CHAPTER - 9

PHYSICO-CHEMICAL CHARACTERISTICS OF FARMERS’ SOIL
INTRODUCTION:- An important factor influencing the productivity of our plant ecosystems is the nature of their soils. Soils are vital for the existence of many forms of life that have evolved on our planet. A mass of mineral particles alone do not constitute a true soil. True soils are influenced, modified and supplemented by living organisms. Plants and animals aid in the development of a soil through the addition of organic matter. Local knowledge related to agriculture can be defined as indigenous skills, knowledge and technology accumulated by local people derived from their interaction with the environment (Altieri, M.A.). Small farmers in traditional farming systems are often confronted with complex and heterogeneous environments, including different soil qualities of which they develop a systematic knowledge. They retain indigenous soil classification or ‘folk soil taxonomy’ and have their indigenous soil / land management practices (Das and Das, 2005). Local soil knowledge can be defined as “the knowledge of soil properties and management possessed by people living in a particular environment for some period of time” (Winklerprins, 1999). Homegardens are classified as a diverse agroforestry system greatly influenced by human societies and by microenvironments. Therefore, the study aimed at analyzing the physico-chemical properties of soils in the homegardens of the local people in the study sites. Homegardens reflect the diversity of human cultures and ecosystems which shape them. It is generally regarded that the homegardens possess a closed nutrient cycling, much similar to tropical forests (Soemarwoto and Conway, 1991; Nair et al., 1999; Kumar and Nair, 2004).

METHOD OF STUDY:- A total of 16 soil samples were collected with three replicates for each sample from 16 farmers’ homegardens of Chaittabasti and Dargakona villages. From both the villages, four rubbish soil and four chitta soil (described by the local people) samples were collected. Also three soil samples each with three replicates were collected from forest gardens of Dargakona village. The
soil samples were collected from 0-15 cm depth with the help of a soil corer (5.2 cm diameter) during March – April in 2009. Soil physico chemical properties were measured by standard procedures mentioned previously in the chapter ‘Methodology’.

DATA ANALYSIS:-- Statistical analysis was performed by standard methods (Zar, 1999).

RESULTS:--

Physical characteristics of soil:- Among the physical properties, soil colour, bulk-density, soil water holding capacity and soil texture were analysed in both Chailtabasti and Dargakona villages. Two local soil types were observed, rubbish and chitta, in homegardens of both the villages.

Chailtabasti :- Soil colour ranged from brown to yellowish brown (Table: 5a)

In Chailtabasti, for rubbish soil bulk density (g/cm$^3$) ranged from 1.42-1.64 g/cm$^3$ with mean of 1.54 g/cm$^3$ and water holding capacity of soils ranged from 30.96-33.98 % with a mean value of 32.45 % (Table 5b ). and the soil type found to fall in the textural class sandy loam (Table: 5c ).

For chitta soil the soil colour range found to be light yellowish brown to brownish yellow (Table: 5a ). The highest bulk density was found to be 1.63 g/cm$^3$ with lowest water holding capacity as 45.36% and bulk-density ranges from 1.21-1.63 g/cm$^3$ and water holding capacity ranged from 45.36-56.10 % (Table: 5b ).

Comparing both rubbish and chitta soils, it was found that chitta which belongs to clay textural class has more water holding capacity than rubbish that belongs to sandy loam texture. This might be due to chitta soil comprising of highest percentage of clay particles of all particles present in the soil (>50%) (Table: 5c ). On the otherhand, percentage of sand particles was found to be highest in rubbish soils (>75%)
which belonged to sandy loam textural class (Table: 5c) indicating a lower water holding capacity value for rubbish soil. But both soil types favour growth of agar seedlings.

It was found that both sandy loam and clay soil favour the growth of *Aquilaria malaccensis*.

Dargakona :-

The soil colour ranges from brown to pale brown to light yellowish brown (Table: 5a). Three different soil colour had been observed in rubbish soil, light yellowish brown for sandy clay loam and both pale brown and brown for sandy loam had been found.

The bulk density in rubbish soil ranged from 1.43-1.66 g/cm³ with mean value 1.58 g/cm³ and water holding capacity ranges from 32.21-36 % with a mean value 33.85 % (Table: 5b).

In chitta soil, the soil colour observed for chitta soil ranges from dark yellowish brown to pale brown to light yellowish brown (Table 5a). The bulk density ranged from 1.34-1.44 g/cm³ with mean value 1.39 g/cm³ and water holding capacity ranges from 38.06-43.69 % with mean value 41.31 % (Table: 5b). Two types of soil textural classes namely sandy clay loam and clay were found for chitta soil.

Forest gardens :- The soil colour range from yellowish brown to pale brown (Table: 5a). The bulk density (g/cm³) of forest garden soils ranged from 1.30 - 1.55 g/cm³ with mean 1.45 g/cm³ and water holding capacity ranges from 34.30 – 40.20 % with a mean 36.47 % (Table: 5b). The soil texture of forest garden soils were found belonging to sandy loam textural class (Table: 5c).
Table 5(a):- Soil colour according to Munsell colour notation of farmers’ soil type in the villages Chailtabasti and Dargakona.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Farmers’ soil type</th>
<th>Colour matrix (Munsell notation)</th>
<th>Soil Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chailtabasti</td>
<td>Rubish</td>
<td>10 YR, 5/3-5/6</td>
<td>Brown – Yellowish Brown</td>
</tr>
<tr>
<td></td>
<td>Chitta</td>
<td>10 YR, 6/4-6/6</td>
<td>Light Yellowish Brown – Brownish Yellow</td>
</tr>
<tr>
<td></td>
<td>Chitta</td>
<td>10 YR, 4/4-6/4</td>
<td>Dark Yellowish Brown – Pale Brown – Light Yellowish Brown</td>
</tr>
<tr>
<td>Forest gardens</td>
<td>Rubish</td>
<td>10 YR, 5/4-6/3</td>
<td>Yellowish Brown – Pale Brown</td>
</tr>
</tbody>
</table>
Table 5(b):- Physical Characteristics of farmer’s soil types in the villages Chaittabasti and Dargakona.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Farmer’s soil type</th>
<th>Bulk Density (g/cm³)</th>
<th>WHC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>Chaittabasti</td>
<td>Rubish</td>
<td>1.42-1.64</td>
<td>1.54</td>
</tr>
<tr>
<td></td>
<td>Chitta</td>
<td>1.21-1.63</td>
<td>1.42</td>
</tr>
<tr>
<td>Dargakona</td>
<td>Rubish</td>
<td>1.43-1.66</td>
<td>1.58</td>
</tr>
<tr>
<td></td>
<td>Chitta</td>
<td>1.34-1.44</td>
<td>1.39</td>
</tr>
<tr>
<td>Forest garden</td>
<td>Rubish</td>
<td>1.30-1.55</td>
<td>1.45</td>
</tr>
</tbody>
</table>
Table 5(c) :- Soil texture of farmers’ soil types.

<table>
<thead>
<tr>
<th>Study sites</th>
<th>Local soil types</th>
<th>Clay (%)</th>
<th>Silt (%)</th>
<th>Sand (%)</th>
<th>Soil Textural Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chailtabasti</td>
<td>Rubish</td>
<td>13.13</td>
<td>11.33</td>
<td>75.53</td>
<td>Sandy loam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.59</td>
<td>10.67</td>
<td>74.74</td>
<td>Sandy loam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.93</td>
<td>8</td>
<td>75.07</td>
<td>Sandy loam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.53</td>
<td>8.27</td>
<td>75.21</td>
<td>Sandy loam</td>
</tr>
<tr>
<td>Chailtabasti</td>
<td>Chitta</td>
<td>52.79</td>
<td>30.47</td>
<td>16.74</td>
<td>Clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52.93</td>
<td>27.53</td>
<td>19.54</td>
<td>Clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50.34</td>
<td>24.98</td>
<td>24.68</td>
<td>Clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>61.61</td>
<td>27</td>
<td>11.4</td>
<td>Clay</td>
</tr>
<tr>
<td>Dargakona</td>
<td>Rubish</td>
<td>14.26</td>
<td>14.47</td>
<td>71.27</td>
<td>Sandy loam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33.98</td>
<td>17.62</td>
<td>48.4</td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23.64</td>
<td>20.88</td>
<td>55.48</td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18.26</td>
<td>10.2</td>
<td>71.54</td>
<td>Sandy loam</td>
</tr>
<tr>
<td>Dargakona</td>
<td>Chitta</td>
<td>32.46</td>
<td>20.2</td>
<td>47.33</td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44.65</td>
<td>21.69</td>
<td>33.67</td>
<td>Clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30.6</td>
<td>22.93</td>
<td>46.47</td>
<td>Sandy clay loam</td>
</tr>
<tr>
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<td></td>
<td>42.23</td>
<td>24.23</td>
<td>33.55</td>
<td>Clay</td>
</tr>
<tr>
<td>Forest gardens</td>
<td>Rubish</td>
<td>15.8</td>
<td>20</td>
<td>64.2</td>
<td>Sandy loam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.26</td>
<td>16.67</td>
<td>70.07</td>
<td>Sandy loam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.26</td>
<td>18</td>
<td>70.74</td>
<td>Sandy loam</td>
</tr>
</tbody>
</table>
In Dargakona village, for rubbish soil two textural classes were identified as sandy loam and sandy clay loam and for chitta soil again two textural classes had been identified as sandy clay loam and clay (Table: 5c).

It was observed from analysis of soil physical properties that because of highest percentage of clay content in clayey soils, the water holding capacity of chitta soil was found more in comparison to rubbish soil. But a variation was observed in the soil characteristics of Dargakona village, as both local soil types belong to two textural classes. Therefore in the chitta soils (sandy clay loam), the percentages of clay content was not comprising highest percentage and both sand and clay particles are proportionately balanced. The range of values were also not having a wider difference (Table: 5c).

It can be noted from the study of physical properties of soils that, *Aquilaria malaccensis* can grow in the soil belonging to sandy loam to sandy clay loam to clay textural class.

Chemical characteristics of soil :-

For chemical analysis, test for soil pH and soil organic carbon (%) were performed.

Chaittabasti:-

In Chaittabasti, for rubish soil, the pH range was found to be 4.34-5.37 with a mean of 4.77 and soil organic carbon ranged from 0.49-0.80 %. For chitta soil, it was found that pH ranges from 4.02 - 4.74 with mean 4.55 and organic carbon ranges from 0.84-1.43 % with mean 1.14 % (Table: 6). In rubbish soil the pH fall in the category of extremely acidic to strongly acidic and in chitta soil it fall in the category extremely acidic to very strongly acidic. Mean organic carbon (%) content was found more in chitta soil than rubish soil. (Table: 6)
<table>
<thead>
<tr>
<th>Study sites</th>
<th>pH</th>
<th>Mean</th>
<th>Range</th>
<th>CV(%)</th>
<th>Mean</th>
<th>Range</th>
<th>CV(%)</th>
<th>Category of pH (acc.to Brady, 1990)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmer's soil types</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubish</td>
<td>4.34-5.37</td>
<td>4.77</td>
<td>4.55-5.13</td>
<td>4.93</td>
<td>4.66</td>
<td>4.43-4.80</td>
<td>4.37</td>
<td>Rubish</td>
</tr>
<tr>
<td>Chaltaasti</td>
<td>4.02-4.74</td>
<td>4.55</td>
<td>4.68-5.39</td>
<td>4.93</td>
<td>4.66</td>
<td>4.43-4.80</td>
<td>4.37</td>
<td>Rubish</td>
</tr>
<tr>
<td>Chaltaasti</td>
<td>4.43-4.80</td>
<td>4.66</td>
<td>4.68-5.39</td>
<td>4.93</td>
<td>4.66</td>
<td>4.43-4.80</td>
<td>4.37</td>
<td>Chaltaasti</td>
</tr>
<tr>
<td>Dargakona</td>
<td>4.28-4.60</td>
<td>4.37</td>
<td>4.60-5.13</td>
<td>4.93</td>
<td>4.66</td>
<td>4.43-4.80</td>
<td>4.37</td>
<td>Extremely acidic</td>
</tr>
<tr>
<td>Forest garden</td>
<td>4.28-4.52</td>
<td>4.37</td>
<td>4.52-5.13</td>
<td>4.93</td>
<td>4.66</td>
<td>4.43-4.80</td>
<td>4.37</td>
<td>Extremely acidic</td>
</tr>
</tbody>
</table>

Table 6: Chemical characteristics of farmers' soil type in Chaltaasti and Dargakona villages.
Dargakona:-

In Dargakona village, for rubbish soil pH ranged from 4.59-5.13 with mean 4.93 and organic carbon (%) ranged from 0.44-0.83 % with mean 0.62 % (Table: 6). In chitta soil, the pH ranged from 4.43-4.80 with mean 4.66 and soil organic carbon ranged from 0.57-1.41 % with a mean 1.04 (Table: 6). Here also in this site it was found that the mean organic carbon (%) was more in chitta soil than rubbish soil.

Forest gardens:-

The pH of forest gardens soils ranged from 4.28 - 4.52 with mean pH 4.37 and the it fall in the category ‘extremely acid’ according to Brady,1990. Organic carbon (%) content ranged from 0.88 – 1.37 % with a mean 1.09 % (Table 6).

It was found that the mean pH for the soils of Chailtabasti and Dargakona villages fall in the ‘ very strongly acidic’ category (according to Brady, 1990) (Table:6 ).

DISCUSSION:- Tree based agroforestry systems like the homegardens hold considerable potential in conserving and maintaining the soil fertility and productivity. Tree plantation in such systems improves soil physical, chemical and biological properties through accretion and decomposition of organic matter through litterfall and roots (Singh and Sharma, 2007). Farmers’ knowledge system provides a framework determination of soil quality in homegardens.

Farmers in Chailtabasti and Dargakona villages, use soil characteristics such as slope, soil colour, soil texture as indicator of soil quality. They cultivate agar seedlings in the areas where the seedlings can get available water from soils. According to the farmers, in study sites the soils of banana zone have high water holding capacity because of formation of humus surrounding the roots of banana. In the present study also, some people said that near banana plants Agar seedlings can be grown as these soils have more water holding capacity.
Soil colour is an indirect expression of a number of important soil qualities which are otherwise not easily quantified. A black colour is usually an indicator of organic matter accumulation at the surface, though the intensity of the black colour is not always linked to the amount of carbon in the soil.

Farmers in Chailtabasti and Dargakona village use soil colour as an indicator of soil fertility, water holding capacity and texture. Soil colour is an important indicator for classifying soils and is used by traditional farmers all over the world (Habarurema and Steiner, 1997; Bellon et al., 1999; Mango, 1999). Colour in various types of soils is primarily due to the amount of organic matter and chemical state of the iron and other compounds in the mineral fraction of the soil. Other minerals such as quartz, granite, and heavy black minerals may also influence soil colour. The colour of a soil can reveal a great deal about the drainage conditions (Brady, 1990).

In the present study, it was found that Chitta soil possess more darker colours than Rubish soils; and again Chitta soil of textural class clay as well as sandy clay loam both were found more darker than Rubish soil which belonged to sandy loam texture in Chailtabasti village and also in forest gardens.

Bulk density is a measure of the weight of soil per unit volume (g/cm$^3$) usually given on an oven-dry basis. Bulk density is mainly influenced by texture and organic matter content. Soil physical properties revealed that BD (g/cm$^3$) is lowest for Chitta soil while water holding capacity is highest for it. Greater WHC of Chitta soil is related to its textural class as, sandy clay loam textural classes have the greater water retaining capacity than sandy loam and loamy sand textural class (Brady and Weil, 2004).

The bulk density tends to be lower in fine texture soils such as silt loams, clay and clay loams and where adequate organic matter is present (Brady, 1990). Present study also validated the fact. Scholes et al., (1994) also mentioned that increasing soil organic matter results in reduced bulk density.
Das and Das (2004) recommended that the traditional soil classification are maintained in many farming systems based on surface soil characteristics generally positively correlated to the findings of laboratory analysis. In the present study sites, farmers believed that Chitta soil (sandy clay loam and clay) as soils of higher fertility and Rubish soil (sandy loam) are poor in quality but at the same time this Rubish soil was found supporting a satisfactory growth of Agar (*Aquilaria malaccensis*) saplings. Although analytical study revealed that sandy loam soils are having higher bulk density and lower water holding capacity they were found suitable for Agar cultivation.

The water holding capacity was found more in Chitta soils which is belonged to clay texture in Chailtabasti and both clay and sandy clay loam in Dargakona village. The more water holding capacity of Chitta soil might be due to higher percentage of silt and clay particles, lower bulk density and higher organic carbon content. Lower bulk density indicates that the soil is not compacted and has more porosity. Analysis of physical properties showed that the water holding capacity is lower in Rubish soils than Chitta soils in both the villages. The predominance of sand in these soils increase the percentage of macropores and thereby lowers the water retention capacity of the soil. Chitta soil was found having more water holding capacity than rubbish. Water holding capacity of Clayey soil is more than sandy loam and sandy clay loam, also sandy clay loam soils have more WHC(%) than sandy loam and loam textural class (Brady and Weil, 2004). Chitta soil which have high clay content and believed to be rich in fertility. Analytical study revealed that sandy clay loam soil have high water holding capacity.

Soil texture refers to the relative proportions of various size particles in a given soil. This is an important soil characteristics. Sandy soils are considered as ‘light’, clayey soil as ‘heavy’ since they are either easy or more difficult in tilling and cultivation. Texture also has a major impact on the hydraulic properties of soils, both in terms of water infiltration and water retention capacity. The Chitta soils of Chailtabasti village were found to have highest water holding capacity as these soils belonged to Clay textural class and possess more than 50 % of clay particles in particle distribution. Forest
garden soils were found belonging to sandy loam textural class with moderate water holding capacity. It was also reported that *A. malaccensis* can grow well on sandy loam soils (Beniwal, 1989?). Clay content improves WHC of soil which in turn is crucial for nutrient retention of soil. The findings of the present study resemble the farmers’ statement that Chitta soil is more fertile. But a better growth was observed in Rubish soil (sandy loam). It proved that *Aquilaria malaccensis* can grow in a wide range of soil characteristics from sandy loam to sandy clay loam to clay soils.

The pH of the soil samples ranged from 4.02 – 5.37 for all soils in the homegardens of the two villages including the forest garden soils. So the pH values of the present study was found to be lower than the values ranging from 5.9 – 6.4 in the homegardens of Thailand (Gajaseni and Gajaseni, 1999). Soehartono *et al.*, (2002) found the pH ranging from 4.70 – 5.11. Belder *et al.*, (2007) found a pH range 3.6-5.2 in basins, between basins and the farmers’ practice plot in Zimbabwe. In general, forest soils are slightly lower in terms of pH than homegarden soils and it also verified by the present study. According to propositions made by Brady (1990), pH of farmers soils varied from very strongly acidic to strongly acidic in nature. Thus, the farmers’ soil knowledge gives an idea that *A. malaccensis* can grow in relation to wide range of soil conditions.

Organic carbon was found more in chitta soil than rubbish. Brady (1990) observed that soils with high silt and clay have higher organic carbon content and is an indicator of fertility status of soils. Organic carbon content (%) was found highest in farmers’ soils at 20-40 cm depth than other two plots basins and between basins at all depyh in Zimbabwe (Beider *et al.*, 2007). Carbon content was found more in forest garden soil than homegarden soils, which may be due to addition of organic matter through litter and fine roots. In the present study it also fall in the range 0.88 – 1.37 % for forest garden soil with average OC (%) 1.09 %. Organic carbon content was also found to be higher in Athalimati and Chittamati which fall in the textural class sandy clay loam (Das and Das, 2004).