Effect of varying land uses on important soil properties and their co-relation with organic carbon in soils of Navsari Agricultural University, Main Campus, Navsari (Gujarat)

AMARESH DAS AND MD. ZUBER ANSARI

SUMMARY

An investigation was carried out with an objective to study the effect of varying land uses on some important properties of soils (organic carbon, EC, pH, available major nutrients, available sulphur, available micronutrients, bulk density and water stable aggregates > 0.5 mm) of Navsari Agricultural University main campus, Navsari and also to find out the their co-relations with SOC as to varying land uses. Ten different land uses namely, Oil palm plantation, Sapota plantation, Mango plantation, Sugarcane crop, Rice crop, Pulses and oilseed crops, Banana plantation, Vegetable crops, Floriculture crops and Barren land (LU10) covering an area of 333.42 hectares of NAU main campus were selected for the present study. The results revealed that soil organic carbon(SOC) under different land uses varied from 2.4 to 9.7 g kg$^{-1}$ with the order: Oil palm > mango > sapota > sugarcane > pulses and oil seeds > banana > rice > vegetables > floriculture > barren land. Soil salinity irrespective of land uses varied from 0.27 to 0.52 dS m$^{-1}$ and was below problematic limit. Soil pH varied from 5.82 to 8.00 with no appreciable difference amongst land uses, barring rice soil with acidic pH (5.82). Available nitrogen varied from low to highly medium status ((494 kg ha$^{-1}$)) following the order : Pulses and oil seeds > oil palm > mango > sapota > sugarcane > banana > rice> floriculture > barren > vegetables. Available phosphorus varying from 33.29 to 60.30 kg P$_2$O$_5$ ha$^{-1}$ maintained the following order: Sugarcane > oil palm > mango > sapota > pulses and oilseeds > vegetables > banana > floriculture > rice > barren land, while available potassium was high, except rice soil with 143.2 kg K$_2$O ha$^{-1}$. Available sulphur varying from 15.03 to 23.25 mg kg$^{-1}$ portrayed medium to high status. Available zinc was deficient in most soils, except rice and oil palm soil. Available iron and manganese exhibited low to high status. Available copper indicated deficient to marginal status. Bulk density of soils varied from 1.45 to 1.83 Mg m$^{-3}$ following descending order: Barren > flouriculture > vegetable > rice > banana > pulses and oilseed > sugarcane > oil palm > sapota > mango. Water stable aggregates of size > 0.5mm (macro aggregates) varied from 24.19 (rice)to 66.53 per cent(sapota), Some significant or highly significant correlations of soil properties with SOC were observed with bulk density, available nitrogen, sulphur and water stable aggregates. The overall results suggest that land should not be kept barren and efforts should be made for improving SOC having low status. Soils having low to marginally medium status of available nitrogen, phosphorus and potassium and deficient in available Zn, Fe, Mn, Cu, call for proper management and corrective measures through avoiding excessive cultivation practices, application of organics and following crop rotation to sustain crop yield and soil quality.


KEY WORDS: Land uses, Soil properties, SOC, Co-relation

The ability of soil to supply nutrients in available form varies with the change in soil properties and conditions. The climate and the soil of a region have great bearing on sources, availability and degree of organic materials in soil, while the land use pattern significantly influences the soil organic carbon (SOC) content, nutrient status and also physical, physico-chemical properties of soil to certain extent. SOC is a good indicator of soil productivity potential. It affects physical, chemical and biological properties of soil and plays a crucial role in sustaining soil quality, agricultural production and environmental quality (Zhang et al., 2003 and Andrews et al., 2004). SOC is very stable but is very reactive and a large quantity can be lost through changes in agricultural
land use particularly from tillage, erosion, fallowing, deforestation as well as different management practices (Yang et al., 2003) leading to deterioration of soil health. Organic materials and their decomposition products have large bearing on the nutrient content and cation exchange capacity of soils and are responsible perhaps more than any other single factor for the stability of soil aggregates which is again the key indicator of soil structure. Further, organic carbon is the major constituent for most of the microorganisms and acts as source of energy. Keeping all the above points in view an investigation was carried out with an objective to study the effect of varying land uses on some important properties of soils of Navsari Agricultural University main campus, Navsari and also to find out the their co-relation with SOC as to varying land uses.

EXPERIMENTAL METHODS

The area under study covered 333.42 hectares (excluding roads, office-buildings, residential colonies) of land at Navsari Agricultural University (NAU), main campus, which the mean monthly minimum temperature ranges of July and August. December and January are winter months with mean monthly minimum temperature range 25\(^0\)\text{C} to 35\(^0\)\text{C}. April and May are the hotter months during which the mean monthly minimum temperature ranges from 33\(^0\)\text{C} to 35\(^0\)\text{C}.

Ten different land were used namely, 1) Oil palm plantation (LU\(_1\)), 2) Sapota plantation (LU\(_2\)), 3) Mango plantation (LU\(_3\)), 4) Sugarcane crop (LU\(_4\)), 5) Rice crop (LU\(_5\)), 6) Pulses and oilseed crops (LU\(_6\)), 7) Banana plantation (LU\(_7\)), 8) Vegetable crops (LU\(_8\)), 9) Floriculture crops (LU\(_9\)) and 10) Barren land (LU\(_{10}\)) covering the above referred area of NAU main campus were selected and taken under study. However, for comparison of data and interpretation LU\(_1\) to LU\(_3\), LU\(_4\) to LU\(_6\), and LU\(_9\) to LU\(_{10}\) were considered as tree/plantation group, agricultural group, horticultural group, respectively. From each land use system ten representative soil samples were taken from a depth of 0-22.5 cm (except for mango, sapota and oil palm plantation, where depth of samples was 0-30 cm). Samples were air-dried, cleaned and properly grinded to pass through 2 mm sieve. The processed soil samples were kept in proper place for laboratory analysis purposes. Analysis were done for organic carbon, available major (N, P, O\(_2\), K\(_2\)O), secondary (S) and micro nutrients (Zn, Fe, Mn and Cu) as well as physical properties (bulk density and water stable aggregates (WSA) of size > 0.5 mm). Sand, silt and clay per cent were determined by international pipette method (Piper, 1966), pH and EC were determined at 1 : 2.5 soil : water ratio as described by Jackson (1979), soil organic carbon by Walkley and Black rapid titration method (Jackson,1979), Available N by 0.32 per cent alkaline potassium permanganate method (Subbiah and Asija, 1956), available P\(_2\)O\(_5\) by 0.5 M NaHCO\(_3\) (pH 8.5) method following Olsen et al. (1954), available K\(_2\)O by Flame photometric method (extraction with 1 N NH\(_4\)OAc) as per Jackson (1979), available S by Turbodensitive method (extraction with 0.15% CaCl\(_2\)) following Chopra and Kanwar (1980), DTPA extractable Fe, Mn, Zn and Cu by 0.05 M DTPA and estimated on AAS spectrophotometer following Subbiah and Asija (1956), bulk density by Black method (Black,1965) and water stable aggregate (>0.5mm) by Yoder’s method (Yoder, 1936).

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation are summarized below:

Soil organic carbon (SOC):

The results (Table 1) revealed that mean soil organic carbon (SOC) irrespective of different land uses varied from 2.4 to 9.7 g kg\(^{-1}\) with the highest and lowest value being associated with oil palm land use and barren land, respectively. SOC, however, followed the order: Oil palm > mango > sapota > sugarcane > pulses and oil seeds > banana > rice > vegetables > floriculture > barren land indicating that tree/plantation group displayed higher SOC as compared to those under agricultural group, Horticultural group and Barren land. The reason for higher SOC under oil palm, sapota and mango i.e. tree/plantation group might be ascribed to higher addition of organic biomass through litter fall and least disturbance of these soils. On the contrary, least addition of organic biomass, less canopy coverage and high decomposition rate are major reasons for the least SOC under barren land. Results are in good agreement with Kumar et al. (2006), Singh et al. (2006), Zhang et al. (2006) and Dhaliwal et al. (2008), wherein they found higher SOC under tree plantation in forest or plantation land uses as compared...
to agricultural land use and waste land use system. Poor carbon status in barren land of NAU campus suggests that this land should not be allowed to remain barren; rather it should be put under green cover or tree/plantation in order to sustain soil quality and ecological stability as well. Relatively low SOC under floriculture and vegetable land uses necessitate improved management practices through addition of more organic manures/biomass in these soils for possible increase in crop yield and for sustenance of soil quality/health as well.

**EC and pH:**

Soils under all land uses exhibited salinity below problematic limit, showing its variation in mean values from 0.27 to 0.52 dS m\(^{-1}\). However, the land uses with respect to salinity may be placed as: rice > Sugarcane > banana > floriculture > oil palm > sapota > pulses and oil seed > vegetable > barren > mango. Relatively higher salt accumulation in surface soil of rice, sugarcane and banana might have arisen from soluble salts accumulated through higher quantum or frequency of applied irrigation water to these crops. Result is supported by the finding of Somasundaram *et al.* (2009). Minimum salt accumulation under mango plantation might be due to less surface evaporation owing to higher canopy coverage coupled with no watering/irrigation. However, differences in soil salinity as to different crops/vegetations/barren land might be attributable to varying degree of irrigation, canopy coverage and salt absorption capacity of plants/vegetations/trees.

Mean soil pH irrespective of land uses varied from 5.82 to 8.0 with no appreciable difference amongst land uses, excepting rice which showed acidic (pH 5.82) soil reaction. Application of higher quantum of water, acid producing fertilizers and removal of basic cations through leaching, are major contributing factors responsible for higher soil acidity under rice. Soils under sapota were slightly alkaline and in rest were, more or less, normal in reaction. Singh *et al.* (2006) reported higher pH under orchard, while Dhaliwal *et al.* (2008) mentioned comparatively higher pH in undisturbed soil as against cultivated land. However, results highly corroborate with the findings of Negassa and Gebrekidfan (2003).

**Available major nutrients:**

Mean available soil nitrogen (Table 1) irrespective of land uses varied from 211.0 to 334.5 kg N ha\(^{-1}\) exhibiting medium to low status. Soils under pulses and oil seed recorded comparatively higher available soil nitrogen (494 kg ha\(^{-1}\)) might be due to addition of N in soil over the years on decomposition of N-nodules containing plant-biomass where atmospheric nitrogen was fixed by bacteria through symbiotic process. Next to pulses and oil seed, tree/plantation group analyzed higher mean available soil nitrogen as compared to rest of the land uses. In respect to available N ranking of various land uses are as: Pulses and oil seed > oil palm > mango > sapota > sugarcane > banana > rice > floriculture > barren > vegetable. Comparatively higher available nitrogen under oil palm, mango, sapota, sugarcane, banana and rice soils over others might be due to higher content of native SOC. The results are in confirmative of the findings of Kumar *et al.* (2006) and Dhaliwal *et al.* (2008). The least content of available nitrogen in soil under vegetables might be due to low SOC coupled with higher uptake of both native and applied nitrogen. Low SOC under floriculture and barren land possibly led to low mineralization of nitrogen in these soils. Low or marginally medium status of mean available nitrogen in major land uses of the campus call for special care for crop selection and appropriate management/measures for improving status of available nitrogen through addition of more organic manures/composts/bio-composts and/or raising pulse/leguminous crops in rotation for sustaining crop yield and soil quality.

Mean available soil phosphorus varying widely from 33.29 to 60.30 kg ha\(^{-1}\), exhibited (Table 1) medium to high rating under varying land uses. In general, all cultivated soils analyzed higher available phosphorus over barren land or undisturbed soil. Order of land use with respect to available phosphorus is as: sugarcane > oil palm > mango > sapota > pulses and oil seed > vegetable > banana > floriculture > rice > barren. Higher available phosphorus in soils under tree/plantation over other cultivated soils and barren land might be due to higher organic biomass and their subsequent decomposition. Reason for build up of phosphorus, particularly in sugarcane land use as a result of continuous application of both organic and inorganic fertilizers as a part of management for harvesting higher yield, can not be ruled out. These results are fully supported by the findings of Dhaliwal *et al.* (2008) and partially by Kumar *et al.* (2006). The results suggest that application of phosphorus must be monitored on yearly basis and should based on plant uptake- crop yield and build up of phosphorus in soil. Type of vegetation/crop, application of fertilizer/manures and variation in uptake of phosphorus by crops, are some of the major factors responsible for variation of mean available soil phosphorus under rest of the land uses.

Irrespective of land uses, mean soil available potassium varying from 143.2 to 421.3 K\(_2\)O kg ha\(^{-1}\) depicted marginally medium to high status. Except rice,
all other land uses showed high available potassium. While the highest value was recorded under sugarcane, the lowest one was registered under rice land use. Major factors responsible for high depletion of available potassium in rice soils might be leaching losses coupled with higher uptake and no replenishment. Low status of available potassium in rice and floriculture soils of this campus needs proper attention in potassium management for balanced nutrition and higher crop production. Change in cropping pattern/land use, management of crop and plant uptake are some key factors for variation of mean available potassium in soils under different land uses (Ganeshamurthy and Srinivasarao, 2009).

Mean available sulphur varying from 15.03 to 23.25 mg kg\(^{-1}\) showed medium to high status when all land uses were considered. The highest value (23.25 mg kg\(^{-1}\)) was associated with banana land use, while the lowest one (15.03 mg kg\(^{-1}\)) was found to be associated with floriculture land use. The order can be expressed as: banana > sapota > pulses and oilseed > mango > oil palm > barren > rice > vegetable > sugarcane > floriculture. Comparatively higher available S in Sapota, mango, banana, pulses and oilseed and oil palm land uses might be attributed to higher SOC which might have played a major role in generating available sulphur in these soils. Desai et al. (2009) found that soils receiving organics or crop residue exhibited higher available sulphur as compared to soils receiving only inorganic inputs. Application of recommended dose of sulphur in pulses and oilseed crops might be another reason for higher content of sulphur in these soils. Looking to the demand of crop for sulphur i.e. oil seeds > pulses > cereals, emphasis should be given on
the selection of crop vs. land and management practices which in turn, would play a crucial role in controlling the optimum production of crops in the campus soils.

**Available micro nutrients:**

Mean of available zinc ranged widely from 0.21 to 0.63 mg kg\(^{-1}\) showing deficient status in most soils, barring rice and oil palm soil. The highest and the lowest value of available Zn were associated with rice and floriculture land uses, respectively. The addition of recommended dose of Zn as a part of management practices might be reason for analyzing comparatively higher available Zn in rice soil. Deficient status of available Zn in most land uses calls for adoption of corrective measures as to avoid Zn deficiency in the near future. Kattyal and Datta (2004) and Somasundaram et al. (2009) expressed similar opinion.

Available iron ranged from 4.19 to 20.48 mg kg\(^{-1}\) (mean values), exhibiting low to high available status and the highest and the lowest value were associated with rice soil and vegetable soil, respectively. Results indicated that different land uses impacted differently on available Fe content of soil. Exceptionally high available Fe under rice soil might have arisen due to lower pH and reduced environment of soils under water logged condition. Soils under vegetable crop, Sapota and barren land exhibited low to marginal status, while in others (except rice) status of available Fe were medium. The differences in available Fe content might be ascribed to the accelerated nutrient removal by crop under varying land uses and crop intensification. The available Fe below sufficiency range (6 to 8 mg kg\(^{-1}\)) particularly under sapota, vegetable and floriculture suggests that Fe deficiency symptoms may develop in near future unless replenishment is done through addition of organic matter or some other means (Sharma, 2001).

Mean of available manganese varied appreciably (4.95 to 19.24 mg kg\(^{-1}\)) from low to high status, the highest and the lowest value being associated with rice and sapota soils, respectively. Soil available Mn followed, more or less, similar trend as that of available iron under different land uses. Soils under vegetable crops and sapota exhibited low to marginal status, while in other systems (except rice) status of available Mn was medium. Exceptionally high available Mn under rice soil was due to lower pH of soils with reduced environment as higher pH transforms divalent form of Mn into tri or tetravalent forms which are water-insoluble and not available to crop plants. The available Mn below sufficiency range (6 to 8 mg kg\(^{-1}\)) particularly in sapota and vegetable system indicated (Sharma, 2001) that Mn deficiency should to be corrected to avoid possible adverse effect on crop yield under these land uses.

Available copper under varying land use systems varied from 0.11 to 0.28 mg kg\(^{-1}\) (mean values) indicating deficient to marginal status. Oil palm, sapota, mango, sugarcane and rice land uses, exhibited marginal level of copper, while in rest of the land uses the same were deficient. Oil palm, sapota, mango and sugarcane land uses exhibited marginal level of Cu, while in rest the same was found to be deficient as per ratings of Lindsay and Norvell (1978). However, as per the critical limit of Katyal and Sharma (1991), soils of pulses and oil seed, sugarcane, banana, vegetable land uses and barren land were below the critical limit, while in rest of land uses the same was medium which might be due to higher SOC. In case of oil palm, slightly higher available Cu over others might have arisen from continues addition of fertilizer containing Cu as a filler material as mentioned earlier by Somasundaram et al. (2009).

**Bulk density:**

Mean value of bulk density of soil under different land uses varied from 1.45 to 1.83 mg m\(^{-3}\) following descending order: Barren > floriculture > vegetable > rice > banana > pulses and oilseed > sugarcane > oil palm > sapota > mango. Bulk density of soils under mango, sapota and oil palm i.e., under tree/Plantation group was low (1.45 to 1.49 Mg m\(^{-3}\)) as compared to those under other land uses might be due to higher SOC or organic matter through addition of leaf-litter and twigs etc. to these soils as organic matter influences aggregate formation resulting in decrease in bulk density (Manthan and Kannan, 1993). On the other hand, the highest bulk density (1.83 mg m\(^{-3}\)) observed in barren land was possibly due to no ploughing/tillage operation coupled with less organic matter addition under minimum canopy coverage. Sharma and Bali (2000) reported the highest bulk density in uncultivated land. Bulk density of soils under other land uses depicted intermediate values depending upon native SOC, crops/vegetations, their management including tillage practices. Results corroborate with the findings of Dhaliwal et al. (2008).

**Water stable aggregates (>0.5mm):**

Irrespective of land uses per cent of mean water stable aggregates >0.5 mm (macro aggregates) varied widely (24.19 to 66.53 per cent), the highest and the lowest value being associated with sapota and rice land uses, respectively. Comparatively higher per cent of macro aggregates were observed under sapota, mango and oil palm land use system i.e., tree/plantation group followed by pulses and oil seed and sugarcane land uses i.e.,
agricultural group (excluding rice), followed by vegetable, floriculture and banana land uses i.e. Horticultural group. The higher per cent of water stable aggregates under tree/plantation land use group might be attributed to relatively higher organic carbon or organic matter content and low tillage operation of these soils. Similar reason was also put forwarded by Mathon and Kannan (1993). The presence of the lowest per cent of macro aggregates under rice soil might be due to higher disintegration of aggregates/structures as a result of puddling operations. Results indicated that cultivation practices, particularly in soils under agricultural group and horticultural group where rate of organic matter loss was more possibly by accelerated microbial decomposition, reduced the proportion of water stable macro-aggregates, which hint us to adopt conservation agriculture to certain extent in order to expand minimum energy for ecological stability. These findings corroborate with the findings of Monreal and Kodama (1997). The barren land though contained the lowest per cent of carbon, exhibited the second lowest and low tillage operation of these soils. Similar reason was also put forwarded by Mathon and Kannan (1993). 

Correlation of soil properties with SOC under different land uses:

Correlation of other soil properties with SOC under different land uses are presented in Table 2. The result revealed that the correlations between SOC and pH under sugarcane (r= -0.90**) and rice (r= -0.66*) land uses were observed to be highly significant and significant, respectively. This finding is in conformity with Pal and Shrupali (2006). In rest of the land uses the co-relations could not reach to the level of significance. So far as soil EC_{2.5} is concerned, correlations of SOC with EC were found significant or highly significant under mango (r=0.67*), sugarcane (r=0.90**) and banana (r= 0.82**) land uses.

In case of available N, positive correlations with SOC had reached to the level of high significance under oil palm (r= 0.84**), and floriculture (r=0.93**) land uses and to significant level under sugarcane (r=0.70*) land use. Such positive correlation between SOC and available N was also observed by Kumar et al. (2006) and Dhaliwal et al. (2008). However, in banana land use, a highly significant negative correlation (r=-0.77**) existed between SOC and nitrogen. Only in soils of sugarcane, a high significant positive correlation (r=0.95**) was found between SOC and available P. Available P showed poor negative correlation in rice, floriculture and vegetable land uses and positive correlation in rest of the land uses with SOC. Negative correlation between organic carbon and P was also reported by Das et al. (1997). Barring the barren land, in all other land use systems, organic carbon was positively correlated with available K. However, correlations became highly significant only in sugarcane (r=0.87**) and banana (r=0.92**) land uses. Positive correlation between SOC and sulphur was significant or highly significant under sapota (r=0.69*), sugarcane (r=0.82**), and banana (r=0.88**) land uses, while significant but negative correlation (r=-0.63*) was observed only in vegetable land use. In rest of the land uses co-relations between SOC and sulphur were found to be non-significant. 

Only under sugarcane and banana land use, correlations between available Zn and SOC were observed highly significant (r=0.78**, r=0.81**) and positive. Such positive correlation was observed earlier by Venkatesh et al. (2003) and Dhaliwal et al. (2008).

<table>
<thead>
<tr>
<th>Land use Parameter</th>
<th>Oil Palm</th>
<th>Sapota</th>
<th>Mango</th>
<th>Sugarcane</th>
<th>Rice</th>
<th>Pulses and oil seed</th>
<th>Banana</th>
<th>Vegetable</th>
<th>Floriculture</th>
<th>Barren</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH_{2.5}</td>
<td>0.16</td>
<td>0.16</td>
<td>0.55</td>
<td>-0.90**</td>
<td>-0.66*</td>
<td>0.23</td>
<td>0.41</td>
<td>-0.32</td>
<td>0.30</td>
<td>0.48</td>
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<tr>
<td>EC_{2.5}</td>
<td>0.48</td>
<td>-0.35</td>
<td>0.67*</td>
<td>0.90**</td>
<td>-0.43</td>
<td>-0.07</td>
<td>0.82**</td>
<td>0.48</td>
<td>-0.07</td>
<td>-0.14</td>
</tr>
<tr>
<td>Avail.N</td>
<td>0.84**</td>
<td>0.42</td>
<td>0.34</td>
<td>0.70*</td>
<td>0.47</td>
<td>0.31</td>
<td>-0.77**</td>
<td>-0.19</td>
<td>0.93**</td>
<td>-0.30</td>
</tr>
<tr>
<td>Avail.P</td>
<td>0.00</td>
<td>0.33</td>
<td>0.03</td>
<td>0.95**</td>
<td>-0.25</td>
<td>0.30</td>
<td>0.32</td>
<td>-0.10</td>
<td>-0.36</td>
<td>0.53</td>
</tr>
<tr>
<td>Avail.K</td>
<td>0.38</td>
<td>0.37</td>
<td>0.33</td>
<td>0.87**</td>
<td>0.14</td>
<td>0.17</td>
<td>0.92**</td>
<td>0.09</td>
<td>0.47</td>
<td>-0.23</td>
</tr>
<tr>
<td>Avail.S</td>
<td>0.26</td>
<td>0.69*</td>
<td>0.27</td>
<td>0.82**</td>
<td>-0.12</td>
<td>-0.60</td>
<td>0.88**</td>
<td>-0.63*</td>
<td>-0.01</td>
<td>-0.21</td>
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<tr>
<td>Avail.Zn</td>
<td>-0.53</td>
<td>0.10</td>
<td>0.15</td>
<td>0.78**</td>
<td>0.08</td>
<td>-0.32</td>
<td>0.81**</td>
<td>-0.62</td>
<td>-0.07</td>
<td>-0.44</td>
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<tr>
<td>Avail.Fe</td>
<td>-0.24</td>
<td>-0.40</td>
<td>0.20</td>
<td>0.53</td>
<td>-0.61</td>
<td>0.29</td>
<td>0.60</td>
<td>0.11</td>
<td>0.17</td>
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<tr>
<td>Avail.Cu</td>
<td>-0.69*</td>
<td>0.29</td>
<td>0.39</td>
<td>0.79**</td>
<td>0.52</td>
<td>0.22</td>
<td>0.46</td>
<td>-0.21</td>
<td>0.22</td>
<td>0.91**</td>
</tr>
<tr>
<td>Avail.Mn</td>
<td>-0.19</td>
<td>0.05</td>
<td>-0.07</td>
<td>0.37</td>
<td>-0.66*</td>
<td>0.66*</td>
<td>-0.28</td>
<td>0.22</td>
<td>-0.10</td>
<td>-0.42</td>
</tr>
<tr>
<td>B.D</td>
<td>-0.91**</td>
<td>-0.91**</td>
<td>-0.64</td>
<td>-0.99**</td>
<td>-0.91**</td>
<td>-0.96**</td>
<td>-0.96**</td>
<td>-0.85**</td>
<td>0.15</td>
<td>-0.20</td>
</tr>
<tr>
<td>WSA (&gt;0.5mm)</td>
<td>-0.31</td>
<td>0.00</td>
<td>0.84**</td>
<td>0.93**</td>
<td>0.05</td>
<td>0.40</td>
<td>-0.27</td>
<td>0.00</td>
<td>0.34</td>
<td>0.75**</td>
</tr>
</tbody>
</table>

* and ** indicate significance of values at P=0.05 and 0.01, respectively.
However, positive co-relations in oil palm, pulses and oil seed, floriculture, vegetable land uses and barren land, negative correlations in other land uses were found non-significant. In case of available Fe, no significant correlation existed. However, negative correlations were observed in oil palm, sapota, rice land use and barren land are in conformity with the findings of Reddy and Agarwala (1972) and positive correlations in the rest of the land uses are in good agreement with Singh et al. (2006). Available Mn had shown significant positive correlation ($r=0.66^*$) under pulse and oil seed and a significant negative correlation ($r=-0.66^*$) under rice. In rest of the land uses correlations are either positive or negative, but could not reach to the level of significance. So far as available Cu is concerned, in sugarcane land use ($r=0.79^{**}$) and in barren land ($r=0.91^{**}$) correlations were found to be highly significant and positive. Such positive correlation of available Cu with organic carbon was previously noted by Venkatesh et al. (2003). Oil palm land use, however, had shown a highly significant but negative correlation ($r=-0.69^{**}$) which are in conformity with the findings of Das et al. (1997).

In case of bulk density, highly negative and significant correlations with SOC were observed in almost all land uses, except floriculture and banana land (Table 2). This fact indicates that SOC has a large bearing on the regulation of soil bulk density almost in all the land uses of NAU campus. The results are well supported by Mathan and Kannan (1993) and Bhattacharyya (2007). Water stable aggregate of size $>0.5$mm had been found to correlate significantly or highly significantly and positively with SOC in mango ($r=0.84^{**}$) and sugarcane ($r=0.93^{**}$) land uses and in barren land ($r=0.75^{**}$). Zhang et al. (2008) reported that soil organic matters were related positively to water stable aggregates.

**Conclusion:**

It can be concluded from the overall results that land should not be kept barren and efforts should be made for improving SOC having low status. Proper management practices and corrective measures through adopting crop rotation, avoiding excessive cultivation and application of organics are required to be taken for soils having low to marginally medium status of available nitrogen, phosphorus and potassium and deficient in available Zn, Fe, Mn, Cu, for sustaining crop yield and over all soil quality.

**LITERATURE CITED**


