CHAPTER - V

SOIL AND AGRICULTURE
Introduction

The influence of climatic factor on agricultural activities in the district has been underlined in the previous chapter. The type of crops grown in the district and fluctuation in yield of the main crop i.e aman are very much functions of the seasonal rhythm of temperature and rainfall. Next to climate the most important physical element influencing agriculture is soil. Successful crop cultivation requires suitable fertile soil. Fertility of the soil is again the function of its physico-chemical characteristic viz. mechanical composition or texture, structure, organic matter, soil reaction, base exchange capacity and above all the presence of nutrients. Soil moisture and soil air are much controlled by texture. They greatly determines the nature of crop to be grown in a particular soil. Organic matter, one of the important constituents of soil greatly influences crop cultivation. In addition to its control over soil moisture and air, it provides the soil with enormous essential plant nutrients. The inherent fertility of the soil greatly depends on the nutrient content of it. The greater the presence of plant nutrients in the soil the greater is its fertility and hence such a soil requires less input of fertilizer to have maximum return. The availability of nutrients for plant growth does not
only depend on the nutrient content of the soil, but also on the nature of soil reaction ie alkaline, acidic or neutral.

In this chapter an attempt has been made to reveal the spatial variation of some important physico-chemical characteristics of soil viz. texture, soil reaction, soil nutrients (Nitrogen, potassium, phosphorus) and organic matter content. In the succeeding part in order to show the dependence of crop yield on the soil the yield of aus paddy has been correlated with the aforesaid constituents and the physico-chemical properties of soil. Last of all an attempt has been made to classify the land according to its capability to produce crop. Before discussing all those points it is imperative to have broad generalised picture of soil condition of the district and the soil profile.

**General Characteristic of Soil**

For planning land utilization, the Directorate of Agriculture, Government of West Bengal recently carried out a systematic study of the genesis and constitution of different types of soil occurring in the district. The pedological investigation was based on Kellog's method as suggested by the Indian Council of Agricultural Research and is popularly known as the 'Reconnaissance Soil Survey' under 'Stewart's Scheme (1952-56)'. By examining the morphology of soil as expressed in
its profile at every six miles, a soil map was prepared. According to this observation the soil of the district may be classified into two groups namely red and alluvial groups. The alluvial soils are classified into two families namely the Ganga alluvium and the Damodar alluvium. Soils of each family are again subdivided into six associations viz. (i) Ganga riverine, (ii) Ganga flat lands, (iii) Ganga low lands, (iv) Damodar riverine, (v) Damodar flat lands and (vi) Damodar low lands.

Red Soils: They occupy a small area in the Western half of the Goghat police station. They are mildly acidic, poor in calcium, nitrogen and phosphorus, light in texture and porous. They respond well to irrigation and produce a good crop of boro paddy, wheat, gram, etc with a moderate application of phosphatic and nitrogenous fertilizers.

Ganga Riverine Soils: These soils occur in northern and eastern parts of Polba and Chinsurah police stations and are divided into two phases - inundated (young) and high land (early maturity stage). In its inundated phase the water table is very high and the profile development shallow and immature. These characteristics are noticed in the char lands adjacent to the Bhagirathi, the Saraswati, the Behula, and the Kunti which remain submerged during the rains and the annual deposit of silt
Keeps up their fertility. Wherever such silt deposit occur the cultivation of early aus (autumn rice) water melon and patal (Tricyosanthes dioica) thrives without irrigation. In the high land phase the soils are of brownish colour due to soil wash, hydrolysis and oxidation and the subsoil is usually composed of sand which is grey to greyish white in colour. Such soils occur in the old and comparatively higher river banks and support a variety of riparian crops.

Ganga Flat Lands: These soils, occurring in the eastern part of Jangipara, north western part of Chanditala and central part of Balagarh police stations display a slightly immature profile. Here some illuviation of clay has taken place at the lower layers and the subsoil is getting enriched at the expense of moderate leaching of top soils. The soil types vary from clay to sand depending upon the difference in micro-topography and at places they are calcareous.

Ganga Low Lands: The soils occur in the south-eastern parts of Haripal, Singur and Chanditala police stations and are characterized by profiles having clay at the top and light subsoils which occasionally consist of riverborne coarse sand with calcium carbonate deposits. These lands present maximum irrigational difficulties inasmuch as the region comprises abandoned river beds and silted up hills and gets inundated during
the rains. The subsoil generally consists of silty clay and has a good percentage of sodium saturation in exchange complex.

**Damodar Riverine Soils**: This association occurs in the south-east, east and north-east parts of Goghat P.S., in the whole of Arambagh P.S. excepting some patches to the north and in the South-east corner, in Pursurah, Tarakeswar, in Dhaniakhali excepting its south eastern part, in the central and north-western portion of Jangipara, in the south-west and the north-west of Haripal, in the northern part of Singur, in the eastern part of Polba and in Pandua excepting some parts in the south. The soil displays an immature profile development with irregular sequence of sandy layers which are very often coarse and yellowish brown in colour. These tracts had an inundated phase leading to the development of large swamps at places or the deposit of laminae of sandy top-soils along the braided channels.

**Damodar Flat Lands**: This soil association occupies almost a flat topography and is now out of reach of floods from which the Damodar riverine lands suffer. It occurs in the West, north, west and south-west parts of Goghat P.S., in the south-western parts of Arambagh P.S., north-western parts of Khanakul, western half of Jangipara, south-western section of Dhaniakhali, north-eastern corner of Haripal, in a small part of Singur, in the West-central and north-western parts
of Polba, northern parts of Magra, south-western parts of Balagarh and in the southern portion of Panduah police station. Distinct soil horizons are not found in these soils, although the soil profile displays distinguishable layers by their colour, moisture content and other physical characteristics. There is very slight illuviation of sesquioxides in the lower layers. Calcium, potassium and clay indicate that a process of leaching has started, and as a result of all these, the surface has turned slightly acid. There are occasional dlomitic concretions of fairly big sizes occurring at random in the profile. The manner of distribution of these concretions indicate that these are floodborne deposits and have not formed in situ. Brown iron concretions also occur in lower layers which do not effervescence with hydrogen peroxide indicating absence of manganese. In the trans-Damodar area which is beyond the canal-commanded zone, such soils range from clay-loam, sandy-clay-loam to loamy sand and sand. Leaching by irrigation water reduce the low calcium status resulting in greater acidity. Application of phosphate with nitrogen in the case of grain and potash with nitrogen in the case of jute is necessary to ensure optimum production.
The Damodar Uplands: This association occurs in a limited area in the extreme north of Arambagh police station. Here the soils have mature profiles. Illuviation of clay, sesquioxide and calcium have taken place. Mottlings are present. Dolomite concretions occur often in thick layers. The morphology, physico-chemical properties and the situation of soil show that the problems of salinization, raising of water table and formation of swamps may not be serious problem affecting it. It is mildly acidic, partially unsaturated and has therefore a tendency to be washed away by surface currents, leading to sheet erosion. This displacement of top soil from the cultivated fields may result in loss of fertility necessitating flood protection and conservation measures.

Profile Character:

Information regarding the character of soil profiles are available for 9 samples in Hooghly district. (Table 12A to 12 K Appendix). In all cases the profiles have been investigated upto a depth of more than 50 inches (125 mm). This indicates that the soil cover in the district is enormously thick.
In most cases it is found that the properties of $\text{R}_2\text{O}_3$, CaO, clay, air dry moisture, water soluble salts and base in the soil increase with depth (Fig. 17A to 17K). The increasing proportion of clay in deeper layers, however, is not invariably associated with a reduction in the amount of coarse sand as the middle categories of fine sand and silt may greatly disturb the normal inverse correlation between the two, yet the soil in the lower horizons is usually more compact and heavier than that at the surface.

Carbon, Nitrogen, potassium and phosphorus constituents, those are responsible for the mineralo-organic nutrient status of soil do not show any definite pattern of distribution along the profile.

What is meant by above findings is that while the distribution of $\text{R}_2\text{O}_3$, clay and bases indicate the nature and amplitude of the pedogenic factors in operation that of carbon and the plant nutrients indicates the extent to which the soil has been modified either by man or by subaerial processes.

**Physico-Chemical Characteristic of the Soil**

**Organic matter**

Organic matter is an essential characteristic constituent of soils. Organic matter influences physical and
chemical properties of soils far out of proportion to the small quantities present. It commonly accounts for at least half the cation-exchange capacity of soils and is responsible perhaps more than any other single factor for the stability of soil aggregates. Furthermore it supplies energy and body-building constituents for the microorganisms. Nutrient status of the soil is very much linked with this constituent as several plant nutrients are released through the decomposition of organic matter. Moisture holding capacity of the soil also depends on amount of organic matter presents in the soil. Because of all these reasons this constituent of the soil plays an important role in crop cultivation.

Situated in tropical region the soil in the district is comparatively poor in organic matter. The organic matter content varies from 0.75 per cent to 1.99 per cent on an average. (Table 13 Appendix). The highest percentage (1.99) occurs in Balagarth block and the lowest one (0.75) in Serampore-Uttarpara block. The organic matter content gradually increases in the central part of the district constituting major parts of Singur, Haripal, Tarakeswar.
HOOGHLY
SPATIAL VARIATION OF ORGANIC MATTER
(IN PER CENT)

Fig. 18
and Pursurah (Fig. 18). The percentage is also considerably higher in south-eastern part of Balagarh, in the central part of Dhaniakhali, northern part of Khanakul and in major part of Arambagh blocks. Organic matter content is low in Panduah, Chanditala Jangipara and Goghat blocks.

Soil Texture:

Soil texture refers to the percentage by weight of each of the three mineral fractions sand, silt and clay. These fractions are defined in terms of the diameter in micrometres of the particles ranging from less than 0.002 mm to 2 mm. Particles larger than 2 mm. in diameter are excluded from soil texture determinations 6.

Soil texture is of fundamental importance to agriculture as it is one of the principal factor determining soil climate. Texture influences soil-water and soil-air, the optimum condition of which helps maximising the growth of plants. It has been shown by Fennah and Murray (1957,222-7) that crops thrive best under condition of high light intensity only when the ratio between soil air approaches 1 : 1 *.

The finding is significant as it follows from this that productivity (other things remaining constant) may not increase with increasing rainfall or water supply even when absolute supply falls short of the absolute requirement.
Smaller the porosity of the soil faster will the air be excluded from it leading to reduction in the uptake rate of rainfall and consequent reduction in yield. Soil porosity in turn is determined by the texture and structure of the soil. The texture also controls the nutrient capacity of the soil for plant growth. The finer fraction of soil, like clay and organic matter are important for their capacities to store water and plant nutrients. The finer particles also help to bind soil particles together into structural aggregates. The largest particles (usually sand) serve as a skeleton to the soil. These particles support most of the weight borne by the soil and help to make the soil permeable and well aerated.

Sandy soils are usually quite permeable to air, water, and roots, but they have two important limitations. One is their relatively low water-holding capacities; the second is that they are poor storehouses for plant nutrients. They must receive frequent addition of water and plant nutrient in order to be highly productive. The presence of a high percentage of organic matter would help to overcome these limitations.

Pore space refers to the interstitial space occupied by soil particle while porosity means the permeability of soil to water. These two properties are closely related to texture particularly the amount of clay in the soil. Lahiri and Venkataraman (1958, 80-85) working on the Bankura, Soil confirmed this.
but most sandy soils are low in organic matter. These limitations of sandy soils can of course be overcome if both fertilizers and irrigation water are available. They can be made highly productive with these additions, but the costs are large. One hazard is the loss of applied fertilizer by leaching if too much fertilizer and water are applied. The limited capacity of sandy soil to store water and plant nutrients is related to the relatively small surface area of its soil particles ie, pore space.

The surface area of clay is not only large, it is also electrically charged. The charge gives clays the capacity to hold plant nutrients or their surface in forms available to plants, but sands do not have this capacity. The loss of plant nutrients by leaching is therefore very small compared with the losses that might occur if the same amount of nutrients were present in sandy soil. Clay holds much water than sands largely because they have a large surface area to be covered with water. An amount of water that would cause leaching in a sandy soil might not wet a clay soil deep enough to cause leaching. Dissolved nutrients are lost from the soil only when water penetrates beyond the reach of plant roots and becomes drainage water. Soils containing too much clay may
have high water-holding capacity but inadequate aeration. This problem can of course be overcome if it contains much organic matter. Organic matter helps to hold the clay particles together in clusters that have air space between them. The most prevalent problem with clay soils is caused by their stickiness. When wet, they stick to plows; they are hard when dry.

Loamy soils are highly desirable for most uses. They have enough clay to store adequate amounts of water and plant nutrients for optimum plant growth but not so much clay as to cause poor aeration or to make working with them difficult. They contain enough silt to gradually form more clay and to release fresh plant nutrients as it weathers.

The preceding discussion highlights that the textural variation of soil in an agrarian sector has important influence on crop production. As such the study of spatial variation in soil texture and the respective class of soil according to its texture in the district is imperative. The words sand, silt, clay, and loam are used to name soil textures. Loam refers to a mixture of sand silt and clay that exhibits the properties of each fraction about equally. It contains less clay than sand and silt because clay properties are strongly
1. PANDUAH
2. CHINSURAH - MOGRA
3. BALAGRAH
4. HARIPAL
5. POLBA - DADPUR
6. ARAMBAGH
7. JANGIPARA
8. DHANIAKHALI
9. CHANDITALA
10. SINGUR
11. TARAKESWAR
12. KHANAKUL
13. GOGHAT
14. SERAMPORE - UTTAPARA
15. PURSURAH

Fig. 19

HOOGHLY
SOIL TEXTURE
expressed relative to the amount of clay present. The texture names corresponding to specified percentages of sand, silt and clay occurring in the district (Table 14 Appendix) have been determined from the triangle shown in Fig. 19. (U.S.D.A. System). Textural classes identified according to this system almost exactly fit with the local names suggested by the farmers of the district. The following table represents the distribution of different soil texture.

Table 1. Textural classes of soil.

<table>
<thead>
<tr>
<th>Textural Groups</th>
<th>Local names</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>Entel</td>
<td>Chinsurah - Mogra, Chanditala, Pandua, Polba-Dedpur, Khanakul.</td>
</tr>
<tr>
<td>Clay</td>
<td>Doash entel</td>
<td>Arambagh, Palsagarh, Haripal</td>
</tr>
<tr>
<td>Silty clay loam</td>
<td>Pali entel doash</td>
<td>Singur.</td>
</tr>
<tr>
<td>Silty clay</td>
<td>Pali entel</td>
<td>Tarakeswar.</td>
</tr>
<tr>
<td>Silt loam</td>
<td>Pali doash</td>
<td>Pursurah, Serampore-Uttarpura.</td>
</tr>
<tr>
<td>Sandy clay loam</td>
<td>Bele metel</td>
<td>Jangipara.</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>Bele doash</td>
<td>Goghat, Dhaniakhali.</td>
</tr>
</tbody>
</table>
Among the textural classes clay or entel predominates in the district (Fig. 20). Clay is the principal component of such soil. As such this soil is very much conducive for amin cultivation. This type of soil occurs in Chinsurah - Kogra, Chanditala, Panduah, Polba - Dadpur and Khanakul.

Clay loam or doash entel contains between 27 and 40 per cent of clay and between 20 and 45 per cent of sand. This type of soil occurs in Arambagh, Balagarh and Haripal blocks.

Silty clay loam or Pali entel doash contains 27 to 40 per cent clay and less than 20 per cent sand. Such soil occurs in only one block namely Singur.

Silty clay or Pali entel contains 40 per cent or more of clay together with 40 per cent or more of silt. It occurs in Tarakeswar.

Silt loam or pali doash contains between 50 and 80 per cent of silt with less than 12 per cent of clay. Such type occurs in Pursurah and Serampore-Uttarpara.

Sandy clay loam or bele metel refers to a type where there is even distribution of different components with
higher percentage of sand than clay. This type occurs in Jangipara.

Bele doash is equivalent of sandy loam. It contains 43-52 per cent of sand with less than 20 per cent of clay. Such class occurs in Goghat and Dhanakali.

**Soil reaction:**

The acidity alkalinity status of a soil is referred to as the soil reaction. This property of soil expressed in $P^H$ values influences agriculture both directly and indirectly. There is evidence that $P^H$ has little direct effect on plant growth. Varying the concentrations of $H^+$ and $OH^-$ ions over a wide range seems to make no difference to plants so long as other factors are kept favourable. Indirect effects however are numerous and potent. A soil at $P^H 4$ probably has enough soluble $Al^{++++}$ to be very detrimental to most plants, whereas nutrient solutions at $P^H 4$ show no such problem.

The most universal effect of $P^H$ on plant growth is nutritional. The $P^H$ value of the soil influences the rate of plant nutrient release by weathering, the solubility of all materials in the soil and the amount of nutrient ions stored on the cation-exchange sites. The $P^H$ is therefore
a very good guide for predicting which plant nutrients are most likely to be deficient. Most nitrogen and sulfur mineral compounds (except calcium sulfate) are highly soluble at any $P^H$ and subject to rapid leaching. The supply of these nutrients therefore comes mostly from organic sources and is limited by slow decomposition of organic matter. The rate of the mineralization of these elements from organic matter is fastest between $P^H$ 6 and 8. Phosphorus compounds in soils have low solubilities. A $P^H$ between 6.5 and 7.5 is usually best for phosphorus availability. Phosphates become available again above $P^H$ 8.5 because such high $P^H$ values indicate a high percentage of sodium salts. Potassium is soluble at any $P^H$ but is removed from solution by sorption. Some of it is held in exchangeable sites, but some is held more tightly. As a soil is leached and becomes acid the total potassium declines, and the amount available also declines. Iron, manganese, copper and zinc decrease in solubility at high $P^H$. Deficiency of any of these may limit plant growth in high-lime or alkaline soils. It appears therefore that a $P^H$ value near neutral is best for most plants. The availability of all the plant nutrients is at least reasonably satisfactory at $P^H$ values between 6.5 and 7.5.
Fig. 21

HOOGHLY
SPATIAL VARIATION OF SOIL \( p^H \)
Another way in which $P^H$ is related to plant growth is through the physical condition of the soil. Soil $P^H$ values above 8.5 indicate the presence of considerable $Na^+$ and the likelihood of dispersed soil colloids. Plant growth is markedly reduced where colloids are dispersed and is completely eliminated where the condition is severe. The dispersed clay particles so completely plug the soil pores that water and air movements become intolerably slow and plant cannot grow.

Spatial variation in soil $P^H$: Soil $P^H$ in the district varies from 4.8 to 8.1 (Table 13 Appendix). In the eastern part of the district soil $P^H$ ranges from 6.0 to 7.5. Whereas in the western part it varies from 5.5 to 6.5 (Fig. 21). It is evident that soil reaction in the district as a whole is conducive for the cultivation of major crops. In Goghat, Khanakul, Arambagh, Dhaniakhali and Panduah blocks the soil exhibits slight acidic to neutral reaction ($P^H$ 5.5 - 6.5). In Major parts of Singur, Haripal, Balagarh and Serampore-Uttarpura blocks soil reaction is neutral to slight alkaline ($P^H$ 7.0-8.1).

The distribution of soil $P^H$ in the district is broadly related to the drainage map of the country. Areas of higher $P^H$ values are usually associated with the valleys of major
streams and their tributaries while neutral or slightly acidic reaction is found over the interfluve section. The general relationship between drainage and soil PH however is not of a total correspondence. Complexities in the pattern are produced by the intricacy of the drainage itself and other factors like the chemical composition of the soil, underground water, micro variation of relief.

Fertility Status

The productivity of soil is its ability to produce crops. It depends upon many factors: soil fertility, water supply, slope of the land, depth to water table or to a layer that is hard for plant roots to break through, climate, cultivation practices and so on. Among these the soil fertility is the most important factor influencing productivity of soil. Other factors remaining the same, the greater the fertility of the soil the greater is the productivity of it.

Soil fertility refers to the nutrient supplying property of soil. Plants like any other living things need food if they are to live and grow. If they are well fed there is a good chance that they will grow fast, be strong, and therefore, resistant to insects and disease and yields heavily. If they
are poorly fed they are sure to grow slowly, to become weak and produce low yield. From the standpoint of agricultural production soil fertility is best understood by considering the nutrient requirements of plant and the supply of the nutrient. The chief plant nutrients are carbon hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, magnesium, calcium, iron manganese, zinc, copper, boron and molybdenum. Three of these, carbon, hydrogen and oxygen are supplied to the plant from almost inexhaustible sources, air and water. Other elements are chiefly obtained from the soil. Of the thirteen essential elements obtained from the soil by plant six are used in relatively large quantities. These are called macronutrients. They are nitrogen, potassium, phosphorus, calcium, magnesium and sulfur. The other nutrients (iron, manganese, copper, zinc, boron, molybdenum, and chlorine) are used by higher plants in very small amounts and as a consequence are called micronutrients. Among the macro nutrients, nitrogen, phosphorus and potassium often limit crop production. It is the quantities of these three in a soil which usually determine its fertility. The importance of these element in respect of the soil fertility can be judged from the removal of these nutrients by some selective crops.
Table 2 Nutrient removal by a few selected crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Part of Crop</th>
<th>Yield of Crop in pound/acre</th>
<th>Nutrient removed by plant in lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Wheat</td>
<td>Grain</td>
<td>2,000</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>4,000</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>52</td>
</tr>
<tr>
<td>Paddy</td>
<td>Grain</td>
<td>2,500</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>5,000</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>73</td>
</tr>
<tr>
<td>Bazra</td>
<td>Grain</td>
<td>800</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>3,200</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Maize</td>
<td>Grain</td>
<td>2,400</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>9,600</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>102</td>
</tr>
</tbody>
</table>

Average from a variety of Indian Sources.
Soil Nitrogen

Of all the chemical properties of soil that determine its fertility status, nitrogen is by far the most important. This element is an important constituent of proteins and is required by plants in comparatively large amount. The amount of nitrogen in the soil is a small, while the quantity withdrawn annually by crops in comparatively large. Of the three elements (nitrogen, phosphorus, potassium) usually applied in commercial fertilizers, nitrogen seems to have the quickest and most pronounced effect. It tends primarily to encourage above ground vegetative growth and thus imparts to leaves a deep green colour. With cereals it increases the plumpness of the grains and their percentage of protein. With all plants, nitrogen is a regulator in that it governs to a considerable degree the utilization of potassium, phosphorus and other constituents. An excess of fertilization with this element is harmful as it leads to excessive vegetative growth, delayed maturity and lodging. Thus the application of nitrogenous fertilizers should be at optimum level which is depended on the nitrogen content of the soil. A knowledge about this is therefore
imperative for judicious application of nitrogenous fertilizers. Nitrogen in soil occurs chiefly in the organic form and its availability to crop depends on its easy conversion in the soil in to the inorganic ammonical and nitrate forms.

The bulk of the nitrogen supply of any normal soil is present as a constituent of the decayed or decaying plant and animal material including microbes all of which are grouped together under organic matter. In addition to the nitrogen of the organic matter the soil contains small amounts of nitrogen in inorganic forms mainly nitrates and ammoniacal compounds. Some workers on the process of nitrogen fixation in tropical soil believe that the most important source of nitrogen in such soil is the leguminous plants growing symbiotically with the Rhizobium bacteria in their root nodules. These bacteria fix atmospheric nitrogen in the soil in a form which become available to the legumes. Tropical legumes under a favourable condition are considered to be equal or even superior to temperate legumes for nitrogen fixation (Morris & Henzell, 1960 pp. 941-42).
HOOGHLY
SPATIAL VARIATION OF SOIL NITROGEN
(IN PER CENT)

Fig. 22
It is generally believed that the Indian soils are deficient in nitrogen. This district is also no exception in this respect. Such low nitrogen content is due to its low organic matter content in tropical environment. In the district this element varies from 0.3 to 0.99 per cent (Table 13 Appendix). The highest figure (0.99) occurs in Tarakeswar and Polba-Dadpur block and the lowest (0.3) occur in Khanakul block. Only in five blocks out of fifteen the nitrogen level is medium (0.06 to 0.099 per cent). In the remaining blocks the nitrogen content of the soil is very low varying from 0.03 to 0.05 per cent. In respect of spatial distribution of this constituent no apparent generalization can be made on the first glance at the map (Fig. 22) but a careful examination of the same will reveal that the distribution has some conformity with the layout of the physiography, and drainage of the country. Higher percentages of nitrogen are associated with the samples collected from near the rivers while those on interfluves are generally deficient. Comparison of the map showing distribution of organic matter and nitrogen reveals that the distribution of soil nitrogen greatly conforms to the distribution of organic matter. As the chief source of nitrogen is the organic matter such conformity seems to be justified.
HOOGHLY
SPATIAL VARIATION OF PHOSPHORUS
(IN Kg/HECTARE)

Fig. 23
Phosphorus

With the possible exception of nitrogen, no other elements has been as critical in the growth of plants in the field as has phosphorus. A lack of this element is doubly serious, since it may prevent other nutrients from being acquired by plants. It plays an important role in plant nutrition namely (1) in stimulating root growth, (2) in hastening crop maturity and improving the quality of the grain. Phosphorus occurs as constituent of organic matter and soil minerals.

The phosphorus content of the soil in the district to 170 kg/hectare varies from 110.5 Kg/hectare (Table 13 Appendix). The highest figure (170Kg/hectare) occurs in Panduah and the lowest figure (110.5Kg/hectare) in Jangipara. It seems that Hooghly is placed at favourable situation regarding the state of Phosphorus supply than in regard to nitrogen. Compared to other districts in West Bengal also Hooghly's position is better as the average percentage of sample belonging to the 'High' group in West Bengal as a whole is only 52.87 pound per hectare. As in the case of nitrogen the distribution of Phosphorus (Fig. 23) also seems to be guided by drainage to a considerable extent. Since both
nitrogen and phosphorus are related to drainage at least partially in their distribution they are conform with each other by some degree. This may be well illustrated by a visual comparison of the maps (Fig. 22-23) showing the distribution of phosphorus with that of nitrogen.

**Potassium:**

The third important plant nutrient is potassium. The presence of adequate available potassium in the soil has much to do with the general tone and vigour of the plants grown. Moreover by increasing crop resistance to certain diseases and by encouraging the root system potassium tends to counteract the ill effects of too much nitrogen. In delaying maturity potassium works against undue ripening influences of phosphorus.\(^{13}\) In a general way, it exerts a balancing effect on both nitrogen and phosphorus and consequently is especially important in a mixed fertilizer. This element is important to cereals in grain formation giving plump heavy kernels. Abundant available potassium also is absolutely necessary for tuber development. Consequently, the percentage of this element usually is comparatively high in mixed fertilizers recommended for potatoes\(^{14}\).
HOOGHLY
SPATIAL VARIATION OF POTASSIUM
(IN Kg/HECTARE)

Fig. 24
In fact all root crops respond to liberal application of potassium. This element occurs in the soil both in soil minerals and organic matter.

There is a general opinion that tropical soils do not pose much of a problem regarding the supply of potassium. In West Bengal however, the potassium content of the soil is thought to be low in general except in selected locations. Potassium content of the soil in the district is usually high ranging from 160.7 Kg/hectare to 276.52 Kg/hectare (Table 13 Appendix). The highest figure occurs in Tarakeswar and the lowest one in Arambagh block. The soil in Balagarh, Panduah, Chinsurah-Hogra, Polba-Dadpur, Dhaniakhali, Tarakeswar, Haripal, Singur, Khanakul and Serampore-Uttarpara block shows higher potassium content ranging from 225.5 to 176.52 Kg/hectare. While in the remaining blocks the potassium content is considerably low averaging 160.70 to 185.22 Kg/hectare (Fig. 24).

A glance on the maps (Fig. 18 & 24) showing the distribution of organic matter and potassium of the soil respectively reveals that the distribution of organic matter greatly conforms to that of the potassium. The central, northern and eastern parts of the dist. is comparatively
rich in potassium content of the soil. Where as the rest of the district is comparatively poor in potassium content of the soil.

Dependence of yield of crop on the physicochemical properties of soil

According to Haussenbuiller (1963-P.1) the evaluation of inherent fertility status of the soil requires the study of soil as a medium of plant growth and he also emphasized that in this attempt one must endeavour to relate as many properties of soil to its capacity for producing crops as possible. Griggs (1969) has rightly argued that "When the whole world is being dealt with, climatic criteria is probably the best indicators of agricultural potentiality. But in smaller areas soil type morphology, drainage condition and slope assume for greater significance." Azzi (1956) in evaluating the effects of soil on crop production considered three groups of characteristics viz. (1) chemical capacity (2) water balance and (3) workability. In the present context the author has considered the physico-chemical properties of soil. For the chemical behaviour of the soil such indices as soil reaction, organic
matter, nitrogen, phosphorus and potassium have been taken into consideration. For physical properties of soil, the textural characteristic has been considered. In order to show the dependence of crop yield on the physical and chemical properties of soil a correlation analysis has been made. For this purpose all these indices are taken as the independent variable and per unit yield of aus paddy (H.Y.V.) is taken as dependent variable. For the correlation analysis each block is awarded proportional score values expressed in percentage for the individual indices (independent variables). Then the yield of aus paddy of different blocks has been correlated with the score values of individual indices in the following manner.

The Soil Reaction and yield: In the previous discussion it has been found that soil reaction, expressed in $\text{pH}$ values plays a profound role in nutritional effect of the soil. As such, crop yield is greatly dependent on soil reaction. The favourable soil reaction for the growth of aus paddy has been taken into consideration. It has been found that paddy favours a $\text{pH}$ range of 6.5 to 7.5 i.e. slightly acidic to slightly alkaline passing through neutrality (Bal and Misra - 1932). In the correlation analysis the blocks having $\text{pH}$ values between 6.5 and 7.5 are awarded with highest score value of 100. The upward as well as
downward deviation of $P^H$ value from the optimum range is regarded as the proportional unsuitability for paddy and the score value is decreased correspondingly. The score values awarded to different blocks are shown in the table-15 A (Appendix). The correlation coefficient (Spearman's rank correlation coefficient), between the two variables is $+0.20$. Comparatively low positive correlation coefficient between these two variables indicates that the effect of soil reaction on crop yield has been some what masked by other variables or some other factors.

**Organic Matter and Yield**: Considering that increasing amount of organic matter responses to increasing crop yield the block having the highest percentage value of organic matter is awarded a score of 100. The decrease in percentage of organic matter is calculated as the corresponding decrease in score value. The score values awarded to different blocks are shown in the table 15 A (Appendix). The correlation co-efficient between these two variables is $+0.07$. This suggests a very lower degree of positive correlation between the two variables. As to the cause of low degree of positive correlation the present author is of opinion that the effect of organic matter has been masked due to the application of inorganic fertilizers.
Nitrogen and Yield: In the preceding discussion relating to chemical fertility status of the soil it has been realized that nitrogen limits the crop growth to a great extent. It has been stated by Russel (1950) "Nitrogen and phosphate are the two plant foods that most limit crop yield in regions where water is not the limiting factor". Various investigations relating to rice culture done at various stations in India show that there is a notable correspondence between the nitrogen levels of the soil and the performance of rice plant with reference to the production of grain and straw. The responses made by rice plants to soil nitrogen is however higher in the case of japonica variety than in indica. Conditioned by other factors like crop duration, drainage condition, aeration, light intensity and other nutrients the importance of nitrogen is almost universal in all soil conditions of India (I.C.I.R. 1960 p. 157).

Assuming that higher the nitrogen content higher is the crop yield, the block having highest value of nitrogen is awarded with a score value of 100. In awarding score values for other blocks the corresponding decrease in nitrogen content is made directly proportional. (Table. 15 A Appendix).
The correlation co-efficient between the two variables has been calculated to be $+0.33$, which is almost significant at 5 per cent level. Saha (1969) working independently in Rampurhat subdivision of Birbhum a well drained area found a positive correlation co-efficient of $0.35$ between the same two variables. Low correlation co-efficient in Hooghly district indicates that nitrogen is not the only factor affecting crop production.

Phosphorus and Yield: "Prior to 1952 evidences collected from a large number of trials conducted at experimental stations all of the country had shown that unlike nitrogen, phosphate generally gave no response except in certain places in the states of M.P., Bihar and Bombay". (G.C.A.R. 1960). This does not of course undermine the importance of phosphates in agronomic practices as the properties of phosphates are proved to be helpful in a number of indirect ways even to rice culturists.

In order to show the correlation between these two variables the score values for individual block have been awarded following the same principle as organic matter and nitrogen. The correlation co-efficient has been found to be $+0.33$. 
Postassium and Yield: Potassium, being one of the important element of plant nutrients, has important bearing on crop yield. This can be justified by the correlation co-efficient between the two variables. For correlation purpose score values in respect of potassium have been awarded to individual blocks following the same principle as followed for nitrogen, phosphorus and organic matter. (Table 15A Appendix). The correlation coefficient is +0.34.

Soil Texture and Yield: It is universally accepted that loamy soil with considerable percentages of silt and fine sand and some amount of clay shows better crop yield and afford ease in tillage. The deviation from the loam towards both sandy and clayey types is rated as increasingly inferiority in productive capacity. Storie's principle of awarding score value to individual textural classes is based on this principle (Storie - 1933).²⁰

At first the textural classes based on U.S.D.A. system is followed and score values have been assigned following storie's method as shown in the following table.
Table 3. Percent rating of textural classes according to soil.

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Per Cent Rating</th>
<th>Name of the Blocks</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay loam</td>
<td>85</td>
<td>Arambagh, Balagarh, Haripal</td>
<td>3</td>
</tr>
<tr>
<td>Clay</td>
<td>60</td>
<td>Chinsurah-Hogra, Chanditala, Panduah, Polba, Khanakul.</td>
<td>5</td>
</tr>
<tr>
<td>Sandy Clay loam</td>
<td>90</td>
<td>Jangipara</td>
<td>1</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>95</td>
<td>Goghat, DhaniaKhali</td>
<td>2</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>70</td>
<td>Tarakeswar</td>
<td>1</td>
</tr>
<tr>
<td>Silt loam</td>
<td>100</td>
<td>Pursurah, Serampore-Uttarpara</td>
<td>2</td>
</tr>
<tr>
<td>Silty clay loam</td>
<td>80</td>
<td>Singur</td>
<td>1</td>
</tr>
</tbody>
</table>
The correlation analysis between these two variables using Storie's method of per cent rating for textural classes suggests a negative correlation co-efficient of -0.18.

This fact is, however, contrary to the findings of Saha (1969) working on land capability classification. The negative correlation between these two variables was also found out by Das (1975). The present author infers that the per cent rating by Storie was done considering only the wheat yield. Therefore the grading will be different if paddy is considered. So the present author has reoriented the per cent rating for soil texture according to the requirement of paddy. As the textural groups having higher percentage of clay are much suitable for paddy cultivation, greater score values have been awarded to the blocks having such soil texture. The score values was reoriented accordingly as represented in the following table.
Table 4. Percent ratings of textural classes according to present author.

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Percent ratings</th>
<th>Name of the blocks</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay loam</td>
<td>100</td>
<td>Arambagh, Balagarh, Haripal</td>
<td>3</td>
</tr>
<tr>
<td>Clay</td>
<td>85</td>
<td>Chinsurah-Iorga, Chanditala, Pandua, Folba-Dadpur, Khanakul</td>
<td>5</td>
</tr>
<tr>
<td>Sandy Clay loam</td>
<td>70</td>
<td>Jangipara</td>
<td>1</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>60</td>
<td>Soghat, DhaniaKhali</td>
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</tr>
<tr>
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<tr>
<td>Silt loam</td>
<td>80</td>
<td>Pursurah, Serampore-Uttarpara</td>
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</tr>
<tr>
<td>Silty clay loam</td>
<td>90</td>
<td>Singur</td>
<td>1</td>
</tr>
</tbody>
</table>
HOOGHLY
RELATION BETWEEN SOIL
FERTILITY AND YIELD OF AUS

Proportionate score value for fertility of Soil

Yield of aus in kg/acre

Fig. 25
Following the above mentioned score values (Table 15A Appendix) for soil texture according to the present author the correlation coefficient was found to be of + 0.38. Thus higher positive correlation has been found between these two variables using the above mentioned score values for soil texture. Regarding the low correlation co-efficient the author is of opinion that other chemical properties of soil particularly the nutrient status and $F_2$ have overshadowed the effect of soil texture on the crop yield.

The correlation analysis between the yield of aus paddy (depended variable) and physico-chemical properties of soil (texture, soil reaction, organic matter, potassium, phosphorus, nitrogen all independed variables) reveals that the independed variables are correlated with the depended variable to a varying extent. In no case a very high positive correlation co-efficient has been found. It is because of the fact that yield of crop is not the function of an individual independed variable but the cumulative function of them. This can be justified by the correlation analysis between the yield of aus paddy and the total score obtained by the individual blocks in respect of individual independed variable (Fig. 25). The correlation co-efficient was found to be of + 0.45 which is significant at 5 per cent level.
Classification of land according to productive capacity of soil

Soils vary widely in their productive capacities and therefore there is need for some methods of comparing the relative productive capacities of different soils, specially in places where a large number of widely divergent soil conditions exist. Such a soil rating would be useful in land classification and land evaluation.

A number of attempts have been made to determine the productivity ratings of soils by different workers namely Storie (1933), Clarks (1950), Strik (1953) and Shome and Roychaudhury.

A. Azzi (1955) in Italy worked on the problem of soil rating most efficiently and determined the chemical capacity of the soil introducing statistical calculations of index number, effective index number and proportionate index number. In this method he considered the soil organic matter, nitrogen, Phosphorus and Potassium. But Azzi's index chart was not sufficient to classify the soil into different subgroups as there are many other physical factors which influence the crop production to a great extent.
Storie's index was considered to be more helpful in tackling the problem of ratification as he considered several factors namely Factor A: Soil profile which include depth and permeability, Factor B: Soil texture, Factor C: slope, Factor X: Miscellaneous (Factors that can be modified by management e.g. drainage, alkali, nutrient level, acidity, erosion and micro relief.) In this system the ratings are calculated from percentage values awarded to individual characteristic of soil. The values of the three factors are expressed as percentage of the maximum.

Chatterjee, et. al. (1963) attempting towards fertility classification of some of the soils of two villages of Hooghly district, took into consideration - nitrogen, phosphoric, potassium organic matter, soil texture and soil reaction for indices. But for measuring fertility index they considered only soil texture, organic matter, nitrogen, Phosphorus and potassium and score values assigned to them were expressed in percentage in proportion to the highest one as used in Aizzie's method. Thus they found that the land with highest productivity ratings accounted for the highest production per unit area or vice versa.

It has been observed earlier from the correlation between yield of aus paddy and physico-chemical property of soil viz. organic matter, soil texture, soil reaction, nitrogen,
HOOGHLY
LAND CLASSES ACCORDING TO PRODUCTIVITY OF SOIL

LAND CLASSES

GRADE I
GRADE II
GRADE III

Fig. 26
phosphorus and potassium that there is positive correlation.

A very high positive correlation was found between soil rating percentage (Total score value) and the yield of aus paddy. (Table 15A Appendix.) For land classification therefore the total score value of the individual blocks has been taken into consideration and proportionate score values have been calculated. Such values are expressed in percentages, the highest one being 100 and others are calculated proportionately. The score values have then been graded in to three inorder to identify respective classes of land according to its productivity which are as follows, (Fig. 26).

Table 5. Soil classes according to its productive capacity.

<table>
<thead>
<tr>
<th>Score Value</th>
<th>Class of land</th>
<th>Name of the blocks belonging to each class.</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 - 100</td>
<td>Grade I</td>
<td>Chinsurah-Nogra, Polba-Dadpur, Tarakeswar, Singur, Balagarh</td>
</tr>
<tr>
<td>80 - 89</td>
<td>Grade II</td>
<td>Panduah, Pursurah, Dhamiakhali, Karipal, Arambagh, Khanakul, Serampur-Uttarpura</td>
</tr>
<tr>
<td>70 - 79</td>
<td>Grade III</td>
<td>Jangipara, Chanditala, Soghat</td>
</tr>
</tbody>
</table>

N.B.- Vide Table 153 Appendix.
If the story's basis of grading soil (Grade I (excellent): soils rate between 80 and 100 percent, Grade II (Good): soils rating between 60 and 79 per cent, Grade III (Fair): soils rating between 40 and 59 per cent, Grade IV (Poor): soil rating between 20 and 59 per cent, Grade V (Very poor) soils rating between 10 and 29 per cent and grade VI (Non-agricultural): soils rating less than 10 per cent.) is taken into consideration the soil of the district will fall into two grades viz. grade I and grade II. This indicates that the soils are very much productive and conducive for successful cultivation of crops. This has been possible due to the dominance of plain land having no perceptible variation in slope, good drainage, favourable soil texture, moderate to high nutrient content and favourable soil reaction.

Remark

It is evident that the soil condition of the district as a whole is conducive for agricultural activities. Broadly the physico-chemical properties of soil are helpful for the cultivation of the type of crops determined by climate. The textural classes of the soil are in general very suitable for the cultivation of rice, jute, potato, vegetables, oil seeds etc the predominant crops of the district.
Organic matter status of the soil in the district is not at the satisfactory level like all other soils in India. As such the yield of the major crops can be sufficiently increased if organic fertilizers is applied to the soil.

Soil reaction is also favourable for crop cultivation as it is neutral to slightly acidic and alkaline. Availability of soil nutrient to the plant is not hampered by the soil reaction.

Nutrient status of the soil is fairly high to medium. Though the nitrogen content of the soil is low somewhat, the content of other important plant nutrient, i.e., phosphorus and particularly potassium is fairly high.

Thus in terms of productive capacity the soils of the district belong to grade I and grade II according to Storie's system of soil rating. Yield of the crop is very much related to the productive capacity of the soil which is greatly depended on the physico-chemical properties of soil.
Reference


3. Final report of All India Soil Survey Scheme, I.C. A.R., Bulletin No. 73.


20. Storie, R.E........, 1933, An Index for Rating the Agricultural Values of Soils-California Agricultural Experimental Station, Bulletin, California.