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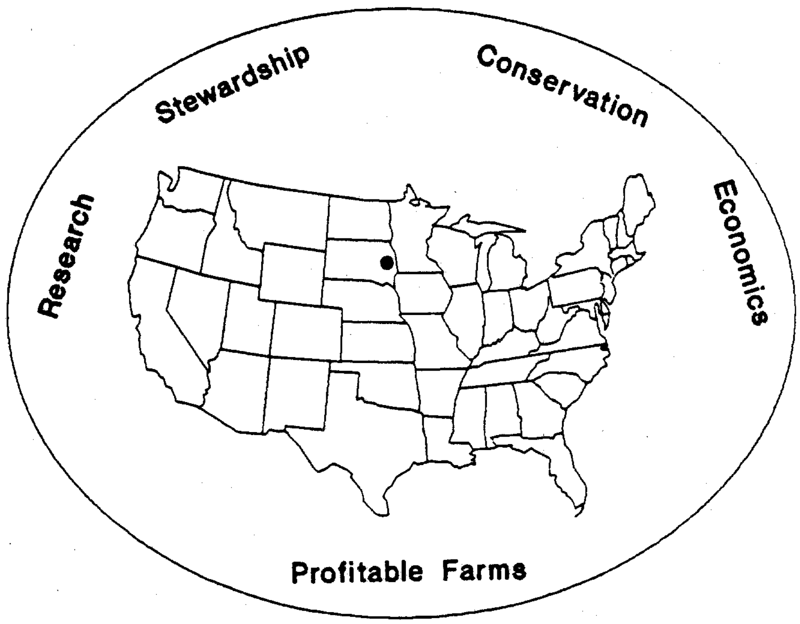
First Annual Report

Eastern South Dakota Soil and Water Research Farm



Prepared by:

North Central Soil Conservation Research Lab, Morris MN

Northern Grain Insects Research Lab, Brookings SD

South Dakota State University, Brookings SD

Agricultural Research Service
United States Department of Agriculture

PLANT SCIENCE DEPARTMENT
AGRICULTURAL EXPERIMENT STATION
SOUTH DAKOTA STATE UNIVERSITY

Annual Report

Eastern South Dakota Soil and Water Research Farm

Volume 1, November 1989

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S. J. Hubbard, Technical Editor

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Dr. Gerald R. Sutter, Research Entomologist

South Dakota State University, Brookings, SD

Dr. Dwayne L. Beck, Assoc. Professor, Agricultural Experiment Station
Dr. Darrell W. DeBoer, Professor, Agricultural Engineering
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Dr. Diane Holland Rickerl, Asst. Professor, Plant Science
Dr. Thomas E. Schumacher, Assoc. Professor, Plant Science
Dr. James D. Smolik, Professor, Plant Science
Dr. Donald C. Taylor, Professor, Economics
Dr. David D. Walgenbach, Professor, Plant Science

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History of the Eastern South Dakota Soil and Water Research Farm

The Eastern South Dakota Soil and Water Research Farm, Inc. is a non-profit organization consisting of a Board of Directors elected from each of 15 Soil and Water Conservation Districts in eastern South Dakota. Brookings, Codington, Clark, Day, Deuel, Hamlin, Kingsbury, Lake, Lincoln, Marshall, McCook, Minnehaha, Minor, Moody, and Turner Soil and Water Conservation Districts are represented on the Board of Directors. The purpose of the corporation is to promote research of efficient farm production practices that conserve soil and water resources.

The corporation purchased 100 acres of land in Lake County, South Dakota, near the community of Madison in 1959. This land was leased to the Agricultural Research Service, United States Department of Agriculture. The work performed at the Madison farm included evaluation of the erosion of different soil types, development of tillage practices to conserve soil and water, determination of efficient crop production methods, and modelling plant-insect interactions. Research was conducted by scientists from the North Central Soil and Water Conservation Laboratory, ARS, Morris, MN; the Northern Grain Insects Research Laboratory, ARS, Brookings, SD; and the South Dakota State Agricultural Experiment Station.

In an effort to improve program efficiency and facilitate productive cooperative research programs that would more effectively solve some of the problems that are associated with agriculture in eastern South Dakota, the Board of Directors decided to relocate the research farm to a closer proximity to the research laboratories. The Madison research farm was sold in 1987, and the Corporation purchased another tract of land in Brookings County.

The Brookings research farm consists of 80 acres located approximately one mile north of the campus of South Dakota State University. The soils found on this farm are characteristic of those found in northeastern South Dakota and west central Minnesota and are similar to soils common to the northern corn belt.

Research Prospectus

Safety of groundwater from chemical contamination and the long-term economic viability and environmental compatibility of agricultural production practices are foremost concerns of the public, farmers, and the scientific community. The widespread use of fertilizers and pesticides for agricultural production poses several significant and interdependent problems. Agricultural chemical contamination of groundwater supplies has the potential for catastrophic impact upon human health, wildlife, and the environment. The high energy and economic costs associated with the production and use of fertilizers and pesticides may cause conventional crop production practices which rely on high levels of chemical inputs to become economically infeasible in the near future. As the deleterious environmental and economic consequences of conventional high-input farming practices continue to compound the future of the family farm, of rural communities and of an American lifestyle becomes increasingly more bleak, the sociological and economic upheaval that is occurring in rural America will undoubtedly worsen if we continue along our current course.

The problems outlined above are complex, and therefore have no simple solution. No single scientific discipline can adequately address these problems in a manner that will achieve effective solutions. Rather, scientists representing many disciplines will need to join forces and focus simultaneously on these problems with the goal of finding acceptable solutions. Herein lies the importance of the Brookings research farm. This research farm provides the impetus and the opportunity for the scientific personnel from South Dakota State University and the Agricultural Research Service to address the complex problems outlined above. A research project that would integrate as many scientific disciplines as possible from the various institutions in a truly meaningful way and would focus upon groundwater quality and sustainable agriculture would have the best chance of having impact upon changing currently used agricultural production methods.

Brookings Research Farm Planning Committee Actions

During the fall/winter of 1988/1989, scientists from ARS and SDSU met for in-depth discussions of possible research thrusts for the Brookings research farm. Initial discussions centered around developing a mission statement for the Brookings research farm. The following version was adopted:

> The mission of the Brookings research farm will be to provide information which can be used to develop improved systems for sustainable agriculture and to protect groundwater quality.

Because of the long-term nature of sustainable agriculture research and the need for an understanding of the spatial variability and water flow patterns of soils for groundwater quality research, it was decided that certain base-line information would be collected:

1) Detailed soil sampling on 100-foot grid spacing to a depth of 10 feet and on 200-foot grid spacing to a depth of 50 feet would be carried out in an effort to determine soil physical properties and nutrient status. Repeated measurements of this type on 5-year intervals would allow monitoring of long-term trends and changes in the nutrient profiles as a result of different management practices.

2) Yield information compiled through detailed sampling can be related to soil physical properties and can provide unique information on spatial variability that may not be available in other research farms. Wheat yields from the 1989 growing season taken on 100-foot grid spacing would provide initial and base-line information for future comparison.

Discussion then centered on the design of the long-term tillage rotation systems to be employed on the Brookings research farm. All scientists agreed on five systems defined as follows:

1. Continuous corn/conventional tillage, high input system
2. Corn-soybean rotation/conventional tillage
3. Corn-soybean rotation/ridge tillage
4. Corn-soybean-small grain-forage legume rotation/ conservation tillage
5. Continuous grass system for comparison of regeneration of soil physical properties

There was a consensus that specific research projects prepared by scientists interested in performing research on the farm would be reviewed by all participating members of the planning committee. Opportunities of cooperative interactions in collecting data from the field plots will be identified. Once details of specific research projects are in place, a detailed experimental field plan will be established for the entire farm.

The research proposals contained in this annual report outline the objectives and procedures for research on the Brookings research farm. At this time, no money is available for specific funding of these research projects. Consequently, these research proposals represent what the scientists want to do if and when funding becomes available.

ECONOMIC ANALYSIS OF ROTATION SYSTEMS

The proposed economics research is intended to complement the research by natural scientists on the five long-term rotation systems undertaken at the Brookings Research Farm.

Principal Investigators

Dr. Thomas L. Dobbs
Professor of Agricultural Economics
South Dakota State University
Brookings, SD 57007
Phone: 605-688-4874

Dr. Donald C. Taylor
Professor of Agricultural Economics
South Dakota State University
Brookings, SD 57007
Phone: 605-688-4872

Justification

The general public, policymakers, and many farmers are concerned over the environmental degradation (e.g., groundwater contamination, soil erosion), intensive capital needs (and, hence, intensified producer risk exposure), and adverse personal health implications to farmers and diet-sensitive consumers than can result from conventional farming techniques. The persistence of huge federal budgets is also compelling legislators to examine ways of reducing government expenditures, including a lessening of the large federal subsidies that have been extended to agriculture during the 1980s.

Sustainable farming practices--involving slightly to greatly reduced use of synthetic chemicals and more generally off-farm purchased inputs and increased use of crop rotations, integration of livestock with crops, mechanical and biological pest control, and integrated pest management--offer one possible means of meeting these concerns and needs. A first step in evaluating the prospective efficacy of sustainable farming practices is to determine the biological and physical feasibility and sustainability of the practices. Those determined to meet such biological and physical criteria then need to be examined from an economic standpoint.

From the standpoint of individual producers, are prospective profits with sustainable farming systems adequate to at least insure financial solvency and hopefully, also, the provision of adequate income to meet family needs? From the standpoint of public policymakers, is the adoption of sustainable farming systems likely to enhance or detract from the economic vitality of rural, small-town economies? What are the likely implications of sustainable agriculture for aggregate food production, food prices, international agricultural trade, and shifts in regional agricultural production patterns?

The proposed research is intended to provide insights on the answers to questions such as these, with greater emphasis to individual producer questions than to macro-economic questions. The proposed research parallels and complements that which has been undertaken since 1984, under conditions of somewhat less rainfall and different soils, at SDSU's Agricultural Experiment Station Northeast Research Farm near Watertown (e.g., Dobbs et al., 1988; Dobbs and Mends, 1989). It complements other research being undertaken at SDSU since 1988 aimed at determining the nature and economic viability of sustainable farming methods practiced on South Dakota farms (e.g., Taylor et al., 1989).

Objectives

The overall objective of the proposed research is to determine the economic viability and implications of the sustainable agricultural practices tested at the Brookings Research Farm. To meet this overall objective, three specific objectives will be examined. Since one of the rotations being examined involves a 4-year crop cycle and atypical (relative to what can be expected in the longer term) "transition" effects--immediately after the conversion from conventional to sustainable practices--are almost inevitable, the examination of the specific objectives within the proposed 5-year time frame can be at best only preliminary.

1. To determine and compare the average profitability of the five long-term rotation systems.
2. To determine and compare the production risks associated with the five long-term rotation systems.
3. To determine how changes in farm policies influence the relative economic practicality of sustainable and conventional farming systems.

Research Methods

The research will involve a major emphasis on the preparation and use of individual crop enterprise and overall crop rotation budgets. These budgets will be based most directly on the results from the various years of field testing the five crop rotations on the Brookings Research Farm. Data required in the budgeting which are not generated directly from the field trials will be obtained from other sources, including the parallel research being undertaken at the SDSU Northeast Research Farm near Watertown.

The analytic approaches for developing the budgets that have been used with the Watertown data will be followed in the development of the budgets for the Brookings Research Farm data. The budgets will provide information necessary for dealing with the first objective. Some of the methods for analyzing risk that are being employed in a current Masters thesis in the SDSU Economics Department (by Thiong Liong Min) will be used for exploring the second objective.

Whole-farm analysis will be used for examining the third objective. Again, the techniques developed for analyzing the Watertown data will be drawn upon in the proposed research. This could involve using both spreadsheet and FINPACK (a farm financial management package) analysis (See Leddy et al., 1988). Resulting from this analysis will be an indication of the prospective implications for the various farming systems being studied from one-at-a-time changes in current farm program provisions.

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Effects of Cropping Systems on Insects, Weeds, and Insect Transmitted Diseases of Small Grains and Corn

Principal Investigators

N. C. Elliott
USDA, ARS, NPA
Northern Grain Insects Res Lab
Rural Route #3
Brookings, SD 57006

R. W. Kieckhefer
USDA, ARS, NPA
Northern Grain Insects Res Lab
Rural Route #3
Brookings, SD 57006

Introduction and Rational

Tillage systems have been shown to influence the composition of insect and weed communities in field crops. Crop rotation and management practices also influence insects and weeds. Furthermore, populations of these two groups of organisms are interdependent; weed density and species composition can influence arthropod community and population dynamics. Effects of conservation tillage on insect pests of corn and small grains have been studied in some regions of the U.S. There are few generalities that can be drawn from published studies; pest populations can increase, decrease, or be unaffected by various conservation tillage practices compared with conventional tillage. Less research has been conducted on insect pest populations in corn and small grains grown in various low-input production systems compared with currently popular crop production systems. Effects of both conservation tillage and low-input cropping systems on natural enemies of insect pests is also lacking. No published research of this type exists from the Northern Great Plains region. In low-input cropping systems management practices used to control pests will differ from those used in conventional systems. Insecticide and herbicide use will typically be less frequent and in lower quantity than in conventional systems and cultural and physical methods of control will be relied on more heavily.

The first step then, in research on pest management of insects, insect vectored diseases, and weeds in alternate cropping systems in the Northern Great Plains is to determine the insect pest and weed species occurring in these systems, their abundance, seasonal patterns of occurrence, interactions with other organisms and natural enemies. This information will permit us to determine the insects, weeds, and diseases that are likely to present the greatest problems to crop production in low-input systems and the potential for biological control of these pests and how populations of these organisms change with time as the cropping system evolves. This research will also establish a framework for future studies that are directed at development of specific methods of integrated pest management in low-input farming systems, and the feasibility of altering agroecosystem design to facilitate effective pest management that is consistent with the philosophy of economically and environmentally sustainable agricultural production.

Objectives

The objectives of this study are as follows: (1) to determine population densities, seasonal occurrence, and community composition of soil surface and aerial plant inhabiting insect pests, beneficial insects, and weeds in the differing tillage and cropping systems established on the Brookings research farm; (2) to assess the pest status of various insects and weeds in different tillage and cropping systems; (3) to determine the incidence of insect vectored diseases of corn and small grains in different cropping systems; (4) to determine the impact of natural enemies of insect pests in low-input cropping systems. The emphasis in all objectives will be to describe and evaluate pest and natural enemy interactions and determine how these interactions change over the course of the conversion to alternate/low-input cropping systems.

Outline of Methods

A. General Sampling Methods

Insect and weed populations will be taken at one to two week intervals throughout the growing seasons of corn and small grains in both conventional and low-input cropping systems; other crops will be sampled intermittently. Disease incidence will be evaluated for corn and small grains at appropriate times.

1. Insect Population Sampling

   Initially, aerial dwelling insect populations will be sampled using three methods: sweepnet, suction sampler, and visual counts. Soil surface dwelling insects will be sampled using pitfall traps. Weeds will be sampled using the canopy cover method. Once the key components of insect and weed communities in different crops/cropping systems are determined, specific sampling methods will be determined for these species. These specific sampling methods will be chosen to provide greater efficiency or accuracy, or because they more directly relate to absolute population density than the methods used initially. All sampling methods used will be nondestructive, or will involve, at most, dissection of samples of plants. Destructive plant samples, if they are required, will be small enough and infrequent enough so that other objectives of the farm, such as yield determination, will not be jeopardized. Numbers of corn rootworm beetles emerging from corn plots will be estimated using emergence traps (5 traps per plot). Use of these traps requires destruction of ca. 1 m of corn in a single row for each trap installed.

2. Weed Population Sampling

   The canopy cover method will be used in sampling weeds. This method is nondestructive and gives estimates of absolute density of each weed species.

B. Natural Enemy Impact on Insect Pests

Specific details cannot be given until we obtain sufficient knowledge of pests and natural enemies in the low-input systems established on the Brookings research farm. Methods of evaluating natural enemy impact on insect pests will include replicated natural enemy exclusion studies and manipulation of natural enemy and pest densities in enclosures.

Soil Macropore Development and Root Function in Long Term Sustainable Systems

Principal Investigators

W. E. Riedell
USDA, ARS, NPA
Northern Grain Insects Res Lab
Rural Route #3
Brookings, SD 57006

T. E. Schumacher
Department of Plant Science
South Dakota State University
Brookings, SD 57007

Low input sustainable agriculture (LISA) can be defined as the effective and productive use of natural resources so that they are conserved or enhanced while still producing commodities. A basic tenant of LISA is that sustainable systems must be economically viable (minimize inputs, maximize profits). Assessment of costs, returns, and risks associated with LISA must be documented by economists before farmers will embrace the strategy of LISA in their agricultural commodity production systems.

One aspect of the economic feasibility of LISA relates to the financial strategies of input substitutions. Integrated pest management is a good example of the substitution of knowledge related to economic thresholds for prophylactic chemical use. Other examples include the substitution of crop rotation and conservation tillage practice for pesticide, fertilizer, and irrigation inputs. The projection that the amount of land under conservation tillage will double in the next 10 to 20 years (Magleby 1985 J. Soil Water Conserv 40:274) is a tribute to the economic feasibility of these tillage practices.

No-till and ridge till systems have several attributes that allow them to be incorporated into LISA. Soil erosion is reduced because crop residue is left after harvest. Soil moisture is conserved because the soil profile is not disturbed. These conservation tillage practices also aid in controlling weeds by eliminating the constant stirring up of weed seeds. Banded fertilizer application efficiently provides nutrients to the soil zone close to the growing roots. In cooler climates, ridge till accelerates spring soil warming and drying of the seedbed allowing farmers to get crops planted earlier.

One drawback to the adaptation and use of these conservation tillage practices in sustainable systems is that a 3- to 5-year-period is needed for these tillage treatments to evolve. The positive attributes associated with conservation tillage may or may not be present during this period of evolution. Indeed, the biggest financial risk after the adaptation of a sustainable system by the farmer comes in the first 3 to 5 years (F. Kirschenmann 1985 Northern Plains Sustainable Ag Society). It is during this time period that the new system would have to prove its economic feasibility. Failure of the system, because of a lack of knowledge of how this system would be expected to evolve, could be a real possibility during this critical time period.

There are also other important advantages of long-term sustainable systems beside economic gain. These include maintenance of an optimal physical environment for topsoil nutrient availability, increased water infiltration into the root zone, increased ability of the soil to buffer short term environmental changes, and a minimization of contamination of surface and ground water. All of these advantages are inter-related and dependent at least in part on soil pore size distribution, geometry, continuity, and stability. Many of the proposed sustainable systems have a significant impact on the pore systems of the soil. In general, pore systems become more ordered with an increase in the number and continuity of macropores. This occurs primarily through the action of plant roots, earthworms, and other biological organisms. Intensive seedbed preparation increases the randomization of the pore systems and reduces the quantity and quality of macropore systems in the upper soil body. Because root growth generally takes the path of least resistance, the presence or absence of macropores may determine the form of the root system and may impact nutrient and water availability. The development and morphology of the root system could be affected to varying degrees by macropore distribution. Because macropores that extend from the soil surface to the bottom of the root zone are important preferential flow paths for water, the development and stability of macropores could have significant impact upon the infiltration of water into the root zone and beyond.

Objective

Soil physical parameters, root morphology, and root function change with conservation tillage practice. Chemical input requirements (fertilizer and pesticides) also change. A more thorough and complete understanding of how these changes affect crop growth and yield is needed as a base for measuring the economic feasibility of sustainable systems. The most direct way to accomplish this is to plant similar crops in companion fields, one crop produced by conventional methods, the other by sustainable methods. Such cropping regimes, which will be present at the Brookings Research Farm, will be used to assess the feasibility of sustainable systems.

The primary objective of the proposed study will be to assess the changes in soil physical properties, root morphology, root function, and yield of crop plants in conventional and long-term sustainable systems. Studies will be done in such a way as to provide information which can be used to develop improved systems for sustainable agriculture.

Methods

It is presumed that the physical properties of soils under conservation tillage practices used in the sustainable systems will undergo a transformation towards new equilibria. Measurements of soil physical properties will be assessed over time during the first several years. Measurements will include:

1) Bulk density/porosity
2) Organic carbon
3) Water content
4) Air-filled pore space
5) Hydraulic conductivity
6) Seasonal temperature profiles
7) Aggregate stability
8) Unconfined flow tension infiltration
9) Visual counts of macropores
10) Air permeability measurements at specified tensions
11) Bypass flow measurements using Bouma techniques

The specific methods of Mielke et al. (1986 Soil Tillage Res 7:355) will be used.

A second presumption is that changes in soil physical properties will cause changes in root growth parameters. Such changes could affect nutrient use efficiency and water use efficiency. Measurements of root growth and root morphology will be assessed over time during the first several years. Measurements will include:

1) Total root length
2) Root diameter
3) Root density at different soil depths
4) Root branching patterns
5) Root hair formation
6) Angle of root growth

Soil cores will be taken, and the soil washed free of the roots. Root length and diameter will be measured using the line intersect method of Rowse and Phillips (1974). Root systems will be dug, washed, and rated for root morphological characteristics.

Changes in crop yield will be assessed on a seasonal basis.

Surface Compaction by Positional Variability
A Proposed Study

Principal Investigators

M. Lindstrom
USDA, ARS
North Central Soil Conservation Research Lab
Morris, MN 56267

T. Schumacher
Dept. of Plant Science
South Dakota State University
Brookings, SD 57007

G. Lemme
Dept. of Plant Science
South Dakota State University
Brookings, SD 57007

Surface compaction from wheeltracks is a common occurrence in all tillage systems during the growing season. The effect of surface compaction on crop productivity is generally considered to be negative. Root limitation in the compacted soil zone is dependent on the effect of surface compaction on soil strength and aeration. Under conditions where surface compaction does not produce root limiting conditions, compaction may have no effect or even a positive effect on crop performance. However, even under conditions when surface compaction does result in a root limitation, the effects on crop performance may not be as large as expected. Under these conditions the horizontal and vertical distribution of root limiting soil density is critical in determining crop response. A uniformly high bulk density across the soil surface and including the top 6 to 12 inches of the root zone would be expected to be detrimental to crop performance. A high bulk density in a wheeltrack positioned in the interrow may not have much effect on crop performance because of the phenomenon of compensatory growth within the root system. The effect of compensatory growth on crop productivity is dependent on the availability of favorable soil conditions elsewhere in the soil body. One might expect a single wheeltrack on one side of the row to have limited effect on crop performance in a moderate to deep soil but a much greater effect in a shallow soil or soil with additional root restrictions within the soil body. A wheeltrack on either side of the row would be expected to compound this effect especially if there is some type of natural root limitation within the soil body. The effects of surface compaction on crop performance would then be expected to vary across a landscape of soils of differing depths.

Objectives

Our objectives in this study would be to evaluate the effects of surface compaction from wheel traffic across landscape position and tillage systems. Tillage systems and crop rotations would be as described in the tillage by landscape study. Positional variability of compaction would include:

1. wheeltrack on both sides of a row
2. wheeltrack on one side of the row
3. wheeltrack on both sides and on the row
4. wheeltrack on one side and on the row

*5. no wheeltracks or row compaction

*Only if five row equipment is available. (Additional options if a wider span tractor is available would be no compaction over a three row range to eliminate competition effects.)

The level of compaction to be used on the row and wheeltrack is subject to discussion. This could be controlled through a targeted bulk density (1.4 or greater for first 6 inches) or a targeted penetrometer reading at given moisture content or a given axle load.

Factors to be measured:

a. crop growth, development and yield
b. bulk density and/or penetrometer measurements
c. nutrient uptake (especially K)
d. root growth
e. macropore distribution in selected treatments.

Soil Tillage by Landscape Position

Principal Investigators

T. Schumacher
Dept. of Plant Science
South Dakota State University
Brookings, SD 57006

G. Lemme
Dept. of Plant Science
South Dakota State University
Brookings, SD 57006

M. Lindstrom
USDA, ARS
North Central Soil Conservation Research Lab
Morris, MN 56267

Conservation or reduced tillage systems have been shown to be effective tillage systems in many cases. Initial incentive for using conservation tillage was soil erosion control. Surface residue resultant from conservation tillage has been credited for the erosion control. The more residue left on the surface the more effective the erosion control. Later incentives for use of conservation tillage systems has been economic benefits. More acres have probably been converted to conservation tillage systems due to economic benefits than due to soil erosion control. However, conservation tillage systems have not performed as good as conventional tillage systems (moldboard plow based systems) in all cases. Generally conservation tillage systems, including no-till, have been consistent or better in yields than conventional tillage on well drained, medium textured soils. Areas with reduced crop yields due to conservation tillage have been associated with soils having inherent physical limitations, such as drainage, wetness level (degree and frequency of wetness), structural stability, and the presence of restrictive layers. In effect, the performance of tillage systems is not necessarily constant over soil types and years.

Objectives

Our objectives in the proposed project "Soil tillage by landscape position" is to evaluate tillage systems over a landscape continuum ranging from a low-lying soil series subject to excess water accumulation to a ridge top showing evidence of erosion degradation and including common soil types inclusive between these extremes. Factors to be considered in this project will include:

a) crop development and yield
b) soil structural and physical properties
c) soil chemical properties
d) nutrient uptake.

These factors will be correlated as to soil type and crop rotation.

Proposed location of the study would begin at the Lismore silty clay loam (LA) soil series located on the south side of the farm near the center (east-west direction) and go west through the deep Vienna loam (DVB) over the Vienna loam (VC) and into the Vienna loam (VB). Soil series present in this transect include soils with deep mollic epipedons (LA & DVB), resultant from deposition, subject to excess water accumulation and perched water tables; soil series with a shallow mollic epipedon (VC), resultant from soil erosion, which will tend to be droughty; and a non-eroded more representative soil series (VB) formed from glacial till. This transect represents soil properties commonly found in field situations with an undulating landscape.

Tillage systems proposed are:

a) fall moldboard plow, spring disc or field cultivate
b) fall chisel plow, spring disc or field cultivate
c) ridge till

Crop rotations proposed are:

a) continuous corn
b) corn-soybeans
c) soybeans-corn

A total of 9 plots result from these treatments and will begin at the Lismore soil series and run west into the non-eroded Vienna (VB). Each individual plot will run as a continuum through the plot area; no replications are proposed because suitable land areas are not available to allow replication. Plot widths proposed are 20 to 24 rows depending on available area. Additional area to accommodate the "Surface Compaction by Positional Variability" study is included in this proposed area. Total plot width would be 450 feet to 540 feet depending on individual plot widths. Total plot length will require approximately 700 feet to run through the proposed soil series.

Other studies that could be incorporated into this project in addition to the surface compaction study could include:

a) nutrient transformation and utilization
b) weed and weed seed populations
c) incidence of disease
d) tillage rotation - may require additional plot widths
e) others

Landscape Position and Surface Compaction Effects on Soil Nitrate Movement

Nitrate movement in the soil study to be incorporated in soil tillage by landscape position and surface compaction by positional variability studies

Investigator

D. H. Rickerl
Dept. of Plant Science
South Dakota State University
Brookings, SD 57006

Justification

Nitrate contamination of groundwater is a serious problem in eastern South Dakota within the Big Sioux Aquifer. Best management practices have been developed for croplands overlaying this shallow aquifer, but less information is available concerning management of adjacent soils with fluctuating water tables and varying densities. Tillage and crop rotation can influence water percolation through the profile and subsequent nitrate leaching. This study will address the interacting effects of landscape position and surface compaction in several farming systems on nitrate movement in soils.

Objectives

1. To determine the effects of landscape position on soil nitrate movement.
2. To determine the effects of surface compaction on soil nitrate movement.
3. To determine the interactions between landscape position and surface compaction and their effect on soil nitrate leaching.

Treatments

1. Landscape positions (soil series):
   a. Lismore silty clay loam (LA and deep Vienna loam (VB) with deep mollic epipedons, resultant from deposition, subject to excess water accumulation and perched water tables;
   b. Vienna loam (VC) with a shallow mollic epipedon resultant from soil erosion, which tends to be droughty;
   c. Vienna loam (VB) which has formed from glacial till and is non-eroded.
2. Tillage systems:
   a. Fall moldboard plow, spring disc;
   b. Fall chisel plow, spring disc;
   c. Ridge-till.

3. Crop rotations:

   a. Continuous corn;
   b. Corn-soybean rotation;
   c. Soybean corn rotation.

4. Positional variability of compaction:

   a. Wheeltrack on both sides of a row;
   b. Wheeltrack on one side of a row;
   c. Wheeltrack on both sides and on the row;
   d. Wheeltrack on one side and on the row.

Data Collection

1. Soil cores will be taken to a depth of 120 cm and analyzed for nitrate content, bulk density, and soil moisture during late fall, early spring, and late spring.

2. Freeze-thaw measurements will be made from soil frost tubes installed to a depth of 120 cm and read weekly from December 1 through April.

3. Plant samples will be taken at harvest time for analysis of total N content.

Data Analysis

Data will be analyzed using a PC-SAS program. Both ANOVA and Regression Analysis will be run.

Rotation and Tillage Effects on Mycorrhizae

Soil organisms study to be incorporated into long-term rotations systems.

Principal Investigator

D. H. Rickerl
Dept. of Plant Science
South Dakota State University
Brookings, SD 57006

Justification

Mycorrhizal fungi are important in crop plants because of their role in phosphorous (P) nutrition. Previous studies indicate that cropping sequences and tillage patterns influence mycorrhizal infection of crop roots. Early infection can increase P uptake in young plants at a time when P availability is limited by cold soil temperatures. Mycorrhizae survive in living plant roots and also as spores in the soil. This study will determine the influence of tillage and crop rotation on mycorrhizal root infection and on the distribution of mycorrhizal spores through the soil profile.

Objectives

1. To determine the effects of long-term tillage and crop rotations on the rate and intensity of mycorrhizal infection.

2. To determine the effects of long-term tillage and crop rotations on mycorrhizal spore distribution throughout the soil profile.

Treatments

Long-term rotations:

1. Continuous corn/conventional tillage, high input system;
2. Corn-soybean rotation/conventional tillage, high input system;
3. Corn soybean rotation/ridge-till, reduce input system;
4. Corn-soybean-small grain-forage legume rotation/conservation tillage, sustainable system;
5. Sustainable cover.

Data Collection

1. Plant samples will be collected at 3, 6, 9 and 12 weeks after planting. Data will include: top growth and nutrient analysis, root growth and nutrient analysis, mycorrhizal infection by root length and sign.

2. Soil samples will be collected each fall in 15 cm increments to a depth of 120 cm. Mycorrhizal spores will be identified and counted.

Data Analysis

Data will be analyzed using a PC-SAS program. Both ANOVA and Regression Analysis will be run.

Rotation and Tillage Effects on Nitrate Movement through the Soil

Nitrate movement in the soil study to be incorporated into long-term rotations systems.

Investigator

D. H. Rickerl
Dept. of Plant Science
South Dakota State University
Brookings, SD 57006

Justification

Sustainable agriculture includes both economic and environmental longevity. This study is designed to determine long-term effects of several crop and tillage systems. An important long-term effect is the influence of these systems on nitrogen movement in the soil profile. Soil nitrates can move through the soil with rainfall and it is likely that nitrates move with soil freeze-thaw activity. The determination of interacting effects of tillage and crop rotations on freeze-thaw activity and nitrate movement in the soil is the major goal of this proposal.

Objectives

1. To determine the effects of tillage and crop rotation on nitrate movement through the soil profile.

2. To determine the influence of tillage and crop rotation on soil freeze-thaw patterns.

3. To determine the interaction between nitrate movement and freeze-thaw patterns as affected by tillage and crop rotation.

Treatments

Long-term rotations:

1. Continuous corn/conventional tillage, high input system;
2. Corn-soybean rotation/conventional tillage, high input system;
3. Corn-soybean rotation/ridge till, reduced input system;
4. Corn-soybean-small grain-forage legume rotation/conservation tillage, sustainable system;
5. Sustainable cover.

Data Collection

1. Freeze-thaw measurements will be made from soil frost tubes installed to a depth of 120 cm and read weekly from December through April.

2. Soil cores will be taken to a depth of 120 cm and analyzed in 15 cm increments for nitrate content, bulk density and soil moisture during late fall, early spring, and late spring.

3. Plant samples will be taken at harvest time for analysis of total N content.

Data Analysis

Data will be analyzed using a PC-SAS program. Both ANOVA and Regression Analysis will be run.

Influence of Cropping Systems on the Establishment and Survival of Corn Rootworm Larvae

Principal Investigators

J. J. Jackson
USDA, ARS, NPA
Northern Grain Insects Res Lab
Rural Route #3
Brookings, SD 57006

R. D. Gustin
USDA, ARS, NPA
Northern Grain Insects Res Lab
Rural Route #3
Brookings, SD 57006

T. E. Schumacher
Department of Plant Science
South Dakota State University
Brookings, SD 57007

Rootworms are the most serious insect pest of corn in the U.S. Economic losses including control costs have been estimated at nearly one billion dollars annually. Both adults and larvae can inflict damage but larval damage is most serious; larvae feeding on the root system reduce the stability of the plant and deprive the plant of moisture and nutrients. Larvae hatch from overwintering eggs when the corn plant is about 8 inches tall. Larvae must move through the soil to locate and establish on a root within a few days or they will perish. Physical properties of the soil are known to influence the establishment and survival of rootworm larvae and different cropping systems are known to influence soil physical properties. We propose to determine (1) if rootworm larval establishment and survival differs when corn is grown in different cropping systems; (2) which soil physical properties most influence rootworm establishment and survival; (3) if soil physical properties are directly or indirectly influencing rootworm establishment and survival.

This study would utilize all cropping systems where corn is included. It would be conducted after the cropping systems have been established and major soil physical properties are judged to be stable. Preliminary evaluations and methods development will be conducted in the preceding years. An approximate study area of 20 by 30 feet would be needed in each cropping system (one contiguous area or smaller areas throughout the system could be used). The study would be repeated over 2-3 years. The study would disturb the soil where plants are removed to evaluate larval establishment and survival and where evaluations on soil physical properties are conducted. It should not adversely affect the long-term maintenance of the cropping systems.

General Methods:

Individual corn plants will be artificially infested with rootworm eggs. The eggs will be applied at several different distances and depths. Plants will be extracted at intervals and the root system searched to determine larval establishment and survival.

Measurements on soil properties will include temperature, bulk density, water content, and porosity. If differences in establishment and survival appear to be affected by factors other than soil physical properties (i.e., soil microorganisms, plant responses, etc.), additional factors will be evaluated. Of particular interest are pathogenic organisms such as nematodes and fungi.

This study will benefit significantly from the establishment of several cropping systems, including conservation tillage, and the cooperative nature of projects proposed for the Eastern South Dakota Soil and Water Research Farm. Measurements on soil physical properties and rootworm larval population ecology should be useful to several proposed projects at the ESDSW Research Farm.

This study will serve as a preamble to additional studies that will evaluate the efficacy of augmented or introduced rootworm larval pathogens or parasites.

C_3 and C_4 Grass Plant Succession in Cultivated Swards

Principal Investigators

K. D. Kephart
Department of Plant Science
South Dakota State University
Brookings, SD 57007

T. E. Schumacher
Department of Plant Science
South Dakota State University
Brookings, SD 57007

Differences in photosynthesis and growth between C_3 and C_4 species have been widely documented. The distribution of C_3 and C_4 species is influenced greatly by temperature and causes a displacement of growth for the two types. Because of temperature related responses, C_3 and C_4 species grown in native mixtures are displaced according to growth season and microenvironment. This displacement allows the different species to exploit resources at differing times and complement the total seasonal growth of the plant community. Differences in phenology, which lead to seasonal displacement, provides for ecological niches within the seasonal biomass production of a plant community. For example, western wheatgrass [Pascopyrum smithii (Rydb.) and Love] (C_3) and blue grama [Bouteloua gracilis (H.B.K.) Lag. ext Steud.] (C_4) coexist in many shortgrass prairie ecosystems. The temperature optimum for growth and photosynthesis coincides with the seasonal temperatures under which these species are the major biomass component. Western wheatgrass grows before the onset of high summer temperatures, whereas blue grama grows best during warm summer periods. C_3 and C_4 species may also coexist in time, but are displaced according to microenvironment.

Ecological interactions of C_3 and C_4 species have been investigated extensively for native, natural ecosystems. Further work is needed, however, addressing plant succession of cultivated C_3 and C_4 grass swards when grown in mixtures. Programs such as the Conservation Reserve Program promote use of forage grasses to minimize soil erosion for a period of time longer than most traditional crop rotations. Programs also exist which promote use of forage species for wildlife habitat and a mixture of complementary species is desirable.

The objective of this research is to determine relative plant growth and species composition of a grass sward previously sown with a mixture of C_3 and C_4 forage grasses.

Experimental Procedures

The grass mixture will be established on an area to be designated by personnel at the Northern Grain Insects Research Laboratory. The area should be fallow for one growing season prior to planting to minimize weed problems and insure adequate soil moisture. Grasses will be planted in early June with a cultipacker seeder. Grass species will include switchgrass (Panicum virgatum L.), big bluestem (Andropogon gerardii Vit.), and blue grama as C_4 entries and intermediate wheatgrass [Elytrigia intermedia (Host) Nevksi], creeping foxtail (Alopecurus arundinaceus Poir.), and orchardgrass (Dactylis glomerata L.) and C_3 entries. Seed for all species will be bulked in the proper ratios prior to planting. Weed control will consist of 2-4,D applications and clipping with a forage harvester. Soil samples will be obtained at the time of planting.

Data will not be collected during the establishment year. Sampling will begin the year after establishment and will occur every 3 wk from mid May until mid September. Changes in species composition, total-herbage digestibility, phenology,and soil properties will be monitored over a 10-yr period. Measured soil properties will include organic matter concentration, bulk density, pH, and aggregate stability. Other collaborative work will be invited from entomologists, botanists, range scientists, etc.

Research progress reports will be submitted to the Northern Grain Insects Research Laboratory and to the South Dakota Agricultural Experiment Station. Results of the completed research will be submitted for publication in refereed research journals.