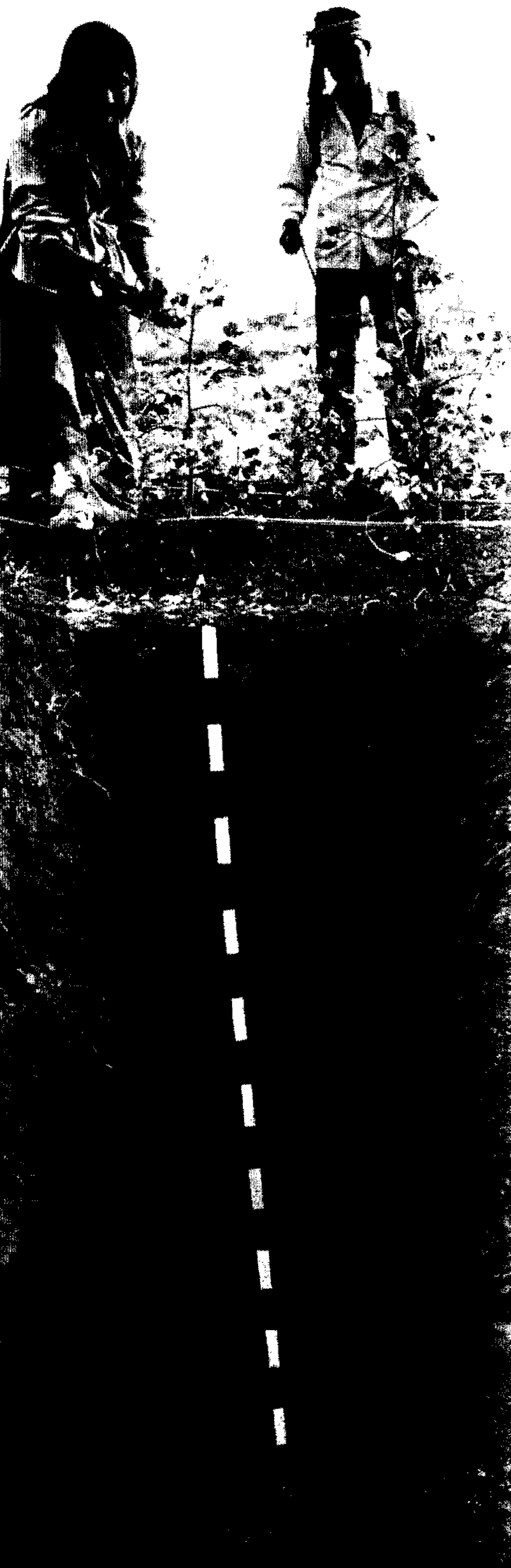
Evaluation of soil physical properties under long-term organic and conventional agricultural systems in Central India



Master thesis

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Date of submission: April 2015
Matric no: 463964
M.Sc. Agricultural Sciences

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In collaboration with

UNI FREIBURG FiBL bioRe

Financially supported by

Foundation fiat panis

I. Abstract

Soil structure is a crucial factor for agricultural success particularly in the clay-rich 'black cotton soils' of India, where intensive management has increased the risk of soil structure deterioration. Soil structure can be improved by biomass supply as practiced in organic farming systems. This thesis analyzed whether long-term organic farming systems (i) increase cracking and loosen soil, (ii) increase infiltration, (iii) decrease surface runoff, (iv) increase soil organic carbon (SOC), pH and electrical conductivity, (v) increase the size of structural soil units, and (vi) decrease plowing costs compared to conventional farming systems.

Therefore, a 7-year-old long-term trial was analyzed, which is comprised of a two-year crop rotation of cotton-soybean/wheat in four farming systems (biological-dynamic, biological-organic, conventional, and conventional with genetically modified *Bt* cotton). The organic systems were fertilized with composted organic manure, whereas the conventional systems received an integrated fertilization of mineral fertilizer with a smaller amount of farmyard manure. On site, cracking was analyzed by photogrammetry analysis, bulk density by core sampling, infiltration by infiltrometers, and surface runoff by rainfall simulation. SOC was analyzed by a combination of Scheibler analysis and combustion in an elemental analyzer. The pH and electrical conductivity were determined in a 1:2.5 soil:water suspension. In order to analyze size and shape of the aggregates, dynamic image analysis (QICPIC method) was improved and adapted. The QICPIC method provided an automatic size analysis of spherical particles in a fast water stream by rear illumination with a pulsed laser light. In combination with wet sieving and sonication, this QICPIC method allowed the assessment of both water-stable and sonication-stable aggregates.

In combination, the organic systems demonstrated 1.8 times higher cracking ($p=0.04$) and 2 % looser subsoils (20-40 cm) in the wheat strip ($p=0.04$). In addition, organic systems indicated 1.1 g kg^{-1} or 5.1 Mg ha^{-1} more SOC within the top 40 cm than the conventional systems, although these differences were not statistically different ($p=0.16$). Despite an expected influence of organic systems on SOC and bulk density of the topsoils (0-20 cm), due to the impact of land management and high carbon turnover at the study site, this was not observed. A lower pH within conventional systems was related to acidifying turnover of applied urea and lower biomass supply. The impact of various farming systems on soil structure was demonstrated by the QICPIC method: Organic topsoils formed more microaggregates <110 µm than conventional ($p=0.02$) that were also rounder if sized 30-90 µm ($p=0.02$) and more stable to sonication if sized <30 µm ($p=0.04$). Such decreasing size trend in organic systems was related to preferential interaction of the added biomass with clay-sized structural units. On the contrary, in the conventional systems more mesoaggregates 140-390 µm developed. Such increasing size trend was attributed to lower biomass supply and less interactions with clay-

sized structural units. However, the high pH (H_2O) of 8.3 within organic systems was interrelated with the increasing size trend towards microaggregates (p=0.008), lower infiltration (p=0.005), and higher wet surface runoff (p=0.077). This size trend in organic systems caused detrimental effects like reduced infiltration, increased surface runoff and thereby posed major challenges to the sustainable management of soil fertility. A positive effect was, however, by 640 ₹ ha^{-1} cheaper plowing in the organic systems than in conventional systems (p=0.003).

The results of this thesis showed initial changes of soil structure after conversion to organic farming in comparison with conventional farming. Especially the influences of the clayey soil properties on aggregation and on other processes, as well as mutual interrelations of these structural soil properties, were demonstrated in this study. Aggregate proportion indices were demonstrated to quantify well the ecological reaction of soil structure. Such investigation is critical in order to evaluate the impact of organic and conventional farming systems on soil fertility and, thereby, influence food security and rural livelihoods.