Soil fertility evaluation under different land use system in tropical humid region of Kerala, India

Abstract

Soil related constraints are studied since the post green revolution era because of wide spread deficiencies of mineral nutrients in majority of states. There is a need for correcting deficiencies of nutrients for sustained crop production. Thus, evaluation and assessing nutrient status is must under various land use in order to recommend soil and crop specific nutrient. Randomly collected 155 geo-referenced surface (0-15 cm) soil samples under various land use from Elamdesam block of Idukki district, Kerala were analysed for essential nutrients with pH and EC. Mean values for all the nutrients under different land use were calculated for comparison. Further, soils were separated using soil test rating chart for interpretations under various category. Results revealed that, soils are very strongly acidic in reaction. Organic carbon content is high. Phosphorus content varied from low to medium and potassium content was very low to medium. Available calcium and magnesium were very low and sulphur is medium. Copper content was adequate and zinc and boron were deficit. Among land use, pineapple land use recorded higher EC (0.10 dS m\(^{-1}\)), available P (82.19 kg ha\(^{-1}\)), K (196.32 kg ha\(^{-1}\)) and S (11.49 ppm) whereas paddy soils recorded higher pH (5.08), Ca (264.33 ppm), Fe (98.70 ppm), Cu (3.95 ppm) and B (0.32 ppm). Similarly, rubber growing soils have higher Mn (6.92 ppm) whereas oil palm soils have higher organic carbon (2.80 percent). Banana land use has higher EC (0.10 dS m\(^{-1}\)) and Zn (1.26 ppm) and coconut soil has higher Mg (34.96 ppm).

Key words: Soil fertility status, evaluation, land use, Elamdesam block, Kerala

Introduction

Soil is the source of mineral nutrients for crop production which is not renewable under continuous cultivation due to crop removable as well as leaching losses. The dynamic nature of soil is highly influenced by human induced as well as natural processes of soil formation (Kavitha and Sujatha, 2015). With the time soils undergo changes rapidly in their physical, chemical and biological properties. Addition of inputs such as chemical fertilizers,
organic manures, insecticides and pesticides alter the properties of soil. Hence, soil testing
and knowing the status of soil fertility is a necessary step towards sustainable soil
management. Soil test status based recommendation of nutrients, manures results in better
crop production and productivity apart from maintaining soil health. Thus, soil fertility
evaluation is a fundamental aspect to keep the soil nutrient balance, which indicates quantity
of nutrients to be added for higher crop yields besides reducing the cost of cultivation and
environmental pollution. Therefore the study highlights the status of soil fertility in various
land use systems in tropical humid region of Kerala, India

1. Materials and methods

Details of the study area:

Elamdesam block falls under the agro-ecological zone foot hills and high hills, the
agro ecological units 12 and 14 i.e. southern and central foot hills and southern high hills,
respectively. These units are subdivided in to forests, denudational hills, lateritic terrain and
lateritic valley lying between north latitudes $9^\circ 46' 38.2''$ and $10^\circ 2' 18.14''$ and east
longitudes $76^\circ 42' 59.49''$ and $76^\circ 53' 46.99''$. There are seven panchayats namely
Vannapuram, Kodikulam, Karimannor, Udumbannoor, Alakode, Velliymattom and
Kudayathoor in the Elamdesam block and eight villages covering a total geographical area of
40,307 ha. Villages are further divided in to number of wards for the purpose of
administration. Geology of the area is charnockite and granite gneiss of the Archaen age.
elevation ranges from 30 m in low land to 850 m in high hills. Climate is tropical humid
monsoon type. Rainfall ranges from 3462 mm to 3602 mm and mean annual temperature
varies between $22 \degree C$ to $27 \degree C$. Length of dry period is two to two and a half months. High
hills are covered by mixed forest whereas foot hills and midlands have plantation of rubber,
coconut, pepper, banana, pineapple, arecanut, cocoa, nutmeg, cashew. Low land is occupied
by paddy and tapioca, banana, coconut arecanut and rubber were also cultivating in raised
beds. Laterites and Ultisols are the major soil type which, are well drained, shallow to very
deep, strongly acidic in nature. Study area with soil sampling sites given in Figure 1.
Soil sampling and analysis:

In Elamdesam block agriculture is the fundamental livelihood activity among the people. Major land uses are rubber plantations, mixed forest plantations and paddy cultivation. 155 geo-referenced surface (0-15 cm) soil samples were collected from the different land use. Soils were air dried, sieved through 2mm sieve. The processed soil samples were analysed for organic carbon by Walkley and Black (1934), available phosphorus by Bray and Kurtz (1945), pHs (1:2.5), electrical conductivity, available potassium, available calcium and magnesium by Jackson (1973), available sulphur by Black (1965), available micronutrients (1N HCl extraction) followed by Lindsay and Norvel (1978) and available boron by Wolf (1974) method.

Soil analysis data were grouped based on land use. Mean values for all the nutrients under different land use were calculated for comparison. Further, soils were separated using
soil test rating chart for interpretations under various class and data were expressed in the form of graph.

2. Results and discussion

Data pertaining to soil nutrient status are furnished in figures 2 to 11 and the mean and range values of soil nutrients under different land use are given in Table 1.

3.1 pH, electrical conductivity and organic carbon

The acidification of soils is a serious constraint to crop production in the region. The pH of the soils of Elamdesam block varied from 4.06 to 6.48 (Fig. 2). Among total soils studied 57.41 percent soils are very strongly acidic followed by extremely acidic (18.06 percent) and strongly acidic (18.06 percent). Only few samples are moderately and slightly acidic in reaction. The pH under different land use did not differ much, highest mean pH noticed in pineapple land use (5.08) followed by paddy (4.90) and banana (4.90) and the lowest pH (4.83) noticed in soils of oil palm land use. The higher acidity recorded might be due to leaching of bases by irrigation water as well as higher rainfall associated with better drainage condition. Soils of the humid tropics are generally acidic in reaction due to intense leaching condition and the consequent loss of basic cations. The intensification of agriculture through high yielding crop varieties and external inputs of acid producing chemical fertilizers aggravated the problem of soil acidity. Strongly acid soils affect plant available nutrients, decomposition of organic matter and also plant roots due to higher concentration of aluminium ion in soil solution. Thus application of lime is must to neutralize the acidity generated (Rajasekharan et al., 2013).

The electrical conductivity of the soils of different land use varied from 0.018 to 0.32 dS m$^{-1}$. The mean EC value was highest (0.1 dS m$^{-1}$) under banana and pineapple growing soils and the lowest EC (0.05 dS m$^{-1}$) recorded in oil palm land use. Lowest EC recorded due to leaching of soluble salts by irrigation water and also due to high rain fall. The low EC of soils indicate the conditions prevailed was not favourable for accumulation of salts (Roy et al., 1962).
The organic carbon content of the soils of the Elamdesam block varied from 0.89 to 3.34 percent (Fig. 3). Among total soils, 56.77 percent soils recorded high in organic carbon and 36.77 percent soils recorded very high. Only 10 samples out of 155 samples recorded medium class. The mean organic carbon in various land use was highest in oil palm land use (2.8 percent) followed by paddy soils (2.56 percent) and the lowest (2.05 percent) was noticed in pineapple land use. Higher organic carbon recorded might be due to continuous addition of organic matter through perennial plantation crops. Mineralization of organic matter is constrained in acid soils. Hence it is necessary to correct soil acidity to benefit from high levels of organic matter. Higher levels of organic carbon not only provides part of nitrogen requirement of the crop plants but also enhance nutrient and water retention capacity of soils and create favourable environment (Rajasekharan et al., 2013).
2.2 Primary nutrients

The phosphorus content of Elamdesam soils varied from 1.08 to 453.2 kg ha\(^{-1}\) (Fig. 4). Among total soils studied, 27.74 percent soils falling under low, 23.23 percent under medium class and only 15 samples recorded high in available P. The mean available P content under different land use was highest in pineapple growing soils (82.19 kg ha\(^{-1}\)) followed by rubber growing soils (43.63 kg ha\(^{-1}\)) and the lowest was recorded in oil palm plantations (7.18 kg ha\(^{-1}\)). There is a build up of P in pineapple land use which, imbalances the availability and uptake of other essential plant nutrients besides leading to pollution of soil, water and environment. P is often described as the second liming nutrient for crop production. After nitrogen. Thus correction of soil acidity through liming can leads to release of P fixed by soil constituents in to the available pool. Hence, it is recommended to get the soils tested regularly and apply fertilizer accordingly (Mini and Usha Mathew, 2015).

![Figure 4: Status of available phosphorus in soils of Elamdesam block; VL-very low; L-low; M-medium; H-high; VH-very high; EH-extremely high](image)

Potassium levels in soils of Elamdesam block varied from 11.35 to 494.28 kg ha\(^{-1}\) (Fig. 5). Among total samples, 33.55 percent samples are falling under medium and 30.32 samples under very low and low category each. Only two samples recorded very high category. In case of land use, pineapple growing soils recorded higher available K (196.32 kg ha\(^{-1}\)) followed by banana land use (149.77 kg ha\(^{-1}\)) and the lowest mean values of available K recorded in paddy soils (62.41 kg ha\(^{-1}\)). In general, the potassium status of Kerala soils is found to be low and the reason can be attributed to the tropical climate and predominance of kaolinitic clay mineral characterized by low K (Mini and Usha Mathew, 2015). Kavitha and Sujatha (2015) reported that the probable reason might be the leaching condition brought in by irrigation coupled with strong acidity which does not permit retention of potassium on the soil exchangeable complex. Rajasekharan et al. (2013) reported that the highly weathered
and leached soils of Kerala developed under humid tropics do not have any significant amount of potassium bearing minerals. Cation exchange capacity of the low activity clay minerals in the soils (mainly kaolinite) does not permit retention of significant amount of potassium in exchangeable form. Thus regular application of potassium fertilizer to crop plants is as many splits are necessary.

Fig. 5: Status of available potassium in soils of Elamdesam block; VL-very low; L-low; M-medium; H-high; VH-very high

2.3 Secondary nutrients

The available calcium (Ca) content of the soils of the Elamdesam varied from 18.44 to 977.05 ppm (Fig. 6). Among total samples studied, 67.10 percent of samples recorded very low category followed by adequate category (20.65 ppm) and 19 samples falling under low class. In case of land use, paddy soils recorded higher available calcium (264.33 ppm) followed by banana growing soils (213.03 ppm) and oil palm land use noticed lower value (133.32 ppm). The lower levels of calcium might be due to continuous addition of acidifying chemical fertilizers. There is a direct relationship exists between pH and available calcium content of the soil. Medhe et al. (2012) reported similar results. Rajasekharan et al. (2013) reported that lower availability of calcium mainly because of lack of mineral bearing this element. Thus application of liming materials to alleviate soil acidity shall ensure the supply of the nutrient wherever deficient.
The magnesium (Mg) content of the soil varied from 3.86 to 223.67 ppm (Fig. 7). Among total samples, 86.45 percent samples are very low followed by 12.26 percent samples falling under low category. Cultivation of coconut recorded higher mean available Mg (34.96 ppm) followed by banana growing soils (33.59 ppm) and the lowest mean available Mg recorded in oil palm growing soils. Similar results reported by Mini and Usha Mathew (2015).
Available sulphur (S) content varied from 0.83 to 28.3 ppm in soils of Elamdesam block (Fig. 8). Among total soils analysed, 49.03 percent samples are medium followed by 27.74 percent samples under adequate category and only one sample falling in high category. In case of land use pineapple growing soils recorded higher mean available S (11.49 ppm) followed by banana growing soils (8.98 ppm) and the lowest S recorded in coconut growing soils. Continuous application of S containing fertilizer like ammonium phosphate might be maintained S level in medium category. Singh et al. (2012) reported the significant negative relationship between S and pH. Thus S deficiency can be managed by applying magnesium sulphate (Mini and Usha Mathew, 2015).

2.4 Micronutrients nutrients

The iron (Fe) and manganese (Mn) content of soils of Elamdesam block varied from 10.4 to 242.1 ppm and 0.9 to 22 ppm, respectively. Among the land use, available Fe content was highest in paddy soils (98.70 ppm) followed by coconut and banana growing soils (34.23 and 33.13 ppm, respectively) and the lowest mean value recorded in pineapple land use (18.38 ppm). In case of manganese, highest mean Mn content recorded in rubber soils (6.22 ppm) followed by oil palm land use (5.50 ppm) and the lowest Mn content noticed in coconut soils (2.8 ppm).

The copper (Cu) content of soils of Elamdesam block varied from 0.6 to 20.5 ppm (Fig. 9). Among total soils studied 93.55 percent of samples are adequate in available copper and only one sample noticed higher category. In case of land use paddy soils recorded higher mean value (3.95 ppm) followed by rubber soils (3.46 ppm) and the lower mean Cu content recorded in oil palm soils (0.83 ppm). The adequate availability of copper in soil might be due to its an ingredient in common fungicide and their frequent application either to soil or in crops might increase its level and also copper has strong negative correlation with pH but positively correlated with organic carbon (Kavitha and Sujatha, 2015).
The zinc (Zn) content of the soils of the Elamdesam block soils varied from 0.3 to 11.00 ppm (Fig. 10). Among total soils studied 72.26 percent of samples are deficit of Zn and 27.74 percent samples are adequate. In case of land use, banana growing soils recorded higher Zn content (1.26 ppm) followed by rubber growing soils (1.2 ppm) and the lower mean value noticed in pineapple land use (0.68 ppm). Kavitha and Sujatha (2015) reported strong negative correlation between Zn and pH. Similar results reported by Nair et al. (2013).

The available boron (B) content of soils of Elamdesam block varied from 0.09 to 0.60 ppm (Fig. 11). Out of total soils studied 92.90 percent of soils are deficit and 7.10 percent of soils are adequate in available boron content. Among the land use, paddy growing soils have recorded higher mean boron content (0.32 ppm) followed by rubber soils (0.31 ppm) and the lower mean B content recorded in pineapple (0.27 ppm) and oil palm (0.27 ppm) soils. The lower level of B might be due to leaching by high rainfall. Similar results reported by Mini
and Usha Mathew (2015). Kavitha and Sujatha (2015) reported significant positive correlation between B and pH. However, managing B is also difficult because of its high mobility. Application of borax or foliar spray of borax solution can supply availability of boron.

Fig. 11: Status of available boron in soils of Elamdesam block; Def- Deficit; Adq- Adequate

3. Conclusions

Soils of the Elamdesam block are varied in soil fertility status under different land use. Amelioration of soil acidity and external inputs of essential nutrients is must for successful crop production. The status of available nutrition provides the basis for soil and crop specific, mineral nutrition recommendation in all the land use in order to maintain soil nutrient balance and also to enhance higher crop production and productivity.


4. References


Table 1: Soil fertility status under different land use (mean and range values) in soils of Elamdesam block, Idukki district, Kerala.

<table>
<thead>
<tr>
<th></th>
<th>pHe (1:2)</th>
<th>EC (dS/m)</th>
<th>OC (%)</th>
<th>P (Kg/ha)</th>
<th>K (Kg/ha)</th>
<th>Ca (ppm)</th>
<th>Mg (ppm)</th>
<th>S (PPM)</th>
<th>Fe (ppm)</th>
<th>Mn (ppm)</th>
<th>Cu (ppm)</th>
<th>Zn (ppm)</th>
<th>B (ppm)</th>
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<tr>
<td>Banana</td>
<td>4.90</td>
<td>0.10</td>
<td>2.07</td>
<td>26.84</td>
<td>149.77</td>
<td>213.03</td>
<td>33.59</td>
<td>8.98</td>
<td>33.13</td>
<td>5.33</td>
<td>2.96</td>
<td>1.26</td>
<td>0.30</td>
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<td>Coconut</td>
<td>4.83</td>
<td>0.08</td>
<td>2.35</td>
<td>17.77</td>
<td>80.19</td>
<td>155.61</td>
<td>34.96</td>
<td>4.72</td>
<td>34.23</td>
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<td>2.82</td>
<td>0.80</td>
<td>0.30</td>
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<tr>
<td>Oil palm</td>
<td>4.90</td>
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<td>2.80</td>
<td>7.18</td>
<td>95.18</td>
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<td>26.55</td>
<td>62.41</td>
<td>264.33</td>
<td>31.70</td>
<td>6.53</td>
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<td>4.67</td>
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<td>0.32</td>
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<tr>
<td>Pineapple</td>
<td>4.88</td>
<td>0.10</td>
<td>2.05</td>
<td>82.19</td>
<td>196.32</td>
<td>166.80</td>
<td>19.21</td>
<td>11.49</td>
<td>18.38</td>
<td>4.78</td>
<td>3.34</td>
<td>0.68</td>
<td>0.27</td>
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<tr>
<td>Rubber</td>
<td>4.86</td>
<td>0.07</td>
<td>2.30</td>
<td>43.63</td>
<td>130.75</td>
<td>173.72</td>
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<td>8.97</td>
<td>26.32</td>
<td>6.92</td>
<td>3.46</td>
<td>1.20</td>
<td>0.31</td>
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<tr>
<td>Range</td>
<td>4.06-6.48</td>
<td>0.018-0.32</td>
<td>0.89-3.34</td>
<td>1.08-453.20</td>
<td>11.35-494.28</td>
<td>18.44-977.05</td>
<td>3.86-223.67</td>
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<td>10.40-242.10</td>
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