CHAPTER IV
CHEMICAL PROPERTIES OF SOIL AND PRODUCTIVITY

The chemical properties of the soil play a major role for their nutrition in the plant growth. There are various types of chemical constituents present in the soil. Of these, organic matter, nitrogen, phosphorus and potassium are known as the major plant nutrients; calcium, magnesium and sulphur as secondary nutrients; iron, manganese, copper, zinc, boron, molybdenum and chloride as micro-nutrients. In the present study, only the major ones e.g. organic matter, nitrogen, phosphorus and potassium have been considered. Phosphorus and potassium have been expressed as phosphorus pentoxide and potassium oxide respectively. pH is also an important property of the soil. The chemical status of the soil depends also on the pH of the soil.

Organic Matter

In tropical countries, organic matter status of soils is a very important one in determining the quality of a soil. In the process of decay, it becomes valuable as a fertility component of the soil. It is a potential source of nitrogen, phosphorus and sulphur. It improves physical properties of the soil like structure, water holding capacity and tilth. In the study area, the main sources of accumulation of organic matter are the remains of animal and plant tissues specially the green chlorophyllous parts of grass.
The organic compounds and the applies farm yard manure through the activity of micro-organisms (enzymes) a complicated changes take place leading to a specific and relatively stable amorphous substance known as humus.

Humus represent a mixture of decomposed product of carbohydrates, proteins, fats, resins, wax and other similar substances. These complex compounds are gradually decomposed by soil organism into simple mineral salts, carbon-dioxide, organic acids, ammonia, methane, and free nitrogen, depending upon the initial composition of the organic matter. Organic matter decomposes through micro-biological process. The mineralization of nitrogen in the soil take place in two steps e.g. ammonification and nitrification, during the course of decay of organic matter. At the first step ammonia (NH₃) is produced through the decomposition of any nitrogenous organic matter by the ammonifying bacteria. In the second step ammonia oxidizes to nitrous acid (HNO₂) by bacterium 'Nitrosomonas' and finally into nitric acid (HNO₃) by the bacterium 'Nitrobacteur'. It is at this stage that nitrogen is available to plants.

Russell²³¹ (1953) found that a small part of the total nitrogen in the soil is present in the available form, for plant nutrition, is not the total quantity of nitrogen in the soil but rate
it which the nitrogen is made available by further decomposition of organic matter. The rate of decomposition increases with increase of temperature. So in the summer more supply of humus nitrogen is available to growing plant when they need it most.

The microbial action on soil organic matter is its almost complete mineralization of reduction to inorganic substances. 

Fawcet 

(1952) found that the micro-organisms liberate nutrients such as, nitrates, phosphates, sulphates and carbon-dioxide required for plant growth. He also observed that the symbiotic nitrogen fixing bacteria 'Rhizobia' in the root of leguminous plants, affect the fixation of large quantities of nitrogen from the air. The intermediate products of bacterial decomposition of soil organic matter or certain organic product synthesized in the soil by some micro-organisms are believed to produce plant growth stimulating substances including vitamin and hormones.

Farmers mostly use farm-yard manure in their cultivated land before the monsoon sets in (April-May) and when the temperature in high. The presence of unrotten manure and plant material like stubbles, straw, dried leaves, etc., the supply of carbon is high relative to the supply of nitrogen i.e. it shows wide carbon nitrogen ratio. The supply of carbon largely determine the size of soil population. The organism continues to multiply until their further
increase is stopped by shortage of nitrogen which the microorganism requires for their body building.

In order to get more body building material the soil organisms now utilize and lock up not only the nitrogen in the manure but also the nitrogen in the soil that is available to plant. At this stage plant often suffers from lack of nitrogen inspite of the fact that some nitrogen is added to the soil. The farmers are aware of this by their experience, so they do not sow any crop immediately after farm yard manure.

The wide C : N ratio is not benificial to plant growth unless it is brought down below 20 when the N₂ which the soil bacteria robbed of, made available to plants. Wider ratio causes some soil nitrogen to be immobilized and narrower ratios permit some mineralization to occur as the organic matter decomposes.

The farmer use the farmyard manure, oil cakes and green composts. In recent years, application of chemical manures like ammonium sulphate, phosphate or mixture, etc., are very common. Recently some farmers use microbe fertilizer for enrichment of nitrogen source in the soil. Microb fertilizer in the population culture of specific strains of Rhizobium, Azotobactor and Clostridium as these bacteria can fix atmospheric nitrogen made available
to higher plants.

Soil productivity mainly depends on soil structure, aggregation, texture, micro-organism activity and these are maintained by the application of organic manure. N.R. Dhar$^{89}$ (1972) prefers application of farmyard manure for increasing organic matter and other chemical nutrients of soil. Dhar has shown by his research that nitrates produced in soil by adding nitrogenous fertilizers can react with the humus organic matter and deplete the humus content of the soil.

Organic matter has also properties of cation exchange capacity. Organic matter improves the soil by holding nutritive ions by exchange. Broadbent et al. (1952) reported that the cation exchange capacity for 100 gms of organic matter from various soils, average 67 m.e. with potassium, 134 m.e. with barium and 287 m.e. with divalent copper.

The organic matter content present in the 76 soil samples were determined by Walkley and Black$^{285}$ method (1934) and the results are expressed in q/ha $\left(Appendix\ A_3, \ pp.\ 196-97\right)$.

The organic matter content of soil samples ranges between 58.81 to 221.48 q/ha $\left(Appendix\ B_6, \ pp.\ 222-23\right)$.
Table No.16 : Frequency distribution of organic matter

<table>
<thead>
<tr>
<th>Organic matter (g/ha)</th>
<th>Frequency</th>
<th>Frequency (%)</th>
<th>Sample No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-95</td>
<td>11</td>
<td>14</td>
<td>1,3,5,6,18,31,32,34,36,63,66,</td>
</tr>
<tr>
<td>95-140</td>
<td>37</td>
<td>49</td>
<td>8,9,11,12,13,14,15,16,17,19,20, 21,22,23,24,25,33,35,39,40,42, 43,48,49,50,51,52,55,56,58,60, 64,65,68,71,74,75,</td>
</tr>
<tr>
<td>140-185</td>
<td>17</td>
<td>23</td>
<td>4,7,26,28,29,37,38,41,45,47, 53,57,61,62,70,72,76.</td>
</tr>
<tr>
<td>185-230</td>
<td>11</td>
<td>14</td>
<td>2,10,27,30,44,46,54,59,67,69, 73.</td>
</tr>
</tbody>
</table>

The distribution pattern of organic matter is diagrammatically represented by means of a histogram and corresponding frequency curve (inset diagram, Map No.18). The curve shows that the distribution of organic matter is almost normal.

A scrutiny of the histogram reveals that out of 76 soil samples 49 percent samples lie between 95-140 g/ha; 23 percent lie samples lie between 140-185 g/ha; 14 percent lie between 185-230 g/ha and 14 percent lie between 50-95 g/ha. The above data indicate that the amount of organic matter content in the study area is low to very low.
SPATIAL DISTRIBUTION OF ORGANIC MATTER

-24°N

LEGEND

\begin{tabular}{|c|c|}
\hline
IN q/ha & % Frequency of Samples \\
\hline
50 - 95 & 14 \\
95 - 140 & 49 \\
140 - 185 & 23 \\
185 - 230 & 14 \\
\hline
\end{tabular}

Y_c = 8.39 + 0.10 X

Map No. 18
To determine the nature of relationship between organic matter content and corresponding yield of paddy, the following quantitative method has been employed.

As a first approximation a scatter diagram is drawn. Organic matter content g/ha is plotted along the x-axis and the corresponding yield of the paddy is plotted along the y-axis. The points thus obtained in the scatter diagram shows that there is positive correlation between organic matter present in the soil and the corresponding yield of the paddy.

Table No.17 : Worksheet for coefficient of correlation

<table>
<thead>
<tr>
<th>N</th>
<th>ΣX</th>
<th>ΣY</th>
<th>ΣX²</th>
<th>ΣY²</th>
<th>ΣXY</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>9941.46</td>
<td>1611</td>
<td>1412278.7</td>
<td>36278.5</td>
<td>221682.45</td>
</tr>
</tbody>
</table>

Source: Computed by the author

Appendix B6, pp.221-222

From the above values coefficient of correlation (r) between x (Organic matter content) and y (yield of the paddy) can be calculated as follows:
\[ r = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{N \sum X^2 - (\sum X)^2} \sqrt{N \sum Y^2 - (\sum Y)^2}} \]

\[ = \frac{76 \times 221682.45 - 9941.46 \times 1611}{\sqrt{76 \times 1412278.70 - (9941.46)^2} \sqrt{76 \times 36278.50 - (1611)^2}} \]

\[ = \frac{16847866 - 16015692}{\sqrt{(107333181.2 - 98832627) (2757166 - 2595321)}} \]

\[ = \frac{832174}{\sqrt{8500554.2 \times 161845}} \]

\[ = \frac{832174}{1172933} \]

\[ = 0.71 \]

Hence, the coefficient of correlation \( r \) = 0.71.

A high positive correlation is obtained between organic matter content and yield of the paddy in the respective field. This suggests that organic matter can influence production as far as higher return of paddy in the area is concerned. So application of organic matter to the paddy fields may be recommended.
Organic matter, living or dead, exert a profound influence on soil fertility. Though it is not alone responsible for the paddy production but it plays a dominant role along with other nutrient element for the production of paddy in the respective field.

Soil Nitrogen:

Nitrogen is vitally most important nutrient element in plant for its growth and yield of crop. It encourages the vegetative development of plants by imparting a healthy green colour to the leaves. Crops grown for their roots and seeds need sufficient nitrogen. Its deficiency retards growth and root development, turns the foliage yellowish or pale green and lowers crop yield and quality of fruits, vegetables and grains. Mc. Murtrey\textsuperscript{170} (1948) finds that plants manifest lack of green colour in region of nitrogen deficiency. Grass and grain crops particularly rice, wheat and millets show yellowish green colour of leaves followed by drying of older leaves. So nitrogen is a very important nutrient element for plant.

Earlier, it has been discussed in the organic matter that bulk of nitrogen supply in soil is contained in humus. But in this form it is unavailable to plants. It becomes available when
it has been converted into nitrate by bacterial action. Nitrogen in plants is stored as nitrate in sap. The ammonium (NH$_4^+$) ion absorbed by the roots but the excess amount which is not needed for plants is oxidised to nitrate. Raheja $^{215}$ (1966) has observed that in paddy grown under anaerobic conditions of standing water nitrogen is principally observed as ammonium (NH$_4^+$) ion, but nitrogen in sap is found as nitrate (NO$_3^-$) and not as ammonium (NH$_4^+$) ion.

Nitrogen is the most mobile element of all mineral nutrients absorbed by plants for their growth. Under favourable environmental conditions it rapidly mineralises in soil and may be taken up by crops or escapes in gaseous state or may even leach down into the subsoil beyond the root zone of the plants. In the study area the accumulation of nitrogen in soils is generally low because of hot climate. Jenny $^{136}$ (1930) showed that the content of soil nitrogen decreases with the increase in the annual temperature and approaches zero as a limit. But with the increase in humidity, the content of soil nitrogen increases at any given temperature and approaches a limit fixed by the temperature. Siever and Holt (1923) established a good positive correlation between rainfall and nitrogen. They found that excessive rainfall helps to leach out nitrogen and thus generally happens in areas having a rainfall of over 102 cm. This is also true for the study area, average rainfall 130 cm, where much of the nutrient materials, particularly nitrogen is leached out.
various workers studied recently that crop yield can be increased by the addition of nitrogeneous fertilizer to the soil, where supply of water is adequate.

Vaidyanathan (1934) and Vishwanath (1937) find that responses of ammonium sulphate application to soil fairly high for most crops such as paddy, cotton, millets, etc. A.V. Bapat et al. proved very successfully the effect of nitrogen level on the yield and quality of fibre varieties of capsularies of jute and their residual effect on mustard.

The author has estimated the amount of total nitrogen in 76 soil samples by Kjeldahl method (Appendix A4, pp.198-200).

The total nitrogen content of soil samples range between 3.14 to 12.77 g/ha.
Table No. 18: Frequency distribution of Nitrogen

<table>
<thead>
<tr>
<th>Nitrogen (q/ha)</th>
<th>Frequency</th>
<th>Frequency (%)</th>
<th>Sample No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5.5</td>
<td>11</td>
<td>15</td>
<td>1, 3, 5, 6, 31, 32, 34, 36, 50, 63, 66.</td>
</tr>
<tr>
<td>5.5-8.0</td>
<td>36</td>
<td>47</td>
<td>8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 35, 39, 40, 42, 48, 49, 51, 52, 55, 56, 58, 60, 64, 65, 68, 71, 74, 76.</td>
</tr>
<tr>
<td>8.0-10.5</td>
<td>19</td>
<td>25</td>
<td>4, 26, 27, 28, 29, 30, 37, 38, 41, 43, 45, 47, 53, 57, 61, 62, 70, 72, 76.</td>
</tr>
<tr>
<td>10.5-13.0</td>
<td>10</td>
<td>13</td>
<td>2, 7, 33, 44, 46, 54, 59, 67, 69, 73.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>76</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

The distribution pattern of nitrogen is diagrammatically represented by means of a histogram and corresponding frequency curve (inset diagram, Map No. 19). The curve shows that the distribution of nitrogen is almost normal. It is observed that soil samples having very low nitrogen content 3 to 5.5 q/ha have 15 percent frequency of occurrence; soil samples having low nitrogen content 5.5 to 8.0 q/ha have 47 percent frequency of occurrence; soil samples having moderate nitrogen content 8 to 10.5 q/ha have 25 percent frequency of occurrence and only 13 percent of the samples have higher value of nitrogen 10.5 to 13.0 q/ha. So most of the soil areas have low amount of nitrogen.
SPATIAL DISTRIBUTION OF NITROGEN

LEGEND

IN q/ha % Frequency of Samples
3.0 - 5.5 15
5.5 - 8.0 47
8.0 - 10.5 25
10.5 - 13.0 13

Histogram

% Frequency of Samples
50 40 30 20 10
3 5 7 9 11 13 Nitrogen (q/ha)

Scatter Diagram

Yc = 8.17 + 1.74x

Production (q/ha)

Map No.19
The nature of relationship between total nitrogen and corresponding yield of paddy the following quantitative method has been employed.

As a first approximation a scatter diagram is drawn. Total nitrogen q/ha is plotted along the x-axis and the corresponding yield of the paddy is plotted along the y-axis. The points thus obtained in the scatter diagram show that there is positive correlation between total nitrogen present in the soil and the corresponding yield of the paddy.

Table No.19 : Worksheet for coefficient of correlation

<table>
<thead>
<tr>
<th>N</th>
<th>ΣX</th>
<th>ΣY</th>
<th>ΣX²</th>
<th>ΣY²</th>
<th>ΣXY</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>570.52</td>
<td>1611</td>
<td>4653.9214</td>
<td>36278.50</td>
<td>12737.43</td>
</tr>
</tbody>
</table>

Source : Computed by the author

From the above values coefficient of correlation (r) between x (total nitrogen content) and Y (yield of the paddy) can be calculated as follows :
\[ r_{yx} = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{\left\{ N \sum X^2 - (\sum X)^2 \right\} \left\{ N \sum Y^2 - (\sum Y)^2 \right\}}} \]

\[ = \frac{76 \times 12737.43 - 570.82 \times 1611}{\sqrt{\left\{ 76 \times 4653.9214 - (570.52)^2 \right\} \left\{ 76 \times 36278.50 - (1611)^2 \right\}}} \]

\[ = \frac{968044.68 - 919107.72}{\sqrt{(353698.03 - 325493.07)(2757166 - 2595321)}} \]

\[ = \frac{48936.96}{\sqrt{28204.96 \times 161845}} \]

\[ = \frac{48936.96}{67563.55} \]

\[ = 0.72 \]

Hence the co-efficient of correlation between total nitrogen content and yield of the paddy = 0.72.

This high positive correlation value suggests that nitrogen has fairly strong influence on the yield of paddy.

**Soil Phosphorus**

Like nitrogen, phosphorus is also a major nutrient required
for crop production. Phosphorus may act as a vigour of plant and improves the quality of crops. It is essential for energy transformations and metabolic processes in plant life. Sufficient amount of phosphorus is required for normal transformation of carbohydrates in the plants. It helps the formation of new cell, development of fibrous roots, hastens leaf development, the formation of grains, the maturation of crops and assimilation of fats in plants. It increases the resistance power to diseases and strengthen the stems of cereal plants. The presence of phosphorus acids in the uptake of potassium and offsets the harmful effects of excess nitrogen in the plant. According to C.A. Black (1957), phosphorus perform function in plant metabolism, structure and reproduction which cannot be performed by other elements. Buckman et al. (1960) found that phosphorus makes its contribution through its favourable effect on growth, flowering, fruiting including seed formation and resistance to diseases. Owing to phosphorus deficiency in the soil, plants fail to develop a satisfactory root system and sometime develop a tendency to show a reddish or purple discolouration of the stem and foliage owing to an increase accumulation of free reducing sugar.

Roychowdhuri (1952) found that more than 2 million tons of phosphoric acid are being annually removed from the Indian soil by
various agricultural crops and very little of it is replaced by the way of manures, plant residues and fertilizers.

Plants uptake phosphorus from the soil in the form of phosphate ($\text{PO}_4^{3-}$). The principal fact is that in whatever form of phosphate are applied to the soil they rapidly become insoluble and mostly unavailable to plants.

S.P. Roychoudhury$^{230}$ (1966) found that in strongly acid or highly alkaline soil phosphorus in fertilizer quickly goes to these unavailable forms and is useable by the plant for only a short period.

The phosphorus in the soil solution is the direct source of phosphorus for the growing plant. Plant absorb phosphate in the ionic forms, $\text{H}_2\text{PO}_4^-$ and $\text{HPO}_4^{2-}$. Seatz and Stanberry (1963) found that plant absorb $\text{H}_2\text{PO}_4^-$ ions 10 times more than the $\text{HPO}_4^{2-}$ ions.

The phosphorus uptake increases in the presence of high concentrations of rapidly absorbed cations and depressed by the presence in the nutrient medium of rapidly absorbable anions. Excessive addition of lime may reduce phosphorus absorption due to decreased availability of phosphorus associated with a high $\text{HPO}_4^{2-}:\text{H}_2\text{PO}_4^-$ ratio. Acid soils to a pH near about the neutral point by living promotes the plant availability of both native soil phosphorus and that of the fertilizer.
The available phosphorus content as $P_2O_5$ of 76 soil samples have been determined by colorimeter after extraction of the soluble soil phosphorus in 0.5 (N) sodium bicarbonate solution (Olsen's method) \( \text{Appendix A}_5, \text{pp. 201-2} \)

The $P_2O_5$ content of soil samples lies between 0.09 to 1.55 q/ha. \( \text{Appendix B}_8, \text{pp. 228-2} \)

**Table No. 20 : Frequency distribution of $P_2O_5$**

<table>
<thead>
<tr>
<th>$P_2O_5$ (q/ha)</th>
<th>Frequency</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.09-0.46</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>0.46-0.83</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>0.83-1.20</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>1.20-1.57</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>76</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

On the basis of the $P_2O_5$ values a histogram with corresponding frequency curve (insert diagram, Map No.20) has been drawn. The curve clearly illustrates that the distribution of $P_2O_5$ is almost normal.
It may be noted that 22 percent soil samples have very low \( P_2O_5 \) content 0.09 to 0.46 g/ha; 40 percent samples have low \( P_2O_5 \) content 0.46 to 0.83 g/ha; 26 percent samples have medium \( P_2O_5 \) content 0.83 to 1.20 g/ha; and only 12 percent samples have high \( P_2O_5 \) content 1.20 to 1.57 g/ha.

To determine nature of relationship between available \( P_2O_5 \) and corresponding yield of paddy the following quantitative method has been employed.

As a first approximation a scatter diagram is drawn. Available \( P_2O_5 \) g/ha is plotted along the x-axis and the corresponding yield of the paddy is plotted along y-axis. The points thus obtained in the scatter diagram shown that there is positive correlation between available \( P_2O_5 \) present in the soil and the corresponding yield of the paddy.

Table No. 21 : Worksheet for coefficient of correlation

<table>
<thead>
<tr>
<th>( N )</th>
<th>( \Sigma X )</th>
<th>( \Sigma Y )</th>
<th>( \Sigma X^2 )</th>
<th>( \Sigma Y^2 )</th>
<th>( \Sigma XY )</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>54.99</td>
<td>1611</td>
<td>48.9135</td>
<td>36278.50</td>
<td>1269.51</td>
</tr>
</tbody>
</table>

Source: Computed by the author

\( \text{Appendix B}, \text{ pp.228-229} \)
From the above values coefficient of correlation \( r \) between \( x \) (available \( P_2O_5 \)) and \( y \) (yield of the paddy) can be calculated as follows:

\[
\begin{align*}
    r &= \frac{N \Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\{N \Sigma X^2 - (\Sigma X)^2\} \{N \Sigma Y^2 - (\Sigma Y)^2\}}} \\
    &= \frac{76 \times 1269.53 - 54.99 \times 1611}{\sqrt{\{76 \times 48.9135 - (54.99)^2\} \{76 \times 36278.50 - (1611)^2\}}} \\
    &= \frac{96484.28 - 88588.89}{\sqrt{(3717.426 - 3023.001) \times (2757166 - 2595321)}} \\
    &= \frac{7895.39}{\sqrt{693.5259 \times 161848}} \\
    &= \frac{7895.39}{10594.44} \\
    &= 0.75.
\end{align*}
\]

Hence the coefficient of correlation = 0.75.

A high positive correlation value is obtained between available \( P_2O_5 \) value and corresponding yield of the paddy suggest that phosphorus has a fairly strong influence on the yield of the paddy.
Soil Potassium

Potassium is an essential nutrient for plant growth. It plays an important role for synthesis of carbohydrates and proteins in plants. Ronald (1946) found that potassium helps growth of leaves in plants and makes them more efficient in the synthesis of carbohydrate. So an ample supply of potassium is of special value to carbohydrate-rich crops e.g. sugarcane, potato and sugar-beet. Webster and Verner (1954) suggest that potassium is essential in protein synthesis. Cereals produce plump grains and rigid straw with an adequate supply of potassium. Alten and Ratuje (1952) and Richards (1956) established that there is a relation between potassium content and the intensity of photosynthesis in plants. Russell (1951) and Black (1957) state that potassium acts as an important part in plant metabolism. Potassium increases disease resistance in plants and in general by the use of potassium fertilizer many plant diseases can be retarded. Potassium sometimes reduce the adverse effects of nitrogen and so often required by crops which are heavily manured with nitrogenous fertilizers. Plant symptoms of potassium deficiency are indicated by a yellowing of tips and edges of the leaves and later, this widens and the edges start drying up. In the older leaves appear this symptoms first and then in the younger ones. Hombridge (1941), Mc. Murtrey (1948) and Toffe (1953) found that young leaves of plant
turn bluish green, older leaves became red and such leaves are found irregular colorotic and nurotic areas. Aiyer (1948) and Sirkar (1955) have reported that due to potassium deficiency growth is stunted and yellowing of leaves of paddy begin.

The available potassium content as $K_2O$ of 76 soil samples have been determined by flame photometer method after extraction of the soluble soil potassium in normal ammonium acetate solution. 

[Appendix A, pp. 204–5]

The $K_2O$ content of soil samples lies between 0.28 to 4.51 $9/ha$.

[Appendix B, pp. 231–33]

Table No. 22: Frequency distribution of $K_2O$

<table>
<thead>
<tr>
<th>$K_2O$ ($9/ha$)</th>
<th>Frequency (%)</th>
<th>Frequency</th>
<th>Sample No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25-1.35</td>
<td>32</td>
<td>42</td>
<td>3, 5, 6, 9, 10, 11, 12, 14, 15, 16, 20, 21, 24, 30, 31, 32, 34, 36, 38, 39, 42, 44, 51, 52, 55, 56, 58, 63, 65, 66, 68, 71.</td>
</tr>
<tr>
<td>1.35-2.45</td>
<td>19</td>
<td>25</td>
<td>1, 13, 17, 18, 19, 23, 25, 27, 28, 33, 35, 40, 43, 48, 49, 50, 54, 57, 64.</td>
</tr>
<tr>
<td>2.45-3.55</td>
<td>18</td>
<td>24</td>
<td>2, 4, 7, 22, 26, 29, 41, 45, 46, 47, 53, 60, 61, 62, 69, 70, 72, 75.</td>
</tr>
<tr>
<td>3.55-4.65</td>
<td>7</td>
<td>9</td>
<td>8, 37, 59, 67, 73, 74, 76.</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
On the basis of the \( K_2O \) values a histogram with corresponding frequency curve (inset diagram, Map No. 21) has been drawn. The curve clearly illustrates that the distribution of \( K_2O \) is almost normal.

It may be noted that 42 percent soil samples have low \( K_2O \) content 0.25 to 1.35 q/ha; 25 percent soil samples have medium \( K_2O \) content 1.35 to 2.45 q/ha; 24 percent samples have high \( K_2O \) content 2.45 to 3.55 q/ha and 9 percent soil samples have more high \( K_2O \) content 3.55 to 4.65 q/ha. The nature of relationship between available \( K_2O \) and corresponding yield of paddy the following quantitative method has been employed.

As a first approximation a scatter diagram is drawn. Available \( K_2O \) q/ha is plotted along the x-axis and the corresponding yield of the paddy is plotted along the y-axis. The points thus obtained in the scatter diagram shown that there is positive correlation between \( K_2O \) present in the soil and the corresponding yield of the paddy.

Table No. 23: Worksheet for coefficient of correlation.

<table>
<thead>
<tr>
<th>( N )</th>
<th>( \Sigma X )</th>
<th>( \Sigma Y )</th>
<th>( \Sigma X^2 )</th>
<th>( \Sigma Y^2 )</th>
<th>( \Sigma XY )</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>141.13</td>
<td>1611</td>
<td>353.2399</td>
<td>36278.80</td>
<td>3387.76</td>
</tr>
</tbody>
</table>

Source: computed by the author

(Appendix B9, pp. 231-337)
From the above values, coefficient of correlation (r) between x (available K\(_2\)O) and Y (yield of the paddy) can be calculated as follows:

\[
r = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{N \sum X^2 - (\sum X)^2} \sqrt{N \sum Y^2 - (\sum Y)^2}}
\]

\[
= \frac{76 \times 3387.76 - 141.13 \times 1611}{\sqrt{76 \times 538.2399 - (141.13)^2} \sqrt{76 \times 36278.50 - (1611)^2}}
\]

\[
= \frac{257469.76 - 227360.43}{\sqrt{(26846.232 - 19917.677)(2757166 - 2595321)}}
\]

\[
= \frac{30109.33}{\sqrt{6928.555 \times 161845}}
\]

\[
= \frac{30109.33}{33486.577}
\]

\[\neq 0.90.\]

Hence, the coefficient of correlation = 0.90.

A high positive correlation value is obtained between available K\(_2\)O value and yield of the paddy suggests that potassium has strong influence on the yield of the paddy.
Soil Reaction:

Soil reaction indicates the acidity or alkalinity of the soil as expressed in terms of pH values which extends 0-14. Soils with a pH of 7 is said to be neutral, pH from 0-7 indicat acidity and from 7-14 alkalinity. Soil reaction is one of a very large number of interesting factors that effect plant growth.

Soils may be acidic, neutral or alkaline. In highly acidic condition, the shortage of available calcium and magnesium as these exchangeable elements in soil are drained out by leaching converting alkaline soils into acidic ones. The availability of many nutrients e.g. nitrogen, phosphorus, potassium, sulphur, calcium, magnesium and molybdenum may be too low for satisfactory plant growth in strongly acid soils. Albrecht and Smith (1952) consider the conditions called 'Soil Acidity' to be nutrient deficiencies, and the calcium in one of these prominent deficiencies. Buckman and Brady (1960) found that the availability of nitrogen and phosphorus are low with higher acidity. Marries and Pierre (1974) found that considerable amount of aluminium, iron, manganese and boron are soluble at low pH, in fact, they may become toxic to certain plants. They further pointed out that with pH increases, precipitation takes place and the amount of these ions in solution become less and less until at neutrality or somewhat above, certain plants may suffer from lack of available manganese or iron.
It is very difficult to say any critical pH at which a particular crop suffer severely from acidity and the lower limit of pH (i.e. high acidity) below which a crop may fail more or less completely. The soil microbiological process, such as beneficial activity of Azotobacter and nodule-forming bacteria of legumes are adversely affected with increase of acidity. The suitable granulation of soil also becomes difficult to form. So it is necessary to correct soil acidity for cultivating such soils profitably. By liming the harmful effect of soil acidity can be removed.

In the cool moist climate the tolerant of acidity for crops is more than the warm and dry regions.

Most crops respond well to soil from slightly acid to slightly alkaline i.e. pH range from 6.5 to 7.5. Most of the soil nutrients are also available in this pH range. For agricultural purposes alkaline soils are useless because high concentration of OH⁻ ions deleterious to plant growth and with association with the presence of exchangeable sodium in the colloidal complex, causing extreme dispersion on the soil colloids producing a very undesirable kind of soil structure. Jacks¹³² (1954) suggested calcium sulphate treatment for this type of soil. With calcium sulphate treatment soil properties are completely changed. By this treatment exchange of sodium for calcium in the colloidal complex and the
colloids are transformed from a highly dispersed slime state to a flocculated crumby state and the soil becomes permeable porous and workable state.

The phosphate nutrition of higher plants is disturbed when soil pH value higher than 7.0, because insoluble phosphates are formed. Again pH value above 7, the excess of calcium may hinder phosphorus absorption and utilization by plants. Buckman and Brady (1960) found that between pH 6 and 7, the availability of phosphorus is maximum. So phosphorus nutrition of crops, soil pH should be kept within 6 to 7 or very near thereto.

From the above discussion it is concluded that soil reactions (acidity or alkalinity) do not affect the plant growth directly but they are responsible for uptake of nutrients by crops. So soils with more acid should be treated with lime for required pH and with strongly alkaline, manure or chemicals such as ferrous sulphate or flower of sulphur should be applied for lowering the pH. Sulphuric acid is produced by hydrolysis of ferrous sulphate and drastically lowers the pH of the soil. Flowers of sulphur are more active in developing acidity than ferrous sulphate and it is comparatively less expensive.
The pH of 76 soil samples has been determined by pH-meter.

(Appendix A7, pp. 206)

The pH of the soil samples lies between 5 to 7.55.

Table No. 24 : Frequency distribution of pH

<table>
<thead>
<tr>
<th>pH range</th>
<th>Frequency</th>
<th>Frequency (%)</th>
<th>Sample No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-5.65</td>
<td>21</td>
<td>28</td>
<td>1,3,5,6,9,14,15,20,21,24,25,27,30,31,32,33,34,36,38,40,42.</td>
</tr>
<tr>
<td>5.65-6.3</td>
<td>38</td>
<td>50</td>
<td>4,8,10,12,13,16,17,18,19,23,28,35,37,39,41,43,44,45,46,48,49,51,52,54,55,56,57,58,60,61,62,63,64,65,68,70,71,75.</td>
</tr>
<tr>
<td>6.3-6.95</td>
<td>14</td>
<td>18</td>
<td>2,7,22,26,29,47,53,59,66,67,69,73,74,76.</td>
</tr>
<tr>
<td>6.95-7.6</td>
<td>3</td>
<td>4</td>
<td>11,50,72.</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

From the above table it is clear that 28 percent soil samples have pH value 5-5.65; 50 percent soil samples have pH value 5.65-6.3, 18 percent soil samples have pH value 6.3-6.95 and 4 percent soil samples have pH value 6.95-7.6.

On the basis of the pH values a histogram with corresponding frequency curve (inset diagram, Map No. 22) has been drawn. The curve clearly illustrates that the distribution of pH is almost normal.
SPATIAL DISTRIBUTION OF SOIL REACTION

LEGEND

Soil Reaction (pH) % Frequency of Samples

<table>
<thead>
<tr>
<th>pH Range</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - 5.65</td>
<td>28</td>
</tr>
<tr>
<td>5.65 - 6.3</td>
<td>50</td>
</tr>
<tr>
<td>6.3 - 6.95</td>
<td>18</td>
</tr>
<tr>
<td>6.95 - 7.6</td>
<td>4</td>
</tr>
</tbody>
</table>

HISTOGRAM

SCATTER DIAGRAM

Yc = -17.33 + 6.44x

Map No. 22
A scatter diagram has been drawn by plotting pH of the soil along the x-axis and the corresponding yield of the paddy is plotted along the y-axis. The points thus obtained in the scatter diagram show that there is positive correlation between soil pH and the corresponding yield of the paddy.

Table No. 25: Worksheet for coefficient of correlation

<table>
<thead>
<tr>
<th>N</th>
<th>ΣX</th>
<th>ΣY</th>
<th>ΣX²</th>
<th>ΣY²</th>
<th>ΣXY</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>454.55</td>
<td>1611</td>
<td>2743.6975</td>
<td>36278.50</td>
<td>9796.75</td>
</tr>
</tbody>
</table>

Source: Computed by the author

[Appendix B10, pp.134-36]

From the above values coefficient of correlation r between x (soil pH) and y (yield of the paddy) can be calculated as follows:
The best paddy producing areas are those where pH lies between 6.3 to 6.95. So production is higher with slightly acidic condition of soil in the region under study.