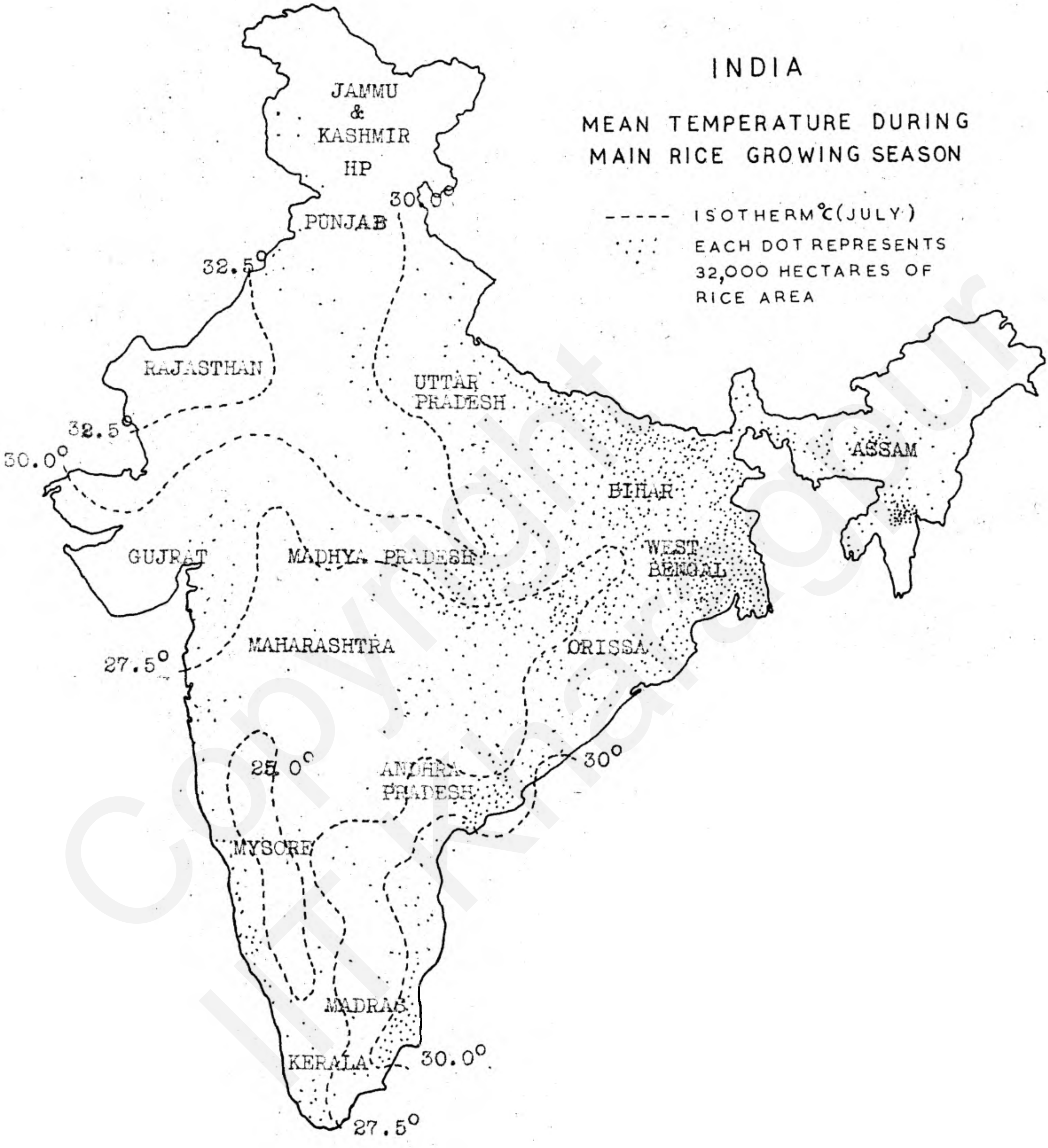
CHAPTER I

INTRODUCTION

The average yield of rice in India, as also in other countries of Asian tropics, is low even under good soil and water management practices. This is often attributed to the lack of adequate light intensity in the rice culture season which coincides with the period of monsoon rains. Recent evidences do not fully reconcile with this view (Papadakis, 1967). Even under highly controlled laboratory condition, energy capture efficiency of the plant has been obtained to be not more than 35 %. CO_2 content of the atmosphere is generally said to be a limiting factor. Most probably, the low yield results from unfavourable temperature conditions. This is very well exemplified by the yield data obtained from the localities having different temperatures during growing season. The Taiwanese rice variety grown in Kashmir Valley with the temperature range of 21° to $27^{\circ}C$ yields twice as much as in Cuttuck (Orissa) where the temperature during the growing season is above $32^{\circ}C$ (Nagai, 1958).

The main rice producing area in India, as shown in the map, lies in the coastal region, in the interior river basin and in the hilly regions of the north. High temperature during culture season (July - October) in the greater part of this area, particularly during night, creates unfavourable photosynthesis - respiration balance. Summer temperature during April to June is highly desiccati


INDIA
MEAN TEMPERATURE DURING MAIN RICE GROWING SEASON
ISOTHERM °C (JULY)
EACH DOT REPRESENTS 32,000 HECTARES OF RICE AREA
JAMMU & KASHMIR
HP
PUNJAB
RAJASTHAN
UTTAR PRADESH
BIHAR
ASSAM
WEST BENGAL
GUJRAT
MADHYA PRADESH
MAHARASHTRA
ORISSA
ANDHRA PRADESH
MYSORE
MADRAS
KERALA
30.0°
32.5°
32.5°
30.0°
27.5°
25.0°
30°
30.0°
27.5°

for rice growth. The maxima may shoot up to 50°C and above (Figure 1). Temperature condition during the spring season (January to March), however, approaches that of the temperate region but cultivation is limited due to lack of water. In the hilly region, the summer temperature is much cooler and, therefore, more favourable for rice growth than in the plains but the severe cold precludes the cultivation in the winter months. It is, thus, apparent that the temperature condition in the larger part of the rice area is not conducive to best rice growth and has limited the scope for the adoption of multiculture i.e. growing two to three crops in succession. Where temperature is favourable, as in Mysore plateau of South India situated at 3,000 ft from sea level, rice is grown as an important crop in all seasons.

Temperature generally receives recognition as a climatic factor and much less as a soil edaphic factor. This is unfortunate as the root system, which sustains plant growth by absorption of water and nutrients, is exposed to soil temperature which is different from aerial temperature. The temperature of submerged soil in which rice is grown, has been observed to be 10° to 12°C less than that of aerial temperature in summer during day time (Figure 1). Such a difference in temperature between root and shoot environment of a growing plant may be of consequence and merits attention. In the context of plant growth, the importance of soil temperature could be well realised from the fact that the whole series of reactions in the soil are dependent on temperature. Under submerged conditions, abundance of water creates a reducing environment.

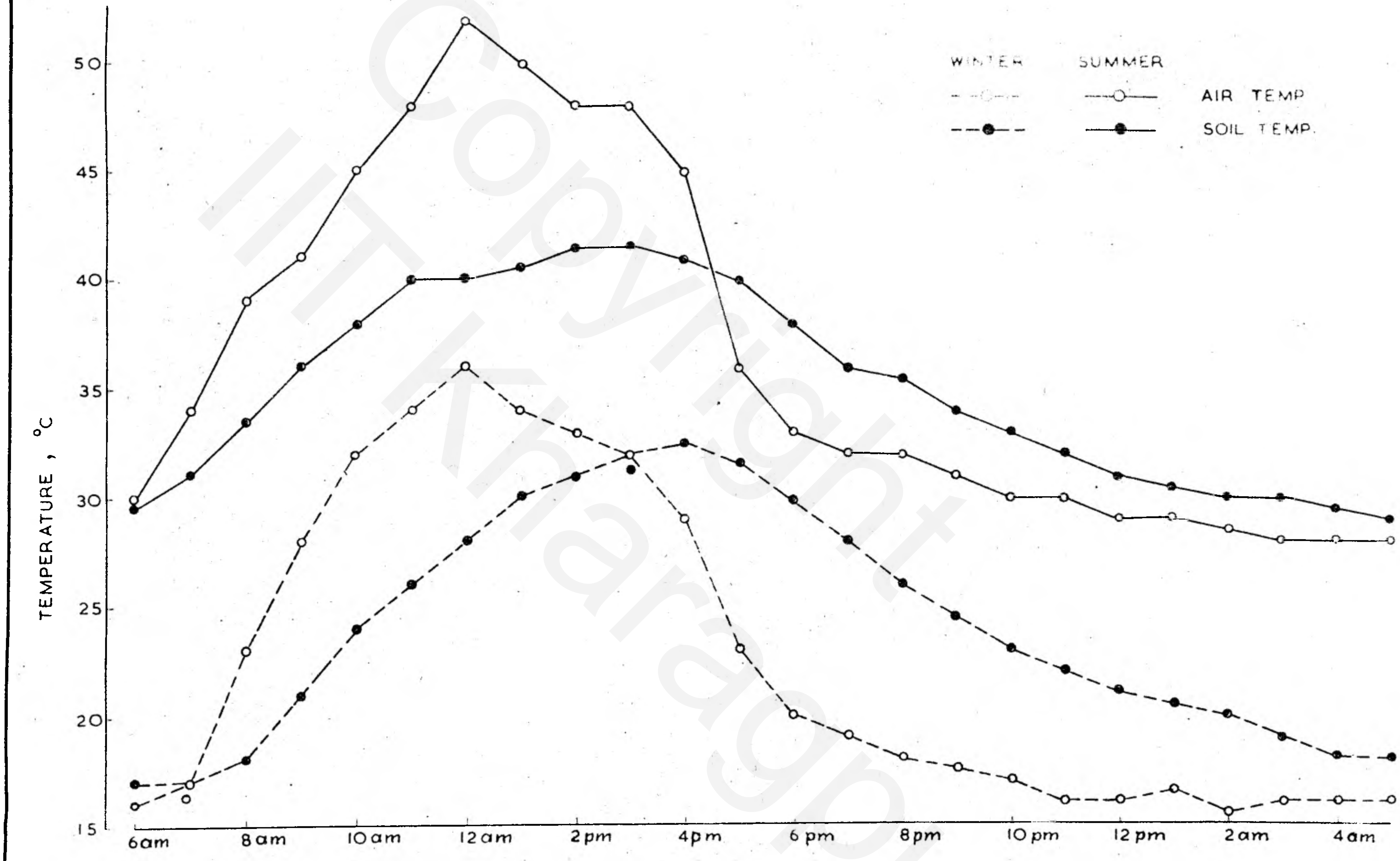


FIG. 1. VARIATION IN AIR TEMPERATURE AND SUBMERGED SOIL TEMPERATURE DURING WINTER (JANUARY 1 TO 2, 1967) AND SUMMER (MAY 27 TO 28, 1967)

The temperature, being an intensity factor, affects the rate process and thereby, alters the chemical environment of the soil. Secondly, addition of organic matter through decaying roots of the growing plants and its subsequent decomposition becomes intensified at high temperature. The resultant toxic products make the soil environment increasingly inhibitive for root growth and root activity (Nojima and Tanaka, 1966). At low temperature, increased gas solubility may be a favourable factor for root activity of the plant.

Besides those processes that supply nutrients to the plant, normal growth processes of the plant itself from seed germination to maturity are affected by temperature. The depressing effect of soil temperature is also asserted upon enzymic products causing rate limitation or rate imbalance, and upon substrate availability by decreasing intracellular gas concentration, changing permeability, transport efficiency and organelle function (Langridge and Mc William, 1967). Some of the vital organs of the plant, such as tiller and panicle primordia, develop at the lower portion of the stems which remain bathed under water. It is natural that they will be affected by the temperature of the bathing medium. Some Japanese workers (Matsushima et al., 1964; Tsunoda, 1964) have laid particular stress to this aspect of temperature response.

The effect of water and soil temperature on rice growth and yield has been studied for quite a long time by Japanese workers (Sato, 1960; Takamura et al., 1961). It is only recently that the effect has been isolated from that of aerial temperature by controlled temperature studies (Chapman and Peterson, 1962; Matsushima et al., 1964; Tsunoda, 1964).

These studies have shown that rice plant is more responsive to water and soil temperature than to aerial temperature. This information is of great consequence from the point of manoeuvrability of water and soil temperature in the field. In Japan, the temperature of rice fields is controlled by regulating water depth or by changing periods of irrigation and interval of drainage practices. Dressing of carbon black and mulching with rice straw and grass leaves have also been tried with success (Sato, 1960).

In India, monoculture is being practised over a large part of the rice area. The rice varieties generally grown are short-day plants which the farmers have selected over the centuries as plants that matched the rythm of the monsoon rains. This practice is not going to solve the growing demand for rice production. The solution lies in the adoption of multiculture practice. Now, the technological advancement has increased the possibility of irrigation in larger part of the rice area. High yielding rice variety such as Taichung (Native)1 is being introduced for intensive cultivation. Some of the characteristics of the plant such as early maturity, photo-nonsensitivity, non-lodging habit and tolerance to heavy dose of nitrogen with increase in yield make it more adoptable for intensive cultivation and multiculture practice in the tropics. If the limitation in rice culture due to unfavourable temperature conditions is even partly overcome by ameliorating soil temperature, it will be possible to adopt multiculture over an extensive area. Before any rational attempt in this direction is made, an understanding of the relations of growth and yield characteristics of the rice plant with soil temperature is but necessary. Such information is scarce in tropical region, more particularly in India.

With the above objectives in mind, the present investigation was undertaken. A general study was first made to observe the growth and yield response of rice plants to varying temperatures and other meteorological elements during the year. The study showed three broad temperature regimes : low, medium and high, which caused considerable variation in grain yield. It was also clear that the effects of unfavourable temperature regimes on plant growth are more damaging only for the periods when the extreme temperatures prevail and that the severity of temperature depends on the growth stage of the rice plant. The effects of seasonal temperature regimes on growth and yield were further examined from the edaphic point of view with reference to the plants grown under specific seasonal temperature regimes. Subsequently, the effects of controlled soil temperature regimes on growth and yield of the rice plants were studied whereby the effects of soil temperature were isolated from that of aerial temperature. The soil temperatures were regulated to follow a definite cycle. This was imperative in view of cyclic nature of temperature variation under natural condition (Figure 2).

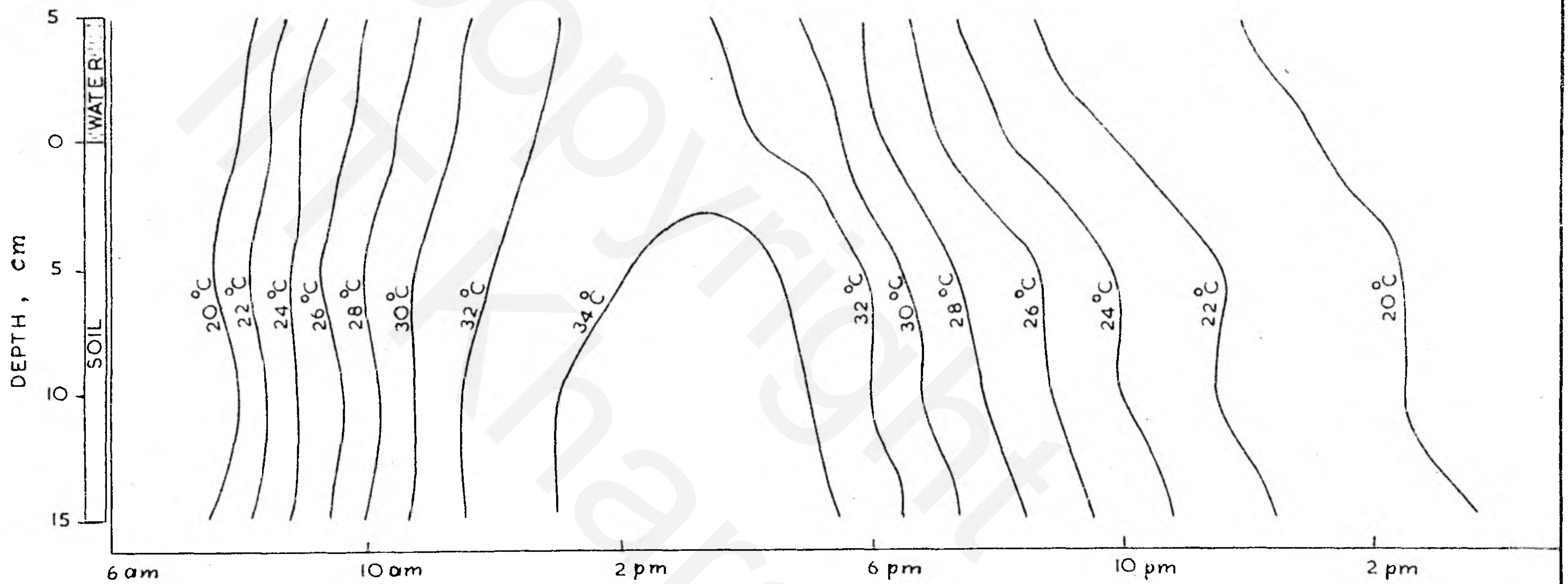


FIG. 2. DIURNAL VARIATION IN SUBMERGED SOIL TEMPERATURE UNDER NATURAL CONDITION. FEB 12-13, 1965. (POT STUDY)

This enabled a valid comparison of the results with that of the natural condition. Past studies attempting to assess the effect of water and soil temperature on plant growth, controlled at constant temperature level, have suffered from failure to meet this requirement.