INTRODUCTION

Rice(*Oryza sativa* L.) is one of the most important crops of India and is the main crop of the eastern region. It alone covers nearly 72 percent of the cultivated area in the State of West Bengal. Its cultivation in India extends from 8° to 35° N latitude and the crop is grown under widely varying conditions of rainfall, altitude, and climate. Rice has a remarkable character that it grows both under water-logged and well drained soil conditions and over a wide range of soil reaction ranging from pH 4.5 to 8.0.

Various factors namely situation of the land, type of the soil, variety of rice, season, intensity and distribution of rainfall, irrigation resources and special agronomic features influence and determine the system of cultivation. There are three principal systems of rice cultivation prevalent in India, namely dry, semidry and wet.

Dry and Semi-dry Cultivation :

The land is ploughed a number of times in the summer month of May and June to obtain the necessary tilth, manure is spread and seed broadcast or drilled. The greater the number of ploughings the better is the tilth obtained (Pillai 1958). The fine seed bed greatly facilitates

drilling, dibbling or broad cast-sowing operations and gives a good start to the crop. Generally 8 to 10 ploughings with a country plough at frequent intervals are considered desirable.

In the semi-dry system, the preparatory cultivation is the same as that adopted for the dry system and seed is broadcast. Usually, in July - August, when the south-west monsoon is active, rain water is impounded in the fields and the young crop of five to six weeks is ploughed crosswise with a narrow wooden plough with about two inches of standing water in the field and planked. The crop recovers and grows vigorously.

Wet System of Cultivation

In the wet system, the land is thoroughly ploughed with a country (wedge type) plough or iron mouldboard plough with two to three inches of standing water in the field. The field is ploughed repeatedly, three to four times with an interval of about four days between each ploughing, and levelled before planting. This process of ploughing with standing water is known as puddling. The puddling is considered essential for the following reasons -

1 It provides a soft seed bed which facilitates the transplanting. The seedlings on transplanting in soft

puddle are invigorated and they put forth fresh roots in all directions. The root system is thus extended and enables the seedling to utilize the food material from all round the area.

2 It helps eliminate weeds which have already sprouted.

3 It reduces the hydraulic conductivity of the soil and hence impounding of water is easy.

4 The reduced hydraulic conductivity decreases the leaching and washing down of the nutrients from the top soil.

5 It helps to set up high redox-potential and this reduced condition is considered congeneal for the rice crop.

In wet system of rice-cultivation there exist two practices of flooding the soil. In some parts, paddy fields are flooded and are intermittently drained and in others the fields are kept flooded throughout the growing season.

A close examination of these practices reveals that it is not yet known which of the wide variety of physical, physico-chemical and biological reactions that

are initiated in the soil due to the adoption of these different systems of cultural practices, are best suited for rice growth. It is now well-known that the physical edaphic factors that influence plant growth are soil moisture, soil air, soil temperature and mechanical impedance. It appears that every crop needs an optimal condition for the best growth. It means that each crop has a specific requirements of air, water, temperature and mechanical anchorage.

If these soil and plant parameters are well defined within a certain range, it is possible to create the same under field conditions. A knowledge of these parameters is the most important tool in the hands of an engineer to design an implement required for a particular tillage operation. For instance, if the seed drill is to be designed for some crop, it is a pre-requisite to know the physical requirement of the seed for germination and seedling emergence. The quantitative information regarding the physical condition of the soil that should be provided around the seed and the seed placement depth, is essential. Similarly unless and until the optimum soil physical conditions for rice growth are clearly understood, it may not be possible to design a puddleror wet land cultivator which would create the desired physical conditions.

The physical conditions of soil may affect the crop directly or indirectly. Many a times, it may not have a direct bearing on the crop growth but it does influence the soil environment as a whole. In rice soils, submergence of soil which sets a reducing condition, has a remarkable bearing on the crop growth. This reducing condition governs the chemical kinetics of paddy soils, which in turn, controls the availability or non-availability of nutrients to the plants.

This knowledge of the physical conditions of the soil helps one to know the degree and the way of soil manipulation so that excessive tillage may be avoided. For example, if the conditionsthat are required for the good rice growth are known, it may not be necessary to give 8 - 10 ploughings with a country plough. This will further help to minimise the cost of tillage.

The four physical edaphic factors that are dependent on the physical conditions of the soil are so closely interrelated that it is difficult to isolate one from the other. In view of this complex situation it is difficult to appraise the soil physical condition completely with one method only. However, soil bulk density measurements are frequently used for the appraisal of the physical conditions of the soil. According to Vomocil (1957),"Bulk density data are readily interpretable in terms of

fundamental soil properties and properties which affect plant growth." This statement explains the importance of soil bulk density measurements in plant growth studies.

Bulk density measurement is also at present one of the best methods used to evaluate the tillage practices. Soil bulk density is defined as the mass of dry soil per unit bulk volume. The bulk volume includes both solids and pores. Any change brought about in the bulk density, therefore, alters the soil air-water retention and movement, thermal conductivity and capacity and mechanical strength. It follows that every crop should have an optimum bulk density which would provide the necessary physical, chemical and biological environment for the maximum crop growth. Optimum bulk densities and air-void ratios for some crops have been reported by Vomocil (1955).

The above discussion poses the question "Is there an optimum soil bulk density for rice crop" ? or " Is there such a range of soil bulk density which would provide the desirable soil physical conditions that are congeneal for the rice growth"?

An answer to these questions was an attempt made in the present investigation to study the effect of varying bulk density in order to find out the optimum soil physical conditions as appraised by the bulk density. Various levels

of the soil bulk density ranging from 1.3 g/cc to 1.8 g/cc were obtained by compacting the soil in the iron cylinders. A suitable technique was developed for the soil compaction. The experiments were carried out in the iron cylinders on the Farm of Agricultural Engineering Department, Indian Institute of Technology, Kharagpur, West Bengal. Some experiments were conducted in the laboratory under controlled conditions of moisture and temperature.

The effect of varying levels of bulk density on the physical properties of the soil before and after the crop growth was studied. It enabled to know the magnitude of changes brought about in the physical conditions of the soil due to the variation in the bulk density. Later on, this helped correlate them with crop growth and find out the factors that affected the growth most. The optimum seed placement depth and bulk density around the seed for the maximum seedling emergence was found out. This was determined in the laboratory under optimum conditions of moisture and temperature. The experiments were carried out to study the effect of varying bulk densities on upland rice (variety Dular) and low land rice (variety Rupsail). Seedling emergence and the other growth components namely height of the plant, number of tillers, dry matter and grain yield were studied and correlated with the physical properties like soil hardness, penetration force, aeration

porosity, capillary porosity and hydraulic conductivity. Since the soil physical properties also influence and determine the availability and uptake of nutrients, nitrogen, phosphorus, iron and manganese contents of the grains were determined. The amount of nutrients available for the crop depends on the root proliferation which in turn, determine the feeding zone. Therefore, the rice root proliferation was studied under various levels of bulk density at different growth stages.