Building Sustainable Soil Systems

Final Report for ES03-065

Project Type: Professional Development Program
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Region: Southern
State: North Carolina
Principal Investigator:

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Project Information

Abstract:

Participants learn how to develop an integrated approach to soils management for sustainable farming systems and to educate growers about those practices. The field training sites had farm-scale composting, cover cropping, tillage, rotation, soil quality, and fertility demonstrations for subsequent participant training sessions. Training sessions was held in western NC in the winter/spring of 2003/2004 and then repeated in eastern NC in the winter/spring of 2004/2005. Four, two day sessions was held in each instance to address subject matter fore mentioned.

Project Objectives:

1) Participants will learn the importance of soil quality and management practices to improve it. Particular emphasis will be given to the impacts of organic matter on soil physical, chemical, and biological parameters. Participants will develop a power-point presentation on soil quality relevant to and for use in county programming.
2) Participants will learn about nutrient cycling, how to construct a nutrient budget for a crop, and how to synchronize nutrient mineralization from organic amendments and residues with crop nutrient requirements. They will use the nutrient management decision aid programs “NLEW” (Nutrient Loss Estimation Work Sheet) and “PLAT” (Phosphorus Loss Assessment Tool) in county educational programs.
3) Participants will learn the advantages and disadvantages of conservation tillage and how to match conservation tillage strategies with particular crops, soils, and other regional conditions. Participants will use the soil quality kit to demonstrate the impacts of different soil tillage strategies on soil physical (bulk density, aggregate stability, strength) and microbiological (respiration) properties.
4) Participants will become familiar with the soil food web and soil microbial processes that affect plant growth. They will sample local soils managed with and without organic inputs, send samples to a soil biology laboratory for analysis, interpret laboratory results, and write an extension newsletter article reporting findings and soil biology concepts to clientele.
5) Participants will become familiar with cover crops and cover cropping strategies.

They will develop rotational cropping strategies that include use of winter and summer cover crops and demonstrate those rotations in their counties.
6) Participants will learn how to create an integrated soil management plan for a diversified farming operation and will use that knowledge to develop plans with two growers.

Introduction:

Past management of nature to meet the food and fiber needs of increasing populations has taxed the resiliency of natural processes to maintain global balances of energy and matter. Increasing farm sustainability is not simply a matter of substituting one product for another, but of moving away from product-focused methods toward process-focused management. The sustainability of the soil resource is only slightly related to fertilizer and other inputs. Instead, sustainability is almost entirely related to management of soil and cropping systems. Intrinsic soil factors like slope, texture, and local rainfall, along with soil management-related factors like forage-based rotations, soil organic matter content, aggregate stability, and tillage practices have a much greater influence on the sustainability of any given farm than does the type or amount of any conventional or non-conventional soil amendment (Doran et al., 1994).
Since the late 1950's, conventional wisdom has popularized the notion that improved inputs such as crop varieties, synthetic nitrogen fertilizers, herbicides for weed control, and pesticides for insect and disease control have replaced management as a necessary means for maintaining and even increasing crop yields (Bullock, 1992). The past generation of soil managers has focused primarily on the chemical properties of soils (i.e. proper soil pH and "nutrient sufficiency") to promote maximum crop yields, often neglecting soil physical and biological parameters (Larson and Pierce, 1991). Monoculture production of cash grain crops and reliance on chemical fertilizers and pesticides to maintain grain yields are related to declining soil productivity and increased environmental contamination (Fraser et al., 1988). Soil research has concentrated on soil chemical and physical factors, with comparative neglect of biological factors. Consequently, there is relatively limited understanding of how best to capitalize on the dynamics and potentials of soil biology so as to enhance the regenerative capacity of soil systems for agriculture.
More agronomic research and empirical experience for biologically based agriculture are called for as a primary means for sustainable crop yields, economic returns, and a diversified rural economy. Motivation for shifting from chemically intensive management to alternative practices includes: concern for protecting human and animal health from the potential hazards of pesticides; concern for protecting air, water, and soil resources; and, a need to lower production costs (Fraser et al., 1988).
Soil erosion is a major environmental threat to the sustainability and productive capacity of agriculture. During the last 100 years, nearly one-third of the world's arable land has been lost by erosion and continues to be lost at a rate of more than 10 million hectares per year (Pimental et al., 1995). Erosion usually results in decreased primary productivity, which in turn adversely affects C storage in soil because of the reduced quantity of organic C returned to the soil as plant residues. Thus the use of management practices that prevent or reduce soil erosion may be the best strategy to maintain, or possibly increase, the world's soil C storage (Gregorich et al., 1998).
Soil degradation by water and wind erosion and depletion of organic matter, with related consequences such as loss of nutrients, are among the main factors affecting the quantity and quality of land and thus the long-term sustainability of

agriculture in the Southern Region (Cannell and Hawes, 1994). Extensive land clearing and intensive tillage for cotton, tobacco and corn in the last 200 years has made these consequences all-too-common in Southern states and clearly increased organic matter loss from soils (Rasmussen and Collins, 1991).

Sustainable systems should favor less tillage in order to conserve soil, water and energy (Conway, 1996). The increased adoption of conservation tillage is generally viewed as a way to enhance environmental quality. It is considered to be an important "best management practice" (BMP) for reducing nonpoint-source pollution from agricultural fields. The proper incorporation of sound, sustainable principles for crop production in conjunction with conservation tillage, at present, offer the only solution for continued row crop production on large acreages in the southeast. It is essential that farmers in Southern states adopt practices that conserve soil water and afford minimum soil disturbance and maximum soil cover, especially during the period of April through July, when intensive rainfall can severely erode soil left loose and bare by tillage for warm-season crops. Leaving crop residues on the soil surface protects it from the erosive forces of heavy rains, particularly on highly erodible Southeastern soils (Tyler et al., 1994).

Numerous studies have demonstrated significant changes in organic matter concentration with time as a function of crop rotation, tillage, fertilizer practices and other agronomic factors (Janzen 1992). Unfortunately, crop residues decompose rapidly in the warm, humid southeastern U.S., making year-round soil protection a challenge and compounding the threat of soil loss on the region’s highly erodible soils. However, Mitchell and Entry (1998) reported results from Alabama’s long-term ‘Old Rotation’ cotton experiment. Long-term planting of winter legumes with no other source of N applied resulted in higher soil organic C in the plow layer compared to continuous cotton with no winter cover crops. They concluded that after 100 years, the Old Rotation indicates that winter legumes and crop rotations result in larger amounts of both C and N in soil, which ultimately contribute to higher cotton and corn yields regardless of other practices. Other studies have reported that relatively short-term tillage and amendment management can significantly impact C, N, and P transformations and transfers within soil organic matter of a southeastern U.S. soil (Kingery et al., 1996).

Although maintenance of crop residues on the soil surface or the growing of cover crops are the best available means of controlling erosion, it has been recognized that the problems of southern reduced-tillage agriculture are unique to the region. Mild winters and prevalence of soil hardpans have required specific management to overcome the disease, pest, weed and root penetration problems that result from these regional characteristics. Recognition and accommodation of all the soil physical and fertility considerations are necessary to design and achieve successful cropping systems that limit soil erosion (Sojka et al., 1984).

Flue-cured tobacco quotas were cut by 35 percent over the 1998 and 1999 growing seasons (Beacham et al., 2000). The loss of demand for tobacco means a loss of jobs and income for southeastern farmers. For many communities, tobacco has not only been a source of economic prosperity, but is also a long established way of life. Specialty crops such as fruits and vegetables offer an economically viable alternative to tobacco production, particularly for smaller producers. However, production of these crops will require growers to subscribe to and implement an entirely new set of soil management practices. Extensive tillage, short rotations, extensive use of chemical inputs, fallow soils before and after cropping, aversion to organic matter additions to soil, and other conventional attitudes and practices will need to be replaced by more sustainable practices appropriate to high-value, intensively managed (in particular, soil water management) specialty crop enterprises.

Although better understanding and practices can serve immediate on-farm needs, they alone would unlikely achieve the desirable changes in farming systems. Policies and institutional arrangements profoundly influence agricultural research and practice, so effective soil health initiatives must also engage broader social and political considerations. This will require a greater balance in research and teaching to emphasize biology and ecology, enhanced linkages between research and extension, new inter-institutional partnerships and collaboration, and increased stakeholder involvement in policy formulation and implementation (Sherwood and Uphoff, 2000).

Many of the concepts addressed above are poorly understood and only narrowly described in traditional agricultural teaching programs. It is important for educators to fully understand the principles of sustainable soil management and to teach those principles to others, in particular, farmers. Participants in this project will learn about the components of sustainable soil management—soil quality (in particular, biological parameters), organic matter management, nutrient management, conservation tillage, long-term rotations, cover cropping, etc. They will learn how to integrate the various components in an integrated approach to soils management in sustainable farming systems.

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Education & Outreach Initiatives

Objective:

Description:

Methods

Planning teams meet during the summer of 2003 to develop a curriculum in sustainable soil management. The team consists of faculty from North Carolina A&T State University (A&T) and North Carolina State University (NCSU), and staff from the Natural Resource Conservation Service (NRCS), the North Carolina Division of Soil and Water Conservation (NCDSWC), and Operation Spring Plant (OSP). Each of these entities recruited growers to participate in the planning process for the training. The growers invited had successfully implemented sustainable soil management practices in their farming operations in the past. Members of the team participated in the training sessions as instructors for both lecture and field training sessions. Each member also contributed materials to a course syllabus and selected readings appropriate to his or her area of expertise.

A full-time Training Coordinator (TC) was hired in the summer of 2003. The TC recruited participants and coordinate the training sessions. The TC produced a class syllabus, course materials, and a sustainable soil management resource notebook. The TC also distributed required reading materials in a timely manner, schedule presentations and field activities by University faculty, distinguished guest speakers, experienced growers, and professional agriculturalists, provide needed infrastructure, and arrange travel, lodging, and associated amenities. Nationally recognized academicians and growers was recruited as featured speakers in the training sessions, and their lectures will be advertised for general public attendance. Growers participated as trainers, and field trips to farms that employ sustainable soil management practices (appropriate to the respective session's topical material) will be arranged in each region. These "field days" was to provide participants with the opportunity to see practices and their effects in situ and to speak with growers about those practices. A required reading for the training was the SARE publication, Building Soils for Better Crops, written by Fred Magdoff and Harold van Es. Other resource materials was gleaned from the reported scientific literature, web searches, sustainable agricultural organizations (for example Appropriate Technology Transfer for Rural America and the Campaign for Sustainable Agriculture), and from the popular literature.

In order to minimize travel time and costs, and maximize participation, the training will be conducted twice. Training sessions was held in western North Carolina in winter/spring of 2003/2004 and repeated in eastern North Carolina in the winter/spring of 2004/2005. Four, two-day sessions was held in each instance to address subject matter. The training took place at the field training sites and include classroom and "hands-on" field activities. A tentative curriculum is outlined below:

Session 1 Topics: Basic Soil Science and the Importance of Soil Organic Matter
Nutrient Cycling and Management/Nutrient Budgeting

Session 2 Topics: Soil Physical Properties/Farm-scale Composting
Cover Cropping/Green Manures/Intercropping/Rotational Strategies

Session 3 Topics: Soil Biology/Soil Health and Quality
Conservation Tillage/Residue Management

Session 4 Topics: Crop and Livestock Rotations//Natural Resource Policy and

Regulation

Outreach and Publications

1.Participants in the training are being surveyed to determine the extent of their outreach efforts resulting from the training.

2.A publication outlining the training protocols, subject matter and participant behavior/knowledge changes is planned.

Outcomes and impacts:

By conducting this course for the past two years the following impacts were accomplished:
1) Agricultural educators promoted cover cropping and reducing tillage as best management practices for maintaining soil productivity.
2) Growers became aware of and understand the importance of soil organic carbon to long-term crop and soil productivity and adopt practices that contribute to carbon and nitrogen cycling in soils.
3) Soil managers reduced reliance on management of the chemical properties of soils (i.e. proper soil pH and “nutrient sufficiency”) to promote maximum crop yields, and implement management practices that positively impact soil physical and biological parameters.
4) Reduced erosion and non-point source pollution of surface waters was a result as growers increase use of cover crops, decrease tillage, and improve residue management.
5) Reduced soil erosion and consequent improvements to water quality increased the recreational opportunities (fishing, swimming, boating) for rural North Carolinians, as well increase their visibility as environmental stewards of natural resources.
6) Farmers experienced cost savings as they transition to more sustainable soil management systems that reduce input costs, increase productivity, and substitute information and management for capital inputs.
7) Tobacco farmers adopted sustainable soil management practices as they transition into alternative, profitable crops.

Project Outcomes

Project outcomes:

After conducting this course over the past two years, participants learn how to develop an integrated approach to soils management for sustainable farming systems and to educate growers about those practices. By having field training demonstrations, participants was able to become more familiar with farm-scale composting, cover cropping, tillage, rotation, soil quality, and fertility demonstrations for subsequent participant training sessions.

Recommendations:

Potential Contributions

If we were to offer this course again in the future, we should consider inviting growers to enroll in the course along with their county extension agent. The growers invited will have implemented sustainable soil management practices on their farming operations in the past. They would be taking this course to refresh or develop the skills prior to this course. We could then evaluate the perspectives of this course between the agents and the growers. The growers would be able to have first hand experience, so that they would not always have to rely on the extension agent. Following completion of the formal training, the growers could help the county extension agents develop educational programs in sustainable soil management in their home counties for their client populations. By having the agent and the grower team up, other farmers would be so hesitant to try some these soil management practices.

Future Recommendations

1. Funding is needed to develop and maintain a Research and Demonstration Center that is dedicated to Soil Management Practices for the Southeast Region. The focus of this Center should be on efforts to increase biomass additions to soil and cost/benefit analysis of varying strategies. In particular, and as energy prices continue to increase, biomass effects from practices such as cover cropping and residue management should receive considerable attention.

2. Sustainable soil managemenet practices should be identified as a “core competency” for Cooperative Extension agents and appropriate educational modules developed for “on-line” or short course training programs. All agricultural agents should be required to achieve competency. Training modules will need to include basic soil science instruction. Either SARE, CCEP or eXtension should take the lead in this effort.

3. Extension agents should be provided with funding (regionally) to develop demonstration centers for sustainable soil management practices.

4. Multi- and inter-sidciplinary efforts in both Research and Extension are needed to investigate and promulgate sustainable soil management practices, because soils are integral to all aspects of production systems.

5. Increased attention must be focused on soil microbial communities and their influence on soil quality and crop productivity.