Adjusted T values for conservation planning in Northwest Himalayas of India

D. Mandal, K.S. Dadhwal, O.P.S. Khola, and B.L. Dhyani

ABSTRACT: Tolerable soil loss (T) is defined as the maximum rate of annual soil erosion that economically and indefinitely will continue to sustain a high level of crop productivity. Currently a T value is assigned to a soil based on its current functional state and structural integrity. However, in India a default T value of 11.2 Mg ha^{-1} yr^{-1} (5.0 t ac^{-1} yr^{-1}) is being followed. Our objective is to provide adjusted T values for India's Northwest Himalayan region by incorporating bulk density, water stable aggregate measurements, infiltration rate, soil carbon, and fertility status into the assessment. A quantitative model was used to sum up overall soil performance to define the current state of soil resource. Scaling functions were used to convert soil parameters to a 0 to 1 scale. The normalized values were then multiplied by appropriate weighting factors based on relative importance and sensitivity analysis of each indicator. A categorical ranking of soil 1, 2, or 3 was given to a soil group based on the overall assessment. A general guideline developed by the USDA-Natural Resources Conservation Service (NRCS) was followed to calculate soil loss tolerance for each soil group using effective soil depth. Adjusted T values for the area ranged between 5.0 and 12.5 Mg ha^{-1} yr^{-1} (2.2 and 5.6 t ac^{-1} yr^{-1}) compared to 11.2 Mg ha^{-1} yr^{-1} (5.0 t ac^{-1} yr^{-1}). Use of the adjusted T values will improve conservation planning, help meet erosion control regulations for development of sustainable farm operations, and improve watershed management in this portion of India.

Keywords: Erosion control regulation (ECR), erosion tolerance, quantitative approach, soil grouping, T value

The tolerable soil loss (T) has been defined in several ways (Resource Conservation Glossary, 1982; McCormack et al., 1982; Lal, 1988; Beach and Gersmehl, 1993; ISSS, 1996) but is generally considered the upper limit of soil erosion that can be allowed without degrading the long-term productivity of a specific soil. The T value is also sometimes called "permissible soil loss" (Kok et al., 1995). If erosion rates are higher than T, they are considered unacceptable and should be reduced. Worldwide, reducing soil erosion is still a major problem; in some areas little progress has been made since Stamey and Smith (1964) proposed a definition and a mathematical procedure to calculate tolerance values.

In India, a generalized T value of 11.2 Mg ha^{-1} yr^{-1} (5.0 t ac^{-1} yr^{-1}) (Wischmeier and Smith, 1978; Mannering, 1981; McCormack et al., 1982) is used for different sets of conditions to develop specific best resource management practices for each area. The goal of conservation planning is to control soil erosion to a rate of T or less to prevent degradation. However, T values are not static and change as soil conditions change. The scientific resources devoted to erosion prediction technology far exceed that to soil quality, including T values. Increased attention to understand how soil erosion affects the soil resource is greatly needed.

About half of the area in the Himalayas is degraded, the severity being more in western Himalayas (Sharma, 2004). For effective conservation planning, the region is required to be delineated in terms of T value. Many indices can be used to describe the well-being of soil and landscapes in relation to erosion; thus T values are widely used in many countries. To date, India has no other more comprehensive soil quality index. Such indices should be based on scientific knowledge, including the recovery mechanisms of the soil resource and the environmental processes linked with it. There are two approaches to determine the soil loss tolerance. The first approach is the economic or cost based assessment that considers both the onsite and offsite effects. The second approach is based on the biophysical issues as determined by current functional state and structural integrity of soils. Theoretically, we could afford to lose soil at the rate at which soil forms. Normally, we use a soil formation rate of 1 in per 30 years. This assumption may not be true for all soils, as formation rate of 1 in per 100 years has also been reported (Piemental et al., 1976). Rather than considering one specific value (11.2 Mg ha^{-1} yr^{-1}; 5.0 t ac^{-1} yr^{-1}), Cole and Higgins (1985) proposed that soil loss tolerance should be assessed in terms of a specific range of values with an acceptable degree of risk. NRCS (1999) proposed typical range of T values in integer steps from 2.5 to 12.5 Mg ha^{-1} yr^{-1} (1.1 to 5.6 t ac^{-1} yr^{-1}).

There has been little research work done on quantitative assessment of soil loss tolerance. Some researchers (Bork and Frielinghaus,1997; Lal, 1998; Renschler and Harbor, 2002) have proposed use of numerous parameters in evaluating soil loss tolerance. The current approach based on a linear relationship between soil erosion and soil profile development should be replaced by a method considering the nonlinearities of rock weathering and soil development processes. In many situations, the establishment of a T value is intended to provide basic information for the maintenance of soil productivity, which becomes one of the foci of sustainability of agricultural land use. Therefore, T values may be determined based on the factors affecting long-term productivity. For practical purposes, T values may be estimated based on rooting depth (USDA-SCS, 1973; DLWC, 1997) and soil groups (USDA-NRCS, 1999). In the present investigation, we have hypothesised that site-specific, adjusted T values need to be defined for different soil types in the Northwest Himalayas. The purpose of this study is to develop an user-friendly quantita-

Debashis Mandal is soil scientist. **Kuldip S. Dadhwal** is head of Soil Science and Agronomy Division. **Om Pal Singh Khola** and **Bihari L. Dhyani** are senior scientists in agronomy and agricultural economics, respectively, at the Central Soil and Water Conservation Research and Training Institute in Dehradun, Uttaranchal, India.