Soil & Tillage Research 141 (2014) 25–31

Contents lists available at ScienceDirect

Soil & Tillage Research

journal homepage: www.elsevier.com/locate/still

Soil property variation under agroforestry based conservation tillage and maize based conventional tillage in Southern Ethiopia

Haile Ketema [a,*], Fantaw Yimer [b]

[a] Dilla University, College of Agriculture and Natural Resources, Department of Natural Resource Management, P.O. Box 419, Dilla, Ethiopia
[b] Hawassa University, Wondo Genet College of Forestry & Natural Resources, P.O. Box 128, Shashemane, Ethiopia

ARTICLE INFO

Article history:
Received 27 July 2013
Received in revised form 12 March 2014
Accepted 23 March 2014

Keywords:
Agroforestry
Conservation tillage
Conventional tillage
Soil properties
Ages of land management

ABSTRACT

With the objectives of assessing variations in selected soil properties, two tillage types: agroforestry based conservation tillage (AFCST) and maize based conventional tillage (MCVT) under three age categories (5, 10 and 15-years) were selected in Chichu and Haroresa Kebels, Dilla Zuria, Ethiopia. A total of 48 composite soil samples (4 replication × 2 tillage types × 3 age categories × 2 soil depth layers: 0–10 cm and 10–20 cm) were collected to analyze texture and soil organic carbon (SOC%). Addational undisturbed core samples were also collected to determine soil bulk density (g cm^{-3}). Water infiltration capacity was also measured in the field using double ring infiltrometer. The results showed that clay and sand textural fractions significantly varied ($p < 0.001$, $p = 0.002$, respectively) with age of land management. Soil bulk density, soil moisture content (SMC), total porosity (P_t) and soil organic carbon (SOC) varied significantly with tillage types ($p < 0.001$) and soil depth ($p < 0.001$). Water infiltration (rate and cumulative) significantly varied ($p < 0.001$) with tillage types: higher in the AFCST than in the MCVT. Lower soil bulk density, higher soil organic carbon (SOC) and soil moisture content (SMC) were observed in the top 0–10 cm soil layer under the AFCST than in the MCVT. Soil bulk density and soil moisture content (SMC) increased while total porosity (P_t) and soil organic carbon (SOC) decreased with soil depth in both tillage types. Improvement in the soil properties under AFCST was due to higher soil organic matter (SOM) input and less soil disturbance. Thus, reducing the frequency of soil disturbance through application of conservation tillage would help to improve the soil quality.

1. Introduction

Tillage influences soil natural phenomena and ecological processes leading to a remarkable change in soil properties. Conventional tillage system deprives soil's capacity to hold water, deteriorates structure stability and compactness, nutrient supply and storage as well as its biological life (Lal, 2004; Marcela, 2009). It is widely recognized as a factor for decline in soil productivity (Murphy et al., 2006). The maintenance of soil health through different practices (e.g. agroforestry based conservation tillage) is essential to sustain soil productivity (Alain and Serigne, 2003; Marcela, 2009). Studies (e.g. Paul, 1993; Reicosky, 2001; Mari and Changing, 2006) have shown the contributions of agroforestry based conservation tillage in improving soil properties. The presence of trees in the farm coupled with minimum soil disturbance improves most soil properties like soil organic matter, soil aggregation, water infiltration and decrease in bulk density (Tsimba et al., 1999; Brady, 2002; Murphy et al., 2006; Romaneckas et al., 2009). Compared to maize based conventional tillage, agroforestry based conservation tillage has many advantages in erosion control, soil and water conservation, and in increasing soil organic matter (Wang and Gao, 2004).

Tillage intensity and frequency as soil management variables affect the physico-chemical properties of the soil (Oguike and Mbagwu, 2009). The intensity and frequency of tillage on maize based conventional tillage is larger than that of agroforestry based conservation tillage (Marcelo et al., 2010). As a result, disaggregation of the soil structure and oxidation of organic matter occur. In areas where conventional tillage is a common practice, soil carbon is lower due to low level of plant residue, increased soil erosion loss and reduced organic matter input to the soil system (Marcela, 2009).

Apart from an initial reconnaissance (Kippie, 2002) and recent report on characterization and classification of the soils of Upper Sala watershed in Dilla Zuria district of Gedeo Zone (Wendemeneh,

* Corresponding author. Tel.: +251 913 17 24 26.
E-mail addresses: haileketema@yahoo.com, haileketema2005@yahoo.com (H. Ketema), fantawyimer2003@yahoo.com (F. Yimer).

http://dx.doi.org/10.1016/j.still.2014.03.011
0167-1987/

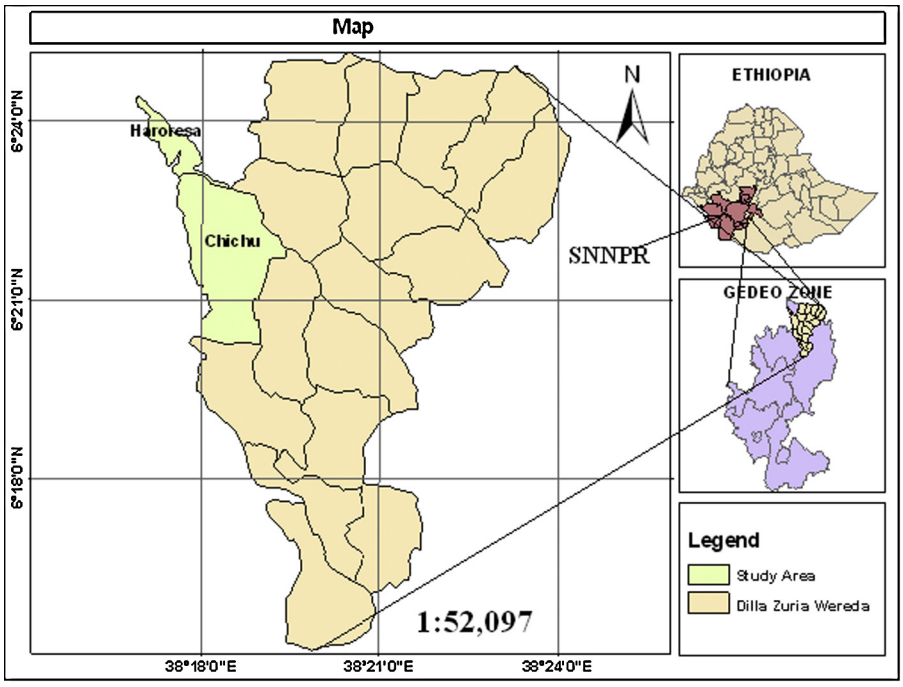

Fig. 1. Location map of the study area.

2010), there has been no study conducted so far to address the effects on soil properties under different management practices: agroforestry based conservation tillage and maize based conventional tillage. This has become an area of particular concern due to the presence of high population pressure and a shifting from agroforestry (conservation tillage) to mono cropping (maize based conventional tillage) practices. This study, therefore, intended to assess the variations in selected soil physico-chemical properties under agroforestry based conservation tillage and maize based conventional tillage in Chichu and Haroresa Dilla Zuria, Ethiopia.

2. Materials and methods

2.1. Description of the study area

The study was undertaken in Chichu and Haroresa Kebeles, Gedeo Zone, Southern Ethiopia (Fig. 1). Geographically, it extends from 6° 18′ 11″ to 6° 25′ 32″ N latitude and from 38° 17′ 40″ to 38° 23′ 43″ E longitude. The altitude ranges from 1450 m to 1800 m above sea level. The study area is characterized by a bimodal rainfall distribution with a maximum between March to June (main rainy season), and a relatively minimum rainfall between August and October (Fig. 2). The mean annual temperature was 20.7 °C, while the mean monthly temperature ranges from 20.1 to 21.9 °C (National Meteorological Services Agency of Ethiopia, 2010).

The dominant soil type in the study is chromic luvisol (Wendemeneh, 2010), with dusky red (2.5 YR 3/2, moist) to dark brown (7.5 YR 3/2, moist) surface horizon; and dark reddish brown (2.5 YR 3/4, moist) to reddish brown (5 YR 4/4, moist) subsurface horizon. Its surface horizon is also characterized by a granular to crumb structure, porous and well aerated with good internal drainage potentials that can be suitable for a wide range of agricultural uses. It has an argillic B (Bt) horizon due to higher accumulation of clay compared to the overlying surface horizon.

The land use system in the study area is not purely crop farming, purely cattle rearing or purely forestry but an integration of these components commonly known as agroforestry practice. Agroforestry based conservation tillage is the most common type (which cover around 78.5% of the total land area) of land management practice. Currently, however, maize based conventional tillage is expanding at the expense of agroforestry based conservation tillage in the study area.

Maize is the most common cereal crop produced in the study area. The local farmers use the traditional *Maresha* plow to prepare their farm for maize production. The plowing system is simple and shallow tilling up to soil depth of 15 cm on average. This traditional *Maresha* (Fig. 3) with its full setup off course could be used in most part of Ethiopia. The whole system of this implement is made up of locally available wood, cattle skin as a strap on the rear side of the beam and on the yoke (Fig. 3). This traditional tillage implement is commonly drafted by oxen (Gebregziabher et al., 2006). The first plowing time for maize crop here in the study area is done as soon as on the onset of the first rain season. Because of its V-shaped ploughing by *Maresha*, the local farmers have to do repeated tillage with any two consecutive tillage operations carried out perpendicular to each other. As a result, the soil is pulverized resulting in weak soil structure and compact formation. Farmers plough 2–3

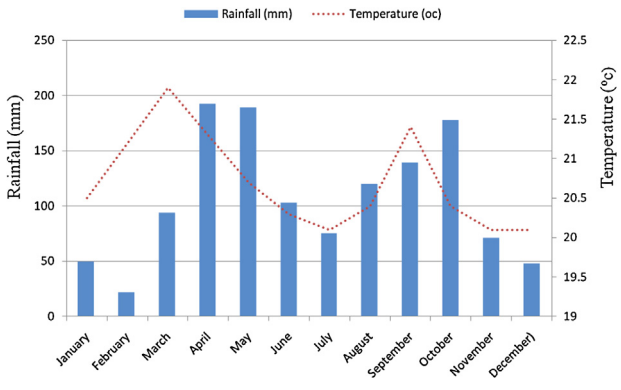

Fig. 2. Mean monthly rainfall and temperature of the study area.