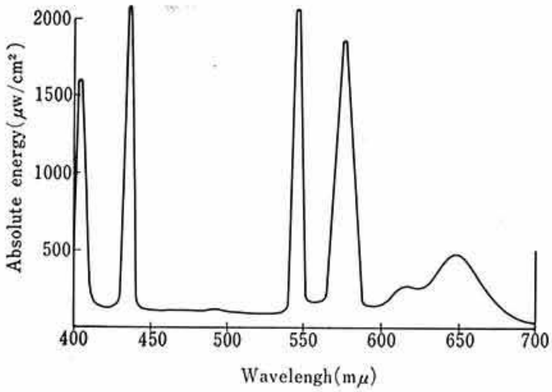


Fig. 13. Spectral energy distribution curve in Growth Cabinet Type 2.