SOIL HEALTH: PERCEPTIONS OF THE PAST, DIRECTIONS FOR THE FUTURE

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INTRODUCTION

Soil health is defined as the capacity of soil to function. Functions of soil include sustaining biological productivity, regulating water flow, storing and cycling nutrients, and filtering, buffering, and transforming organic and inorganic materials. Soil also functions as a habitat and genetic reserve for numerous organisms. Consequently, management strategies that optimize multiple soil functions have a greater potential for improving soil health over management strategies that focus on a single function.

PERCEPTIONS OF THE PAST

Soil health is not a new concept. Greek and Roman philosophers were aware of the importance of soil health to agricultural prosperity over 2000 years ago, and reflected this awareness in their treatises on farm management. As the science of agriculture developed, plant nutrients were identified as essential components of soil health, at least with respect to sustaining biological productivity. This resulted in a paradigm of plant nutrition and soil management that relied heavily on the use of artificial fertilizers and intensive tillage.

Increasing concern over agriculture's impact on the environment has created renewed interest in soil health. Efforts to define soil health in the context of multiple soil functions began in 1977 (Warkentin and Fletcher, 1977), and were followed by more formalized definitions (Larson and Pierce, 1991; Karlen et al., 1997), selection of indicators (Doran and Parkin, 1994), and specific strategies to enhance soil health (Doran et al., 1996).

Recent efforts to quantify soil health have resulted in the development of tools to evaluate the impact of management on the soil and environment. The soil quality test kit (reviewed by Cramer, 1994) and soil health scorecard (USDA-NRCS-SQI, 1999) are two examples of tools that provide users with a means to quickly evaluate soil properties and processes with minimal equipment and expertise. These tools, along with numerous extension-oriented presentations by USDA and university personnel, have increased awareness among producers, conservationists, scientists, and policy makers regarding the importance of soil to agricultural and natural resource sustainability.

DIRECTIONS FOR THE FUTURE

While much has been accomplished in the area of soil health, much more needs to be done. Research efforts to monitor and index indicators of soil health need to be balanced with efforts to clearly define relationships between the status of indicators and specific soil functions. In doing so, there is a need to consider the simultaneity of diverse and occasionally conflicting soil functions and their soil property requirements (Sojka and Upchurch, 1999). Greater relevance to these efforts may be achieved by adopting a broader perspective of soil health; a perspective that establishes strategies for agricultural and natural resource sustainability up front, and then uses indicators encompassing all aspects of agroecosystem performance.

Sustainable agriculture is one that, over the long-term, enhances environmental quality and the resource base on which agriculture depends, provides for basic human food and fiber needs, is economically viable, and enhances the quality of life of farmers and society as a whole (Schaller, 1990). This definition, and others like it, can be used as a starting point to develop specific strategies for agricultural and natural resource sustainability. To make strategies amenable for assessment, however, they need to be organized into measurable categories, as there is no single, summary indicator for sustainability.

The performance of every farm and ranch can be expressed through economic, environmental, and social indicators. Indicators chosen from these categories should be a reflection of producer success and/or natural resource conservation. Indicators should also be relatively easy to measure and simple to interpret. Examples of indicators meeting these criteria include crop yield, profit, risk of crop failure, soil organic matter content, soil depth, percent soil cover, leachable salts (especially NO_3-N), and energy use (Table 1).

Table 1. Proposed indicators for a simplified approach for on-farm assessment of agricultural and natural resource sustainability (after Doran, 2001).

PRODUCER AND SOCIETY NEEDS	RESOURCE AND ENVIRONMENTAL CONSERVATION
YIELDS relative to locale, climate, and soil type.	**SOIL ORGANIC MATTER** change with time, relative to local potential.
PROFITS relative to net returns and degree of subsidization.	**SOIL DEPTH** of topsoil and rooting relative to local potential.
RISK / STABILITY of net returns over time.	**SOIL PROTECTIVE COVER** effective as continuous or stratified.
INPUT / OUTPUT RATIO of energy (renewable and non-renewable) and costs.	**LEACHABLE SALTS (NO_3-N)** at planting and post-harvest.

General management strategies considered to enhance agricultural and natural resource sustainability include crop rotation (for tighter cycling of nutrients), reduction in soil disturbance (to maintain soil organic matter and reduce erosion), and use of renewable biological resources (to reduce auxiliary energy requirements). For these management strategies to be successful, however, it will likely be necessary to make better use of the diversity and resiliency of the biological community in soil.

CONCLUSIONS

1. The concept of soil health has increased awareness among agriculturists regarding the importance of soil in maintaining plant productivity and environmental quality over the long-term.
2. There is a need to better understand relationships between the status of soil health indicators and soil functions, and to consider the occasionally conflicting nature of soil functions and their soil property requirements.
3. The best application of soil health may be under a broader context that first defines strategies to enhance agricultural and natural resource sustainability, and then uses indicators encompassing all aspects of agroecosystem performance.

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