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# Recovery of Soil Organic Carbon under Different Nutrient Management Practices in Acid Soil of Meghalaya

B.C. VERMA[1]*, B.U. CHOUDHURY[1], G.I. RAMKRUSHNA[1], MANOJ KUMAR[1], L.J. BORDOLOI[2], S. HAZARIKA[1], T. RAMESH[1], D. BHUYAN[1]

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## ABSTRACT

Soil organic carbon (SOC) is the central element that affects most of the physical, chemical and biological properties of soil. Soil health and quality are very much dependent on these properties; hence SOC is important in maintaining the soil health and quality. Present study was formulated to see the effect of nutrient management practices on two soil carbon fractions and relative recovery of one over the other. Surface soil samples (0-150 mm) were collected from the field of on-going experiment on soil carbon dynamics under different nutrient management practices on acid soil. Processed soil samples were used for subsequent analysis. Total carbon (TC) content varied from 4.75 to 4.91% and 4.96 to 5.14% across the nutrient management practices under maize and groundnut, respectively. In maize, the SOC content varied from 1.25 to 1.90%, however in groundnut, it varied from 1.26 to 1.98%. Recovery of carbon by dichromate method varied from 26.2 to 38.8% in maize and 25.4 to 38.5% in groundnut, respectively. Recovery is more (30-38%) in recently manured plots. Recovery percentage of carbon is significantly affected by the different nutrient management practices. It implies that recovery percentage of carbon is highly variable and varied due to different nutrient management practices. Hence, the conversion factor (SOC to TC) generated for the one soil or for the one region cannot be applicable for the other soil or region. This conversion factor must be specific for a particular soil or for the particular region and must be developed individually.

**Keywords:** Acid soil, Groundnut, Maize, Meghalaya, Recovery percentage, Soil organic carbon, Total carbon

## INTRODUCTION

Soil organic carbon (SOC) is the key factor of soil which governs most of the soil properties. It is very important for maintaining soil quality, future productivity, and sustainability (Katyal et al. 2001). In addition, being a direct source of plant nutrients, SOC also indirectly influences nutrient availability in soil. Soil contains a significant part of global carbon stock which is important in maintaining overall quality of environment. The most dramatic changes in SOC occur on conversion of land under natural vegetation (e.g. forest, pasture etc.) to arable agriculture (Kern and Johnson 1993). A number of factors like tillage intensity, application of manures and fertilizers, crop rotation, climate etc. contribute to the build-up or losses of organic carbon under arable agriculture (Verma et al. 2010). Application of manures and fertilizers at optimum rate increases the crop production which in turn results in greater residue inputs leading to enhanced build-up of carbon in soil (Nyborg et al. 1995; Rasmussen et al. 1998). Application of animal manures often results in substantial increase in soil organic carbon content and even more effective than inorganic fertilizers (Izaurralde et al. 1997). Even single application of manure if applied at high rate can result in measurable enhancement in SOC in

[1]ICAR Research Complex for NEH Region, Umroi Road, Umaim-793103, Meghalaya
[2] ICAR Research Complex for NEH Region, Nagaland Centre
*Corresponding author's E-mail: bibhash.ssac@gmail.com

temperate climate (Janzen et al. 1998). Several studies indicated that application of FYM, green manure, crop residues, bio fertilizers and other wastes along with inorganic fertilizers enhanced the organic carbon and other plant nutrient content in soils (Anand Swarup and Yaduvanshi 2000; Goswami and Rattan 2000; Aulakh et al. 2001; Sharma and Prasad 2001). Over the years, two basic approaches have been used to quantify total carbon (organic + inorganic) in soil, *viz*. dry and wet combustion (Page et al. 1982). Generally total organic carbon in soil is determined by combustion after removal of inorganic carbon. As both of these procedures are cumbersome and time consuming, assessment and monitoring of soil organic carbon either for agricultural sustainability or environmental quality have been done in most of the studies by dichromate method or Wakley and Black method (Wakley and Black 1934). This method provides widely variable recovery of organic carbon from soils; particularly this method gives much lower recovery of organic carbon in carbonized materials, compared to wet combustion with dichromate involving external heating. Blair et al. (1995) reported both under- and over-estimation of soil organic carbon (SOC) by Walkley and Black Method compared to combustion in cropped and uncropped soils, respectively. Another simpler approach for approximation of total carbon in soils is to determine the loss of soil mass on ignition (Rowell 1994). But this method overestimates the total organic carbon as it is affected by sesquioxide and clay content of soil, in addition to organic matter. With this background present work was conducted to see the effect of nutrient management practices on two soil carbon fractions and relative recovery of one over the other.

## MATERIALS AND METHODS

To accomplish the above stated objective of the present investigation, surface soil samples (0-150 mm) were collected from the field of on-going experiments on soil carbon dynamics under different nutrient management practices on acid soil. Details of treatments of the project are presented in Table 1. About 500 g of each of composite moist soil samples were collected from the different plots and kept for air-dried, ground and passed through 2 mm sieve. These samples

**Table 1:** Details of nutrient management practices applied for maize and groundnut

| Treatments | Details |
|---|---|
| $T_1$ | Control |
| $T_2$ | 100% NPK |
| $T_3$ | 50% NPK + Lime @5q/ha |
| $T_4$ | 100% NPK + Lime @5q/ha |
| $T_5$ | 50% NPK + FYM@5t/ha |
| $T_6$ | 50% NPK + FYM@5t/ha + Lime@5q/ha |
| $T_7$ | 50% NPK + FYM@2.5t/ha + Lime@5q/ha |
| $T_8$ | 50% NPK + Weed Compost@5t/ha |
| $T_9$ | 50% NPK + Weed Compost @5t/ha + Lime@5q/ha |
| $T_{10}$ | 50% NPK + Weed Compost @2.5t/ha + Lime@5q/ha |
| $T_{11}$ | 50% NPK + Vermicopost @5t/ha |
| $T_{12}$ | 50% NPK + Vermicopost @5t/ha + Lime@5q/ha |
| $T_{13}$ | 50% NPK + Vermicopost @2.5t/ha + Lime@5q/ha |
| $T_{14}$ | FYM + Weed Compost + Vermi Compost @2.5 t / ha (1:1:1) |
| $T_{15}$ | FYM + Weed Compost + Vermi Compost @2.5 t / ha (1:1:1) + Lime@5q/ha |

RDF (Recommended Dose of Fertilizers – 80 N- 60 $P_2O_5$ – 40 $K_2O$, Kg / ha) for Maize
RDF (Recommended Dose of Fertilizers – 20 N- 60 $P_2O_5$ – 40 $K_2O$, Kg / ha) for groundnut

were used for subsequent chemical analysis. Total carbon was measured by loss on ignition method. Loss on ignition as an approximate measure of the total carbon in soil was determined by following the procedure of Rowell (1994). For this purpose, 50 g of air dried soil sample was taken in silica crucible and loss in weight of soil between 105°C and 550°C, was determined by using muffle furnace. Soil organic carbon was determined by wet oxidation method or dichromate method of Walkley and Black (1934). Analysis of variance method was followed to elucidate the effect of different nutrient management on the soil organic carbon fraction and their recovery using SPSS.

## RESULTS AND DISCUSSION

Total carbon (measured by Muffle furnace method) content varied from 4.75 to 4.91% and 4.96 to 5.14% across the nutrient management practices under maize and groundnut respectively (Table 2). However the effect of nutrient management practices on this carbon is non-significant in both

**Table 3:** Effect of nutrient management practices on carbon fractions and their recovery under maize and groundnut

| Treatments | Maize | | | Groundnut | | |
|---|---|---|---|---|---|---|
| | SOC(%) | TC(%) | Recovery (%) | SOC(%) | TC (%) | Recovery (%) |
| $T_1$ | 1.25 | 4.77 | 26.2 | 1.26 | 4.96 | 25.4 |
| $T_2$ | 1.35 | 4.79 | 28.3 | 1.38 | 4.99 | 27.6 |
| $T_3$ | 1.28 | 4.75 | 27.1 | 1.33 | 4.96 | 26.7 |
| $T_4$ | 1.41 | 4.79 | 29.4 | 1.44 | 5.01 | 28.6 |
| $T_5$ | 1.66 | 4.85 | 34.2 | 1.67 | 5.05 | 33.1 |
| $T_6$ | 1.67 | 4.87 | 34.3 | 1.84 | 5.09 | 36.2 |
| $T_7$ | 1.55 | 4.80 | 32.2 | 1.66 | 4.99 | 33.3 |
| $T_8$ | 1.49 | 4.86 | 30.6 | 1.57 | 5.07 | 30.8 |
| $T_9$ | 1.45 | 4.87 | 29.7 | 1.50 | 5.09 | 29.5 |
| $T_{10}$ | 1.38 | 4.81 | 28.8 | 1.48 | 5.01 | 29.5 |
| $T_{11}$ | 1.76 | 4.87 | 36.1 | 1.78 | 5.08 | 35.1 |
| $T_{12}$ | 1.74 | 4.88 | 35.7 | 1.74 | 5.10 | 34.2 |
| $T_{13}$ | 1.63 | 4.81 | 33.9 | 1.66 | 5.02 | 33.1 |
| $T_{14}$ | 1.88 | 4.91 | 38.1 | 1.86 | 5.12 | 36.3 |
| $T_{15}$ | 1.90 | 4.91 | 38.8 | 1.98 | 5.14 | 38.5 |
| CD (p=0.05) | 0.15 | 0.23 | 2.86 | 0.23 | 0.19 | 4.64 |

the crops after one year of experiment. Changes in nutrient management practices within the agricultural system cause more subtle changes in total soil organic matter content hence total carbon as well, because of the relatively large quantity of background organic matter already present. Such changes are difficult to detect in a short period of time and are usually demonstrated in long-term (>25 years) experiments (Campbell et al. 1997; Christensen and Johnston 1997). Hence one should not expect the changes in total carbon content within such a short period of time i.e. one year of completion. Soil organic carbon measured by dichromate oxidation method is significantly affected by the different nutrient management practices after one year (Table 2). In maize the SOC content varied from 1.25 to 1.90%, and the soil receiving the compost showed higher content of soil organic carbon. The improvement is more in soil receiving higher dose of compost @ 5.0t/ha compared to @2.5 t /ha. However, still higher improvement was observed in case of plots receiving organic sources of nutrients only. Among the composts, vermicompost induces more improvement followed by FYM and weed compost. In groundnut, the SOC content varied from 1.26 to 1.98%. By and large, like maize almost same trend was observed in SOC content with respect to nutrient management practices in the groundnut also. Addition of nutrients through INM increases the SOC content in soil however, effect is more pronounced in case of organic sources only. This might be due to addition of organic matter through INM or organic sources because these organic residues act as a source of nutrient as well as carbon in soil.

Tiwari et al. (2002) also reported an increase in organic carbon content of soil due to application of nitrogen through integrated sources under soybean-wheat cropping system on a Vertisol. Dichromate method of SOC estimation that uses heat of dilution or minimal heating does not give complete oxidation of organic matter in soil, although the only most active forms of organic carbon are converted to $CO_2$ (Page et al. 1982), so that, we got significant changes in SOC content due to different nutrient management practices after one year of experiment. In the study we focused the measurement of recovery of carbon by the dichromate method and found that recovery of carbon varied from 26.2 to 38.8% in maize and almost similar 25.4 to 38.5% in groundnut. Recovery percentage of carbon is significantly affected by the different nutrient management practices (Table 2). Recovery by dichromate method is more (around 30-38%) in the plots where we added the compost (organic sources), this implies that after addition of compost, through the mineralization process some of the carbon in soil is mineralized and that will be easily oxidized by the dichromate digestion method. It implies that proportion of acid oxidizable carbon content in the recently manured plot is more than other plots. However in the control plot recovery is lowest, around 25%, it implies that, the carbon present in soil is in recalcitrant form and could not be oxidized by the dichromate acid. If we consider the recovery of the carbon by the dichromate method across the nutrient management practices as 25 to 39%, then the conversion factor for SOC to total carbon varied from 2.5 to 4. This gives a wide variation to calculation of one fraction by the others. It is quite different from the conversion factor used commonly as 1.742 for the recovery of carbon by dichromate method. Under present study, recovery of organic carbon by Walkley and Black method was far below than the values (63-86%) used by Allison (1960) for computing the correction factor (1.16 to 1.59) approximately to convert Walkley and Black carbon to total organic carbon. Nelson and Sommers (1982) mentioned that recovery of organic carbon by Walkley and Black method was highly variable and correction factor appropriate for individual soil varied from 1.09 (90%) to 2.27 (44%). Verma et al. (2013) also reported that SOC measured by dichromate method constituted the 15.4 to 43.7% of total organic carbon in agricultural based cropping system. Walkley (1947) found that recovery of this method varied from 2 to 11% in carbonized materials. In a detailed study, Bremner and Jenkinson (1960) found that Walkley and Black method gave low recovery (<36%) of organic carbon from carbonized materials, whereas, methods involving external heating gave substantial (55-110%) and variable recovery of organic carbon from carbonized materials. We represented the $R^2$ values among the TC and SOC (Fig. 1), which shows that TC and SOC are not well related in this experiment. Hence, these two pools should be analyzed separately.

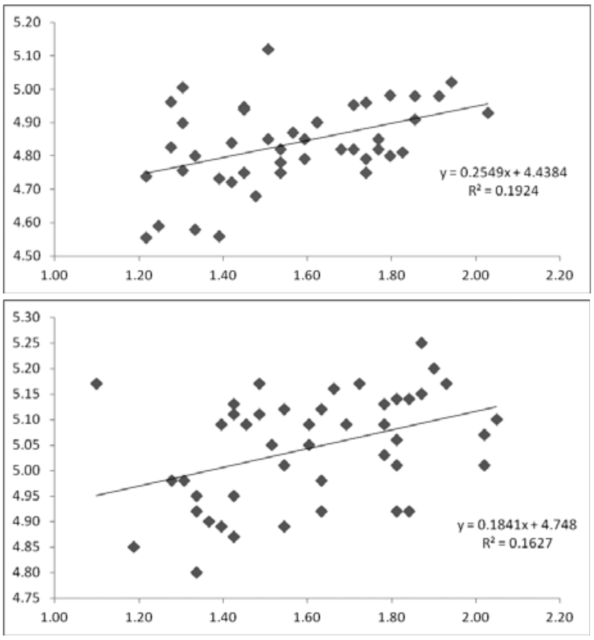


**Fig. 1:** Scatter diagram showing $R^2$ values of TC (Y-axis) to SOC (X-axis) in maize (a) and groundnut (b) (Values are given in %)

## CONCLUSION

This study showed that recovery percentage of carbon is highly variable and varied due to different management factors like nature and amount of manures applied, length of experiment etc. It can be concluded from the present investigation that the conversion factor generated for the one soil or for the one region cannot be applicable for the other soil or region. This conversion factor must be specific for a particular soil or for the particular region and must be developed individually.

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