FY 2007 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 will be 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 will be 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 further understand the physical, chemical and biological properties and processes that control nutrient transformations and cycling, water storage and availability to plants, carbon storage, gas exchange, and plant root growth and function in soils. This information will allow management practices and systems to be developed to overcome soil limitations to crop production, and to provide soil, water and air quality benefits. A greater knowledge of soil properties and processes will also contribute to the development of decision tools to assess the sustainability of soil management practices, to predict where management strategies should be employed, and to document the environmental benefits that will occur from improved practices and systems.

Accomplishments:

- Mycorrhizal fungi found in soil can colonize plant roots and form a symbiotic relationship that enhances crop uptake of nutrients. ARS scientists from Wyndmoor, Pennsylvania and cooperators from New Mexico State University and Michigan State University found that mycorrhizal fungi outside of the root can take up many forms of nitrogen, convert them into amino acids, and transport the amino acids to the root where nitrogen is released and taken up by the plant. The fungi can provide a significant amount of the nitrogen used by the host plant. Successful establishment of the mycorrhizal fungi – host plant symbiosis will facilitate more efficient use of applied nitrogen and will result in lower fertilizer application rates thus saving energy and protecting water and air quality.

- Many of the processes affecting the behavior of herbicides in the environment are mediated by microorganisms, but information about the impact of environmental conditions or management practices on microbial degradation of herbicides is limited. ARS scientists from Urbana, Illinois found that soil nitrogen controls microbial degradation of herbicides. Soil nitrogen levels required for crop production are not conducive to degradation of herbicides such as atrazine and cloransulam-methyl. These herbicides undergo optimal degradation when the microbial community is starved for nitrogen. ARS scientists from Stoneville, Mississippi found that atrazine was degraded more rapidly in soils with a history of atrazine application compared to soils with limited previous atrazine application. They demonstrated that rapid degradation of atrazine reduced control of broadleaf weeds such as pitted morning glory and prickly sida. ARS scientists from Urbana, Illinois, in cooperation with personnel from the University of Illinois and the Army Corps of Engineers, found that under anaerobic conditions, organisms that degrade explosives also can degrade herbicides called dinitroanilines. This information can be used to predict the persistence of herbicides in soil and to develop management practices that allow appropriate weed control, but do not lead to excessive herbicide persistence.

- Knowledge of interactions between rainfall and different soils found across a landscape and managed under contrasting cropping systems is needed to understand and model water movement in watersheds. ARS scientists from Columbia, Missouri demonstrated that depth of the claypan horizon in the soil profile was the main factor controlling all sub-soil hydraulic properties. Cropping practices also affected soil hydraulic properties, but mostly in the top four inches of soil and not equally at all landscape positions. The greatest improvement in infiltration was achieved in backslope positions managed in permanent grass. This research shows that landscape position and management practices interact, and both are important for characterizing hydraulic properties and developing targeted soil-water conservation practices. This information will contribute to the development of conservation practices and systems that can be funded through USDA Conservation Programs to support long-term sustainability of crop production and water quality protection.

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.

- The Central Great Plains Region is a net importer of feed grains. Inadequate moisture during silking/pollen shed is a major limitation to dryland feed-grain production in the region. ARS scientists from Akron, Colorado evaluated a skip-row planting strategy to circumvent water limitations during silking/pollen shed for corn and sorghum. Because of the distance between the skip-row center and the planted row of corn, sorghum or sunflower, soil water in the skip-row is not available to young plants until they are at the reproductive stage of development (silking/pollen shed). An average yield increase of 6 bushels per acre was achieved for skip-row corn over conventional corn and similar responses were obtained with grain sorghum. Corn, grain sorghum, and sunflower are able to extract water from the 0-150 cm soil profile, even at distances of 115 cm away from the planted crop row. This skip-row planting technique should improve grain yields in water limited areas in the Central Great Plains.

- Many soils in the United States suffer from excessive soil compaction and must be tilled annually to eliminate deep compacted layers that limit water movement and root growth. New spatial technologies that control in-row subsoiling to disrupt compacted layers may reduce fuel consumption while promoting increased yields. ARS scientists from Auburn, Alabama conducted a four-year experiment to compare the impact of site-specific subsoiling and uniform deep subsoiling on corn yield, and energy requirements for tillage. Soils were mapped to determine the depth of the compacted layer, then tilled to that depth using site-specific subsoiling. The site-specific subsoiling treatment resulted in the same corn yields as uniform deep subsoiling, but reduced fuel requirements by 24 percent to 43 percent. Therefore, site-specific subsoiling should help producers increase profits by reducing fuel costs while maintaining crop yields.

- Crop residues on the soil surface play a significant role in the overall quality of a soil by reducing erosion, increasing water infiltration, enhancing nutrient cycling and promoting carbon sequestration. Current methods of measuring crop residue cover are inadequate for objectively assessing a large number of fields in a timely manner. ARS scientists from Beltsville, Maryland have developed remote sensing techniques to assess crop residue cover and estimate tillage intensity using aircraft and satellite images. The Natural Resources Conservation Service (NRCS) advises producers to maintain a sufficient residue cover on highly erodible soils. This method will allow NRCS to rapidly estimate crop residue cover and use the information to adjust management practices to increase residue cover where appropriate.

- Crop residue has been identified as a source of biomass for energy production, but additional research is needed to determine the impact of residue removal on soil quality and subsequent crop production. Residue retention controls erosion and soil organic carbon levels, both of which in turn influence crop yield. ARS scientists from around the country, working together in a multi-location project (Renewable Energy Assessment Program) coordinated out of Lincoln, Nebraska and Ames, Iowa, have found that maintaining or enhancing soil organic carbon is more critical to crop yield than erosion control. Therefore, maintaining or enhancing soil organic carbon levels is the factor that controls the amount of residue that can be removed for energy production. In a related investigation, ARS scientists from Ames, Iowa studied four harvest scenarios using a single-pass grain and residue combine. Leaving the lower 40 to 50 cm of each plant and collecting only the cobs and upper plant parts provided the best biofuel feedstock in terms of water content and mineral ash. Harvesting the lower portion of the plant added very little dry matter, slowed harvest efficiency, increased nutrient replacement costs, increased transportation and storage costs, and decreased surface soil protection. Information generated in these investigations will lead to the development of a decision tool to predict appropriate residue harvest for bioenergy production while maintaining soil productivity.

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.

- Water flowing in irrigation furrows can erode soil and transport sediment and associated nutrients from the field. Polyacrylamide (PAM) has been the standard treatment to improve infiltration and control erosion in furrow irrigation, but lower-cost natural product substitutes are being sought. A new treatment containing polysaccharide and PAM was compared to PAM-alone treatment in a field test at Kimberly, Idaho to determine effects on infiltration and soil erosion. The new amendment, which is a blend of potato starch and PAM, increased infiltration 20 percent and reduced soil erosion 65 percent compared to untreated furrows. PAM treatment alone increased infiltration 13 percent and reduced erosion 98 percent compared to untreated furrows. The new polysaccharide plus PAM amendment can be used as an alternative to PAM for improving infiltration on furrow irrigated fields, although greater application rates will be needed to provide similar erosion control to PAM alone.

- Sustainable production of cotton, peanut and other crops in the southern Atlantic Coastal Plain requires that growers minimize negative environmental impacts of production and reduce costs. To this end, conservation practices such as strip-tillage may offer significant benefits. ARS scientists from Tifton, Georgia compiled data from a seven-year comprehensive tillage study in south-central Georgia. Strip-till provided equivalent crop yields and resulted in two times less surface runoff and erosion than conventional tillage. Strip-till reduced herbicide losses by up to 10-fold compared to conventional tillage. This research will promote increased adoption of strip tillage in the region since benefits have been documented and data has been provided that will allow direct cost-benefit analysis.

- Isoxaflutole is a relatively new pre-emergence herbicide used in corn production. The breakdown products of the herbicide have been detected in groundwater and surface water in the United States. ARS scientists from Morris, Minnesota conducted research to measure how quickly isoxaflutole and its breakdown product were degraded in soil, and to what extent they were transported through soil under typical field conditions in a moist, cool environment. Herbicide measurements and simulation modeling showed that little of the herbicide moved deeper than the plant root zone, and that herbicide uptake by plants may be an important route of herbicide dissipation. The results of these studies will help quantify processes affecting isoxaflutole dissipation under field conditions, and will be useful to federal and state regulatory agencies and pesticide manufacturers when evaluating isoxaflutole labeling requirements and application restrictions.

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.

- Market-based carbon credit programs require scientifically sound estimates of soil carbon offset rates for agricultural management systems. ARS scientists from Mandan, North Dakota used data from a review article by the ARS Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network (GRACEnet) to determine appropriate soil carbon offset rates for continuous conservation tillage (no-till) and seeded grassland for a carbon credit program developed by the North Dakota Farmers Union (NDFU) and the Chicago Climate Exchange (CCX). During the 2006 contract year, over 830,000 acres in North Dakota were enrolled in the NDFU program, resulting in net payments to farmers and ranchers of $2.07M. The program was expanded nationwide for the 2007 contract year using soil carbon offset estimates from additional GRACEnet review articles. Carbon credit programs have the potential to realize multiple benefits for agricultural producers, including increased farm income and improvements in soil quality, while concurrently mitigating global climate change.

- Tools are needed to predict changes in soil carbon storage in agricultural systems. ARS scientists at Pendleton, Oregon and Fort Collins, Colorado have developed a carbon sequestration model (CQESTR) to predict the effect of cropping systems, management practices, climate, and soil conditions on carbon storage in agricultural soils. The model has been delivered to the Natural Resources Conservation Service (NRCS) for beta testing and evaluation. CQESTR will help advisors and land managers predict field scale carbon sequestration to assess soil quality improvements and to provide information for soil carbon credit trading.

- Nitrogen (N) losses from agriculture have a negative impact on groundwater, air, and surface water quality. There is considerable interest in providing financial incentives through N credits to encourage producers to reduce N losses to the environment. ARS scientists from Ft. Collins, Colorado defined the concept of reduced losses of N at the field level (delta N losses) based on management practices that reduce N inputs, make more efficient use of N, and prevent N losses. ARS scientists generated and transferred to the Natural Resources Conservation Service (NRCS) data sets of predicted N losses for thousands of soil and management practice combinations using the Nitrogen Loss and Environmental Assessment Package (NLEAP) model and field data from Colorado, Ohio, and Virginia. NRCS and ARS have worked together to develop a prototype Nitrogen Trading Tool that can predict N losses across a range of soils, climate, crops and management practices. With further improvements, this tool will be used to select the most appropriate management practice(s) for nitrogen loss reduction for a given situation, and to provide the basis for N credit trading.