Sustaining soil carbon and nitrogen pools for future cereal production

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Sustainability of the agricultural system is the main concern for food security in the context of a rapidly growing population. The significance of soil organic matter accumulation for sustaining agriculture has long been recognized. In general, an increase in the organic matter content of agricultural soil improves soil quality, crop growth, and system sustainability, and reduces pressure on forest, thereby reducing green house gas emissions to the atmosphere.

Under a given climate, cropping system and management, the soil C and N tend to maintain an equilibrium. Following cultivation related changes, the soil moves gradually toward new C and N values and tries to establish a new equilibrium (Figure 1). The rate of increase or decrease depends on diverse factors such as climate, cropping system, soil characteristics specially texture, N fertilization, organic manure addition, extent of soil tillage, and soil moisture. Depending on the gains and losses of C and N, the functioning of agro-ecosystem can be considered not sustainable, sustainable or highly sustainable. The C and N pools and their turnover rate are different in the agro-ecosystem and natural ecosystem. The loss of C and N resulting from cultivation can have serious implications for chemical, physical, and microbial fertility of soil. The lack of accurate information on effects of continuous cultivation including fertilization specially in tropics has long been considered to be a major knowledge gap. Recently, some systematic efforts have been made to assess the interaction of soil and fertilizer N of soil N and C content and dynamics, and the impact of synthetic fertilizer on depleting soil N reserves is argued (Mulvaney *et al*., 2009).

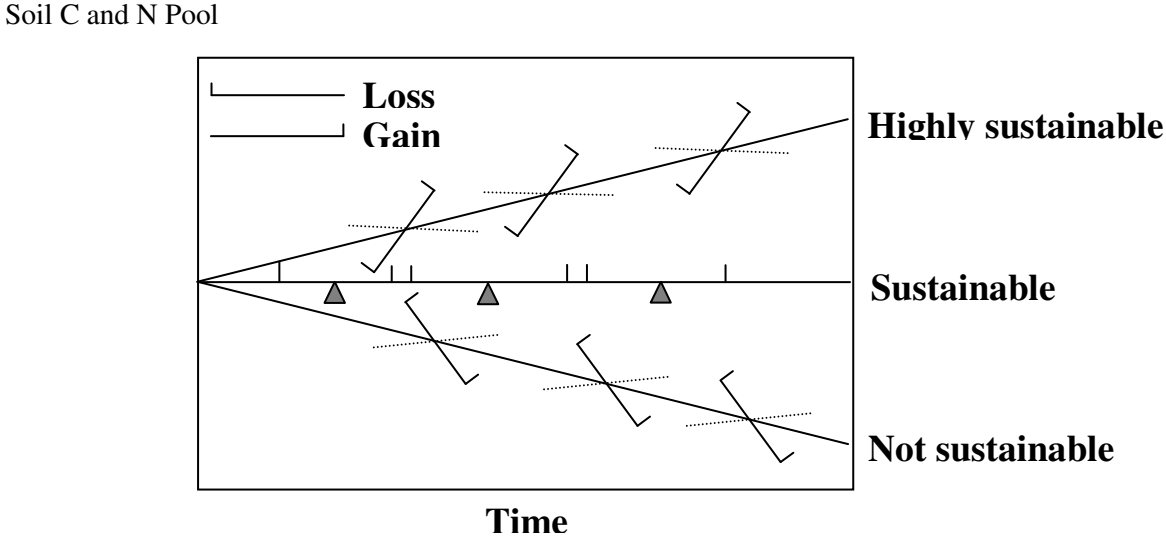

Figure 1. Soil C and N equilibrium concept

Diversified agro-climatic regions of South Asia from subtropical plains to warm-temperate provide opportunities to produce a wide range of agricultural commodities. The most common cropping systems are rice-rice, rice-wheat, rice-maize and maize-wheat. The demand for cereals is estimated to be 50 to 70% higher by 2050 to feed 9.3 billion people (Wood *et al*., 2004). However, cereal based cropping system in South Asia are faced with stagnation in crop productivity. The cultivation of marginal lands together with agricultural intensification on existing land have resulted in a decline in productivity (Ladha *et al*., 2003). Diverse factors including gradual decline in soil C have been attributed to the negative trends in agricultural productivity.

This paper examines the (a) effect of continuous cultivation and fertilization in relation to soil crop

management practices in major cereal based cropping systems on selected soil quality parameters specially soil C and N content, and (b) diverse ways to sustain inherent soil C and N levels. From a large number of long-term experiments and comparison of soils from farmers fields with those of uncultivated fields in Asia, we found widespread decline in soil C and N content. However, declines in total soil C and N tend to be more pronounced and the base levels are lower in crop rotations where soils either remain aerobic (uplands) or goes through cycles of aerobic-anaerobic conditions (upland-lowland). Soils under crop rotations such as rice-rice (lowland-lowland) where anaerobic conditions remain during most of the growing period maintain high base level of soil C and N and often do not show a decline in C and n content. In fixed plot long-term experiments, crop rotations with continuous application of chemical N fertilizer tend to have more loss of soil C, a trend similar to long-term plots without fertilizer-N input. However, plots which received organic amendment with or without N fertilizer tend to show gains of soil C. The ways and means to sustain soil C and N would include: a) minimizing soil disturbance, b) avoiding cycles of soil flooding/drying, c) avoiding dry fallow, d) using quality residue, e) replenishing soil nutrients, f) applying plant need based N, and g) subsurface application of fertilizer N.

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