FY 2008 Annual Report
National Program 202- Soil Resource Management

Introduction

The thin layer of soil at the surface of the earth functions as the central resource for sustaining life. Soil management is one of the critical factors controlling plant production, which in turn supports animal production. Soils also remove impurities to protect water and air quality. A balance needs to be reached between the short-term use of the soil and the long-term sustainability of this critical resource. Protecting, preserving, and enhancing the soil resource are key elements of this National Program.

The goal of the Soil Resource Management National Program is to enable sustainable food, feed, fiber and energy production while protecting the environment. Research is conducted to understand soil physical, chemical, and biological properties and processes to allow development of soil management practices to overcome limitations to productivity and to improve soil, water and air quality. Development of tools to facilitate soil management decisions and to assess the sustainability of soil management practices is an important part of this effort. Research within this National Program can be described in four broad areas: (1) soil properties, processes and functions; (2) soil management for crop production; (3) soil management for environmental stewardship; and (4) decision tools for soil management. Selective accomplishments from these four areas are described in the following section.

Soil Properties, Processes and Functions

Review articles in *Science* magazine and a conference on Frontiers in Soil Science hosted by the National Academies of Science have drawn attention to the importance of the soil resource and to our incomplete knowledge of soil properties, processes and functions. Considerable research will be needed to support management practices and systems that can overcome soil limitations to crop production and provide soil, water and air quality benefits.

Selected Accomplishments

Inoculation with arbuscular mycorrhizal (AM) fungus produces on-farm increases strawberry yield. There are mounting concerns for the sustainability of current, chemically-based, agricultural practices. Small farm profitability, in particular, has been declining and would benefit from innovative, cost-effective means of increasing yields without additional agrochemical inputs. Arbuscular mycorrhizal (AM) fungi are beneficial soil fungi that colonize crop plant roots and help crops take up nutrients from the soil. ARS scientists from the Microbial Biophysics and Residue Chemistry Research Laboratory, Wyndmoor, PA developed a method for on-farm production of AM fungus inoculum. Roots of young strawberry plants, inoculated with the AM fungi during the growth period prior to being transplanted in the field, had 17% greater yield than uninoculated plants. This translated into a $4,720 per acre increase of income at a cost of $28 for production of the inoculum. Better utilization of the natural symbiosis between crops and AM fungi via the inoculum will require less chemical fertilizer

applications for greater yields, and thus enhance the environmental and economic sustainability of U.S. agriculture.

Soil Management for Production

The soil resource supports sustainable food, feed, fiber and energy production. However, agricultural productivity of soils can be limited by erosion, loss of organic matter, compaction, low fertility, poor water infiltration and storage, acidification, and buildup of salts and toxic trace elements. Soil management practices and systems to overcome these limitations need to be developed and evaluated to sustain and enhance the productivity of soil resources.

Selected Accomplishments

Crop residue requirements for sustainable soil management assessed. The amount of crop residue needed to sustain soil quality following biomass harvest for off-farm use such as bioenergy is unknown. An examination of published literature by ARS scientists from the Agroecosystems Management Research Unit in Lincoln, NE found that residue retention rates required for maintaining soil organic matter and supporting soil microbial populations are greater than the amounts needed for erosion control. Additionally, research conducted by Agroecosystems Management Research Unit scientists demonstrated that residue removal on a marginal site reduced corn yields after five years. These findings demonstrate that the amount of corn stover biomass available as a feedstock for cellulosic ethanol production has been overestimated and that residue retention rates for sustainable soil management are greater than previously realized. The results show that the effects of crop residue removal for biomass energy needs to be thoroughly investigated in field trials for each major agro-ecosystem before biomass energy conversion facilities are built and widespread crop residue removal is initiated.

Soil Management for Environmental Stewardship

Soil management practices impact water and air quality by influencing fate and transport of contaminants, and biogeochemical processes that control nutrient and carbon cycling. Research is needed to document the environmental impact of soil management practices, including those designed to overcome limitations to crop production.

Selected Accomplishments

Southeastern farm survey reveals significant soil carbon sequestration with conservation agricultural systems. A long history of tillage and soil erosion has depleted soil organic matter and subsequently degraded soil quality in the southeastern United States. Research has shown that conservation agriculture (including pasture) is able to restore soil organic matter levels, but there is a need for a broad scale evaluation to properly assess the impacts of changing agricultural practices. Scientists from ARS laboratories in Watkinsville, GA and Auburn, AL cooperated with scientists from Auburn University and the University of Asuncion, Paraguay to conduct an on-farm survey of soil organic matter levels under long-term conventional tillage, conservation tillage, and pasture in 87 fields distributed throughout the Southern Piedmont and

Coastal Plain Major Land Resource Areas of AL, GA, SC, NC, and VA. Across locations, soil organic matter under pastures was 75% higher than under conventional tillage and 39% higher than under conservation tillage. The results are complementary to experiment-station data, and can be used by NRCS, extension agents, and producers to promote pasture-based systems and conservation tillage on 202 million acres in the southeastern U.S. Restoration of higher soil organic matter throughout the region will result in improved soil quality, plant productivity and the potential for mitigating global warming.

Early indicator of soil carbon sequestration trends. Management practices designed to sequester carbon in soil require several years before sequestration is noticeable, and lack metrics to indicate if the practices are working during the interim. An indicator that can be used to judge the progress of efforts to increase soil carbon sequestration would provide a useful decision-making tool. A review of the peer-reviewed literature and data from on-going experiments on soil enzyme activity by ARS scientists at the National Soil Erosions Research Laboratory, West Lafayette, IN showed that ß-glucosidase activity, when normalized to soil carbon content indicated the likely trend of soil carbon sequestration. This value ("BGN"), calculated as ß-glucosidase activity divided by the soil carbon content, falls between 11 and 16 for sites with native vegetation, long-term pastures, and some no-till systems. High BGN values such as these indicate systems that will likely sequester carbon in the future. Low BGN values (< 11) indicate management systems that will result in degradation of the soil. The BGN value provides an early indicator of the impact of soil management systems on carbon sequestration and overall soil quality. This provides a means of determining whether changes to a management system are going to result in soil carbon stock changes without having to wait 3-5 years or longer before current analytical techniques can detect changes in soil carbon. The BGN enables earlier remedial management action when soil systems do not respond to management designed to sequester carbon.

Decision Tools for Soil Management

Producers and their advisors need tools to facilitate soil management decisions, to assess the sustainability of soil management practices, and to predict the environmental benefits of these practices.

Selected Accomplishments

New soil test procedures reduce fertilizer applications. Current fertilizer rate recommendations for the heavy clay soils of central Texas often do not result in meaningful crop yield improvements. ARS researchers from the Grassland Soil and Water Research Laboratory in Temple, TX developed new soil testing procedures for fertilizer recommendations. Fertilizer recommendations based on the new soil test methods were evaluated on local producer-owned farms and resulted in savings in fertilizer cost ranging from $2,000 to $40,000, depending on farm size, without a loss in crop yield. Wide use of the new soil testing procedures will reduce fertilizer use, thus resulting in greater profits for farmers and decreased impact from excess fertilizer losses to the environment.

Improved understanding of organic nitrogen cycling in soils enables improved nitrogen fertilizer recommendations for rice. Continuous rice production in the Grand Prairie region of AR has suffered from a substantial (~19%) reduction of grain yield compared to rice rotated with soybean. Research attributed this yield loss to a deficiency of plant uptake of nitrogen during the middle of the growing season. This was due to decreased plant uptake of nitrogen derived from soil organic matter, while plant uptake of fertilizer nitrogen was less affected. ARS scientists in the Soil and Water Quality Research Laboratory in Ames, IA demonstrated that grain yield of continuous rice can be increased by adding more nitrogen fertilizer during the growing season as compensation for the decreased availability of soil organic nitrogen. This recommendation is being shared with and adopted by farmers and is expected to increase rice yields.

Future

The NP 202 Soils Research Program is being combined with the NP 203 Air Quality and NP 204 Global Change programs to form the NP 212 Climate Change, Soils and Emissions Research Program. Following a workshop during May 2008, research directions for air quality and climate change research were developed and formalized by the NP 212 Action Plan. The existing NP 202 Action Plan has been integrated into the NP 212 Action Plan as current NP 202 Soils projects will continue end according to the schedules set by NP 202.

Soil research under NP 212 is Research Component 4: Maintaining and Enhancing Soil Resources. Problem statements for the research include Controlling soil erosion, Preventing soil degradation, Improving soil management and the efficient use of soil water, and Improving nutrient cycling and use.